Capgemini

WORLD ENERGY MARKETS OBSERVATORY

BALANCING THE FIGHT AGAINST CLIMATE CHANGE WITH ENERGY SECURITY

In collaboration with:

vaasaETT | DE PARDIEU BROCAS MAFFEI AVOCATS | Enerdata

24th Edition | 2022

Contents

WORLD ENERGY MARKETS OBSERVATORY

Figures

02. COMMODITIES & TECHNOLOGIES

I. Oil, Gas And Electricity Markets

II. Ukraine – Russia Crisis Consequences

III. Electricity Prices

IV. Nuclear Energy

V. Renewables Technology

VII. Gigafactories

VIII. Electric Heat Pumps

03. REGIONS DESCRIPTION

I. Europe Energy ID Card

III. China Energy ID Card

04. CLIMATE CHANGE & ENERGY TRANSITION

Climate Change Global Perspective (Emissions, Consumption, Renewables)

Business Case - Energy Transition

Forecasted Investments: Renewables &Networks

Oil & Gas Carbon Neutrality Imperative And Best Foot Forward

Scope 3 Emissions

Corporate Power Purchase Agreements (CPPA)

Public Support To Renewables Development From Subsidies To CFD Mechanisms Repower EU

North America (Usa, Canada) Emissions, Carbon Taxes, Renewables And Energy Efficiency Measures

China Emissions, Carbon Taxes, Renewables And Energy Efficiency Measures

India Emissions, Carbon Taxes, Renewables And Energy Efficiency Measures

Australia Emissions, Carbon Taxes, Renewables And Energy Efficiency Measures

South East Asia Emissions, Carbon Taxes, Renewables And Energy Efficiency Measures

LCOE: Levelized Cost Of Energy

05. INFRASTRUCTURES & ADEQUACY OF SUPPLY

Europe Electricity (Mix Evolution, Consumption, Security of Supply, Capacity Mechanisms)

The Need For Distributed Software Platforms In Transmission & Distribution (T&D)

North America Adequacy of Supply

Australia Security of Supply

Australia Trends In Electricity And Gas

South East Asia Adequacy of Supply

06. RETAIL MARKETS

Climate Change Global Perspective (Emissions, Consumption, Renewables)

North America Consumption Evolution,Average Prices And Retail Prices/ Residential Market/ B2b Market

South East Asia Consumption And Retail Prices/ Residential Market/ B2b Market

07. FINANCE

I. Europe Players, Revenues, Margins, Debts, Dividends

II. NA Players, Revenues, Margins, Debts, Dividends

IV. Australia Players, Revenues, Margins, Debts, Dividends

III. Australia Players Priorities, Market M&A

08. TRANSFORMATION

Digitalization Update: Data Mastery, Artifical Intelligence, And Digital Twins

01

GLOBAL OUTLOOK

Introduction

Successive crises impacting the energy markets:

For more than 20 years, I have written the WEMO editorial and almost every year I have insisted on the risk represented by European dependence on Russian gas.

This dependence has increased over the past two decades due to the reduction of European gas production (drying up of the North Sea fields, gradual closure of Groningen) and the increase of gas consumption which was seen as a transitional energy. Gas has replaced coal and nuclear which was stopped for political reasons (for example in Germany). This has increased Europe's dependence on Russia, especially Germany's. The desire to reduce greenhouse gas emissions (GHGs[1]) to limit the rise in the temperature of our planet, the Fukushima accident, and the fight of some ecologists against nuclear energy (which does not emit any GHGs) as well as economic considerations have caused politicians and some energy players to lose sight of the gas supply risks induced by this dependence. Russia's unjustified invasion of Ukraine and Russian blackmail over its gas supplies demonstrates that Europe has been relatively blind.

For more than two years, the world has gone from one crisis to another. Each of them had significant impacts on energy and climate change issues.

1 GHGs: Green House Gases

1. Covid-19 lockdowns triggered historical drops in energy and GHGs emissions:

At the end of Q1 2020, faced with the pandemic and in the absence of vaccines and treatments, many countries went into lockdown for a few months. Energy consumption fell sharply, due to remote living, which lead to a low use of means of transport, the closing of most stores, the low rate of usage of factories, and the stoppage of many construction sites.

a. Very low energy prices:

Over 2020, global energy consumption fell by 4% and GHGs emissions by 5.8%[2]– the largest falls since 1945. Consequently, energy prices reached low levels: the price of oil was negative in the United States in April because the oil storages were full; the H1 2020, base-load power traded for an average of €23/MWh in Germany[3] ; and the TTF[4] spot natural gas price fell to €3.5/MWh in May 2020[5].

b. Electrical grid stability was threatened:

During the pandemic in Europe, the low volume of consumption and the good climatic conditions led to an electricity mix very heavily composed of renewable energies, which brought virtual blackouts in Germany and in the U.K., demonstrating the need to have schedulable electricity (or storage) to stabilize the electrical grid.

2 https://iea.blob.core.windows.net/assets/d0031107-401d-4a2f-a48b-9eed19457335/GlobalEnergyReview2021.pdf
3 https://www.linkedin.com/pulse/european-electricity-market-1h-2020-key-facts-figures-chakraborty/
4 The Title Transfer Facility, more commonly known as TTF, is a virtual trading point for natural gas in the Netherlands
5 https://fsr.eui.eu/skyrocketing-energy-prices/

This need was also outlined by the August 2020 California blackouts caused by a strong heat wave. California is highly dependent on photovoltaic (PV) solar energy. Without storage facilities and enough schedulable electricity, the grid could not provide enough electricity in the evening to power the air conditioners that were running at full capacity. Following this incident, the regulator decided to deviate from the policy previously adopted and equip the network with schedulable gas turbines.

An exceptional cold spell in Texas caused major power cuts in the winter of 2020-2021, impacting notably the production of semiconductor factories whose supply was already tight.

These incidents illustrate the need:

i. For electrical storage or schedulable production to balance networks having a high proportion of intermittent renewables

ii. To reinforce the networks to make them more resilient in the face of exceptional climate events which should become more frequent with climate change.

c. End of globalization?

The successive lockdowns and breaks in the supply chains (which were amplified in the years that followed) created a desire on the part of companies and public authorities to shorten supply chains and relocate factories that had been moved to low-cost countries back to developed regions.

The desire to shorten the supply chain has triggered concrete decisions on some strategic sectors such as electric batteries (in Europe or in the U.S.), solar panels (in the U.S.), and some electronic components (in the U.S. and now in Europe).

For other goods, particularly consumer goods, this relocation would lead to a sharp rise in prices that would hardly be accepted by consumers.

2. Post-Covid recovery economic growth erased the 2020 energy consumption and carbon emissions decreases

Following the end of lockdowns, the global economy started to grow again. China being the precursor, its GDP growth reached 6.5% in Q4 2020, and 2.3% for the whole 2020. In 2021 China's economy grew by 8.1% year-on-year.

In 2021 all regions enjoyed significant growth and the global economy grew by 6%, more than compensating for the 3.5% drop in 2020.

a. Energy consumption[6], and GHG emissions rose again to roughly catch up with 2019 levels

Global energy demand increased by 4.6% in 2021, more than offsetting the 4% contraction in 2020, and global GHG emissions rebounded by nearly 5%, approaching the 2019 level.

In 2021, EU electricity generation from fossil fuels rose by 4% (+4TWh) year-on-year but remained 6% lower (-64TWh) than before the pandemic because of continued growth in renewables (especially wind and solar) over the 2019-2021 period. Coal fired generation phase-out was on pause since gas power became more expensive than coal by mid-2021 and gas-fired plants utilization dropped. Wind and solar power reached another new record[7] (547TWh), generating 19% of EU electricity and, for the first time, produced more electricity than gas plant. Over 2021, solar electricity boomed across Europe, producing 27% more power in 2021 than in 2019, and doubling in the Netherlands and Spain. Wind and solar power have been responsible for most of the renewables' growth since 2019 as there was only modest growth for the other renewable sources (hydropower, biogas, etc.)

6 As demonstrated in previous WEMO editorials, energy consumption and GHG emissions are still strongly correlated with economic growth
7 https://ember-climate.org/insights/research/european-electricity-review-2022/

b. Investments in renewables continued to grow

In 2021, around $440[8] billion was invested in renewables, more than 70% of total new generation capacity expenditure. In 2021, 295 GW[9] of renewable capacity was installed (up 6% compared to 2020) despite the post-pandemic supply chain problems.

However, *cost of solar PV and wind installations grew,* reversing ten years of decreasing costs. Indeed, in 2021, the recovery shock had a strong impact on the supply chains of some raw materials such as steel and copper leading, with freight prices surge, to an increase in the renewables cost.

As upfront capital and associated financing costs are 70-80% of the wind power levelized cost of electricity (LCOE)[10], and 80-90% of solar PV LCOE, increase in CAPEX greatly impacts these renewables' cost. With increased interest rates, these CAPEX will inevitably grow.

The International Energy Agency (IEA) report[11] estimated that in 2021, the overall investment cost of utility-scale PV and onshore wind plants increased by around 25% (compared to 2019). During that period the price of PV-grade polysilicon has more than quadrupled, steel has increased by 50%, copper by 60%, and aluminium by 80%. In addition, freight fees have increased almost six-fold, resulting in additional costs for the renewables' geographically dispersed supply chain.

The long-term trend of decreasing costs reversal is already visible in wind turbines and PV modules prices, which have increased by 10-25% depending on country and region, erasing two to three years of cost reductions.

In China – which produces around 80% of the world's solar PV modules –their costs have also increased. However, in China wind turbine costs have continued to decrease in 2021, as demand declined following the 2020 deployment boom driven by the planned phase-out of subsidies.

During the end of 2021, even if costs for new solar PV and wind installations have increased, natural gas, oil, and coal prices have increased much faster (see below). Therefore, wind and solar electricity generation has further improved its competitiveness.

3. End 2021, the first energy crisis

Global natural gas consumption rebounded by 4.6% in 2021, more than double the decline seen in 2020[12]. Global natural gas consumption grew at a rapid pace during the first half of 2021 due to a combination of strong economic recovery and colder than average temperatures throughout the Northern hemisphere.

However, the progressive tightening of gas supply-demand and resulting increase in natural gas prices had negative impacts on demand during the second half of the year.
It led to a slowdown in industry-related gas demand amplified by gas-to-coal fuel switching.

In 2021, global electricity demand increased by 6% compared to the previous year.

In Europe, tensions over gas supply have led to a very sharp rise in gas and electricity prices.

Beyond the economic recovery, this "energy crisis" can be attributed to: the lack of wind in the Nordic countries, which led to a deficit in wind electricity production, and the low filling rates of gas reservoirs, due to a limited Russian gas supply. Gazprom has limited its gas sales on the spot market (while honouring its long-term contracts), perhaps to get the Nord Stream 2 pipeline commissioning approved. Gas prices soared to over €150/MWh.

ETS[13] allowances prices increased from €17/tCO_2 in March 2020 to nearly €90/tCO_2 at the end of 2021 because of demand recovery. This growth was amplified by the ETS market reform (Market Stability Reserve[14]) that decreased the number of allowances to be traded on the market.

8 https://www.iea.org/reports/world-energy-investment-2021/executive-summary
https://www.iea.org/reports/world-energy-investment-2022/overview-and-key-findings
9 Peak power
10 LCOE: Levelized Cost Of Electricity
11 https://www.iea.org/articles/what-is-the-impact-of-increasing-commodity-and-energy-prices-on-solar-pv-wind-and-biofuels

12 https://iea.blob.core.windows.net/assets/4298ac47-e19d-4ab0-a8b6-d8652446ddd9/GasMarketReport-Q12022.pdf

13 ETS; Emission Trading System is the European carbon market.
14 https://redshawadvisors.com/learn-carbon/eu-ets/market-stability-reserve/

Despite this increase[15], coal-fired plants became cheaper than gas-fired prices and coal demand increased.

This has resulted in extremely high spot electricity prices around €500/MWh (occasionally). At the end of the year electricity spot price in France was €257/MWh!

Many voices have been raised calling for a reform of electricity markets.

a. Electricity market reform

The current market price formation system is based on the marginal cost of the last (most expensive) power plant needed to ensure supply-demand balance.

A high share (more than 60%) of variable renewable energies such as solar and wind, necessary for energy decarbonization, threatens the security of electricity supply. Indeed, in the absence of wind or sun, if the dependence is too great, there is a risk of a break in the electricity supply (see above). To overcome this difficulty, auxiliary services have been introduced, as well as capacity markets and price curtailment (e.g., since April 4, 2022, the European spot market prices are capped at €4000/MWh[16]).

The European electricity market is therefore an overlay of systems with no real coherence between them: energy market, ancillary services, capacity market…

This raises several issues:

i. The immediate problem in Europe has been rising gas prices, following Russia's attack on Ukraine, which led to soaring electricity prices.

Countries that depend very little on gas-fired plants such as France, Spain, and Portugal asked for an electricity market reform to lessen the correlation between the electricity prices and those of gas. Countries such as Germany and Netherlands, that have a high gas dependency, opposed this reform.

In this context, Spain and Portugal have succeeded in reaching an exemption agreement in March 2022, with the European Commission allowing them to shield electricity prices from the spot gas price. This "Iberian derogation" was justified by the two countries' relatively weak connections to the rest of the European electricity grid. These countries also rely more on renewable energy sources than other EU-states, which means that they are less dependent on gas-fired plants.

According to the Spanish government, around 40% of households and between 70-80% of companies should benefit from this system.

This Iberian derogation will cost €8.4 billion (€6.3 billion for Spain and €2.1 billion for Portugal) and will be applied until May 31, 2023.

The support takes the form of a direct grant to electricity producers aimed at financing part of their fuel cost. The daily payment will be calculated based on the price difference between the market price of natural gas and a gas price cap set at an average of €48.8/MWh on the duration of the measure. The agreement will span 12 months, starting with an average price of €40/MWh and gradually increasing to €50/MWh.

The measure will be financed by:

- Part of the so-called "congestion income" (i.e., the income obtained by the Spanish Transmission System Operator (TSO) as result of cross-border electricity trade between France and Spain), and
- By a charge imposed by Spain and Portugal on some buyers benefitting from the measure.

15 Coal fired plants emit more GHGs than gas ones, hence the need to acquire more ETS allowances. However, if gas prices are much higher compared (in energy content) to coal prices, coal fired plants can become more competitive.
16 https://www.montelnews.com/fr/news/1310865/lue-relve-le-plafond-des-prix-aprs-la-flambe-en-france-

ii. In the mid-term, the current spot market system does not (despite capacity markets) ensure security of supply in the event of strong dependence on intermittent energies; moreover, this system, which is based on short-term prices, does not encourage the long-term investments required.

EU[17] should move, as in the United Kingdom, towards a hybrid system that would combine long-term price signals to encourage investment in low-carbon energies (e.g., Contracts for Difference (CfD)[18] applied to the nuclear plant Hinkley Point C or the RAB model[19] as will be implemented for the Sizewell C nuclear plant) and short-term signals to balance the market.

Hybrid markets should be consistent with regulatory planning processes to ensure coordination of policies and targets (e.g., in France new governmental planning between energy and environmental ministries).

Hybrid markets should also include a mechanism articulating downstream revenue collection and upstream cost recovery. This mechanism should, in principle, allocate costs between consumers in an efficient, equitable, and socially acceptable manner

iii. In its "Final Assessment of the EU Wholesale Electricity Market Design"[20] ACER[21] finds that whilst the current electricity market design is worth keeping, some improvements are needed, including:

- Making short-term electricity markets work better everywhere
- Driving energy transition through efficient long-term markets
- Increasing the electricity system flexibility
- Protecting consumers against excessive volatility
- Tackling non-market barriers and political stumbling blocks
- Preparing for future high energy prices in 'peace time'; being very prudent towards wholesale market intervention in 'war time'.

It recommends notably to incentivize those providers and technologies that can 'smooth' electricity market volatility (e.g., batteries, larger-scale storage, aggregated demand-response providers like electric vehicle fleets owners, energy communities, etc.),

concluding that "these factors combined would seem to imply that any future market design needs to be able to

- remunerate technologies above their marginal costs, sometimes quite significantly so
- incentivise the alleviation or smoothing of volatility in the market.[22] "

However, it does not explicitly recommend an EU electricity market reform.

Despite these too conservative views, on September 9,2022, the EU energy ministers recognized that a wide structural reform for electricity market is required and asked the EU for a legislative proposal by early 2023.

17 EU: European Union
18 The Contracts for Difference (CfD) scheme is the government's main mechanism for supporting low-carbon electricity generation. https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference
19 Nuclear regulated asset base (RAB) model https://www.gov.uk/government/publications/nuclear-regulated-asset-base-rab-model-statement-on-procedure-and-criteria-for-designation

20 https://www.acer.europa.eu/events-and-engagement/news/press-release-acer-publishes-its-final-assessment-eu-wholesale
21 EU Agency for the Cooperation of Energy Regulators

22 https://fsr.eui.eu/acers-assessment-of-the-eu-wholesale-electricity-market-design/

b. Measures to limit retail price increases: EU toolbox[23]

European governments took measures to limit price increases for domestic consumers; this was authorized within the EU toolbox defined by the Commission in October 2021.

These measures were either energy checks, cancellations of taxes, tariff limits, or cancellations of tariff changes.

Here are some examples[24] :

i. Britain has a price cap on the most widely used household energy contracts and the newlyappointed Prime Minister Liz Truss said on September 8,2022, that her government will cap domestic energy prices for homes and businesses to ease a cost-of-living crisis

ii. In June 2022, Danish lawmakers agreed to a cash handout to the elderly and other measures totalling 3.1 billion Danish crowns (€440 million) to cushion the impact of soaring inflation and high energy prices.

iii. In France, gas tariffs were blocked, and, in October 2021, the government announced a cap on the increase of electricity tariffs at 4%, believing that the cancellation of certain taxes would be enough to fulfil this commitment. But the increase in spot electricity prices during Q4 2021 led them, under pressure from alternative suppliers, to compel EDF at the start of 2022 to sell 20TWh more under ARENH[25] regulation to its competitors at a price of €46.2/MWh while spot prices reached €257/MWh(!!) at the end of 2022. This measure contributed to limit the electricity price as the volume of ARENH enters the stacking used for the tariff calculation. However, it had a very negative impact on EDF's share price and finances (-€8.4 billion in EBITDA), notably because at the beginning of 2022, all EDF's production was already sold forward. New measures announced since the Ukraine crisis – such as helping companies with their higher gas and power bills – bring the total cost of the government package to around €25 billion.

iv. German workers and families will receive extra cash, cheaper oil, and cut-price public transport tickets. Workers who pay income tax will receive a one-off energy price allowance of €300. Families will receive a one-time bonus of €100 per child, which doubles for those on low incomes. However, German households will have to pay almost €500 more a year for gas after a levy was set to help utilities cover the cost of replacing Russian supplies (see below Uniper case).

v. Greece has imposed a cap on payments to power producers to reflect their real production costs.

vi. In early August 2022, the Italian government approved an €17 billion aid package to help shield firms and families from surging energy costs and rising consumer prices. That comes on top of around €35 billion budgeted since January 2022 to soften the impact of sky-high electricity, gas, and oil prices.

23 file:///C:/Users/clewiner/Downloads/Factsheet_-_A_toolbox_for_action_and_support_.pdf.pdf

24 Reuter, August 17, 2022

25 ARENH: Regulated access to historic nuclear energy (ARENH) allows 'alternative' (or non-historic) energy suppliers to have access to a quarter of EDF's nuclear electricity production at a fixed price presently €42/MWh) https://www.magnuscmd.com/the-arenh-regulated-access-to-frances-historic-nuclear-energy/

vii. The Netherlands has cut energy taxes for its 8 million households.

viii. Norway has been subsidising household electricity bills since December 2021 and currently covers 80% of the portion of power bills above a certain rate. This is due to increase to 90% from September 2022.

ix. Poland has announced tax cuts on energy, oil, and basic food items, as well as cash handouts for households. It has also extended regulated gas prices for households until 2027.

x. Romania' s coalition government has implemented a scheme capping gas and electricity bills for households and other users up to certain monthly consumption levels, and compensating energy suppliers for the difference.

xi. Sweden has set aside 6 billion Swedish crowns (€600 million) to compensate households worst hit by the surge in electricity prices.

However, if consumers are protected from rising energy prices, they will not be encouraged to save energy.

Targeted measures to help the less favoured populations (such as energy checks) should be more efficient than supporting measures for the whole population that are very costly.

4. The invasion of Ukraine by Russia endangers EU security of energy supplies

On February 24, 2022, Russia invaded Ukraine. This unjustified and cruel war has large consequences on the European and worldwide energy markets.

a. Before this war, Russia was the main EU supplier of crude oil, natural gas, and solid fossil fuels, providing around 60% of the EU energy needs.

Russia was the world's leading exporter of gas, exporting 201.7 billion cubic meters (bcm)[26] of gas via pipelines and 39.6 bcm of liquefied natural gas (LNG[27]). *Russian gas accounted for 45% of the EU gas imports and 40% of its consumption.* The most dependant countries were Germany, Italy, Austria, Slovakia, and Hungary.

In 2021, Europe was the first destination for Russian gas and Germany was the main export destination of natural gas from Russia, at 23.7% of the total gas export volume in 2021.

Russia is the world's third largest oil producer. In 2020, China was the first destination of Russian exported crude oil, while the Netherlands and Germany were the second and third destinations, respectively. In 2021, Russia accounted for 26% of the EU crude oil imports and 43% of refined EU products imports.[28]

In 2020, Russia exported 177 million tonnes of thermal coal and 30 million tonnes of metallurgical coal, making it the third and fourth largest exporter in the world. *About 30% of Europe's metallurgical coal imports and 60% of thermal coal imports originated from Russia.*[29]

b. In reaction against this unjustified invasion, the EU adopted sanctions to dry up the Russian financing of the war.

i. On April 7, 2022, the EU member states gave the green light to an *embargo on Russian coal* with a four-month grace period. Russian coal exportation to the EU amounted to €4 billion a year.
At the same meeting, the EU decided on closing the bloc's ports to Russian vessels. This blockage will hamper sales of Russian LNG to Europe and force Russian LNG carriers to take longer routes to sell their gas in Asia.

ii. *European sanctions on oil:*
On May 30, 2022, the 27 EU countries reached an agreement to reduce their Russian oil imports by 90% by year end. Following this decision, the OPEC+ countries[30] agreed on June 2, 2022, to increase their crude oil production by 650,000 barrels per day (bpd)[31] in July and August.

This increase is higher than that of 430,000 bpd applied each month since these countries started to increase their production again after the Covid-19 shock.
In total, they were committed to producing 43.2 million bpd in July and 43.85 million bpd in August. On August 3, 2022, they decided to increase their production level only by 100,000 bpd for September despite demands from the U.S. president for more increases.

In a reverse move, OPEC+ recommended at its September meeting, to reduce its production target by 100,000 bpd from October to "return to August quotas". This is to respond to global recession fears as well as sliding oil prices. However, OPEC+ is not delivering on its quota amount; the combined OPEC+ shortfall to quotas is above 3 million bpd, with almost every country underproducing. Only Saudi Arabia, the UAE and Russia have spare capacity.
The EU, which is very dependent on Russian diesel imports (2 mt/month), has been looking for supply alternatives. The task is difficult. However, the surge in diesel prices led to a demand decrease[32] and there are possible alternative suppliers including the United States, Middle East, and Asia.

26 bcm: billion cubic meters
27 LNG: Liquified Natural Gas
28 https://www.enerdata.net/publications/daily-energy-news/eu-will-ban-russian-oil-imports.html#:~:text=In%202020%2C%20the%20EU%20consume
29 https://www.gem.wiki/Russia_and_coal
30 OPEC+ is a group of 24 oil-producing nations, made up of the 14 members of the Organization of Petroleum Exporting Countries (OPEC), and 10 other non-OPEC members, including Russia.
31 bpd: barrels per day
32 For example, in France, in June 2022, diesel consumption fell by 5% compared to the previous year.

iii. *Gas situation:*

- *The EU, which is very strongly dependent on Russian gas supplies, is not ready to sanction these supplies. Rather, it is Russia that is taking advantage of its dominant position.*

At first, Russia demanded payment in rubles for its gas even though the contracts are denominated in dollars. Following their refusal to pay in rubles, Moscow cut off the gas tap to Bulgaria, Poland, the Netherlands, Denmark, and Latvia. But these countries had planned to assume their independence and the Kremlin's decision only accelerated an ongoing process. By the end of April, following its entry in NATO, Finland received no more Russian gas, though the country depends only at 6% on gas for its energy supplies. Following the German, French, and Italian visit to Ukraine on June 16, on the pretext of a maintenance problem, flows were cut by 60% to Germany and by 40% to France and Italy. Also, OMV from Austria, SPP from Slovakia, and the Czech operator received only 50% of normal Russian gas flows. On July 11, 2022, Nord Stream 1 stopped its operations for maintenance. On July 21, 2022, after this maintenance completion, Russian gas flows via the Nord Stream 1 pipeline restarted, but only at 40% of its full capacity. Finally, at the beginning of September, Russia completely cut off gas deliveries passing through Nordstream1. This pipeline has a capacity of 55.5 bcm and the gas flows transiting through it represented approximately 35% of Russian gas deliveries to Europe before the crisis (155 bcm). These cuts will make gas storage filling more difficult and more expensive, and increase the threats on gas supply for the winter.

On September 27, 2022 powerful underwater explosions in the Baltic Sea have very seriously damaged both Nord Stream pipelines

- *Many European countries have begun to wean themselves off Russian gas.*

It represented at the beginning of June 2022, 35% of German gas imports, against 55% at the beginning of March. According to Ursula Von der Leyen, EU commission president, at the beginning of September 2022, the EU share of Russian gas imports was reduced to 9% (instead of 40% at the beginning of the year)[33] . Consequently, Russia's natural gas exports by pipeline to the EU and the U.K. declined by almost 40% during the first seven months of 2022[34] , compared with the same period in 2021, and by almost 50% compared with the previous five-year (2017–21) average.

On July 26, 2022, the EU agreed to cut its gas consumption by 15% to avoid a winter crisis triggered by a sharp reduction or total shutdown of Russian gas supplies to the bloc. From August 1, 2022, until the end of March 2023, all EU member states will strive for a 15% reduction in gas consumption. In the event of a major supply shock – a complete shutdown of Russian gas – the EU may declare an emergency and make the target mandatory with immediate effect. Countries that took little or no Russian energy objected to making sacrifices for those that benefited from years of cheap fuel from their eastern neighbor. In the end, all countries in the bloc supported the plan except for Hungary. France, Luxembourg, and the Netherlands supported the original plan, fearing the economic ripples of a recession from the German economy.[35]

- *In this worrying situation, the commissioning of the Baltic Pipe will enable Poland to increase its gas import capacity.*

The "Baltic Pipe" project will allow Poland to receive supplies of Norwegian gas through the Baltic Sea. The pipeline is expected to have an annual transport capacity of 10 bcm and is on target to start pumping gas by October 2022. With this new pipeline and a new LNG terminal, Poland is quadrupling its gas import capacity and will compensate for the Russian gas cuts. It could also soon be able to help Germany, which is scrambling to replace its own Russian gas.

iv. *Since Q4 2021 fossil fuel prices (mainly gas prices) surged. These price increases in turn impacted electricity prices that also soared.*

– Oil prices: Let's recall that in April 2020 due to the Covid-19 pandemics and lockdowns, WTI oil price went negative and Brent oil price was below $20/bl.[36]

33 https://www.eeas.europa.eu/eeas/europe%E2%80%99s-energy-balancing-act_en?s=177
34 https://www.eia.gov/todayinenergy/detail.php?id=53379

35 https://www.theguardian.com/world/2022/jul/26/how-does-the-eu-plan-to-cut-gas-usage-by-15-this-winter
36 $/barrel

In 2021, thanks to economic recovery, oil prices increased to around $80/bl at year end. Since the beginning of 2022, due to geopolitical events and a solid economic situation worldwide, prices increased to around $120/bl with peaks at $130/bl. However, in mid-August 2022, oil prices fell below their pre-war level over fears of a global economic slowdown, lowering oil and oil products consumption. On the supply side, Russia started to gradually increase its oil production amid easing of sanctions-related curbs and increased purchases from Asian buyers. Also, diplomatic efforts to revive the 2015 Iran nuclear deal and ease the sanctions could boost Iranian oil exports.

– Coal prices: Coal is the major fuel used for generating electricity worldwide. Since the COP26 commitment to shift away from coal[37] , the geopolitical situation has changed the coal perspective. In 2021, the gas prices increase – which made coal-fired power plants more competitive than gas-fired ones – resulted in a 9% increase of coal consumption used to produce electricity. In 2022, threats on Russian gas availability pushed leaders to allow coal-fired power plants life extensions or the reopening of old power stations After a minimum of $50/t reached in April 2020, they increased in 2021 to $250/t. However, due to the strong anticipated demand for coal, coal prices rose faster than oil prices to reach $400/t (8 times its 2020 price) in July 2022.

– We must mention a side effect of the coal scheduled exit: the port and rail capacities previously used for the coal transport have been reallocated. So, coal transport has become problematic.

– European gas prices: As with the other commodities, gas prices decreased during the first lockdowns to around €3.5/MWh in May 2020 and started to grow again by the end of 2020. From May 2021 to September 2021, prices went up because of tight LNG supply and narrow pipeline flows from Russia. From October 2021 through the end of February 2022, uncertainty of supply from Russia, notably around Nord Stream 2 commissioning, pushed prices up to €180/MWh by the end of 2021. Early 2022 LNG supply to Europe increased (thanks to high gas prices) and prices went down.

The Russian invasion of Ukraine and worries over Russian gas supply increased prices again and they reached a peak of €225/MWh in March 2022. Higher than expected Russian flows and reassessment of supply diversification options pushed prices down in the following months. In this phase, price developments seemed less driven by physical shortages and more by the extreme near-term uncertainty.

At the end of July 2022, prices soared to €226/MWh, after Gazprom decreased Nord Stream 1 gas flows to 20% of their nominal value. At the end of August, the 2022 year-end future TFF gas price was above $300/MWh, reflecting a fear of gas cuts during the winter. Let's note that gas prices in Europe are no longer correlated to oil price, as the latter decreased to $100/bl (their pre-war level).

– The U.S. gas price rose from 1.71/MBTU[38] at the end of March 2020 to $6.66/MBTU in early July 2022, an impressive 3.8 times growth, like the European gas prices' growth. However, let's keep in mind that thanks to shale gas (a source that European countries do not plan to explore and exploit), U.S. prices are much cheaper than European prices: at € 22.3/MWh in early July 2022, the Henry Hub[39] price is 8 times cheaper that the European TTF price. This gives a big competitive advantage to the U.S. industry.

37 https://www.bbc.com/news/science-environment-59159018

38 MBTU :Million British Thermal Unit

39 Henry Hub is he best-known of all natural gas trading points in North America

Le Figaro August 23, 2022

HOME

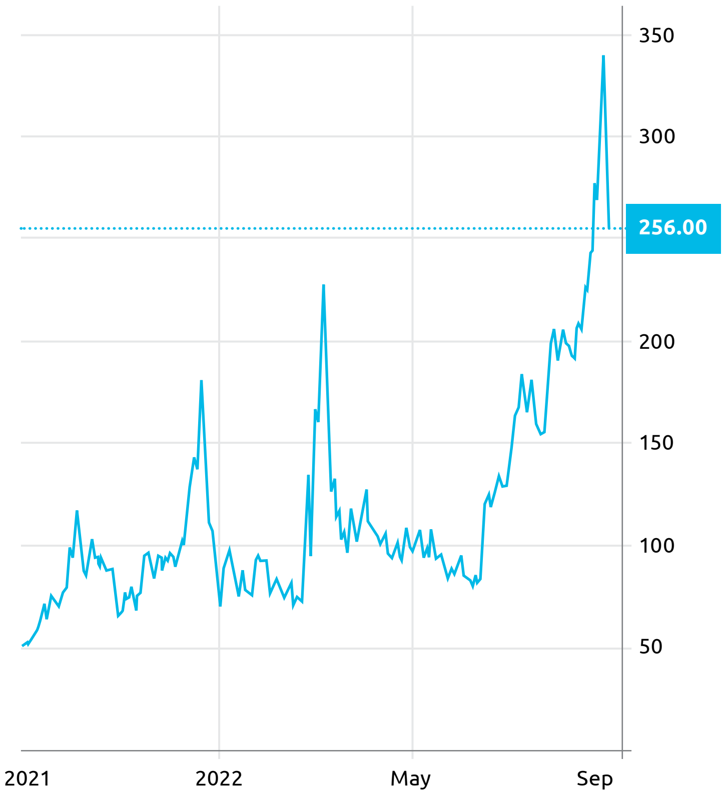
v. *European Electricity prices:*

As with other forms of energy, the price of electricity was at its lowest in April 2020 at €10/MWh and started to rise at the end of 2020. During Q4 2021, thanks to the electricity spot market operating mechanism (see above) that ties spot electricity price to that of gas, electricity prices grew. They jumped to €450/MWh in December 2021 when EDF announced the discovery of stress corrosion on the emergency water supply circuit of the Chooz B1 reactor. In consultation with the French Nuclear Safety Authority, EDF decided to shut down this reactor to diagnose the problem and repair it. Subsequently, this problem of stress corrosion was discovered on the entire 1400 MW series and on the 1300 series. It seems that the reactors of the 900 MW series (the oldest) do not have these problems. At the end of 2021, the electricity price fell to €257/MWh.

The Russian oil embargo decided by the European Commission pushed electricity spot prices to more than €500/MWh. They went down then up again at the end of the first half of 2022 when Russia cut off Nord Stream 1 gas flows. By end of August 2022, this price was around €590/MWh.

By end of August 2022, the year-ahead contract for German electricity reached €995/MWh hours, the French equivalent surged to more than €1,100 /MWh – a more than ten-fold increase in both countries from last year. As for gas, these incredibly high prices reflect blackout fears.

Natural Gas EU Dutch TTF (EUR/MWh)



c. **Despite EU imports reductions, Russian fossil fuel financial inflow grew** over H1 2022. Indeed fossil fuel energy price increases have more than compensated for the lower Russian flows to Europe and the discounts that Russia made on its exports out of Europe, allowing Russia to fill its war chest. Fossil fuels exports brought more in 2022 to Russia than in 2021. In May 2022, Russia earned $922[40] million in hydrocarbon export revenue every day, up $260 million from May 2021.

However, in H2 2022, EU coal and oil sanctions will start to be effective and Russian gas exports to Europe will be reduced. Compared with the start of the invasion, the reductions in Russian fossil fuels exports have resulted in €170 million per day in lost revenue in July and August.[41] The overall fall in export volumes was driven by a drop in exports to the EU which fell by 35%. After the EU coal ban entered into force on August 10, 2022, Russia's coal export volumes fell to the lowest level since the start of the invasion as Russia failed to find other buyers to replace falling EU demand.

In addition, since the stop of gas deliveries via Nord Stream 1, early September, Gazprom's revenues declined, by around 30%, dropping from around $100 million per day to around $ 70 million.[42]

An internal Russian report viewed by Bloomberg,[43] warns of deep and prolonged economic damage as the impact of US and European sanctions spreads.

In 2022, the annual contraction of Russia's GDP should amount to 6%. Two of the three scenarios in the report show this contraction accelerating in 2023 and GDP returning to the pre-war level only at the end of the decade or later.

d. **Russia Ukraine invasion energy facet.**

The cross-dependence of Russia vis-à-vis Ukraine for its gas export to Europe, and of Ukraine vis-à-vis Russia for the gas supply has generated numerous crises over the past twenty years.The most striking events were the gas cuts to Europe during the winters of 2006 and 2009.

In January 2009, Russia cut gas supplies to Ukraine and ten European countries for three consecutive weeks in the middle of winter due to disputes! The Bulgarians had no heating and Slovakia declared a state of emergency.

The price of Russian gas bought by Ukraine depended heavily on political considerations and fluctuated depending on Ukraine's leaders' rapprochement or distancing from the European Union.[44]

At the beginning of the 21st century, 80% of the natural gas exported from Russia to Europe passed through Ukraine.

To free itself from this dependence, Gazprom undertook in 2005, with the support of Germany, the construction of the Nord Stream 1 gas pipeline, which would allow gas to be transported directly from Russia to Germany without passing through Ukraine.

This gas pipeline, financed by a consortium led by former German Chancellor Gerhard Schröder, was commissioned in 2012. As a result, the Russian gas transit through Ukraine fell by 40%, reducing Ukraine gas toll revenue.

In 2014, Russia invaded and then annexed Crimea. This annexation was strongly disapproved of by Europe and the United States, though they were powerless to return these territories to Ukraine.

The doubling of Nord Stream 1 (Nord Stream 2), justified by the closed German nuclear reactors' replacement by gas-fired plants, raised numerous oppositions but benefited from the unfailing support of former German Chancellor Angela Merkel.

40 Le Figaro August 23, 2022
41 https://energyandcleanair.org/publication/financing-putins-war-fossil-fuel-exports-from-russia-in-the-first-six-months-of-the-invasion-of-ukraine/
42 https://www.lesechos.fr/monde/europe/petrole-et-gaz-la-russie-engrange-des-recettes-record-malgre-les-embargos-1785965

43 https://finance.yahoo.com/news/russia-risks-bigger-longer-sanctions-135601014.html
44 In 2013 the Ukrainian national gas company bought 13 bcm of gas from Russia at the market price of $400 per thousand cubic meters. In December 2013, this price was reduced to a "friendly price" of $268 following Ukraine's decision to renounce signing an economic agreement with the EU.

For strategic reasons and to sell its LNG to Europe, the United States opposed the construction of this gas pipeline and the American Congress voted in 2019 to impose sanctions against the companies working for this project. This delayed its construction significantly.

The Danish government has also delayed the progress of the section crossing its country due to environmental reasons, but also to have time to complete the Baltic Pipe (see above).

In a delaying manoeuvre, the European Union amended its gas directive in 2019 to require that all new gas connections entering its territorial waters be unbundled from any parent energy supplier.

This was not the case of Nord Stream 2, which was owned by Gazprom. The Germans managed to postpone this directive implementation to allow for the pipeline completion!

At the end of 2021, the gas pipeline was completed, but the new German Chancellor Olaf Scholz suspended its commissioning authorization on February 22, 2022, following statements by the Russian President recognizing the independence of the two self-proclaimed Donbass republics.

On February 24, Russia invaded Ukraine.

Poland has always been opposed to these gas pipelines, fearing for its gas supplies. Thus, Polish Prime Minister Mateusz Morawiecki said: “Once Nord Stream 2 is built, Putin can do with Ukraine what he wants... And we will potentially have his army on the eastern border of the EU.”

By annexing Crimea, Russia got its hands on a significant part of Ukraine’s oil and gas reserves located in the Black Sea.

By trying to conquer the Donbass, Russia not only wants to annex a partially Russian-speaking province, but also grab Ukraine’s gas and coal reserves. Indeed, Ukraine is the sixth largest coal country in the world and 80% of its reserves are in the Donbass. 90% of its gas production is in this region, which also contains significant unconventional gas reserves.

Finally, if Russia managed to conquer all of Ukraine, it would have an important gas infrastructure for its gas exports.

In addition, since the beginning of March 2022, the Russians have occupied the Zaporizhia site in southern Ukraine (the largest nuclear electricity production center in Europe). Beyond nuclear security issues (see below), this plant control is strategic for Russia because it could be disconnected from the Ukrainian grid and reconnected to the Russian grid to supply Donbass and Russia. Considering this analysis, one can think that reconstituting the great Russia is perhaps not the only goal of President Putin in this bloody war.

As in other wars, the seizure of energy reserves and electricity generation capacity is an important Russian strategic goal

e. Concerns over Europe security of energy supply:

If Russia completely cut off gas supplies to Europe, this would have major consequences for the security of gas and electricity supplies.

i. *Gas:* In 2021, the EU consumed 400 bcm of gas, of which 90% was imported. About 45% of gas imports came from Russia, i.e., 155 bcm/year.

The gas share in the total energy consumption and the dependence rate on Russian gas vary according to European countries. In 2021, in Germany, gas supplies a high share of its energy consumption (26% of its energy needs) with 66% coming from Russia, making it particularly vulnerable. This is also the case for Italy, with its energy needs supplied at 40% by gas and a 43% share of Russian gas.
France, where only 15% of energy needs are supplied by gas with only 16% of it coming from Russia, is much less vulnerable to Russian gas cuts.

The security of gas supply over the coming winter will depend on three factors: the degree of filling of storage facilities; gas import flows; and the energy savings campaigns' effectiveness.

To best ensure energy supplies during the 2022-2023 winter, the various European countries are filling their gas tanks as quickly as possible. The total EU gas reserves capacity is equivalent to 25% of its annual consumption. The latter is much higher in winter than in summer.

In Germany, it is a Gazprom subsidiary that owned the largest European storage facility (Rehden), showing how tight the Germany-Russia ties were on gas! In April 2022, the German government took control of this strategic infrastructure and announced a multi-billion-euro rescue plan to avoid the bankruptcy of the owning company that could have jeopardized the country's energy security. The level of gas in this reservoir, with a capacity of 4 billion m^3, had been deliberately kept low by Gazprom to increase pressure on Germany. Thus, by mid-2022, it was only filled at 8%, compared to 55% for all other German gas reservoirs.

In May 2022, Europe introduced the obligation to fill the tanks at least at 80% before November 2022.

Some countries, such as France, have reinforced the filling obligation from 85% on November 1 to 100% on the same date. At the end of August, the filling rate in France was already 90% ahead of previous years. Until mid-June 2022, in France, Germany and Italy, the reservoir filling gas came mainly from Russia. With the restricted Russian gas flows to Europe, this gas is coming from other sources: LNG and re-export of gas from countries such as Spain (which has six LNG terminals) to Germany by example.

This underlines the importance of LNG terminals and Germany's strategic error under Chancellor Merkel in not wanting to build them.

Incentives for energy saving have been launched in many European countries (see below). Gas rationing measures are also being considered in Germany.

ii. *Electricity:* In 2022, the availability of the French nuclear fleet was insufficient, which poses threats to the security of electricity supply in Europe. Following stress corrosion discovered in the most recent EDF nuclear power plants, EDF adjusted its nuclear production estimate for 2022 from 295-315TWh initially to 280-300TWh. In August EDF announced that its nuclear production would be at the bottom of the range (280TWh).

France, which was a net electricity exporter, has become an importer. In addition, despite the substitution of coal for gas in power plants, the lack of gas in Germany should limit its electricity production and prevent it from exporting power to France at the time of winter peak demand. Already in April 2022, a cold spell caused peak demand in France to rise to 70 GW for a domestic production of 63.6 GW. The outages were avoided thanks to 800 MW saved by a collective response to the RTE[45] red alert and the import of 9 GW from Germany and England.

45 RTE: » Réseau de Transport d'Electricité » is the French TSO.

However, during a cold winter, the peak demand can rise to 100 GW, and Germany may not be able to export electricity. The recommissioning of the Saint-Avold coal-fired power plant with a capacity of 0.5 GW is not enough. This capacity is much lower than the capacity of the two reactors at Fessenheim (1.8 GW) that were prematurely closed for political reasons in June 2020. These reactors will be lacking this winter to meet demand.

iii. *On September, 9,2022* EU Energy Council met to define *emergency measures* to mitigate high energy prices and support electricity and gas demand reduction to strengthen the EU's winter preparedness.

The energy ministers invited the Commission to propose 4 "packages" by mid-September.

- *First package:* measures aimed at capping at €180/MWh the revenues of inframarginal electricity producers[46] with low costs of production and at introducing a solidarity contribution from fossil fuel companies to be used to mitigate the high energy prices impact on customers. National schemes and support mechanisms should be compatible with EU-wide measures.
- *Second package:* emergency and temporary intervention, including gas price cap that should also help limiting the high gas prices impact on electricity. This measure, that refers to a price cap on gas imported from Russia via pipeline, would be complex to implement. Moreover, Russian officials have stated that Gazprom would not sell gas at below market levels. This request by the Commission reveals that at the time of the meeting, the EU Energy ministers were ready to accept a ban on Russian gas imports to Europe as they represented only 9% of total gas imports and as EU gas storage were filled at 83%.
- *Third package:* incentives enabling a coordinated electricity demand-reduction across the EU to address energy scarcity and high energy prices. It should be noted that while the gas demand has reduced by 14% Year on Year, the electricity consumption has reduced only by 0.6%.
- *Fourth package:* measures to address reduced liquidity and notably the counterparty collateralobligations that have sky rocked with the electricity prices surge.
- *Carbon ETS:* the ministers confirmed that selling ETS certificates that are in the MSR[47] inventory to raise funds for REPowerEU plan could be part of the solution. Selling these certificates will push ETS prices (and electricity prices) down but would give a negative signal towards the will to combat climate change

However, these measures if adopted, could take time to be implemented. In the meantime, mild temperatures, a strong economic slowdown, and a significant citizen mobilization could prevent power cuts.

46 Inframarginal electricity producers are those that do not set the marginal price They include nuclear, lignite and most renewables — except for some types of hydropower, biomass and biogas.

47 MSR : Market Stability Reserve

f. Ukraine security of energy supply:

Even in a country at war like Ukraine, which faces many vital problems, security of energy supply is important. To improve it, the EU politicians and technicians managed to synchronize Ukraine (and Moldova) grids to the European grid in record speed in March 2022.

Also, Ukraine, together with Moldova and Georgia, will be able to benefit from future EU common purchases of gas. With the gas TSOs in neighbouring Member States, the EU has helped secure increased reverse flows between the EU and Ukraine until the end of the year and is ready to facilitate their extension.

Moreover, Ukraine has the largest gas storage capacity in Europe; it is in the EU joint interest to have it used for its security of supply.

In addition, Ukraine could export 250MW to Europe and progressively grow to 3000 MW. This extra power could be badly needed this winter.

However, as mentioned above, if the Zaporizhzhia nuclear plant is either stopped or reconnected to the Russian grid, Ukraine's electricity supply will be very negatively impacted.

Russian invasion of Ukraine

5. The H2 2022 economic and financial crisis should reduce energy demand and decrease the tension on energy supply

At the end of 2021 and during the first half of 2022, inflation rates were at a 40-year high. In June 2022, U.S. inflation reached 9.1% (in annual variation), the highest since November 1981. In the U.K., inflation rates were like in the U.S. In June, annual inflation reached 7.6% in Germany and 5.8% in France. The origin of this inflation can be summarized as “too much money chasing too few goods”.

Indeed, to respond to the Covid-19 related crisis, central banks injected a lot of liquidities in the markets. Also, during the pandemic, households amassed savings as they were stuck at home, and government support that continued into 2021 helped them put away even more money.

Now as they try to spend this money, there are too few goods. Factory shutdowns tied to the pandemic, global shipping backlogs, and reduced production have resulted in product shortages. Because demand has outstripped the supply of goods, companies have been able to charge more without losing customers. The high energy prices (especially in Europe) are also pushing inflation up. People are worried on their purchasing power, and some are striking to obtain higher wages. Sometimes these strikes are targeting strategic energy installations, as in Norway at Equinor gas assets in June 2022 that resulted in a temporary gas price increase.

Moreover, the acceptance of higher prices resulting from energy transition, so-called “greenflation”[48] will have to be monitored by governments that are very attentive to protest movements like the “yellow vests” in France.

To fight inflation in the U.S. and in Europe, central banks are raising interest rates that were very low and sometimes negative. To bring back inflation at its “nominal” value of 2%, they will act to cool down the economy. As a result, the Western world could experience a stagflation period[49] with higher unemployment.

As energy demand is correlated to economy growth, demand could decrease, and energy prices could fall.

This demand decrease could help on the winter passage.

6. The energy crisis had different impacts on Energy players

a. **Oil majors** took advantage of rising oil and gas prices and made windfall profits in Q2 2022. Thus, the five oil majors (Exxon and Chevron (U.S.), Shell and BP (U.K.), and TotalEnergies (France)) have published cumulative profits of $60 billion for Q2 2022. These exceptional Q2 results followed a first quarter marked by the depreciation of assets linked to their withdrawal from Russia.

b. Some **utilities** took advantage of the rise in energy prices. For instance, the French Engie succeeded in reducing, by mid-year, its residual exposure to Russian gas to 4TWh (compared to a maximum exposure of 15TWh announced in March 2022) and published good financial results. Thus, in the first half of 2022, the Engie group generated a net income (group share) of €5 billion, compared to €2.3 billion a year earlier. Others, such as the Italian Enel or the Spanish Endesa suffered a little from the difficulties of the market. Finally, the Spanish Iberdrola compensated for the difficulties of its domestic activities with its good performance internationally.

c. However, **two major utilities, EDF and Uniper, suffered greatly from the situation on the gas and electricity markets.**

i. EDF has encountered technical problems in some of its nuclear power plants (stress corrosion), which have forced it to close them for assessing the situation and repairs. This will drastically reduce its production of nuclear electricity in 2022 and 2023. In addition, the French government forced EDF in early 2022, to sell an additional 20TWh to its competitors under the ARENH[50] regulation at a price of €46.2/MWh, while market prices at the end of 2021 reached €257/MWh.

48 These are the costs incurred by the energy and ecological transition.
49 Prolonged period of low growth and high inflation

50 ARENH : Accès Régulé à l’Electricité Nucléaire Historique

The need to source electricity on the spot market at dizzying prices and the cost of repairs induced by stress corrosion have weighed on EDF's EBITDA for the first half of 2022 by around €10.3 billion. The negative impact on EBITDA of the French government's decision to increase ARENH volumes amounts to €8.34 billion. Thus, in August 2022, EDF initiated a disputed procedure with the French State, and a claim for compensation for its losses.

EDF's financial situation deteriorated sharply with a net loss of €5.3billion at the end of H1 2022. The results for the full 2022 year look even worse than expected: the electricity producer now estimates that the drop in its nuclear production will cost it around €24 billion in EBITDA.

Under these conditions, and given its high debt (approximately €44 billion), it was becoming increasingly difficult for EDF, as a listed company, to finance itself and implement the investments necessary for the renewal of the French nuclear fleet.

To support EDF, *the French State decided in July 2022 to renationalize EDF* by acquiring on the market, through a simplified public purchase offering at a price around €12/share, the 16% of shares it lacks to own 100% of the company.

ii. Uniper Group is Germany's main gas importer and storage operator. It has felt the war in Ukraine full impact as, since mid-June 2022, the company has been receiving only less than half of contractually negotiated gas volumes from Gazprom. To continue to supply its customers, the group not only had to buy the missing quantities on the spot market, where prices have exploded, but also draw on its own reserves.

Without being able to immediately pass on this increase to its customers, Uniper was heading rapidly for bankruptcy, its losses amounting to several tens of millions of euros per day. For the first half of 2022, its financial loss amounted to €12.4 billion.

On July 22, 2022, the German chancellor Olaf Scholtz announced a Uniper rescue with a €15 billion bailout that is among the biggest in German corporate history. The German government will take a 30% stake in Uniper, reducing the ownership of its Finnish parent Fortum to 56% (from nearly 80%). Finally, in September, the German State decided to buy out the 56% stake of Fortum, for €500 million.

Uniper would be allowed to pass on the gas purchase price increases to its customers. For a family of four, the gas bill could increase by €200-300 per year. However, the government will take new measures to support the purchasing power of ordinary Germans.

d. Many European energy retailers were bankrupted.

To gain market share, some of them agreed to low gas or electricity prices without purchasing on the forward markets the necessary energy. They found themselves trapped because they were forced to buy at very high prices to resell at low prices. This has led to many bankruptcies.

For example, in the U.K. during 2021 and early 2022, 31 energy companies have gone bust, leaving over two million customers dependent on the safety net provided by the market regulator, Ofgem, to maintain their supplies and protect their credit balances while moving to a new supplier.[51]

In France, some retailers have gone bust as Hydroption or closed their French activities as the British Bulb Energy, or stopped to enrol new clients as CDiscount, Vattenfall, Alterna, Green Yellow or Plüm. By the end of August 2022, the Spanish Iberdrola has terminated its electricity supply contracts to thousands of French customers.

A consolidation of the retail market is therefore happening. This is a reverse movement compared to that of the pre-Covid years when the number of players in the retail market increased steadily following the electricity and gas markets liberalization.

51 https://www.forbes.com/uk/advisor/energy/failed-uk-energy-suppliers-update/

e. Renewables M&A market was bullish:

In 2021[52], robust demand for renewable assets was supported by low interest rates, Environmental, Social and Governance (ESG) considerations, and companies' aggressive renewable energy and decarbonization targets. This market remained hot, despite industry headwinds that included disruptions to supply chains, trade developments that negatively impacted the sector, and policy uncertainty. Energy transition deals accounted for about 20% of all energy-sector deals greater than $1 billion.

The market is strongly driven by the oil & gas majors' push to become Big Energy (not only Big Oil) companies. For example, in the U.S., Renewable Energy Group was acquired by Chevron Corp. for $3.15 billion on June 13, 2022.

Financial players, such as investment funds, are also active in this M&A market. For example, in July 2022, the investment fund Ardian entered exclusive negotiations with the large French retailer Casino to acquire the control of its renewable energy production subsidiary: GreenYellow.

The operation values this company, created fifteen years ago by installing solar panels on the roofs of hypermarkets, at €1.4 billion for an expected EBITDA of €80 million in 2022. The urgent need to green its portfolio has led Ardian to agree to this high price.

It is this desire to be able to invest more in renewable energies that prompted Engie to sell Equans, its service subsidiary (which employs 74,000 people and has a turnover of around €12 billion) to the Bouygues group for €7.1 billion. This acquisition will allow Bouygues[53] to become a world leader in the multi-technical services market, a growing market which plays a central role in energy transition.

52 https://www.fticonsulting.com/insights/articles/us-renewable-energy-ma-review-2021-outlook-2022

53 https://www.equans.fr/sites/g/files/tkmtob136/files/2022-04/CP%20BOUYGUES.pdf

How to manage energy supply in europe without russian fossil energies?

While it will not be easy to replace Russian coal and oil, the critical issue is Russian gas replacement.

To prepare for this eventuality, various actions must be taken including energy conservation, European domestic gas production increase, LNG imports increase, gas imports from new countries, coal-fired plants substitution to gas-fired plants, electrification increase, renewables installation increase, and an end of nuclear power plant shutdowns.

1. Energy efficiency and conservation gains are among the fastest, cheapest, and easiest ways to deal with the challenges posed by Russian gas cuts.

Ten European Union Member States declared various stages of a gas emergency. In escalating the gas system to the second highest “alarm” stage-one step away from government energy rationing- German Energy and Economics Minister Robert Habeck called on Germans to “make a difference” by voluntarily changing their consumption behavior to conserve energy.

In France, at the end of June 2022, the CEOs of the three French energy companies, Engie, TotalEnergies, and EDF, urged the French to immediately reduce their consumption of fuel, oil, electricity, and gas in response to the risk of shortages threatening “social cohesion” next winter. This call was aimed at individuals and businesses. One week later, 84 business leaders, called in turn to save energy, but in a more proactive perspective, to “go from emergency sobriety to organized sobriety”.

Policymakers around the world should make reducing energy consumption a central component of any strategy[54], as increasing efficiency can simultaneously reduce Russian leverage, counteract high energy prices, and curb carbon emissions to address climate change.

According to the International Energy Agency (IEA),[55] lowering the thermostat for heating by just 1 degree Celsius in European buildings would curb gas use by 10 bcm per year, which is equivalent to 20% of the volumes that came from Russia to Europe through Nord Stream 1.[56]

In Germany, where 31% of gas is used by households and one in two homes is heated by gas, the association of cities and towns advocates reducing the temperature to 18 or 19 degrees, against the 20 to 22 degrees currently imposed on apartment landlords between October 1 and April 30.

And in the IEA’s roadmap to achieve net-zero emissions, energy efficiency delivers the second-largest contribution to GHG emissions reduction over the next decade through measures such as retrofitting buildings, switching to less power-hungry appliances, using higher fuel economy standards for vehicles, and improving the recovery of industrial waste heat. REPowerEU includes a goal of increasing energy savings for efficiency from 9 to 13% by 2030, compared to the EU’s 2020 reference scenario.

France, for example, has announced subsidies increases for housing retrofitting and for the installation of heat pumps to replace less-efficient gas boilers. France has also adopted in 2021, the bold RE2020 building’s regulations aimed at reducing the energy consumption and GHG emissions over the building’s life cycle.

Digital innovations, such as remote control of heating and cooling domestic systems or virtual meetings, are expanding the scale and scope of energy efficiency.

54 https://foreignpolicy.com/2022/06/29/energy-demand-supply-efficiency-conservation-oil-gas-crisis-russia-europe-prices-inflation/?utmsource=Center+on+Global+Energy+Policy+Mailing+List&utm_campaign=97b71ec5f0-EMAIL_CAMPAIGN_2019_09_18_12_40_COPY_01&utm_medium=email&utm_term=0_0773077aac-97b71ec5f0-102386971
55 https://www.iea.org/reports/energy-efficiency-2021
56 In comparison, Nord Stream1 capacity is 55 billion cubic meters/year

For example, during the 2020 Covid-related lockdowns, electricity demand dropped by 9% in European countries[57] and by 11% in China.

The question for this winter is:

Will government impose again a minimum number of remote work days per week that would save transportation fossil fuel energies and probably decrease the net heating needs? [58]

There are numerous reasons why energy efficiency and conservation have not been the public and political priority. Governments are afraid of social rebellions so they are cautious about imposing what can be perceived as personal sacrifices by citizens. Indeed, in response to today's high prices, governments prefer to cushion the shock by subsidies or tax suspension, while high energy prices are recognized as a key factor to trigger energy conservation.

2. Replacement of Russian gas by other gases includes European domestic gas production increase, LNG imports increase, and gas imports from new countries.

a. Domestic gas production increase avoids dependency on non-European gas imports:

i. *In the short term:* The Netherlands decided to reopen its largest onshore gas field Groningen, which was shut down due to earthquakes likely caused by gas extraction. Despite the risks, this decision is supported by the Groningen population itself. A survey published in a local newspaper in early March 2022, showed that 61% of respondents in the area were in favour of raising the field's output to 12bcm a year to decrease reliance on Russian gas.

ii. *Biogas:* The REPowerEU plan includes a target to produce 35bcm a year of biomethane[59] within the EU by 2030. The target will replace 20% of former natural gas imports from Russia by a sustainable, cheaper, and locally-produced alternative. The deployment of biomethane to replace fossil fuels does not require large investments to develop new infrastructure since the existing gas infrastructure is biomethane-ready.

Biomethane can be produced starting from €55/MWh, whereas natural gas prices are much higher. While other renewable gases, such as green hydrogen, need time to scale up and are expensive, biomethane is available now and scalable.

In 2020, Europe was the largest worldwide producer of biogas, producing 18bcm of biogas and biomethane, including 3bcm of biomethane.

Germany is by far the largest European market, and home to two-thirds of Europe's biogas plant capacity. Energy crops were the primary feedstock choice that underpinned the growth of Germany's biogas industry. Despite environmental advantages over fossil fuels, this feedstock also poses sustainability risks, including competition with food crops, water and air pollution, loss of soil quality, increased erosion, and reduced biodiversity. German policy has recently shifted towards the use of crop residues, sequential crops,[60] livestock waste, and the capture of methane from landfill sites. Other countries such as Denmark, France, Italy, and the Netherlands have actively promoted biogas production. According to the study carried out by InraeTransfert,[61] residues from agricultural plants, livestock effluents, and intermediate crops for energy purposes "could provide 50 to 75% of the production of renewable gas".

57 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7834155/
58 The difference between less offices heating and more home heating

59 The key difference between biogas and biomethane is that biogas is a mixture of methane and carbon dioxide, contains about 90% methane and other components. if biogas is compressed it can be used as a vehicle fuel. If biogas is cleaned up and upgraded to natural gas standards, it's then known as biomethane and can be used in a similar way to methane.

60 Sequential crops allow to combine food and renewable energy production in a sustained way. https://www.europeanbiogas.eu
61 https://www.inrae.fr/sites/default/files/pdf/Rapport%20ACV_Biomethane%20issu%20de%20ressources%20agricoles_INRAE%20Transfert_GRDF

Countries where biogas production is the most developed are tending to limit investment subsidies and feed-in tariffs to move towards tendering systems that encourage the reduction of production costs and limit the reliance on public support. Some countries are also stimulating the demand for biomethane fuel (bioNGV) through exemptions from consumption taxes and carbon tax, as well as by increasing the incorporation rates for biofuels, as required by the European directive on renewable energies.

To achieve its very ambitious biomethane target, the Commission presented a Staff Working Document[62] that includes several possible actions to unlock the potential of biogas and biomethane across all EU countries.

The uptake of biomethane involves a continued support to innovative technologies. This financial support will include streamlining existing funds and funding mechanisms such as common agriculture policy, structural and cohesion funds, Horizon Europe, or the innovation fund, and national funding opportunities.

For example, in France an innovative process deployed by Sublime Energie[63] allows the creation of new local biogas and bioCO_2 supply chains and provides access to the biomass deposit from small farms located far from the networks.

iii. *Unconventional hydrocarbons* (mine gas, shale gas, shale oil) can contribute to the EU's security of supply and competitiveness. Abandoned mine methane (AMM) can be recovered from disused coal mines. AMM projects produce energy (thermal and electrical) with the bonus of reducing atmospheric emissions of methane. This (limited) domestic gas resource is exploited in some countries, including the northern part of France and Belgium. In those regions, it is a former subsidiary of the French National Coal Company, Gazonor, that converts it into electricity.

Much larger resources could be provided by shale gas and shale oil. A 2014 European study[64] has estimated that technically recoverable shale gas resources amount to 14 trillion cubic meters (tcm) and far exceed Europe's conventional natural gas reserves, which are estimated at 5.2 tcm. However, only a few exploration wells have been drilled, so these estimates come with a lot of uncertainty. Poland and France have the largest resources.

While France prohibited the use of hydraulic fracturing for gas and oil production in 2011, Poland was more enthusiastic and some major oil companies (Exxon, Chevron, and ENI) were active in the shale sector. They all left,[65] not so much on geological conditions but because of the absence of a coherent policy on the part of Polish government.

Because of geological conditions, European shale gas would be more expensive than in the U.S. However, if the gas prices in Europe remain high and if the present policy of going without Russian gas remains, more reserves would be economically recoverable and reopening the shale gas debate in Europe would be appropriate.

Let's recall that thanks to shale gas, the U.S. became a large gas producer at low prices (gas is eight times cheaper in the U.S. than in Europe). Moreover, in 2022, the U.S. is the second largest LNG exporter worldwide. The EU is very happy to import this shale gas to fill in for the Russian missing gas!!

62 https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biomethane_en
63 https://sublime-energie.com/

64 https://www.europarl.europa.eu/RegData/etudes/BRIE/2014/542167/EPRS_BRI(2014)542167_REV1_EN.pdf

65 https://visegradpost.com/en/2018/03/29/what-happened-to-polish-shale-gas/

b. Extra LNG purchases are not easy

In 2021, Europe imported 27% of its consumption in the form of LNG; it imported 40% of its consumption from Russia, mostly by pipeline (8% of Russian imports were LNG).

Global LNG production - led by the U.S., Qatar and Australia - is expected to total 500bcm in 2022.[66] Roughly 70% of cargoes on the water are reserved for customers with long-term contracts, while the remaining 30% are sold on the spot market going to the highest bidder. If all the spot LNG went to Europe, it would be enough to replace the gas imports from Russia. However, the import terminals in Europe have spare capacity to take in only about half of that.[67]

However, even if gas prices are significantly higher in Europe than in Asia,[68] not all spot LNG goes to Europe. For example, during the first half of 2022, the U.S. exported 68% of their LNG to Europe, compared with 34% last year.

On March 25, 2022, President Joe Biden announced an agreement committing the U.S. LNG industry to supply an additional 15bcm to Europe through the remainder of the year. This is equivalent to one-tenth of Russian gas supplies to the EU.

Before the June 8, 2022, fire at the Freeport LNG plant in Texas and its shutdown, the United States exported around 100bcm. Freeport's temporary shutdown (it should resume operations by October 2022 or later), will lower U.S. exportation by around 17%.

U.S. LNG capacity will increase in the coming years with the commissioning of Venture Global's latest LNG Calcasieu Pass plant in Louisiana. In the mid-term, the Biden-EU agreement also envisions increasing supply of U.S. LNG to Europe to 50bcm through 2030. This will require an increase in LNG export capacity, which is good news for the industry.

Australia, the first LNG exporter, sells at least 75% of its production via long term contracts. It is not presently in a position to help Europe since it does not have much LNG available, and new supply, which necessitates heavy investment, is at least four years away.

The third worldwide producer, Qatar, sells its capacity via long-term contracts to primarily Asian clients. Qatari LNG is also delivered to the U.K. via a jointly-owned regasification facility (Qatar Petroleum - 67.50% and ExxonMobil - 24.15%) in South Hook, U.K. This joint venture terminal has the potential to supply approximately 20% of U.K. annual gas demand.

In summary, increased importation of LNG could immediately supply around 10% to 20% of the Russian gas missing.
On the mid-term, new liquefication plants in the U.S., Qatar, and Australia will come online and help Europe increase its gas supply diversification.

66 Bloomberg Intelligence
67 https://www.bloomberg.com/news/articles/2022-03-11/what-lng-can-and-can-t-do-to-replace-russian-gas-quicktake
68 LNG price: 33$/mBTU in Europe compared to $29 /mBTU in Asia

c. **The EU and Member States Leaders are actively trying to buy gas from new countries**

i. *African potential:* The European Commission outlines clear opportunities for a continent that has, until now, provided Europe with just over 10% of its gas. Africa's production capacity is expected to double by 2030, according to a study by Rystad Energy.[69] According to this Norwegian consultancy, the existing pipeline infrastructure between North Africa and Europe, as well as historical LNG supply relationships, make Africa, notably Algeria, a solid mid-term European partner.

ii. In June 2022, the EU, *Israel, and Egypt* signed a deal to boost the mid-term natural gas export from Israel to Europe via Egypt. The deal will enable Israel to increase its natural gas exports through existing pipelines to Egyptian ports, where it would be liquefied and then transported to Europe. "This will contribute to our energy security," Ursula von der Leyen, president of the European Commission, tweeted from Cairo.

iii. In July 2022, the EU signed a gas import deal with *Azerbaijan* that envisages "shipment of at least 20bcm of gas annually by 2027". Caspian natural gas would flow to the European Union and, potentially, to Western Balkan countries. However, it would entail significant investments to expand the Southern Gas Corridor pipeline network.

iv. In conclusion, *diversifying EU gas supplying countries is a good strategic move. However, it will bear fruits only on the mid-term.*

d. **The present crisis highlights the strategic importance of LNG re-gas terminals, reverse gas flows, gas storage, and coordinated purchase:**

i. *Re-gas terminal facilities should be increased:*
As analyzed above, Russian gas replacement by LNG is limited by re-gas terminal facilities. As of May 2022, 11 EU Member States were LNG-importing countries, for a total regasification capacity of 160bcm/year. Prior to the Ukraine war, a limited number of projects were either under construction or advanced across Europe. This situation has changed significantly since March 2022, with more than 20 projects announced or accelerated, for a potential total capacity of more than 120bcm/year, around 80% of total 2021 imports from Russia.

Germany, which has a lot of coastal areas able to host LNG terminals, refused to build them up to 2021, as it had tight agreements with Russia. Seven projects have since been announced or accelerated (including four Floating Storage and Regasification Units (FSRUs)[70]) and a public funding of ~€3 billion.

ii. *More reverse flows should be enabled:*
Spain, which has six terminals, and France, which has four, could send imported LNG gas to the northern part of Europe. However, there is a need, stressed many times in past WEMO editorials, to invest in pumping stations to allow gas to flow from west to east and from south to north, thus increasing the EU gas network fluidity. The funding (however modest) of these pumping facilities has slowed down their implementation.

iii. *Gas storage assets should be increased:*
As pointed out earlier in this outlook, it is critical to fill the present gas storage facilities as much as possible. European governments and the EU have passed new legislations providing that gas storage sites must be filled to at least 80% of their capacity by November 1, 2022, and to 90% by November 1 in subsequent years. To help operators fulfill their storage obligations despite price inflation, the German government announced an additional guaranteed credit line via the public bank, KfW.

The envelope would reach €15 billion and will be available to Trading Hub Europe GmbH (THE), responsible for storage. In the mid-term, EU storage assets[71] should be increased to improve security of supply.

69 https://www.rystadenergy.com/newsevents/news/press-releases/gas-starved-europe-looks-to-africa-for-new-supplies/

70 FSRU are specialized ships that can be set up more quickly to import gas while the terminals are under construction

71 There are approximately 115 gas storage facilities in Europe

However, opening new gas storage facilities is difficult on both the technical and local public opinion sides. For example, the British government is in talks with energy firm Centrica about re-opening a giant gas storage facility in Yorkshire, in case European supplies from Russia are cut off.

In the mid-term, as for the OECD strategic oil reserves, *one could envisage the creation of a European strategic gas stock which would be added to the stocks already held by the operators.*

This strategic gas would be stored in decentralized physical storages in Europe and would be sold on the market by the appropriate European body with a collective agreement.

iv. *Coordinated gas purchases:*
On March 25, 2022, EU leaders endorsed the proposal to create a platform for gas purchases at the EU level. The platform will be a voluntary coordination mechanism supporting the purchase of piped gas, LNG, and hydrogen for the Union, making optimal use of the collective political and market weight of the EU.

In the REPowerEU Plan, the Commission announced that as a next step, it will consider the development of a "joint purchasing mechanism" which will negotiate and contract gas purchases on behalf of participating Member States.

However, the European Commission should acquire adequate competence in the negotiation of gas contracts to reach the level of the gas operators who have been experienced in this exercise for decades.

3. Increased coal usage:

On November 4, 2021, Alok Sharma, president of the COP26 declared in Glasgow: "I think we can say that the end of coal is in sight," as some nations agreed to shift away from fossil fuels and particularly coal, to avert the worst impacts of climate change.

A few months after their COP26 commitment, some of the same leaders were not only stopping coal phase out, but also re-opening coal power plants that were mothballed to ensure electricity availability in the context of the Russia-Ukraine war. This crisis demonstrates that policies must balance combat against climate change with security of energy supply.

In June 2022, Austria, Germany, Italy, France, UK, Bulgaria, and the Netherlands announced plans to change their climate policies and re-open old coal plants.

In 2021, the new German coalition government made up of the center-left Social Democrats, Greens, and the liberal Free Democrats had put climate policy at the center of its agenda, aiming to bring forward the country's coal exit to 2030 (instead of 2038 as initially enacted).

However, in 2022, Germany is planning to bring 10 GW of old coal and oil-fired plants into a reserve to help keep the lights on. This is the same amount of capacity as the nuclear power plants that the German Chancellor decided to close in 2011!

This coal generating capacity will increase GHG emissions while nuclear electricity does not emit GHG.[72] If equivalent on the electricity output, this German choice is threatening efforts to combat climate change.

In Austria, where the last coal plant was converted into a gas facility in 2020, the government announced that the factory will once again be outfitted to produce electricity from coal. Once online, the plant is to be used only "in an emergency," according to the Austrian Chancellor office.

The Netherlands launched the "early warning" phase of its energy crisis plan and lifted the production cap on coal-fired plants. Enacted in January 2022, this cap forced coal-fired power stations to operate at a maximum of 35% of full capacity.

The U.K. government is negotiating with EDF to keep West Burton A power station (that was due to close in 2021) available over the 2022-2023 winter. Drax is also extending the life of its coal-powered unit in Yorkshire, which was due to shut in September 2022. Uniper's plant in Ratcliffe-on-Soar, which was also expected to close in September, could also have its life extended. Over the first five months of 2022, electricity produced from coal increased by 20%.[73]

Some Member States and EU officials are rightly concerned about the longer-term threat such a move towards more coal usage would pose to efforts to fight climate change.

4. Green electricity output increase:

a. Energy transition requires the electrification of the economy to get rid of fossil fuels as much as possible, thus decreasing GHG emissions and dependency on imported Russian energies.

However, it requires massive investments. The French situation is revealing of these challenges. The "Energy Futures 2050"[74] report published by RTE states that to achieve carbon neutrality in 2050, French electricity production must be doubled.

France will have to double the investment amounts made in electricity production and transmission to around €20 billion per year over the next few decades. In addition, an investment of €6 billion per year is needed to support a network of charging stations for vehicles, as well as €30 billion per year to insulate buildings and homes. According to RTE, by 2050, electrification would save around €10 billion per year in fossil fuel imports. Comparing these investment amounts to the total French annual investments of around €500 billion shows the extent of the necessary efforts. Without a strong political will and adequate incentives, these investments in electricity are unlikely to be made in full.

As for the means of producing electricity, RTE has studied several scenarios, the least costly of which is the one that provides for a new nuclear program launch and massive renewable energies development.

b. Renewables energy roll out needs to be sped up.

i. *The EU commission proposed a plan to accelerate the rollout of renewables*[75] allowing to end Europe's reliance on Russian fossil fuels by 2027. It proposes to increase its 2030 target for renewables percentage of consumed energy from 40 to 45%. It aims at enabling faster PV deployment and quadrupling the EU photovoltaic electricity production by 2030. Solar development has a lot of growth potential since solar farms projects are better accepted than wind ones; there is still untapped PV solar growth on rooftops, for example, and thermal solar for hot water production is in its infancy.
On top of the investment foreseen under previous climate legislations, an additional €26 billion will be needed for solar energy investment between now and 2027.

However, one must be careful not to replace Russian gas dependency by Chinese solar PV dependency. EU domestic PV production declined sharply over the last decade as many manufacturers (Q-Cell from Germany, for example) could not compete with cheap (and probably subsidized) procurement from the Chinese. As a result, in 2020, 75% of all imports of panels into the EU came from China; Europe is the technology and price taker, rather than leader. *With this new solar PV boost, it is time to favour a European solar panel R&D program and industry to regain sovereignty.*

72 A coal plant emits 1058g of CO_2 per kWh against 6 for nuclear power
73 Rystad June 2022 study

74 https://www.rte-france.com/analyses-tendances-et-prospectives/bilan-previsionnel-2050-futurs-energetiques#:~:text=Futurs%20%C3%A9nerg%C3%A9tiques%202

75 REPowerEU Plan https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_e

Contrary to Europe, the U.S. imposed heavy tariffs on Chinese panels. This regulation helped to repatriate PV cell plants in the country.

ii. *Smart finance:* Delivering the REPowerEU objectives requires €210 billion additional investment from 2022 to 2027. These investments must be met by the private and public sector, and at the national and EU levels.

iii. *To accelerate renewables deployment, administrative procedures need to be alleviated:* Presently it can take around 10 years to get a permit for offshore wind projects; for example, the French Dunkirk offshore wind project was awarded after a call for tenders in 2016 and it should be in operations in 2028! This project is notably combatted by local associations (as "Vent Debout").

Many European leaders announced measures to speed up administrative procedures but hesitate to limit local consultation, which is considered at the heart of democracy.
Situated in this context, the future French Emergency Law aims at making up for its delay in the renewable energy sector and plans to tackle the administrative obstacles that delay these projects. New renewable capacity construction is two times longer in France than in the other European countries. The law provides for electrical connection procedures simplification, for the possibility of reviewing local urban development plans more easily, and the revision of impact studies.

The French government is expecting a major battle of amendments in Parliament on this needed bill. Reinforced regulations could be needed to speed up renewables development. For example, following the break in the connection of renewable installations in 2021, the German government decided on an obligation for each Länder to have 0.2% of its territory covered by renewable installations.

iv. *Electrical metals*[76] are essential to several sectors, in particular, the automotive industry. They play a major role in storing energy in rechargeable batteries. They represent a real supply challenge for manufacturers and R&D departments who are considering alternative solutions. These metals are essentially cobalt, lithium, nickel, and manganese.

For example, a factory producing 30 GWh of battery consumes approximately 33,000 tonnes of graphite, 25,000 tonnes of lithium, 19,000 tonnes of nickel, and 6,000 tonnes of cobalt. Thus, world consumption of cobalt is heading for strong growth of 7% to 10% per year.

Faced with fears of recession, the prices of industrial metals, including copper, fell by 30% in Q2 2022. The LME (London Metal Exchange) index fell in early July by 30% compared to its peak in March 2022.

However, this is not the case for lithium, which is an essential component of EV batteries. In June 2022, Elon Musk and others predicted a lithium shortage. These declarations pushed prices up. Over one year, lithium prices have surged by 430%! The increase comes as the amount of the metal used has almost quadrupled over the last decade. The lithium extracting process has to be improved (notably by decreasing its environmental impact) and investments in mines have to grow for the industry to catch up with the rising demand.

The European Commission is preparing a "Raw Materials Act" to protect European companies. It should include: a mutualization of strategic stocks, intervention of the European Investment Bank (EIB), and metals recycling development.

c. Nuclear electricity is the carbon-free electricity that allows safe grid operation with a high percentage of renewables.

i. *Nuclear Renaissance:* The absence of a nuclear accident for more than 11 years, the need to accelerate measures to limit greenhouse gas emissions, and to have a schedulable source of electricity in addition to renewable energies, are the elements that explain the change in Western public opinion vis-à-vis nuclear power.

76 36th Cyclope report 202. https://dauphine.psl.eu/dauphine/media-et-communication/article/parution-du-36e-rapport-cyclope-le-monde-dhier

Moreover, nuclear energy can be considered as a domestic energy source. Of course, it needs uranium for its fuel manufacturing and uranium is often imported from countries such as Kazakhstan, Canada, and Australia. However, uranium reserves are well distributed across different regions and, thanks to uranium being very high in energy density, nuclear operators can have stockpiles for several years of consumption.

This nuclear renaissance was recorded in Europe by the final adoption in June 2022 of its taxonomy "Complementary Delegated Act".[77] It includes some fossil gas and nuclear energy activities as transitional activities contributing to climate change mitigation.

The EU taxonomy is a tool to help financiers and companies in their investment choices. It defines conditions that an economic activity must meet to qualify as environmentally sustainable.[78]

Several Heads of State or governments have made commitments in favour of nuclear energy:

- In France: President Emmanuel Macron announced on February 10, 2022, a construction program for six EPRs[79] (followed by eight others), as well as the extension of the life of the existing fleet.

- In the United Kingdom, two EPRs are under construction at Hinkley Point C, built by a consortium between the French EDF and the Chinese CGN. Funding for this very long-term project has been secured through the Contracts for Difference (CfD) scheme that incentivizes investment in low-carbon electricity generation by providing their developers with protection from volatile wholesale prices. In this scheme, the developer pays the entire plant constructing cost, in return for an agreed fixed price for electricity output once the plant is online. However, this approach places the entire construction risk on developers. The British government has said it will take a 20% stake in the two proposed Sizewell C EPRs nuclear power project.

A new funding model "Regulated Asset Base-RAB" should be used. Under this model, the developer receives a licence from an economic regulator to charge a regulated price to consumers in exchange for providing the infrastructure in question.

In May 2022, former U.K. Prime Minister Boris Johnson said that nuclear power needed to play a larger role as Europe tries to move away from dependency on Russian oil and gas and reiterated the government's objective of building one new nuclear power station every year.

- On November 15, 2021,[80] U.S. President Joe Biden signed into law the bipartisan "Infrastructure Investment and Jobs Act". The $1.2 trillion package contains a total of more than $62 billion for the DOE to deliver a "more equitable clean energy future", including $8.45 billion to prevent the premature retirement of existing nuclear plants and invest in advanced nuclear projects. In September 2022, California lawmakers have voted to extend the operating life of the state's only nuclear power plant at Diablo Canyon.[81]

- Before the Fukushima accident, due to an exceptional tsunami, Japan had 54 nuclear reactors in operation. As of June 2022, 10 nuclear reactors have been given the go-ahead to restart.

77 https://d1psi0oaxrchqd.cloudfront.net/files/EU-Taxonomy-Climate-Complementary-Delegated-Act-Published-In-Official-Journal-July-2022.pdf?mtime=20220718163933&focal=none
78 https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en
79 EPR is a third generation pressurised water reactor design developed by French Companies (EDF and Framatome)

80 https://www.world-nuclear-news.org/Articles/Nuclear-supporting-infrastructure-bill-becomes-US
81 https://www.neimagazine.com/news/newscalifornia-extend-the-life-of-diablo-canyon-npp-9980465

Japanese Prime Minister Fumio Kishida said he asked for as many as nine nuclear reactors to be online this winter to help with an expected power crunch. Despite local governments agreeing to restart the reactors, some have not yet become operational due to the time required to implement safety measures and complete other construction work.

- China had 53 nuclear power plants at the end of 2021 with a total generating capacity of about 55 GW. The government plans to expand the scale to 70 GW by 2025. Capacity is expected to grow further until it reaches between 120 GW to 150 GW in 2030.
- Russian company Rosatom is involved in 17 reactor projects in Russia or elsewhere.

ii. *New Large Reactors:* The reactors construction in Western countries is accumulating large delays and cost increases. In June 2022, Olkiluoto EPR operator TVO announced that due to generator repairs, normal commissioning of this nuclear reactor in Finland will now be postponed until December 2022, 13 years late and billions of euros over budget.

The French Flamanville 3 EPR should start operations in 2023, eleven years behind schedule and a budget multiplied by almost four (from €3.3 to €12.7 billion, excluding financing costs).

In May 2022, Hinkley Point C commissioning has been postponed from 2025 to 2027.

These root causes of these delays include:

- the third-generation reactors' design complexity;
- the loss of skills;
- the project owners and their subcontractors' unpreparedness;
- the safety authorities' requirements; and
- the Covid-19 crisis, which disrupted work on construction sites.

Although essential to achieve climate goals, new nuclear reactors have far too long a construction time (more than ten years in Europe) to be a solution to the current energy crisis.

In the short term, governments should pull back from the safe nuclear reactors' planned shutdowns. It is what the Belgium government announced on March 2022.[82] Instead of phasing out its nuclear plants by 2025, it committed to take the necessary measures to extend for a further ten years its most recent nuclear reactors' operation.

Germany, intended to definitively close its last three nuclear power plants which provided 6% of the country's electricity generation, at the end of the 2022

However, to deal with possible energy shortages this winter, it decided early September, to leave the Isar 2 and Neckarwestheim nuclear plants on standby until mid-April 2023 on a kind of backup status, available only if the country has no other option.

iii. *Small Modular Reactors (SMRs)*[83] are defined as advanced reactors that produce electricity of up to 300 MW per module. Due partly to the high capital cost of large power reactors and partly to the need to service small electricity grids, *there is a move to develop smaller nuclear units.* They are seen as a much more manageable investment than big ones, the cost of which are difficult to finance. An additional reason for interest in SMRs is that they can more readily replace decommissioned coal-fired plants, which are seldom very large. Generally, they also have more advanced safety features.

There are about 50 SMR[84] designs and concepts globally. Most of them are in various developmental stages. There are currently four SMRs in advanced stages of construction in Argentina, China, and Russia and some, such as projects by TerraPower (345 MW) and X-energy

82 https://www.foronuclear.org/en/updates/news/belgium-decides-on-a-ten-year-extension-of-the-life-of-its-most-recent-nuclear-power-plants/#:~:text=T

83 https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx

84 https://www.iaea.org/topics/small-modular-reactors

(10 MW), are under an advance reactor demonstration program and could possibly be online in 2029 or 2030. A third advanced reactor from NuScale, with about 250 MW, may be ready around that time too.[85] However, concerns on cost (safety studies are as costly as those of large reactors but for a smaller electricity output) and larger waste production per electricity output must be considered. According to a study published in the Proceedings of the National Academy of Sciences, NuScale Power Corp reactors would produce about 1.7 times more waste per electricity output unit than large reactors.[86]

In Western countries, these new projects attract private investors, including small companies. These new investors' involvement indicates a shift taking place from government-funded large companies to smaller ones led by people with entrepreneurial spirit. The best-known example is Bill Gates's advanced nuclear reactor company TerraPower, which teamed up with GE-Hitachi Nuclear Energy and Berkshire Hathaway's power company, PacifiCorp, to eventually build a next-generation small nuclear reactor using new design and fuel technologies.

iv. *Existing reactors maintenance and upgrading:* By the end of 2021, the U.S. commercial nuclear power reactor's average age was about 40 years and, in Europe, 36 years. These reactors require significant maintenance and safety upgrades to incorporate the lessons learned from accidents such as Fukushima or other incidents. EDF has grouped together all the maintenance investments planned for the 2014 to 2025 period (estimated at €55 billion) under the term "Grand Carénage".

At the end of 2021, during maintenance operations, EDF discovered microcracks due to stress corrosion in the 1400 MW and the 1300 MW emergency water supply circuit. This unexpected problem is causing reactor closures for inspections and repairs at a moment of very tense energy supply in Europe. This stress corrosion issue, together with metallurgic problems encountered at the Flamanville 3 reactor (tank cover defaults, welds), demonstrates that metallurgy is a difficult subject and the measuring instruments available today make it possible to detect very small defects. The French safety authority has a break preclusion approach, which leads to having to shut down many reactors. The Anglo-Saxon approach of monitoring and intervening in the event of significant deterioration may seem more appropriate in the current situation. Moreover, it is necessary to develop non-destructive testing and EDF is working on it.

In the medium term, *the extension of existing nuclear reactors' lifetime, if they are in good safety conditions, is desirable.*

It should be noted that the French safety authority ASN has reached an agreement for all 900 MW capacity reactors (32 in total) to receive a lifetime extension.

v. *Nuclear players:* Even if nuclear energy is not among EU-led sanctions against Russia, the Russian equipment provider Rosatom, a reliable supplier, will be excluded from new nuclear projects. The Finnish-led consortium Fennovoima has terminated its contract with Rosatom to build Finland's Hanhikivi 1 nuclear power plant, citing risks linked to the Ukraine war. Except for Hungary, the other European countries that have new nuclear reactors projects (Slovakia, United Kingdom, France, Poland, Romania, and Czech Republic) should exclude Rosatom from the potential suppliers list.

85 https://www.marketwatch.com/story/some-big-investors-are-backing-nuclear-energy-a-potential-savior-to-the-energy-crisis-thats-gripping-the-wor
86 https://www.pnas

HOME

v. *Zaporizhzhia nuclear plant in Ukraine*[87]: This nuclear power plant is equipped with 6 VVER 1000 reactors of Russian design. It is the largest nuclear power plant in Europe. It is in a combat zone, which constitutes a major risk, and which generates high level political interventions and a lot of media coverage. Let's analyse this risk. One can think that the Russians are not irresponsible. They want to invade the country to annex it or make it an ally as a bulwark against NATO; they know that there is no need to cause a nuclear accident and contaminate agricultural areas and cities.

In the event of a problem, the sources for the reactor's core cooling are essential. It is the lack of such cooling that caused the Fukushima disaster. In the case of Zaporizhzhia, there are no credible scenarios in which all possible sources of core cooling could be shut down simultaneously unless an uncontrolled event occurs, such as, for example, following a "misplaced" missile launched by a "hothead". Finally, the main risk could come from a failure in operation, even though the VVER 1000 are modern reactors equipped with many redundancies.

In its building, the core of the reactor is effectively sheltered in a robust island. Its vulnerability is mainly due to the availability of the auxiliaries and water, electricity, and fuel oil sources which are essential to maintain it in safe conditions.

When the plant is on the war front line, there are obvious risks – whether it's normal networks and electrical backup that can be put out of service far from the plant (which happened on August 24, 2022) or whether it's fuel replenishment. Russian cyberattacks are also a threat even though the attackers should not be able to penetrate the operational IT system itself.

In addition, the nuclear units' operation requires calm for the employees who are there 24 hours a day and 7 days a week. This is surely not the case when they are working under the rule of the occupier.

On September 30, 2022, Russia illegally annexed four Ukraine territories including Zaporizhzhia. One day later, the plant Director was kidnapped.

In conclusion, the risk of incidents or accidents at Zaporizhzhia nuclear plant is real and the situation must be closely monitored (for example by the IAEA[88]).

87 Ecologie radicale August 13, 2022

88 IAEA: International Atomic Energy Agency

4. Conclusion:

a. On the short term: To face Russian gas cuts, Europeans should-

i. Re-open Groningen gas field;

ii. Keep in operations Belgian and German nuclear plants whose closure was scheduled;

iii. Buy as much LNG as possible, considering the LNG spare spot volumes and the re-gas facilities capacity;

iv. Invest in gas pipelines to increase their fluidity;

v. Launch as soon as possible major plans for energy conservation; and

vi. Hope that this winter will be mild!

b. On the mid-term; Europeans should

i. Invest in re-gas facilities, especially in Germany;

ii. Implement a bold electricity market reform encouraging low-carbon generation financing;

iii. Accelerate PV solar deployment by persuading populations to accept alleviated procedures;

iv. Be careful not to trade Russian gas dependency against China dependency on PV panels, rare metals, and batteries supply;

c. On the long term

i. Accelerate R&D in energy technologies;

ii. Invest in nuclear plants;

iii. Create favorable financing conditions for long-term green energy projects; and

iv. Avoid being dogmatic

Technological advances are essential for a successful energy transition.

1. Advances in wind and solar technologies:

At present, wind and solar technologies are the most mature renewable technologies after hydropower. Increasing wind and solar contribution to energy demand allows countries to both increase domestic energy resources and decrease GHG emissions.

However, these electricity sources are intermittent and thus require electricity storage to stabilize the electricity grid (see below). They have a low energy density per square meter, requiring them to be deployed on large surfaces to produce significant amounts of energy. Since land resources are limited in Europe and in other countries, there is a need to find new surfaces for these technologies to be installed.

Technology advances aim at improving wind or sun conversion rates to electricity, developing offshore wind or floating solar farms equipped surfaces, and decreasing their environmental footprint.

a. **Progress is continuing in wind power** due to offshore wind turbines' capacity increase, improved blade design, noise reduction, increased number of sensors coupled to Artificial Intelligence (AI) to better monitor the equipment and improve its output, and wind farms repowering to increase their capacity. Repowering brown field projects are better accepted by their neighborhood than green field projects.

i. Turbine recycling is starting to limit the usage of steel, concrete etc. It should be boosted by raw materials' price increases.

ii. Floating Offshore Wind Platforms: Floating wind uses the same turbines as conventional 'seabed-fixed' offshore wind but they are deployed on top of floating structures that are secured to the seabed with mooring lines and anchors. The floating platforms use the same technology as offshore oil and gas platforms. This technology opens the possibility of deploying offshore wind projects on deeper waters both in established markets like the U.K. and France, and in new regions like Japan and the west coast of the U.S.

Floating offshore wind technology is currently in a precommercial phase, with approximately 84 MW installed worldwide at the end of 2019.

Globally in 2019, there were over 7,000 MW in the planning and permitting phases of development, with the first commercial-scale projects expected to be operational in 2024. This technology is less mature than seabed-fixed offshore wind and is currently much more expensive. It is estimated that the LCOE will come down to a global average of $100/MWh in 2025 and $40/MWh in 2050 if the technology overcomes its main challenges: costs and confidence. Floating wind is predicted to grow worldwide to more than 264 GW in 2050.

b. **On the PV solar technology side,** research and development is focusing on semiconducting material to increase the solar-to-electricity conversion rate.

i. Promising materials are perovskite solar cells. According to the U.S. Department of Energy (DOE)[89], halide perovskites conversion efficiencies are over 25% in single-junction cells and over 29% in tandem cells with silicon.[90] They could be easily manufactured in high volume. On one hand, significant technological challenges, mainly their temperature stability must be addressed. On the other hand, there is hope. For instance, researchers from Princeton University, published an article[91] in June 2022 detailing the first perovskite solar cell with a commercially-viable lifetime.

89 https://www.energy.gov/eere/solar/perovskite-solar-cells
90 Compared to 15-20% of Power Efficiency conversion for commercial PV cells
91 https://www.science.org/doi/10.1126/science.abn5679

ii. Apart from innovative materials, creative methods of harvesting maximum solar energy are also emerging as bifacial cells or integrated lenses used as optical boosters in the panels' protective glass to concentrate light while reaching an efficiency of 30%.

Another recent development is reverse solar panels, that can generate electricity at night . They use a power generating device called a thermo-radiative diode, which operates with infrared energy in a similar way to night[92] vision goggles but scaled up.

iii. Solar cell recycling technologies to recover silicon, a material in high demand, are also progressing.

iv. Floating solar panels make it possible to install solar farms on lakes (for example, dam lakes) and thus better exploit the potential of the sun. They have other positive features:

- Floating solar[93] power generating systems typically generate more electricity than ground-mount and rooftop systems due to reduced operating temperature of solar modules resulting from natural cooling from water.
- As the PV system is placed on a water surface, it avoids all the hurdles of land acquisition and concerns of land consumption.
- Floating PV plants can reduce water loss due to evaporation, depending on the surface covered and climate conditions.

However, they also have drawbacks, such as increased installation costs and higher maintenance costs.

Floating PV[94] installations with a total capacity of around 2 GW were in place worldwide at the end of 2019. Experts estimate a total worldwide capacity of 62 GW by 2030. Currently, most of the worldwide installed capacity is in Asia.

2. Marine energies are promising but still quite far from large-scale deployment.

Ocean waves exert tremendous amounts of power that could be utilized as a renewable resource, known as wave energy and tidal energy.

a. Wave Energy[95]:

Wave energy is the energy generated from the up-and-down movement of the ocean. Technologies differ on how to convert wave energy into electricity. Some are based on air compression with large structures; others are based on buoys whose movement generates more decentralized electricity.

The challenges of wave energy include:

i. Its efficiency (the percentage of the wave energy that is captured);

ii. Its durability as the equipment is submerged in sea water. Solutions that do not involve moving parts are best from this point of view;

iii. Maintenance for this equipment is projected to be very expensive because it will be submerged in constantly moving saltwater;

iv. Its cost: estimated pilot-scale wave energy LCOE varies between $370/MWh and $1220/MWh.

Wave energy is generally in the research phase of development and paid for by government grants or research grants. There are no energy companies utilizing wave energy at scale. However, a few start-ups have successfully embarked on this field and have received investments that can reach a few hundred million dollars. For example: OceanPower Technologies (U.S.), AW energy (Finland), SINN Power (Germany), Carnegie Clean Energy (Australia), Eco Wave Power (Israel), Ocean Energy (Ireland and U.S.), Octiteq

92 https://www.azocleantech.com/article.aspx?ArticleID=1593
93 https://www.trace-software.com/blog/floating-pv-plants-a-promising-future-for-solar-energy/
94 https://www.intersolar.de/market-trends/floating-pv-europe#:~:text=Floating%20PV%20installations%20with%20a%20total%20capacity%20of%20around%202,of%2062%20GW%20by%202030.
95 https://www.alliedmarketresearch.com/wave-energy-market-A07823

(Czech Republic), Wave She'll Energy (Australia), Arrecife Energy Systems (Spain), and Corpower Ocean (Norway).

The global wave energy market size was valued at $44 million in 2019 and is projected to reach $141 million in 2027, growing at CAGR[96] of 18% per year from 2020 to 2027.

b. Tidal Energy:

Exploits the natural ebb and flow of coastal tidal waters. The tidal stream devices, which utilize these currents, are similar to submerged wind turbines and are used to exploit the kinetic energy in tidal currents. Thanks to the higher-than-air water density, for the same electricity output, the blades can be smaller and turn more slowly than those of wind turbines.

To increase the flow and power output from the turbine, concentrators may be used around the blades to streamline and concentrate the water flow towards the rotors.

This energy source's main advantages are the density of sea currents and their predictability

The disadvantages are:

i. The very high cost of installing and maintaining tidal turbines. According to 2019 figures from the DOE, the average commercial tidal energy project LCOE is as much as $280/MWh;

ii. Uncertainties about the facilities' lifetime due to equipment corrosion by seawater; and

iii. The concern of fishermen and the impact on marine flora and fauna.

Tidal energy production is still in its infancy. There are very few commercial-sized tidal power plants operating in the world (60 MW for wave and tidal electricity in total). The first plant was in La Rance (France). Presently, the largest facility is the Sihwa Lake Tidal Power Station in South Korea.

The global potential is estimated at 100 GW.

In Europe, the United Kingdom, France, and Norway are the countries best placed to take advantage of this potential.

3. CO_2 capture and storage implementation should be accelerated:

a. Carbon Capture Usage and Storage (CCUS):

In 2021, the energy sector emitted 36 billion tonnes of energy-related GHG worldwide. The crisis triggered by the Russian invasion of Ukraine is leading to an increased use of coal, which is increasing CO_2 emissions.

In addition, Europe, China, and other regions have ambitious hydrogen development plans (see below). In some regions, renewable and nuclear electricity will not be sufficient, so blue hydrogen produced from coal with CO_2 capture will have to be used.

i. *The development of CCUS has been disappointing in the past,* however it is picking up. The past decade saw high-profile project cancellations and government funding programs that failed to deliver. The main reasons were the high cost of CCUS installations, the lack of sustained government incentives, and fears from ecological movements and governments that supporting CCUS would mean supporting a sustained use of fossil fuels. On average, capture capacity of less than 3 million tonnes of CO_2 ($MtCO_2$) has been added worldwide each year since 2010, with annual capture capacity reaching over 40 $MtCO_2$ in 2021, thanks to 27 operating plants.

96 CAGR; Compound Annual Growth Rate

This needs to increase to 1.6 billion tonnes ($GtCO_2$) in 2030 to align with a pathway to net zero by 2050.[97]

Since 2021, there has been significant growth in the number of projects supported by the recognition of the role of CCUS in the fight against climate change, including as one of few solutions to tackle emissions from heavy industry, by the needs related to blue hydrogen, and by increased government incentives.

The U.S. is the most supportive region. There was a significant increase in the 45Q tax credit in 2022,[98] which provided a credit of \$85/tCO_2 for CO_2 that is permanently stored and \$60/tCO_2 with storage in nearly depleted oil fields using Enhanced Oil Recovery. Combined with reduced minimum carbon capture thresholds, this should open the market to a much wider range of projects and accelerate investment in CCUS. This tax credit can be "stacked" with other incentives, including the California Low Carbon Fuel Standard (LCFS), with the value of LCFS credits averaging around \$200/tCO_2 in 2020. An additional \$12 billion of support for CCUS investment in the United States was included in the November 2021 Infrastructure Investment and Jobs Act.

Other countries are now supporting CCUS: Norway has committed \$1.8 billion to the Longship project, which includes the Northern Lights offshore storage hub; the Netherlands has committed up to €2 billion through its sustainable energy and climate fund to the Porthos CCUS hub at the Port of Rotterdam; the United Kingdom has established a £1 billion CCUS Infrastructure Fund with a target of building four CCUS hubs by 2030; and four CCUS projects have been selected in the first funding call for the European Commission's €10 billion "Innovation Fund".

Support for CCUS is also growing in Canada and in Australia.[99]

As a result, the number of projects has dramatically increased. In 2021 there were, in addition to the operating plants, five plants under construction, 66 in advanced development and 97 in early stage or just announced. They are operating or under development in 25 countries around the world, with the United States and Europe accounting for three-quarters of the projects in development.

ii. CCUS installation costs are broken down into capture, transport, and storage costs. If the CO_2 is injected in oil wells, the storage cost is reduced as it contributes to Enhanced Oil Recovery. Looking specifically at carbon capture, the cost can vary greatly by CO_2 source, from a range of \$15-25/tCO_2 for industrial processes producing "pure" or highly-concentrated CO_2 streams (such as ethanol production or natural gas processing) to \$40-120/tCO_2 for processes with "dilute" gas streams, such as cement production and power generation. Transportation cost is relatively small.

- Single plant: According to IEA[100] the average CCUS levelized cost per tCO_2 for a single plant should decrease from \$125/tCO_2 in 2021 to \$98/tCO_2 in 2050. This is still higher than the European ETS emission permits prices that, despite a significant growth, were around €90/tCO_2 by mid-2022.
- Multi-industry hubs are a more competitive solution. They group CO_2 flows captured from plants in industrial zones that can include power generation, chemical production, and oil refining and mutualize transportation and storage. The upfront development costs associated with creating CO_2 transport and storage are thus shared among the different plant owners.The average CCUS levelized cost for hubs should decrease from \$100/tCO_2 in 2021 to \$80/tCO_2 in 2050.[101]

For example, the U.S. Gulf of Mexico region,[102] where many heavy industries are located, provides advantages for an emerging U.S. CCUS sector, aided by vast geologic prospects

97 https://www.iea.org/commentaries/carbon-capture-in-2021-off-and-running-or-another-false-start
98 In the " Inflation Reduction Act" https://www.lw.com/admin/upload/SiteAttachments/Alert-2999.pdf

99 https://www.iea.org/commentaries/is-carbon-capture-too-expensive

100 https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage
101 https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage
102 https://www.offshore-energy.biz/noia-sees-gulf-coasts-potential-for-global-ccus-hub/

for CO_2 storage, extensive infrastructure, and an assessable engineering and energy industry workforce. Exxon Mobil[103] has proposed a giant, $100 billion hub to capture CO_2 emissions along the U.S. Gulf Coast in Texas but warned that government funding would be required to pay for and develop it.

Early projections show that such a facility could bury 50 $MtCO_2$ a year beneath the Gulf of Mexico by 2030, more than all CCUS projects currently operating globally. Exxon said that figure could double by 2040.

iii. Usage: The demand for commercial CO_2 today represents a market of approximately €500 million at the European level, of which the agri-food sector represents nearly 70%. Innovative solutions for using CO_2 as a raw material could emerge over the next several decades in various sectors as cultivation of microalgae, production of synthetic methane, and manufacture of chemicals (as methanol). These new developments could multiply the CO_2 market by up to 30.[104]

iv. Conclusion: Alongside continuous technology improvements, increased government incentives, notably in the U.S., should allow the private sector to contribute to this much-needed technology development.

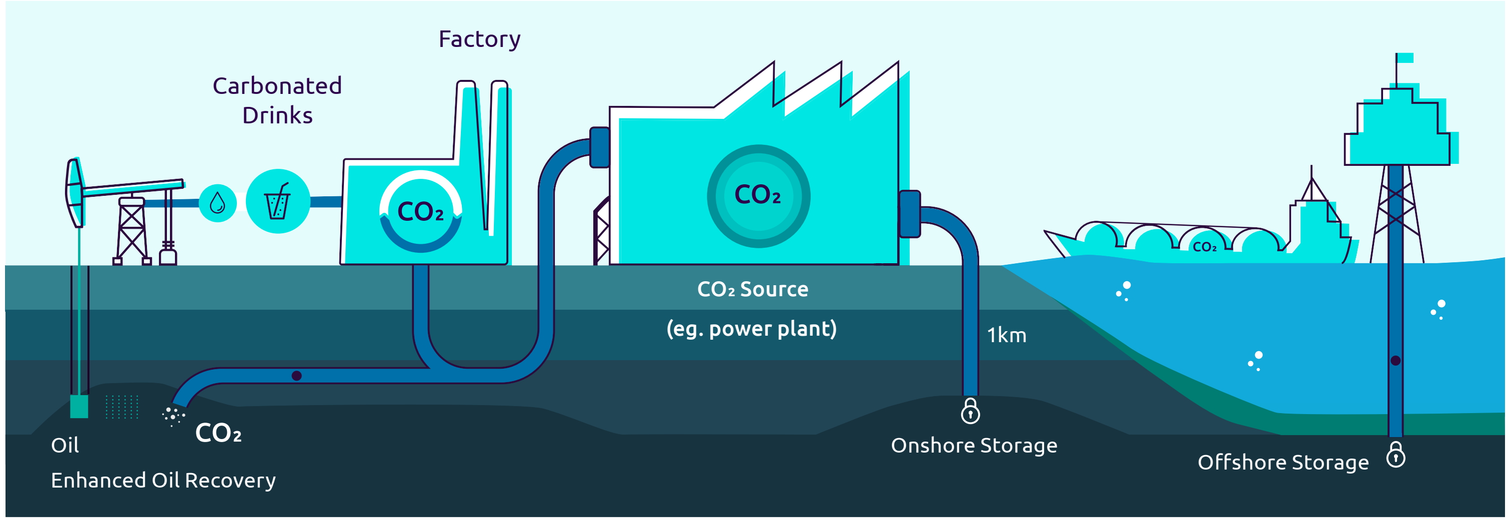
b. **Direct Air Capture (DAC):**

CO_2 represents 0.04% of ambient air. It is therefore achallenge to capture it. Two technologies exist that capture CO_2 through a liquid, which is regenerated at the end of the process, or in a solid with subsequent degassing.

Projections show that the capture of up to millions of tonnes of CO_2 per year could be possible. In the U.S., the August 2022 Inflation Reduction Act provides a 45Q tax credit of $180/$tCO_2$ for DAC projects with geologic sequestration and of $130/$tCO_2$ for DAC projects that use Enhanced Oil Recovery.

However, DAC cost in 2022 is extremely high and the process consumes a lot of energy.

Private support exists also. For example, in April 2021, Elon Musk called attention to this issue by launching the $100 million XPrize Carbon Removal contest,[105] a four-year initiative funded by the Musk Foundation that is offering cash prizes to those developing ways to trap carbon dioxide and "lock it away permanently in an environmentally benign way." In November 2021, XPrize announced the first winners: 23 different groups who will receive a total of $5 million to develop their various proposals.



103 https://www.rigzone.com/news/wire/exxonmobil_pitches_100b_gulf_coast_ccs_hub-20-apr-2021-165208-article/
104 https://www.sia-partners.com/fr/actualites-et-publications/de-nos-experts/les-nouveaux-usages-du-co2

105 https://www.insidehook.com/daily_brief/science/elon-musk-carbon-removal-prize-first-winners

4. Energy Storage:

With the renewable energies growth and the decommissioning of fossil fuel-fired power plants (which are schedulable), the difficulty to balance the grid is increasing. Some solutions are already implemented:

i. *Demand response* enabled by time of use tariffs, aggregation technologies, and devices such as smart meters, including in the residential market, is developing, but the results remain disappointing.

ii. *Smarter grids* are largely deployed, notably in Europe, U.S., Canada, and Japan and help better integrate the variable renewables in the electricity system.

iii. *Grid interconnexions* enable the balancing of intermittent supply with a larger and more diverse demand and contribute to a more efficient use of power resources.

In May 2022, ElecLink, a subsidiary of Getlink, commissioned an interconnection with a 1 GW capacity, linking France to the United Kingdom via a 52 km cable in the Channel Tunnel. ElecLink will contribute to security of supply in the UK and Europe and support better use of renewable energies produced on both sides of the Channel.

In addition to these grids balancing enablers, *increasing electricity storage is key for rapid renewables development.*

Pumped hydro, hydrogen, batteries, and thermal storage are a few of the technologies currently in the spotlight.

Pumped storage hydropower[106] is the best inter-seasonal storage. However, in Europe and in most developed countries, suitable sites have almost all been exploited and the potential for development is limited.

Excluding pumped storage, Bloomberg NF[107] predicts 30% annual growth for the global energy storage market until 2030. In addition to pumped storage, the main technologies are batteries and hydrogen.

a. Presently, batteries can store a few hours of electricity

Weekly and a fortiori inter-seasonal storage is not possible because of the required batteries' weight and volume and because there is self-discharge in the batteries

i. *Batteries for EVs:* Lithium-ion (Li-ion) constitute 95-99% of batteries used for mobility. Today, Li-ion batteries (mainly NCM and LFP batteries[108]) have achieved impressive cost decrease and energy density increase not because of technological breakthroughs, but by building larger plants and optimizing their production methods. By extrapolating the present improvement rate, NCM Li-ion batteries will reach a cost of $100/kWh at the cell level and an energy density of 300Wh/kg before 2030.

Yet, they are not optimal regarding safety and resource-utilization.[109]

- Flammability: Li-ion batteries use an electrolyte in which the main ingredient, by volume, is ethylene carbonate. Because it is flammable, it raises concerns for battery fires and consequently toxic gas emissions.
- Pression on world resources: To achieve the EV sales forecast of 17 million in 2025, lithium supplies will need to double from 2021 levels to reach 0.2 Mt and rise to 0.5 Mt by 2030 (39 million EV sales).[110]

  Cobalt is also used in Li-ion batteries even if equipment manufacturers try to decease its usage. The Democratic Republic of Congo owns over 55% of global reserves and cobalt mining raises concerns on human rights and environmental issues.
- Recycling: To be environmentally friendly, battery producers must recycle their batteries and recover the rare metals used. Otherwise they would quickly consume the whole planet's resources.
  It is possible to recover metals either by pyrometallurgy or by various chemical treatments. These two types of processes consume a lot of energy and emit a lot of GHG. Batteries should be designed to be more easily recyclable: A kind of "Lego" battery designed to be easily dismantled to enable direct recycling (of used electrodes, for example).

106 https://www.energy.gov/eere/water/pumped-storage-hydropower
107 https://www.energy-storage.news/bloombergnef-predicts-30-annual-growth-for-global-energy-storage-market-to-2030/
108 NCM: Lithium, Nickel, Cobalt, Manganese. LFP: Lithium Ion Phosphate https://www.pnnl.gov
109 https://www.dnv.com/to2030/technology/are-solid-state-batteries-the-holy-grail-for-2030.html
110 Energy Aspects data

Recycling plants and metal refining capacity are being built in Europe and in the United States, reducing the distances travelled by used batteries and thus GHG emissions. However, their capacity is currently insufficient to meet a significant fraction of the growing demand for metals.

– There are technological advances to improve current lithium-ion batteries performance – for example, by using anionic reduction to increase battery capacities. Currently only the reactions of the positive ions are used, though one could also use anions, such as oxygen, reactions. These are paths full of progress but also full of challenges.

Installing sensors on the batteries to monitor their state of health is a priority.[111]

– Solid-state batteries have the potential to improve most of the present-day Li-ion battery concerns. A solid-state electrolyte is presumed to be non-combustible or at least resistant to self-ignition. The non-combustible nature of solid-state batteries also reduces the risk of thermal runaway, allowing for a tighter cell packaging and consequently improving the design flexibility and volumetric density.

However, solid-state batteries are currently not commercially available and basic research is still ongoing, with uncertainties and concerns related to high production costs and scalability. In the initial phase of development, solid-state technology is estimated to have high costs, varying in the range of $800/kWh to $400/kWh by 2026.

Despite these challenges, almost all manufacturers have announced strategic partnerships or significant investments in solid state Li-ion batteries.

Volkswagen has already bet $300 million on the California firm QuantumScape since the end of 2020. Ford and BMW have, for their part, invested $135 million in Solid Power, born in 2011 from a University of Colorado spin-off, which itself raised $540 million by going public last year.

Other examples include the start-up Factorial Energy, which finalized a $200 million financing round in January 2022, led by Stellantis and Mercedes-Benz. The latter also announced last February a partnership with the Taiwanese unicorn, ProLogium.

ii. *Stationary batteries do not have the same requirements as batteries for mobility.*

Technologies such as sodium-ion, which are very similar to Li-ion, are being developed and will be able to benefit from all the developments made for Li-ion. These batteries have slightly higher power and longer lifecycles compared to NCM batteries. They have a lower energy density, which is not a problem for stationary batteries that are not limited in weight.

These batteries make it possible to reduce the Western countries' dependence on lithium, but they also use cobalt and nickel, which are rare metals. The Chinese giant CATL, which holds 32.5% of the EV battery market, announced in 2021 a new Na-ion battery that will come on the market in 2023. Its energy density could reach 160Wh/kg (aiming for a density of 200Wh/kg for the next generation) and it recharges to 80% in 15 minutes.

Other battery technologies are in development – in particular, redox vanadium batteries, that can be effectively utilized for all types of stationary energy storage tasks, with higher lifetimes that result in lower Levelized Cost of Energy Storage.[112]

111 JM Tarascon interview https://www.lefigaro.fr/sciences/jean-marie-tarascon-a-moyen-terme-le-lithium-restera-irremplacable-pour-la-mobilite-20220707#:~:text=Sciences%20%26%20Environnement-,Jean-Marie%20Tarascon%3A%20%C2%AB%C3%80%20moyen%20terme%2C%20le%20lithium,restera%20irrempla%C3%A7able%20pour%20la%2 mobilit%C3%A9%C2%BB&text=ENTRETIEN%20-%20Le%20plus%20grand%20sp%C3%A9cialiste,

112 https://www.marketresearch.com/Global-Industry-Analysts-v1039/Vanadium-Redox-Battery-31935486/

Their commercial expansion is expected to be driven primarily by their lower environmental impact in terms of battery disposal and higher energy capacity. These batteries contain no toxic or highly reactive substances and pose no fire hazard, making them more environmentally friendly compared to Li-ion batteries. For mobility, they are impeded by higher capital costs and lower energy density but seem well adapted to grids.

iii. *Uses of batteries on the grid:* Connecting batteries distributed on the electrical network with automation, remote control systems, and algorithms could allow them to be used as a Virtual Power Plant (VPP). This is the principle of "Ringo"[113] launched by RTE in 2020.

iv. *Vehicle to Grid:* Electric vehicle batteries are only used for a few hours a day. By making them available to the network, the TSOs[114] can use them for ancillary network balancing services (frequency adjustment, etc.). Except in certain regions, this opportunity has not yet found a satisfactory commercial model (see 22nd and 23rd WEMO editorials).

b. **Hydrogen is an important energy vector for energy transition** because it makes it possible to decarbonize around 15% of the economy that is not suitable for the direct use of electricity.

In addition, hydrogen allows inter-seasonal storage of electricity, which is not possible with batteries (see above). The energy is returned either in the form of electricity with fuel cells or as hydrogen thanks to its energy content.

Currently hydrogen is produced from methane or coal, which is a process that emits very large quantities of CO_2.[115] It is called "grey hydrogen".

For it to be able to contribute to the energy transition, the production of hydrogen must not emit GHGs. This is the case of "green hydrogen" that is made from electrolysis of water with carbon-free electricity (produced with renewable energies). Since nuclear electricity does not emit GHGs, hydrogen made from nuclear electricity should be counted in Europe as green hydrogen.

This is the case in the U.S. and many other countries. Blue hydrogen, which is made from methane or coal with CCUS, could also contribute to hydrogen development objectives. However, GHG emissions from blue hydrogen production are high, particularly due to the release of fugitive methane. They are only 9-12% less than for grey hydrogen.[116]

i. *All over the world, 80 countries are supporting clean hydrogen production,* either through hydrogen policies or roadmaps, or by providing some support for clean hydrogen projects or research and development.

Altogether these objectives are quite ambitious.

– United States: The $1.2 trillion Infrastructure Investment and Jobs Act authorizes and appropriates $9.5 billion for clean hydrogen research, development, and demonstration programs. Importantly, the Act defines "clean hydrogen" by carbon intensity, explicitly including hydrogen produced from nuclear, as well as renewables. The Act also authorizes $1 billion for a clean hydrogen electrolysis program at the DOE, with a goal to reduce the cost of producing clean hydrogen to less than $2/kg by 2026.

113 https://www.rte-france.com/projets/stockage-electricite-ringo
114 TSO ; Transmission System Operator

115 98% of hydrogen is made from fossil fuels with no CO_2 emissions control and is responsible for 830 Mt of CO_2 each year. - https://www.energypolicy.columbia.edu/research/article/hydrogen-fact-sheet-production-low-carbon-hydrogen

116 "How green is blue hydrogen?" - https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956

The Inflation Reduction Act, signed in August 2022, provides production tax credits for clean hydrogen at a rate of $3/kg, and production tax credits for blue hydrogen at rates between $0.6-$1/kg.

- Canada issued its hydrogen roadmap in December 2020. Its near-term strategy for the next five years is to lay the foundation for the hydrogen economy in the country.

- U.K: In the British Energy Security Strategy published in April 2022, the U.K. government doubled the capacity ambition set out in the Hydrogen Strategy, with the goal now increased to 10 GW of low carbon hydrogen production capacity by 2030, with at least half of this coming from electrolytic hydrogen.

- EU is the most ambitious region for hydrogen development. It issued its hydrogen strategy in 2020 with the priority to develop renewable-produced hydrogen, using mainly wind and solar energy. The strategy envisions three phases. In the first phase, from 2020 up to 2024, the objective is to install at least 6 GW of renewable-based hydrogen electrolyzers, resulting in up to 1 million tons of renewable-produced hydrogen. In a second phase, from 2025 to 2030, the objective is to install at least 40 GW of renewable-based hydrogen electrolyzers in the EU, with up to 10 million tons of renewable-produced hydrogen.

  The EU objective is also to import the same amount of green hydrogen. In a third phase, from 2030 to 2050, renewable-based hydrogen technologies should reach maturity and be deployed at scale to abate all hard-to-decarbonize sectors.

- Japan is the country that first committed to clean hydrogen development. In March 2019, the government of Japan released its third Strategic Roadmap for Hydrogen and Fuel Cells. Japan's roadmap included an ambitious goal of achieving 40,000 fuel cell vehicles by 2020, 200,000 fuel cell vehicles by 2025, and 800,000 by 2030.

- South Korea: In January 2019, South Korea announced its Hydrogen Economy Roadmap. It outlines a goal of producing 6.2 million fuel cell electric vehicles and rolling out at least 1200 refilling stations by 2040.

- China's national hydrogen strategy seems conservative compared to EU objectives on quantitative targets. It aims only for 100,000 to 200,000 tons of annual green hydrogen production by 2025.

However, industry insiders estimate that existing Chinese green hydrogen production capacity has already reached 100,000 tons a year.

A more specific policy is planned as part of China's national decarbonization strategy, which aims to reach the 2060 net zero carbon target. It will likely introduce more ambitious targets for hydrogen applications and integration in the energy system.

- Worldwide: In its recent report,[117] DNV estimates that to reach the Paris Agreement goals, hydrogen should meet around 15% of world energy demand by 2050. In 2030, around 70% of this hydrogen should be green while 30% should be blue.

ii. *Key elements of decarbonized hydrogen development are:*

- Availability of carbon-free energies, or for blue hydrogen, competitiveness and sustainability of CCUS (see above);
- Progress on electrolyzers, allowing green hydrogen production with intermittent electricity sources;
- Ramp-up of the electrolyzers industry;
- Green hydrogen cost decrease as it is presently around three times higher than grey hydrogen's (see 23rd WEMO editorial); and
- Economical and energy-efficient hydrogen long-distance transportation.

- Availability of carbon-free electricity: The renewable capacities growth is, particularly in Europe, insufficient to achieve the Paris Agreement objectives. It will therefore be difficult to devote a large part of this capacity to green hydrogen production.

According to its hydrogen objectives, EU should add 40 GW of renewables capacity by 2026, roughly the same amount as solar and wind capacity additions in 2021. Knowing that:

- Renewable growth objectives are difficult to meet.
- Renewables are already needed to replace fossil fuel and cover the electricity consumption increase; and
- Renewables should (at least partially) replace missing Russian gas

It is unlikely that this objective will be met. To overcome these difficulties, it is necessary to include nuclear electricity sources for green hydrogen production. Ambitious nuclear program development should help to meet long-term hydrogen ambitions.

- Technology challenges: Hydrogen is the smallest molecule on earth, therefore it has a low density and easily penetrates and embrittles the materials used for its production, storage, or transport.

Moreover, in contact with oxygen (and therefore air), it causes explosions. These properties present special cost and safety obstacles at every distribution step, from manufacturing to end-use.

Green hydrogen is obtained by water electrolysis. In the past several years, large efforts were deployed on improving electrolyzer performance, reducing their cost and upscaling their production. Currently there are four main technologies: Alkaline, Proton Exchange Membrane (PEM), Solid Oxide Electrolysis (SOE), and Anion Exchange Membrane (AEM).

Alkaline technology is the most developed but does not respond well to changes in power feed (which is an inconvenience when using intermittent renewable electricity). Newly developed pressurized systems, which are more robust to change in power input, have entered the market.

PEM is known for its ability to ramp up and down very quickly, making it a suitable technology for renewable energy feed. However, it is more costly and uses iridium and platinum, both precious metals. Additional development with PEM should aim at the reduction and recycling of these precious metals which could otherwise limit very large-scale expansion of PEM.

SOE technology is commercially available but is still far behind alkaline and PEM in terms of scale and maturity. AEM is the latest developed technology which is not yet commercialized at relevant scale.

117 DNV_Hydrogen_Report_2022

– **Electrolyzer industry ramp-up:** In May 2022, the EU Commissioner for Internal Market and 20 industry CEOs signed a Joint Declaration whereby the industry committed to a ten-fold increase of its electrolyzer manufacturing capacities by 2025.[118] This should enable the annual EU production of 10 million tons of renewable hydrogen by 2030, set as target in the March 2022 REPowerEU Communication. The Commission will act to put in place a supportive regulatory framework, facilitate access to finance, and promote efficient supply chains. *Let's hope that these EU actions will be vigorous enough to support this very ambitious industrial ramp-up.*

In the U.S., in June 2022,[119] President Joe Biden announced a plan to ramp up electrolyzer manufacturing capacity by granting the DOE access to the $545 million Defense Production Act (DPA) emergency fund to build the U.S. manufacturing capacity in key clean-energy sectors, including electrolyzer manufacturing.

However, two main bottlenecks prevent the rapid increase of electrolyzer manufacturing capacities. First, large investments required in the absence of certainty on the future electrolyzer's market demand. Second, challenges related to building up integrated supply chains and the availability of components and raw materials such as nickel, copper, steel, titanium, and rare metals (such as iridium) at the required scale.

– **Hydrogen transportation:** The competitiveness of the different options will depend on the distance over which hydrogen is transported, its scale, and end use. For distances below 1500 km, transporting hydrogen as a compressed gas by pipeline is generally the cheapest option.[120] This can be done in pure form or blended (2 to 10% presently) into natural gas in gas pipelines. Depending on the pipeline metal hydrogen embrittlement, hydrogen could be transported in the existing natural gas pipelines or will need dedicated pipelines, which would require a significant investment. For example, a group of 23 European gas infrastructure companies has developed a strategy to build a hydrogen backbone that could have, by 2040, a total length of 39,700 km, consisting of approximately 69% retrofitted existing infrastructure and 31% of new hydrogen pipeline.

For distances above 1500 km, shipping transportation is the preferred option. Shipping hydrogen as ammonia or as Liquid Organic Hydrogen Carriers (LOHC) may be most cost-effective. Conversion costs can significantly impact business cases since as much 28% of the transported energy can be consumed during ammonia or LOHC synthesis and its subsequent dehydrogenation to release hydrogen. Moreover, if an accidental release occurs, ammonia is toxic.

Absorption on solid components has been a research subject for many years. Many materials have been studied such as zeolite, nickel compound, and activated carbon. None are already at commercial stage. Mid-2022, scientists from Australia's Deakin University[121] announced that they discovered a way to store hydrogen in powder form. More specifically, hydrogen placed in a sort of centrifuge with boron nitride and steel balls will combine with the nitride and therefore take the form of a powder. This powder can be reheated, releasing unchanged hydrogen that can be sucked up and used.

According to the scientists, hydrogen in powder form is much less difficult to store. Thus, its transportation and use would be simplified.

In addition, this process does not require precious materials, since boron nitride can be produced synthetically without much difficulty. The next phase of this experiment will be its industrial validation through a demonstrator. If validated, this innovation could remove two important obstacles to the deployment of hydrogen: its transportation and storage.

More technology development and large investments in infrastructures need to occur to make large-scale hydrogen trading an industrial reality.

118 https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2829
119 https://www.rechargenews.com/energy-transition/biden-invokes-wartime-legislation-to-ramp-up-us-hydrogen-electrolyser-production-but-what-will-this-mean-in-practice-/2-1-1235045 https://entsog.eu/sites/default/files/2021-
120 https://entsog.eu/sites/default/files/2021-05/ENTSOG_GIE_HydrogenEurope_QandA_hydrogen_transport_and_storage_FINAL_0.pdf
121 https://oudshophead.com/2022/08/15/hydrogen-powder-researchers-have-introduced-a-groundbreaking-discovery/

- Cost reduction: Presently, the levelized cost of green hydrogen is around \$5/kg – three times more than grey hydrogen – while blue hydrogen is at \$3/kg. It is forecasted[122] that globally, green hydrogen will reach cost parity with blue within the next decade.

- Conclusion: Based on the above analysis, country targets for hydrogen development are unlikely to be achieved within the timeframe. This is also the conclusion of DNV in its 2022 Hydrogen report: “We find that hydrogen is not on track to fulfil its full net zero role by mid-century — in fact far from it. Our forecast shows that hydrogen is likely to satisfy just 5% of energy demand by 2050 instead of the 15% required.”

  Therefore, green hydrogen should be reserved for industries where CO_2 is difficult to abate with other technologies, such as in steel, heavy chemicals, and refining.

  It is interesting to note that the current additional cost of green hydrogen may be acceptable in high value-added products such as high-end cars. For example,[123] a €2.2 billion carbon-free iron and steel production plant project located in France was announced at the end of June 2022 by a consortium constituted by the European incubator EIT InnoEnergy.

The company, GravitHy, is aiming to start production in 2027. It will produce direct reduced iron (DRI) using low-carbon hydrogen that will be utilized either on site to make "green steel” or globally traded.

The extra cost of green hydrogen in the production cost of a high-end car is small compared to the benefits of a “green car” sales pitch.

122 DNV_Hydrogen_Report_2022
123 https://eghac.com/gravithy-imminent-market-leader-in-green-iron-and-steel-is-launched-today-by-world-class-industrial-consortium-%EF%BF%BC/

5. Electrical cables:

a. High voltage direct current (HVDC) cables:

There have been many advances in HVDC Cables. This includes XLPE (cross linked polyethylene) insulated cables which enable longer underwater or underground electrical connections. For example, in the NordLink interconnection,[124] a 623 km HVDC submarine cable connects Norway to Germany, providing clean Norwegian hydroelectricity to Germany. These cables are used to connect offshore distant wind farms; their usage will increase with floating wind turbines, which will be built further from the coast.

In Germany, the multi-billion euro "power link corridors" project is a technical breakthrough. It was launched in 2020 by German utilities and consists of three underground electrical corridors of around 750 km each. This project is essential for the green transformation of the country by enabling the electricity produced by offshore wind in the North Sea to be wheeled to the south of Germany where the clean power is needed by industries. Each corridor will be equipped by state-of-the-art 525 kV XLPE insulated underground cable. The three corridors will use around 5000 km of energy cables.

b. Superconducting cables:

Because of superconducting properties (zero resistance) there is no heat generated when the electricity goes through superconducting cables. It is thus possible to transport high amounts of electricity in small cables.

This supports bringing large electricity amounts in urban dense zones. In June 2022, "SNCF Réseau" announced that it will install Nexans superconducting cables to provide power for Montparnasse (France's fourth-largest train station, with more than 50 million passengers annually and more than 90 million expected in 2030). SNCF Réseau will thus need more power to run an ever-increasing number of trains. Only a superconducting cable can combine a reduced diameter and exceptional power to deliver the performance required (5.3 MW per conduit). This also enables SNCF Réseau to save on substantial implementation costs related to infrastructure modification, avoid potential disruptions to rail and road traffic, and limit risks in terms of execution time and the commissioning date.

In U.K., the Super Conductor Applications for Dense Energy Transmission (SCADENT[125]) project is using *high temperature superconducting cables to increase the capacity of the electricity grid in urban areas.* The need for these cables has been highlighted by restrictions on building homes and factories in three areas of London because of limited electricity supply. This project, led by National Grid Electricity Transmission, aims at developing superconducting cables with lower losses.

6. Conclusion:

The energy transition, which is essential for the future of our planet, is slower than expected. Speeding up this transition depends not only on political will, regulations, financial incentives, public and private player involvement, and better information of the general public, but also on faster deployment of new energy technologies.

There has been a lot of scientific progress and technological innovations in this field, increasingly driven by private companies and even start-ups. These developments are occurring in renewable energies, nuclear energy, CO_2 capture, energy storage, batteries, hydrogen, electrical cables, electrical networks, and energy services.

Governments should invest more in these areas, from basic research to technologies' deployment, but also in education and scientific training, which are the pillars of success.

124 Commissioned in May 2021

125 https://www.eenewspower.com/en/superconducting-cable-project-aims-to-boost-urban-electricity-grid/

Has the world lost sight of the need to fight climate change?

The energy crises stress the importance of ensuring energy supplies, which had, before 2022, been neglected in favour of the fight against climate change.

Access to energy, which is a vital good, at an affordable price, must be possible for all the inhabitants of our planet (even if this is unfortunately not yet the case today).

Pre-war situation: In 2021, national climate pledges combined *with other mitigation measures put the world on track for a global temperature rise of 2.7°C by the end of the century.* This is above the threshold of 1.5°C warming and could lead to catastrophic changes for the climate. To keep global warming below 1.5°C this century, annual GHG emissions will need to be cut in half in the next eight years.[126]

Moreover, the present energy crisis is threatening these already fragile climate change-related commitments.

126 UNEP and UNEP CCC (Copenhagen Climate Centre) Emissions Gap report 2021

The question is: Has the world lost sight of the need to fight climate change?

The Russian invasion of Ukraine has reinforced the need in Europe to develop domestic energies such as nuclear and renewable energies. However, building new nuclear plants takes a long time and renewable development deployment is slower than desired; in addition, the volatility of renewables today poses a threat to electrical grid stability. This, combined with the gas high prices and the lack of Russian gas in Europe, explains why nearly all countries are increasing their use of coal for power generation, even if in 2021, at the COP26 meeting, the same country leaders had pledged to phase it out.

However, the political will to combat climate change is still present in western countries and in India. It has to be confirmed in Russia and China.

1. In Europe: EU aims at accelerating the development of renewable energies:

Europe, as a block, is the third worldwide emitter. In Europe, Germany is the largest emitter (compared to France, Germany emits around 75% more GHG per inhabitant[127]).

a. In June 2022, the EU Council adopted its negotiating positions on the **Fit for 55** legislative proposals and is now ready to negotiate with the European parliament.[128] The Fit for 55 package was presented by the European Commission in July 2021. It should enable the European Union to reduce its net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels and to achieve climate neutrality in 2050. It includes 13 legally-binding measures which target the establishment of a carbon tax at the borders of the European Union (Carbon Border Adjustment Mechanism (CBAM)), the strengthening of the European carbon market, and the end of thermal cars sales by 2035.

At the end of these negotiations, the compromise texts will be formally adopted by the Council and the Parliament before becoming legislative acts applicable to all Member States by 2024.

b. In May 2022, the European Commission has presented the **REPowerEU Plan** (see above), to respond to the double urgency of ending the EU's dependence on Russian fossil fuels and tackling the climate crisis. The plan includes several measures to accelerate the rollout of renewables, notably by quadrupling solar installed capacity and increasing green hydrogen availability[129] (see above). This plan should help end EU reliance on Russian fossil fuels by 2027. However, it is very optimistic as it relies exclusively on renewables development (notably solar PV) and discards nuclear energy. Moreover, as analyzed above, hydrogen development will be slower than desired. In addition, it could become outdated if Russian cuts in 2022 all its gas supply to Europe!

c. **The EU taxonomy**[130] of sustainable economic activities is a tool to help investors understand whether an economic activity is sustainable and navigates the transition to a low-carbon economy. After extended debates, in March 2022, the Commission approved a Complementary Climate Delegated Act including, under conditions, specific nuclear and gas energy activities in the list of economic activities covered by the EU taxonomy. It will apply as of January 2023.

2. In the U.S.: President Joe Biden, who signed the Paris Agreement immediately after taking office, included measures to combat climate change in his Build Back Better plan.

The U.S. is the second worldwide GHG emitter.

The U.S. President suffered a defeat at the end of June 2022 with the Supreme Court decision (see below) but succeeded in passing the Inflation Reduction Act, which contains historically high financial incentives to achieve the objectives of the Paris Agreement.

a. On June 30, 2022, *the U.S. Supreme Court imposed limits on the federal government's authority* to issue regulations reducing carbon emissions from power plants.[131] The case was brought by West Virginia on behalf of 18 other mostly Republican-led states, and some of the nation's largest coal companies.

127 https://countryeconomy.com/countries/compare/france/germany?sc=
128 https://www.consilium.europa.eu/en/press/press-releases/2022/06/29/fit-for-55-council-reaches-general-approaches-relating-to-emissions-reductions-and-removals-and-their-social-impacts/
129 https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131
130 https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en
131 https://www.bbc.com/news/science-environment-62000742

These states made up 44% of the U.S. emissions in 2018 and, since 2000, have only achieved, on average, a 7% reduction in their emissions. They are worried that their power sectors would be forced to move away from using coal at a severe economic cost.

After this decision, President Biden declared; "While this decision risks damaging our nation's ability to keep our air clean and combat climate change, I will not relent in using my lawful authorities to protect public health and tackle the climate crisis."

b. However, despite this set back, by mid-August 2022, President Biden signed into law *the biggest climate package in U.S. history:* After months of intense negotiations, much of it focused on garnering the support of two Democratic centrists—Senators Joe Manchin of West Virginia and Kyrsten Sinema of Arizona—the Inflation Reduction Act passed both House and Senate and was signed into law. This $430 billion bill embodies administration to reshape the U.S. economy as it emerged from the coronavirus pandemic.

The bill invests more than $360 billion in energy and climate change programs over the next decade, including cash incentives for electric vehicle consumers and tax breaks to speed up the country's transition to renewable energy sources.

Senate Democrats say the bill will reduce carbon emissions by nearly 40% by 2030, about 10% below the target Biden originally pledged to reach in 2021 at the "Leader's Summit on Climate" that he hosted at the White House.

3. India confirms the targets announced at the COP26 conference

India is the fourth-largest GHG country emitter, behind Europe, and counts for 7% of global emissions. However, the average carbon footprint per person in India is relatively low at 0.56 tonne per year.

On August 3, 2022, India's cabinet approved an updated national climate plan including a 2070 net zero goal and 45% reduction in emissions intensity by 2030.[132]

It is aiming for half of installed electricity generation capacity to come from non-fossil sources at the end of the decade (compared to 40% presently).

132 https://www.climatechangenews.com/2022/08/03/india-approves-climate-plan-with-increased-ambition-clarifying-energy-goals/

4. Russia's decarbonization at risk.

Russia is the world's eleventh-largest economy but the fifth-largest emitter of greenhouse gases. Until 2021, Russia was a passive player on worldwide climate ambition. However, in November 2021 the Russian government adopted a framework climate legislation with a net-zero target by 2060.

The impulse for this initiative could have come from outside the country. For example, EU CBAM, which aims at imposing carbon-related tariffs on imports, has been credited with pushing the Russian government and industry to finally take climate change seriously.[133] With the present sanctions on Russian goods, this incentive is disappearing.

Moreover, the anti-Western rhetoric brought on by the war makes it more difficult to pursue decarbonization plans. Politicians and lobbyists who had already opposed decarbonization efforts have seized the moment to demand a withdrawal from the Paris Agreement at the Russia parliament in May 2022.

133 https://theconversation.com/other-casualties-of-putins-war-in-ukraine-russias-climate-goals-and-science-182995

5. China suspended all cooperation with the United States on global warming.

China and the United States struck a climate deal at the COP26 summit. They pledged to work together to accelerate climate action over the next decade and to meet regularly to 'address the climate crisis'.

China is the largest emitter of GHG. It still massively relies on coal and, in 2022, decided to increase its domestic coal mining by 300 million tonnes within the next three or four years.

Also, China did not take the needed actions to push its carbon price above the recent level of less than $9/t.

However, on August 5, 2022, China suspended all cooperation with the United States on global warming and other areas, in retaliation for the visit to Taiwan by the Speaker of the House of Representatives. The suspension is deemed "irresponsible" by the White House, as was stated by President Joe Biden: "China is not just punishing the United States, it is punishing the whole world."

6. Short-term headwinds against decarbonization

The political measures to combat climate change in Western countries and in India will deliver their first effects in 2024 at the earliest. In the meantime, an increased use of coal will lead to a rise of 2022 and probably 2023 GHG emissions compared to 2021.

However, two factors could counteract this increase and push down GHG emissions.

On the one hand, the effectiveness of the energy saving measures decided by many governments (which could include new containment, even if partial), would reduce GHG emissions which are, as analyzed above, strongly correlated with energy consumption. On the other hand, a sharp global economic slowdown in H2 2022 would lower energy consumption and therefore GHG emissions.

Despite its increasing use of coal, China has experienced major lockdowns linked to Covid-19 and therefore a drop in activity.

This has been amplified by the very hot summer, which led to electricity cuts in some regions. China's economic growth was only 0.4% in Q2 2022, and year-end growth could be only around 3.3% in 2022[134] – the lowest level in more than 40 years (excluding the 2020 Covid-related, low-growth period). The United States could suffer from an economic slowdown linked to high inflation and thus correlated slowdowns of emissions.

Therefore, in the short term, it is difficult to predict the global emissions' evolution given the bearish and bullish factors described above.

134 https://www.business-standard.com/article/international/imf-revises-china-s-2022-growth-by-1-1-predicts-major-global-spillovers-122072601270_1.html#:~:text=The%20International%20Monetary%20Fund%20(IMF,1.3%20per%20cent%20next%20year.

Conclusion:

1. In recent years, insuring energy supplies has been neglected in favour of the fight against climate change (e.g., premature closure of nuclear power plants, use of imported gas as a substitute for nuclear power, commitments on the rapid exit from coal, etc.). **This could result in an electricity and gas shortage this winter in some European countries.**
2. **A balance must be found between these two equally important imperatives** (security of energy supply and the fight against climate change) by combining a long-term vision and pragmatism in the design and implementation of the corresponding policies.
3. Among the measures recommended by European states to avoid a disruption in supply, **energy sobriety** is certainly the one that can give the best results in the short term, if States and major operators quickly launch incentive campaigns for **all** players (residential, tertiary, and industrial) and take appropriate regulatory measures.
4. Europe and the United States rightly want to accelerate the development of renewable energies because they are both domestic and carbon-free. However, **Europe must not exchange a dependence on Russian gas with a dependence on certain energy transition key components, particularly vis-à-vis China** (solar panels, metals, and rare earths, etc.)
5. Nuclear power is an essential component for the decarbonization of electricity and the stability of the electricity grid. Unfortunately, its development comes up against the difficulty of building large third-generation nuclear power plants in Western countries. Like what is done in the United Kingdom, **long-term remuneration systems for nuclear electricity should be put in place to encourage private players to invest in this industry.** In addition, an in-depth reflection involving all stakeholders, considering safety requirements, experience, events around the Zaporizhia power plant, and innovations introduced by new players, should be engaged so that the nuclear renaissance becomes real.
6. The use of coal has increased since the pledge "to accelerate a transition away from unabated coal power generation" at the COP26 conference. This underlines the importance of **rapidly developing competitive CCUS to eliminate CO_2 emissions from coal and gas-fired power plants (as well as other plants using fossil fuels) and produce enough competitive blue hydrogen.**
7. **Green hydrogen should be reserved for industrial processes where emissions cannot be otherwise abated** (for example, in steel, refining, and chemicals) since renewable energies development is late compared to its targets, the electrolysis industry profitable ramp-up is not yet done, and hydrogen long-distance transportation is still a challenge.
8. **In the short term, the energy crisis will delay GHG emissions reduction.** They could rise sharply again in 2022 (compared to 2021) unless during the last part of 2022, the United States, Europe, and China experience a sharp economic slowdown.
9. **In the medium term, the carbon free energies development that are also domestic resources (renewables and nuclear) could benefit from the current energy crisis.**
10. Finally, **governments should invest more in education, research, and innovation.** Moreover, populations, members of the media, and politicians should all receive basic knowledge that is essential to understand how energy works.

“*I hope that you will enjoy reading the 24th edition of WEMO.”*

Colette Lewiner
Paris, September 12,2022

02

COMMODITIES & TECHNOLOGIES

OIL, GAS AND ELECTRICITY MARKETS

CLAIRE GOTHAM
ALEJANDRO BENGUIGUI NADAL
DEBARGHYA MUKHERJEE

Markets shaped by successive crises and resulting volatility

An Overview

Over the past two plus years, the world has gone from one crisis to another. Each of them has had significant impacts on energy and climate change issues, including large impacts on commodities markets across the globe. The first of these crises was Covid-19 and the subsequent lockdowns in the countries around the world. Energy consumption and commodities prices collapsed during the quarantines imposed by governments in 2020.

In 2021, we started to see a robust economic rebound, as citizens started to resume many of their pre-pandemic activities. In some instances, this activity seemed increased to make up for the loss of time under quarantine. However, generation capacity cannot be restarted as quickly as demand. Additionally, oil and gas companies had become more hesitant regarding long-term infrastructure investments, given the recent unprecedented volatility. Commodities and energy markets prices started to increase rapidly in response to this fundamental supply and demand imbalance.

To add to the imbalance, in early 2022, Russia invaded Ukraine. This war (ongoing at publication) intensified energy scarcity globally, particularly in Europe. We saw a new examination of the globalization of the energy markets, with some countries moving to fortify their domestic sources, increase storage, and evaluate the locations of manufacturing. This also has led to a renewed interest in LNG as an energy source.

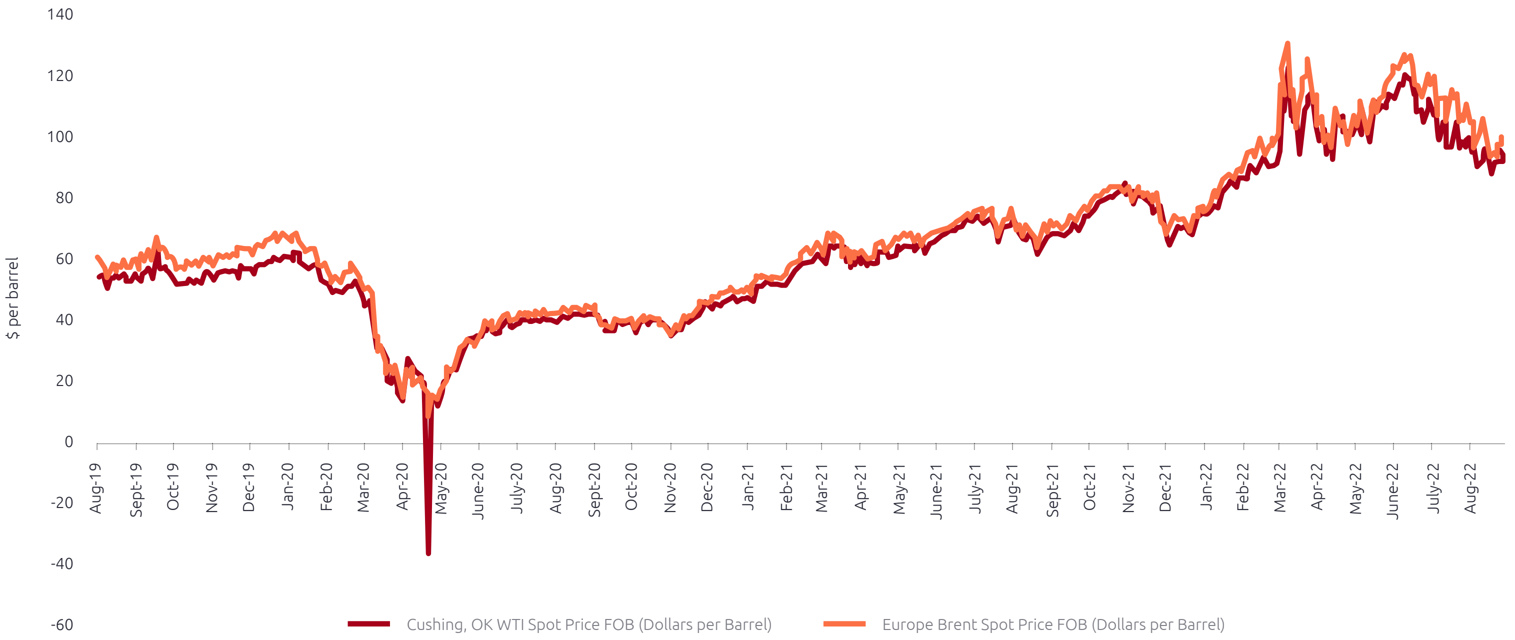
As we move into the final quarter of 2022 and into the winter for both Europe and the U.S., will there be an economic recession that will dampen energy demand? If so, will prices stabilize and allow generation capacity to catch up? There may be market reform in other parts of the world that will lend to this. Across the globe, governments are evaluating/executing price caps and additional government funding to support infrastructure reinforcement, supply security, and the continued build out of additional renewable energy sources. Only time will tell the outcome.

Oil markets: Prices have seen significant volatility and steady increase since Covid-19, a trend that has been further reinforced at the beginning of 2022

- Crude prices saw a sharp increase in both absolute prices and implied volatility in 2021 and particularly 2022.
  - This was a departure from 2020 when WTI oil futures prices went into negative territory for the first time, as the May 2020 contract was expiring and there was not enough demand or storage for the physical oil.
- The price increases since in 2021/22 were due, in part, to the increasing demand, stemming from recovering global economies “post”-pandemic.
- A larger impact of rising crude prices globally was due to the conflict between Russia and Ukraine.
- This began February 24, 2022 when Russia invaded Ukraine; it is an ongoing conflict at the time of publication. This tightened the global crude oil supply significantly, leading to a dramatic rise in value on those remaining available supplies.

FIGURE 1

Evolution crude oil spot prices from 2019 to 2022



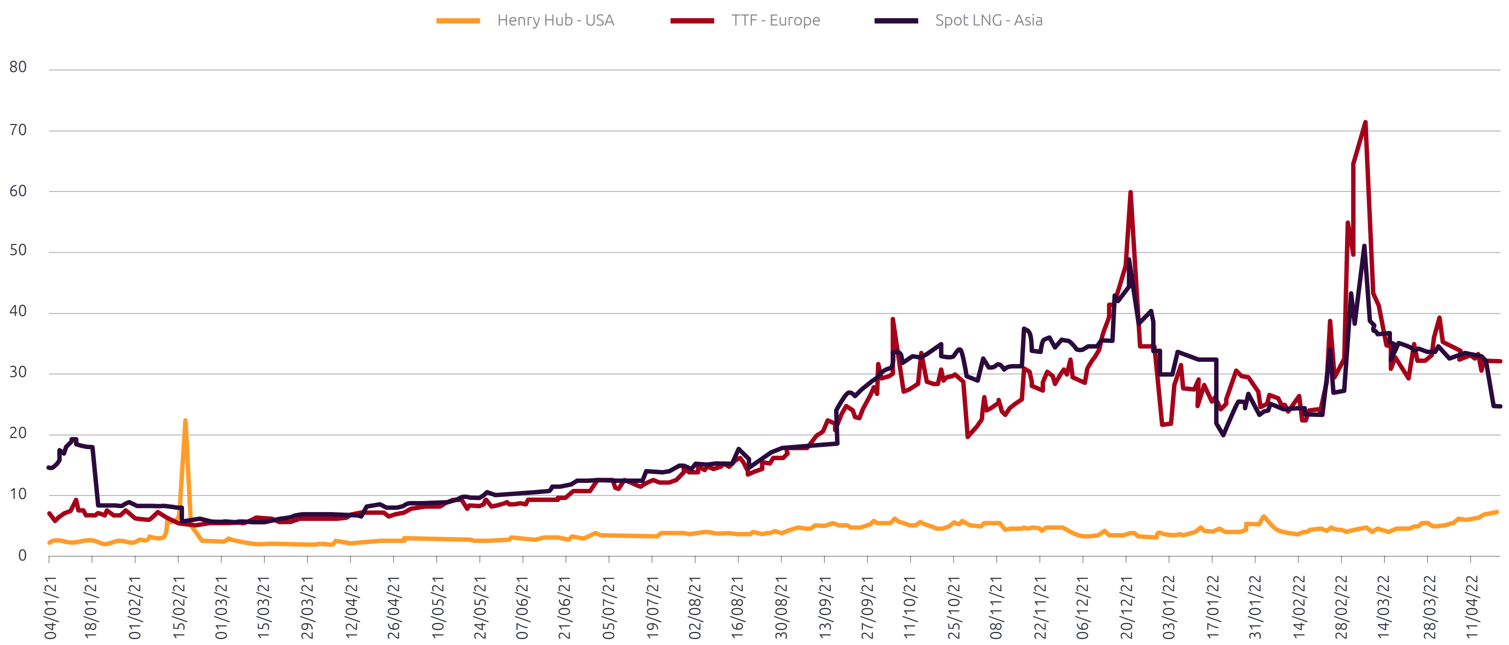
Source: EIA

Gas markets: Gas prices started to soar in Europe and Asia at the end of 2021, while U.S. maintains stable prices thanks to its shale oil reserves

- With the geopolitical crisis caused by Russia/Ukraine and the ensuing energy crisis, 2022 natural gas prices remained at extremely high levels globally.
- The prices were especially high in Europe and Asia in comparison to the U.S.
- The U.S., despite the production pullback that occurred in previous years, still enjoys an abundance on natural gas, thanks to shale deposits. As a result, exports have increased.
  - In the first half of 2022, the U.S. became the world's largest LNG exporter, with the bulk of supplies going to the U.K. and the EU.
  - Global LNG supply increased on the back of growing U.S. LNG exports to Europe, while Asian LNG demand weakened amid warming weather and a Covid-19 recovery in China.
- Prices continued to fluctuate resulting in increased volatility
  - During the past 12 months (July 2021–June 2022), the monthly average Henry Hub natural gas spot price, which is a U.S. benchmark, nearly doubled, according to data from Refinitiv Eikon. The price rose from $3.84/MMBtu in July 2021 to $7.70/MMBtu in June 2022.
- Concern continues regarding the Russia-Ukraine conflict and resulting impacts to the stability and security of European energy supply.

FIGURE 2

Evolution of daily international spot gas prices ($/MMBtu)



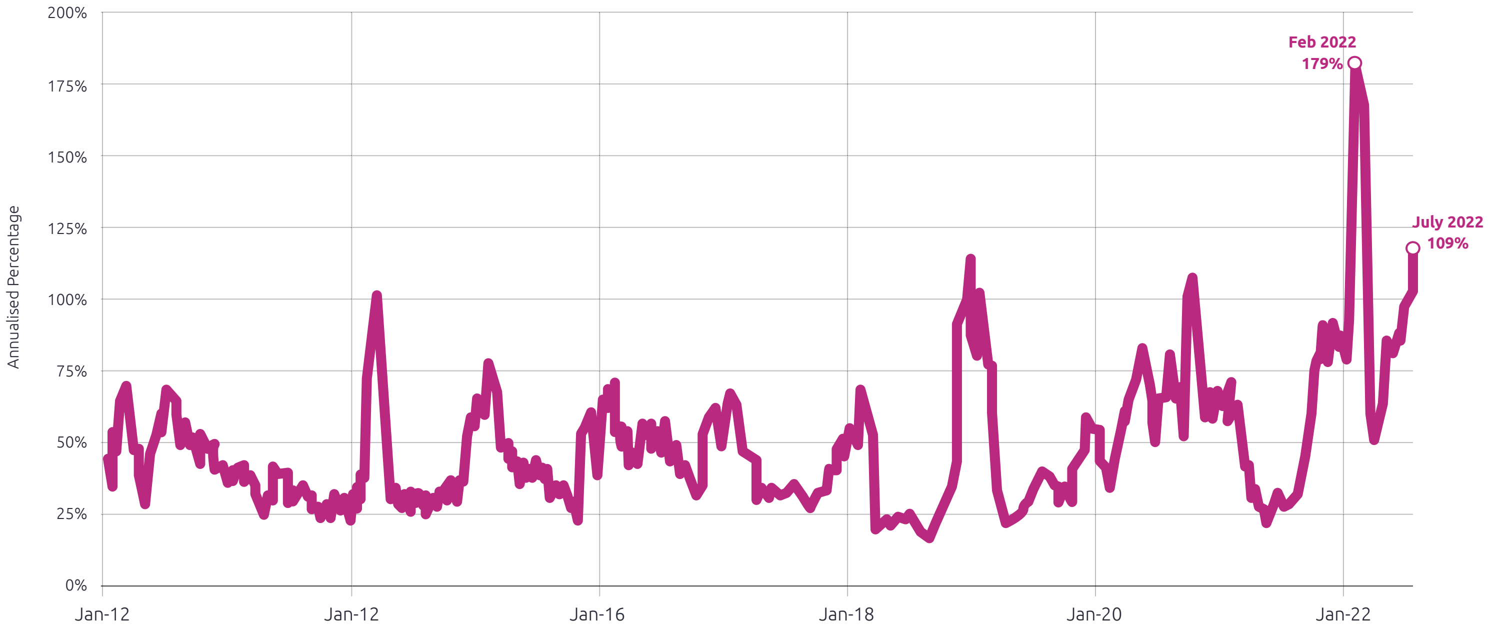
Source: Reuters, IFPEN, CEDIGAZ

Gas markets: The last year has seen gas prices fluctuate drastically, leading other fossil fuels in terms of volatility and market uncertainty

The war in Ukraine and its ensuing geopolitical upheaval has sparked the most volatile gas market in an already tumultuous decade.

FIGURE 3

Natural gas 30-day historical volatility (January 2012 to July 2022)



Data Source: Bloomberg L.P.
Note: Annualised percentage, a widely used trading measure of price volatility, is the standard deviation for the previous 30 days of daily changes in the Henry Hub front-month futures price multiplied by the square root of 252 (number of trading days in a year) multiplied by 100. Percentages are averages for that period.

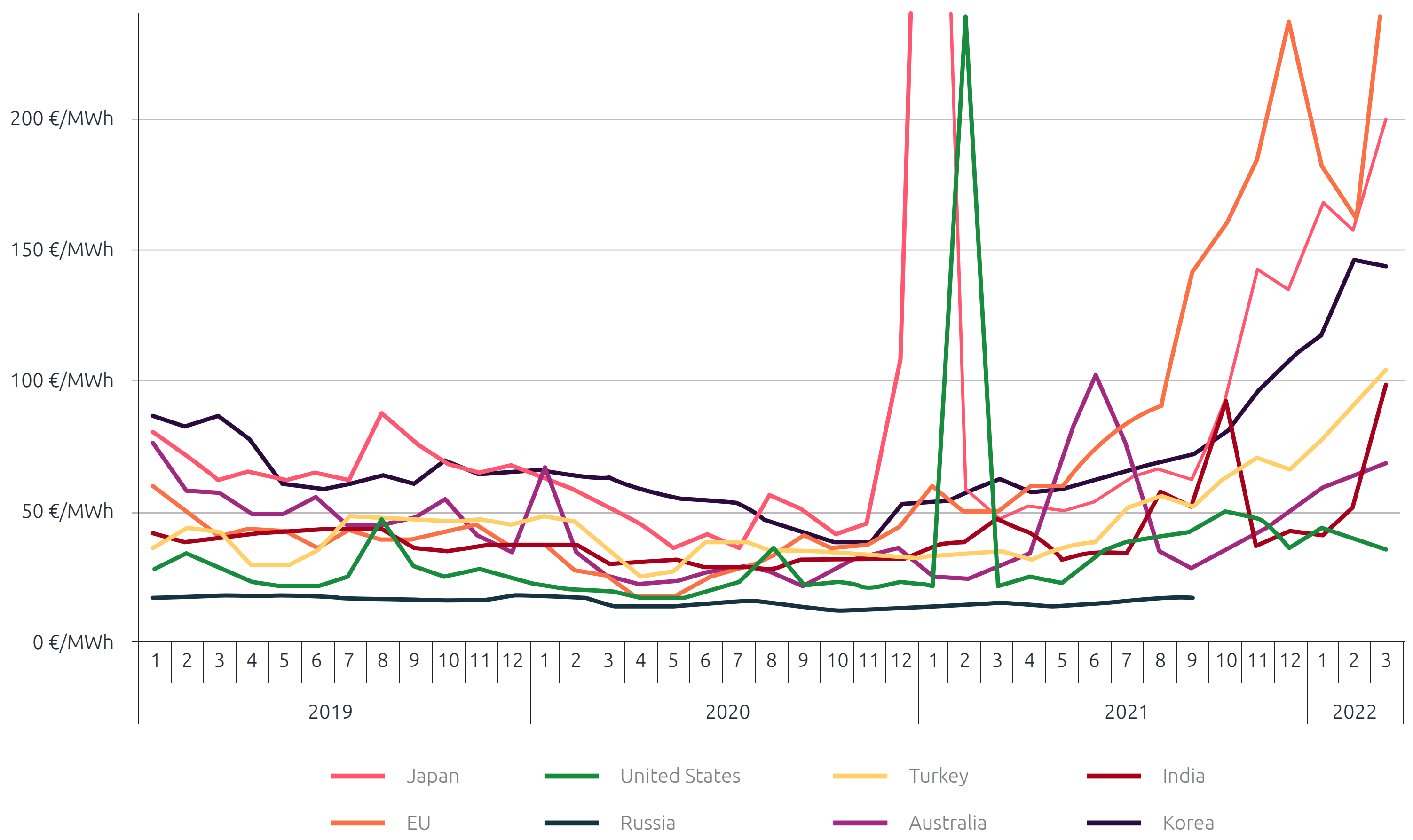
Source: EIA

Electricity markets: Following fossil fuels' price surge, electricity wholesale prices across the globe have increased dramatically, particularly in Europe and Asia

- Rapidly rising fuel costs are to blame for most increases in electricity prices.
- Major price spikes happened in 2021 in several countries:
  - In the U.S., Texas blackouts from winter Storm Uri in February disrupted the ERCOT market. This created large ripple effects on pricing in the other power markets in the U.S., as well as the natural gas market.
  - Japan experienced unprecedented electricity supply and demand pressures caused by an increase in demand due to an unexpected cold wave and a shortage of LNG stocks.
  - Australia also saw price increases in their winter of 2021, with wholesale electricity and gas prices tripling from the previous year. This was caused by the combination of failing coal-fired power plants and soaring global gas costs.
- Prices across all nations (with the obvious exception of Russia) saw a general increase in 2022 mainly due to the war in Ukraine. There was major impact in EU, Japan, and Korea as these countries rely heavily on Russian gas.

FIGURE 9

Monthly average wholesale electricity prices In international markets



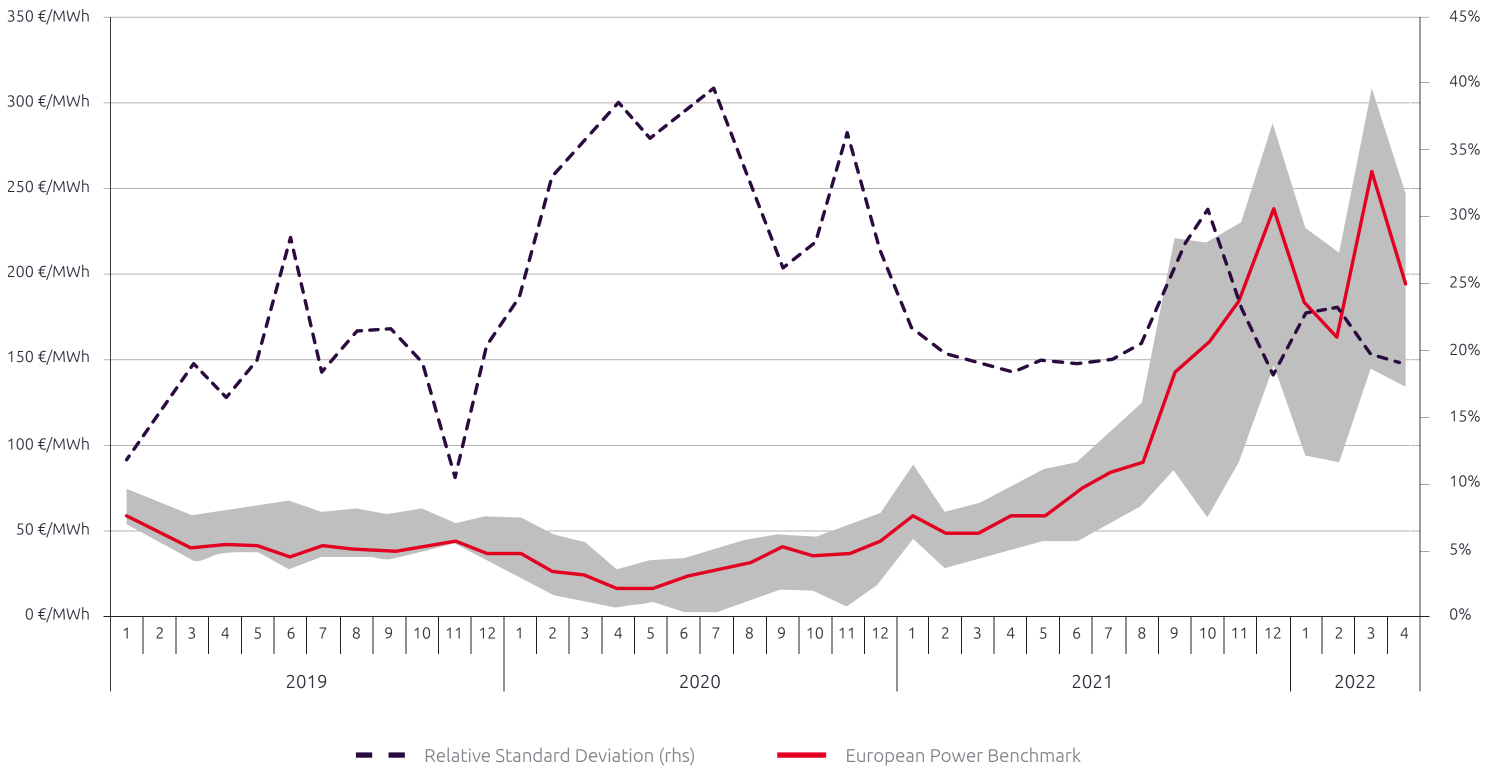
Source: European Commission

Electricity markets: A closer look at Europe shows increasingly high disparity in electricity pricing among EU countries, greatly magnified by price surges in both Q4 2021 and Q1 2022

- Geopolitical turmoil around Europe's energy suppliers has seen electricity prices rapidly surge throughout H2 2021 and Q1 2022.
- Gas prices are at the root of both price hikes. This is due to a diplomatic rift between Morocco and Algeria at the end of 2021 and the war in Ukraine in 2022.
- The chart shows price spikes during these two periods based on the European Power Benchmark (red), which accounts for nine major European markets.
- Lowest and highest regional prices (grey) show increasing disparity in prices between the most and less expensive markets. It illustrates the fact that the energy crisis has affected countries differently, albeit on a common upward trend.
- Price disparity is mainly due to significant differences among countries in their electricity generation mix, making some more sensitive to gas price increases, particularly for countries highly dependent on Russian gas, such as Germany or Italy.
- Consequently, Italy remained the most expensive market for two consecutive quarters (Q4 2021 and Q1 2022).

FIGURE 9

Evolution of lowest and highest regional wholesale electricity prices in the European day-ahead markets and relative standard deviation of regional prices



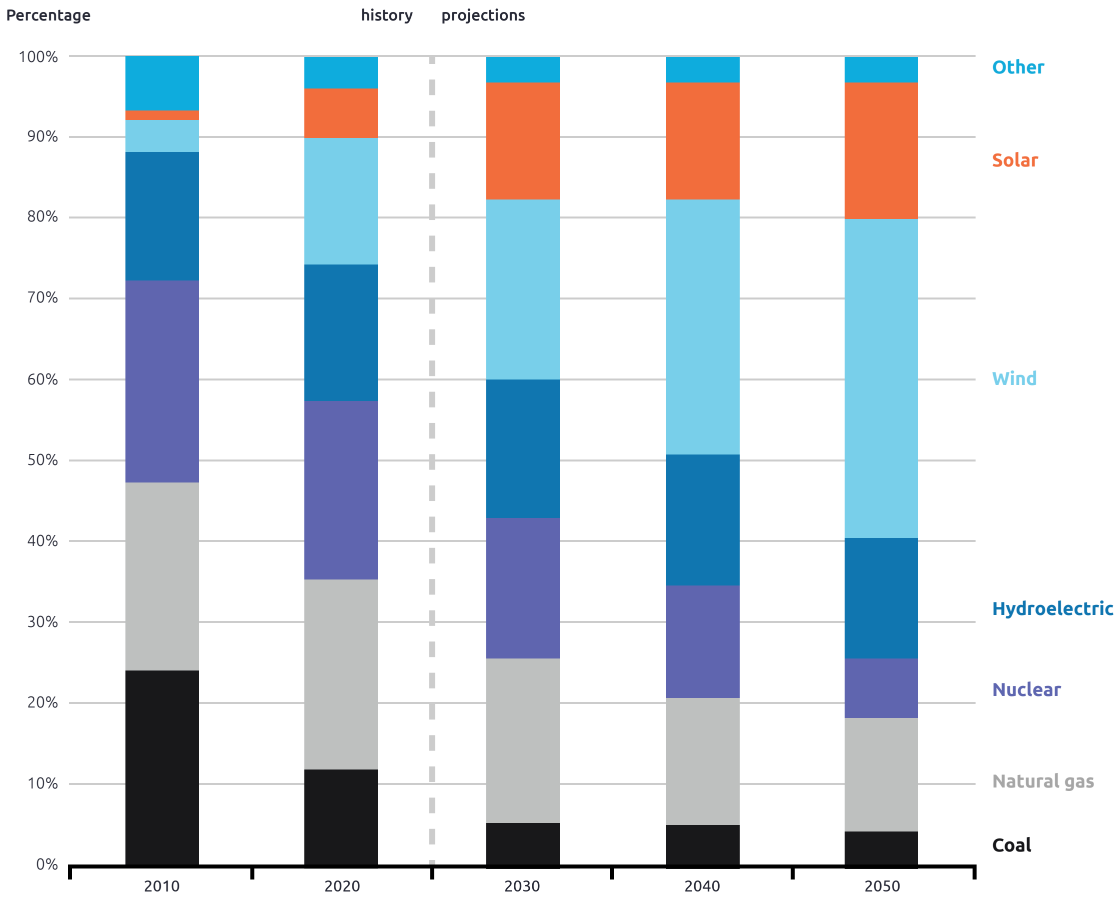
Source: S&P Global Platts, Eurostat. European power exchanges. The shaded area delineates the spectrum of prices across European regions.

Electricity markets: Projected electricity generation mix evolution (Europe vs U.S.)

- Globally:
  - Global electricity demand is projected to increase by 80% between 2020 and 2050 – around double the overall rate of growth in consumption
  - Emerging market and developing economies drive most of the increase in global electricity demand (approximately 85%), fueled mainly by renewables and gas
  - The fuel portfolio mix is expected to shift more heavily to natural gas, with renewables also playing a larger role
  - As coal and nuclear generating capacity retire, new capacity additions come largely from wind and solar technologies
  - However, the current geo-political events impacting energy may cause many nations to re-evaluate nuclear as a power generation source
- In Europe:
  - Wind is forecasted to be the dominant fuel by 2050, with natural gas, hydro, and solar all closely positioned for close to equal shares of second place
  - Natural gas is projected to lose a larger share of generation by 2050 than in the U.S., from 38% to 14%
- In the U.S.:
  - Renewable electricity generation share of overall generation fuels is projected to increase from 19% in 2021 to 41% by 2050
  - Currently, nuclear's share of generation is forecasted to drop from 19% in 2021 to 12% by 2050

FIGURE 6

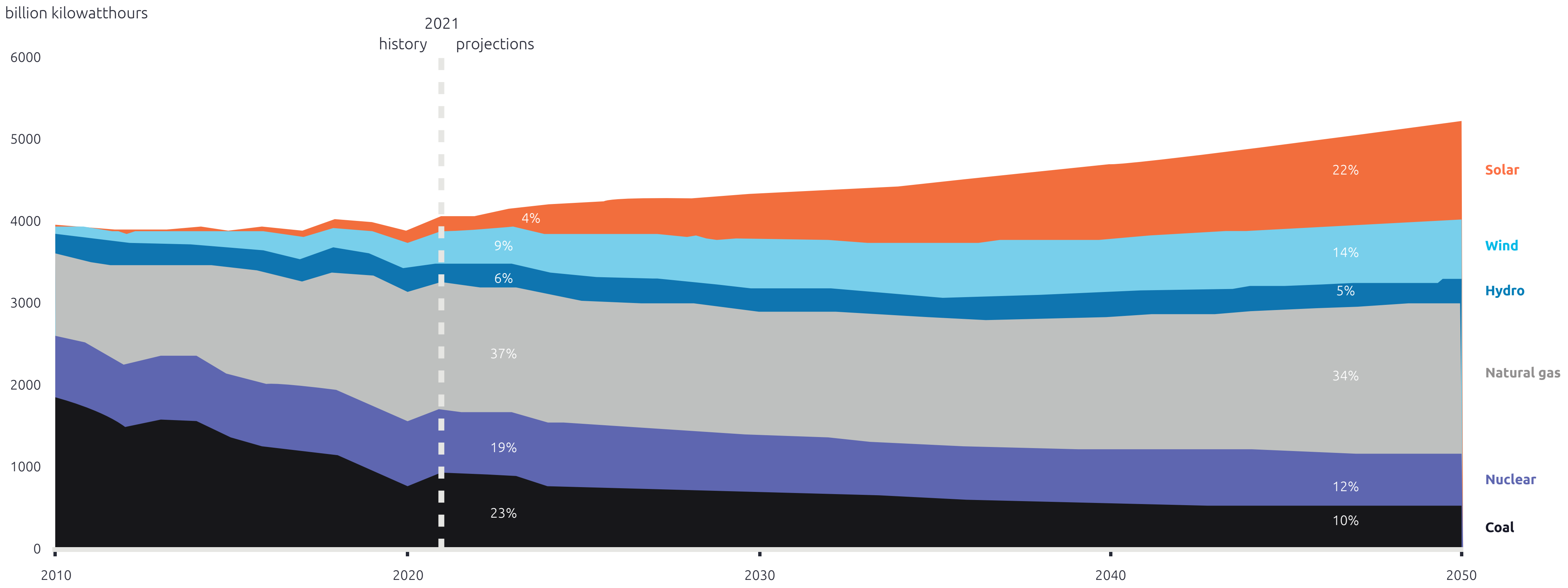
Share of net electricity generation, OECD Europe



Sources: U.S. EIA International Energy Outlook 2021 Reference Case, IEA Flagship Report 2021

FIGURE 7

U.S. electricity generation from selected fuels AEO2022 Reference case



Source: U.S. Energy Information Administration, Annual Energy Outlook 2022 (AEO2022) Reference case; Note: Solar includes both utility-scale and end-use photovoltaic electricity generation.
Link: https://www.eia.gov/outlooks/aeo/ppt/AEO2022_narrative_graphs_electricity.pptx

UKRAINE – RUSSIA CRISIS CONSEQUENCES

PETER KING
PHILIPPE VIÉ
DEBARGHYA MUKHERJEE

High demand post-pandemic and the Russia-Ukraine war have led to an unsustainable and dangerous situation for energy and the economy.

What is the European energy crisis?

European society needs energy that is affordable, reliable, and sustainable. The European energy crisis is a threat to all of these. Demand and prices are rising and there are threats to sufficient supply of energy to meet needs. Furthermore, this crisis may extend the use of carbon fuels and delay decarbonization.

Situation – overreliance on fossil fuels

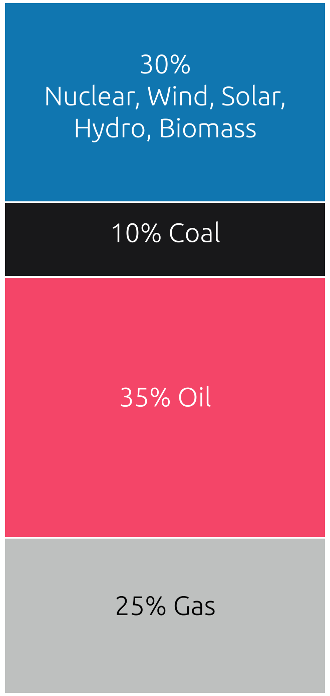
Europe has not made wholesale progress with decarbonizing its economy and therefore remains exposed to global energy prices and threats from hostile governments or geopolitical situations, notably the Russia-Ukraine war.

Europe's economy remains heavily dependent on fossil fuels with about three-quarters of all energy being provided by oil, gas, and coal. A push for renewables has made an impact on how electricity is generated, but with electricity use being around 20% of total energy use, this has yet to make a substantial impact on the overall picture. We should be careful to distinguish between total energy and electricity when reading reports of the progress of renewables.

Russia accounts for 40% of Europe's fossil fuel sources and is therefore a significant player. Established supply chains are hard to replace and Europe does not have the interconnected infrastructure to ease shifting away from Russian sources. For example, Spain and Portugal have several liquefied natural gas (LNG) regassification plants, but the lack of pipelines across the Pyrenees makes getting this gas to the rest of Europe difficult. Russia also provides a significant share of oil and coal burned in Europe.

FIGURE 1

European sources of energy



Source: Eurostat

Carbon is baked into the way we live our lives and run our economies. Industrial processes remain hard to decarbonize, steel production relies on coke from coal, non-fossil fuel steam production is expensive, and our lives rely on petroleum products, from personal transport in our cars to the powder we put in our washing machines.

It is not an entirely bleak picture, and there are examples that demonstrate the path forward for energy supply. France started heavy investment in nuclear power during the 1970s and this means that it is well-placed to withstand the immediate shocks. At the same time, Norway invested heavily in hydroelectric generation to provide over 90% of its electricity. Norway, the U.K., and the Netherlands have North Sea oil and gas reserves that, while past their peak production, still provide a buffer to global supply chain shocks (although prices are still set globally).

The demand side of energy use must also be addressed. Energy efficiency remains costly, difficult, and a lower priority for some governments and most consumers. Housing stock is poorly insulated (renewed around 1% per year), industrial processes are not optimized for energy use, and our economies remain linear rather than circular – anytime, anyplace, anywhere is burning the planet. There is some progress: Adoption of EVs that has started in northern Europe is gathering pace, houses are being upgraded, and consumers are aware of the waste that their lifestyle creates, as well as the carbon emitted by their travel. These deep structural changes require time and a willingness on all parts to change.

An immediate consequence of the European energy crisis – inflation

The path to net zero in 2050 is approximately 10,000 days. The first milestone on this journey, which is to achieve the deep cuts in carbon usage that are needed by 2030, is 3,000 days away. The energy crisis has an immediate horizon of winter 2022, which is just weeks away, and the need for a three-year plan is over 1,000 days. The whole project has very suddenly become a lot more urgent, and the solutions lie in the hands of every individual actor in the energy system. Energy system players account of 75% of emissions along the scopes 1, 2 and mainly 3 (energy use). The need for a diverse energy mix, as well as a bunch of actions to reduce drastically scope 3, will come much sooner than many expected.

The Ukraine crisis comes on top of already high commodities and carbon prices triggered by the post-Covid economic rebound. This demonstrates that structural changes with the energy markets are required in Europe. Energy prices across Europe have already increased and, in some cases, have doubled. In the U.K., car fuel has increased by one-third, and electricity almost doubled with a further increase expected later in 2022. This picture is reflected across Europe – and while most governments have taken actions to protect consumers, the extent to which they can do this in the medium term is limited.

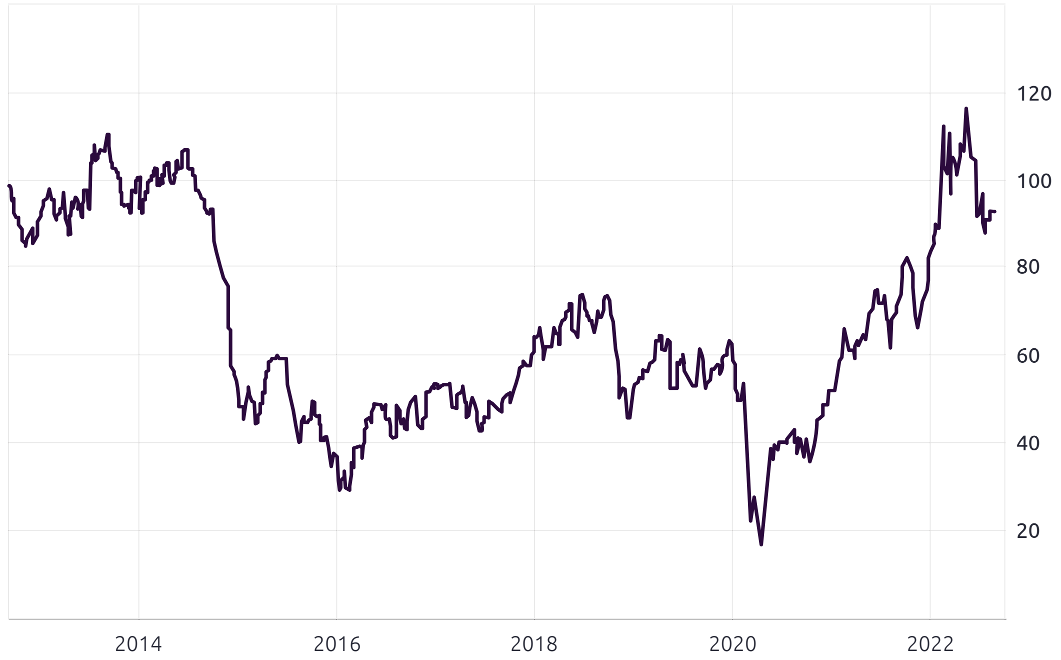
Energy costs account for around 10% of GDP in Europe. About half of this cost is directly paid by consumers in their electricity and gas bills and for the fuel that they put into their cars. The other half of the cost of energy is embedded in the cost of goods and services that they consume. The inflationary consequences of an increase in energy prices are inevitable. Like governments, businesses will try to avoid passing these costs on to consumers to stay competitive, but in the medium term, they will need to do this to stay in business. For energy intensive sectors like food, steel, aluminium, transport, and IT, these price rises may be steep.

It could be the inflationary pressure and the cost of energy that is the primary driver for consumer behavioral change.

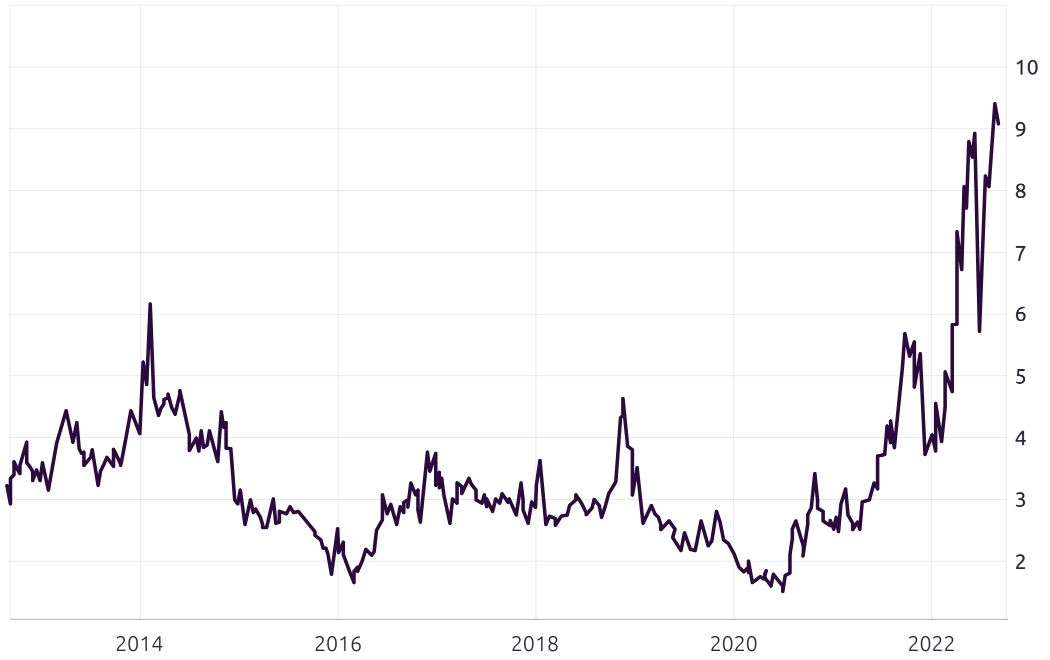
FIGURE 2

Oil & Gas price charts

Crude Oil WTI



Natural Gas



Source: tradingeconomics

The immediate reactions have been to protect consumers and networks

During spring 2022, energy prices went through the roof because of the post-Covid economic rebound, with additional increases triggered by the geopolitical situation. Most European countries acted to protect consumers from an energy price shock, particularly for domestic electricity and gas prices. This has taken the form of price freezes, caps, and rebates. France limited price rises to 4%, which is reported to have cost Electricité De France (EDF) €8.4 billion and dramatically hit its share price. In Norway, subsidies are now €1 billion, with the state paying 80% of bills above a certain level. In the U.K., while prices have almost doubled, the government has announced rebates for households to soften the blow.
Governments and energy system operators have also moved to increase the cybersecurity of their energy networks and supply chains. They fear widespread disruption if hackers can replicate their attacks on the Ukrainian system in 2015.

To provide a buffer against both prices and supply issues, European countries are filling gas storage facilities ahead of winter 2022 and are also trying to keep the gas consumption low by any means.

Not all countries are equally exposed to the crisis

An Economist report shows that three European countries are 100% reliant on Russia for their gas – Austria, Finland, and Lithuania – with a further five exceeding 40%: Slovakia, Hungary, Poland, Germany, and Italy. When these consumption figures are matched to the use of gas-fired electricity generation, Germany and Italy emerge as the most exposed major economies.

It is notable that the European Union has not yet imposed sanctions on Russian energy in the way that they have on the super yachts of oligarchs. At the same time, plans to move away from Russian energy are being debated.

https://www.theguardian.com/business/2022/jan/14/france-edf-cap-household-energy-bills
https://www.reuters.com/markets/commodities/norway-further-raise-household-electricity-subsidy-2022-01-10/
https://www.bbc.co.uk/news/business-58090533
https://www.bbc.co.uk/news/business-60245696
https://www.bbc.co.uk/news/technology-61085480
https://www.reuters.com/world/fbi-says-russian-hackers-scanning-us-energy-systems-pose-current-threat-2022-03-29/
https://en.wikipedia.org/wiki/Ukraine_power_grid_hack

FIGURE 3.1

Energy Transition: Country wise actions (1/4)

Country	Energy Use	% Imported	Key Actions Taken
Austria	More than 72% of electricity production is sourced from renewables (hydro with more than 60%, wind 10%) Gas ~ 16%; Total electricity consumption 72 TWh	Austria obtains 80% of its natural gas from Russia; 8% of Russian crude oil imports	Ordering industry and utilities to make plants run on alternatives to natural gas; like crude oil, hydropower
Belgium	Nuclear accounted for 52% of Belgium's electricity generation in 2021 followed by natural gas (25%), wind (12%, including 7% offshore) and solar (5%); Total electricity consumption 84.2 TWh	Belgium is not very dependent on Russian gas: represents about 6.5% of imports; but depends for 30% on Russian oil	Delaying nuclear decommissioning Cutting VAT on Energy Bills supports EU energy price caps, suspending trading in power crunch
Bulgaria	Lignite coal accounts for 37% followed by Nuclear and Oil for power generation. Total electricity consumption 36 TWh	Bulgaria imported 77% of its gas from Russia	New pipelines and opportunities offered by LNG; additional alternatives by signing long-term LNG supply contracts with US, Qatar or Algeria
Croatia	In 2021, hydroelectric power accounted for 46% of total electricity generation while Gas ranked 2nd at 21.2%. Total electricity consumption 17 TWh	70% of gas imports from Russia	Build new gas pipeline and more than double capacity at its LNG terminal in a bid to secure gas supplies
Cyprus	Oil covers around 90% of the country's needs, solar 3%, biomass 5%, and wind 2%		New natural gas discovery and other alternative ways
Czech Republic	I52.5% fossil fuels (40% lignite, 9.6% natural gas, 2.6% bituminous coal, etc.), 41% nuclear power, and 7% renewables. Total electricity consumption 67 TWh	Czech Republic imported 87% of its gas from Russia in 2021	Ramping up LNG reserves and has secured shipments from new suppliers
Denmark	I52.5% fossil fuels (40% lignite, 9.6% natural gas, 2.6% bituminous coal, etc.), 41% nuclear power, and 7% renewables. Total electricity consumption 67 TWh	75% of the country's gas imports were provided by Russia	Accelerate renewable power development; planned steady investments in offshore wind power (German-Danish Offshore Wind Hub); exchanges from Sweden and Norway

Source: Economist, Capgemini Analysis

https://www.economist.com/europe/2022/01/29/how-will-europe-cope-if-russia-cuts-off-its-gas
https://www.economist.com/briefing/2014/04/03/conscious-uncoupling
https://www.reuters.com/business/energy/austria-plans-order-industry-switch-oil-gas-where-it-can-2022-07-05/
https://www.republicworld.com/world-news/russia-ukraine-crisis/austria-stopped-importing-refining-russian-oil-in-march-claims-omv-articleshow.html
https://www.brusselstimes.com/216570/explained-what-shutting-off-russian-gas-would-mean-for-belgium
https://www.vrt.be/vrtnws/en/2022/05/04/pm-supports-eu-ban-on-russian-oil-but-we-should-make-sure-it-d/
https://www.reuters.com/business/energy/belgium-supports-eu-energy-price-caps-suspending-trading-power-crunch-2022-08-29/
https://www.iea.org/countries/austria
https://www.statista.com/statistics/1234896/austria-distribution-of-electricity-production-by-source/#:~:text=Hydropower%20is%20the%20main%20source,power%20making%20up%209.8%20percent
https://www.enerdata.net/publications/daily-energy-news/nuclear-accounted-52-belgium-power-mix-2021.html#:~:text=According%20to%20the%20Belgian%20power,%2C%20including%207%25%20offshore)%20and
https://www.iea.org/countries/bulgaria
https://www.statista.com/statistics/1234904/bulgaria-distribution-of-electricity-production-by-source/
https://www.rferl.org/a/bulgaria-life-after-russian-gas/31860510.html
https://energy.economictimes.indiatimes.com/news/oil-and-gas/bulgaria-to-open-lng-tender-to-ward-off-gas-shortages/93345268
https://www.euronews.com/my-europe/2022/04/27/poland-and-bulgaria-might-be-fine-without-russian-gas-for-a-few-months-until-next-winter
https://www.government.nl/topics/gas/reducing-dependence-on-russia
https://www.iea.org/countries/norway
https://www.offshore-technology.com/news/norway-gas-eu-russia/
https://www.iea.org/countries/poland

FIGURE 3.2

Energy Transition: Country wise actions (2/4)

Country	Energy Use	% Imported	Key Actions Taken
Estonia	90% of Estonia's power is generated using petroleum and gas derived from oil shale; Total electricity consumption 8.8 TWh	90% of gas import from Russia	Joint leasing of a floating LNG terminal with Finland
Finland	Wood fuel 30%, Oil 19%, Nuclear 18%, in energy mix. Total electricity consumption 81 TWh	Finland imported 92% of its natural gas from Russia in 2021	Strong commitment to nuclear & hydro Adopting Heat Pumps
France	In 2021, nuclear power accounted for over 66% of total electricity generation and hydropower plants ranked 2nd in terms of sources for electricity generation, with 11%. Total electricity consumption 449 TWh	About 17% of its gas supply and 9% of oil coming from Russia	Accelerating nuclear new build Capped consumer bills, cut energy consumption Construction of new infrastructure like a floating plant that will be able to regasify liquid natural gas shipments from overseas
Germany	In 2021, 28% of gross electricity was generated using lignite and hard coal, Natural gas contributed with another 15.4% and combined share of renewables stood at roughly 41%. Total electricity consumption 535 TWh	Germany is particularly dependent on Russian imports, which in 2021 accounted for 55% of its gas supply, 35% of its oil and 45% of its coal	Reconsidering nuclear Slowing Nord Stream 2 Accelerate renewables Coal still on the agenda
Greece	In 2021, 35.8% of total electricity generation was derived from the fossil fuel and wind ranked second with 19.5%. Total electricity consumption 51.5 TWh	Greece relies on Russia for 40% of its gas, two thirds of which is used for power generation	Ramped up imports of LNG, replacing a big chunk of the Russian fuel. Other measures include ramping up coal-fired power capacity, asking consumers to reduce power consumption at peak hours and stopping power exports
Hungary	46% of total electricity generation was derived from Nuclear. 37.4% from fossil fuel-based. Total electricity consumption 43 TWh	85% dependent on Russian gas	Expects to sign a deal with Russia on additional gas shipments of 700 million cubic metres
Ireland	Electricity generated from natural gas at 52%, renewables is 42%, where Wind was 37%. Total electricity consumption 30 TWh	No direct exposure to Russian gas and oil (price of gas in Britain directly influences the price of gas in Ireland	Cut excise duty, VAT

Source: Economist, Capgemini Analysis

https://www.iea.org/countries/croatia
https://www.statista.com/statistics/1235079/croatia-distribution-of-electricity-production-by-source/
https://www.reuters.com/world/europe/croatia-invest-1823-mln-boost-gas-capacities-2022-08-18/
https://apnews.com/article/cyprus-2d9f339f0f6b08560186d47be0b6c32f
https://ceenergynews.com/lng/czech-republic-to-source-3-bcm-of-lng-annually-through-dutch-terminal/#:~:text=In%202021%2C%20the%20Czech%20Republic,gas%20supply%20independently%20of%20Russia.
https://www.bloomberg.com/news/articles/2022-07-19/czechs-tap-lng-as-europe-braces-for-winter-without-russian-gas#xj4y7vzkg
https://www.iea.org/countries/czech-republic
https://www.iea.org/countries/denmark
https://www.statista.com/statistics/1235360/denmark-distribution-of-electricity-production-by-source/
https://www.power-technology.com/comment/denmark-renewable-russian-gas/
https://www.bloomberg.com/news/articles/2022-08-29/german-danish-wind-hub-in-baltic-will-help-replace-russian-gas
https://www.cnbc.com/2022/04/27/russias-gas-supplies-to-poland-bulgaria-uncertain-as-tensions-rise.html
https://www.npr.org/2022/03/30/1089662657/poland-ban-russian-oil
https://www.iea.org/countries/portugal

FIGURE 3.3

Energy Transition: Country wise actions (3/4)

Country	Energy Use	% Imported	Key Actions Taken
Italy	Italy's 2021 renewables share at 36%, Total electricity consumption 300 TWh	Italy gets around 40% of its gas from Russia	Consumer protections from prices ; Highly gas reliant country Increase LNG imports from US, Azerbaijan, Algeria, Tunisia and Libya
Latvia	Total electricity consumption 7 TWh	~90% gas import	Russia resumes natural gas supplies to Latvia
Lithuania	65% of total energy comes from oil and natural gas and 25% from renewables. Total electricity consumption 12.4 TWh	30-40% import of gas from Russia	Klaipeda's LNG terminal, dependant on US and Norway
Luxembourg	60% oil, 20% natural gas; Total electricity consumption 7.5 TWh	Luxembourg's dependence on Russian gas and oil varied between 5-10%	Develop measures in favor of the energy transition, in particular energy efficiency and renewable energies; subsidy of gas, energy bonus, Government assistance
Malta	Natural gas 45%, Oil 50%, 5% renewables. Total electricity consumption 2.5 TWh	Not much dependent	LNG contracts from Azerbaijan, alternative energy pipelines
Netherlands	Natural gas (38%), oil (35%), coal (11%), biofuels and waste (5%), and 11% from nuclear, wind, solar, hydropower and geothermal. Total electricity consumption 114 TWh	Netherlands relies on Russia for some 15% of its gas supplies	Cutting consumer taxes More capacity for importing LNG Placing a bet on Hydrogen
Norway	Over 90% of the electricity production in mainland Norway is from Hydro-power; Total electricity consumption 125 TWh	Significant s an exporter; Norway to increase gas supply to EU as Russia deepens cuts	State paying 50% of bills Net exporter of energy ; Show the way in EVs
Poland	70% coal, 17% renewables; Total electricity consumption 162 TWh	45% of natural gas import from Russia	U.S., Qatar and Norway export LNG to a newly-expanded terminal in Swinoujscie in northwestern Poland

Source: Economist, Capgemini Analysis

https://www.iea.org/countries/estonia
https://news.err.ee/1608557521/estonia-to-stop-importing-russian-gas-by-end-of-2022
https://ies.lublin.pl/en/comments/the-baltic-states-stop-russian-natural-gas-imports/
https://www.trade.gov/country-commercial-guides/finland-energy
https://www.bloomberg.com/news/articles/2022-05-06/finland-is-severing-oil-ties-with-russia-trade-data-show
https://www.iea.org/countries/france
https://www.statista.com/statistics/1235410/france-distribution-of-electricity-production-by-source/
https://www.iddri.org/en/publications-and-events/blog-post/breaking-dependency-russian-gas-perspectives-france-and-germany
https://www.reuters.com/world/europe/russian-gas-cutoff-most-likely-scenario-french-finance-minister-2022-07-10/
https://www.statista.com/statistics/736640/energy-mix-germany/
https://www.iea.org/countries/germany
https://www.iea.org/countries/greece
https://www.statista.com/statistics/1235419/greece-distribution-of-electricity-production-by-source/
https://www.reuters.com/business/energy/greece-resort-power-cuts-if-russian-gas-supplies-disrupted-plan-2022-07-21/#:~:text=Greece%20relies%20on%20Russia%20for,chunk%20of%20the%20Russian%20fuel.
https://www.reuters.com/business/energy/hungary-pm-sees-deal-with-russia-by-end-summer-more-gas-supplies-2022-07-29/
https://www.iea.org/countries/hungary
https://www.theportugalnews.com/news/2022-03-28/only-5-of-imported-energy-in-portugal-from-russia/66081#:~:text=Of%20all%20the%20energy%20consumed,gas%20and%2097.6%25%20from%20oil.&text=Also%20according%20to%20Eurostat%2C%205,and%206%25%20of%20the%20oil.
https://www.euractiv.com/section/energy/news/portugal-seeks-to-position-itself-as-europes-new-gateway-for-gas/
https://www.iea.org/countries/romania
https://www.enerdata.net/publications/daily-energy-news/romanias-power-generation-increased-53-2021.html

FIGURE 3.4

Energy Transition: Country wise actions (4/4)

Country	Energy Use	% Imported	Key Actions Taken
Portugal	40% oil, 23% natural gas, 30% renewables. Total electricity consumption 50 TWh	5% of the energy imported came from Russia: 9.6% of the natural gas used in the country and 6% of the oil	Expanded infrastructure for importing LNG
Romania	Oil accounted for 41% of Romania's primary energy mix in 2021 followed by natural gas (30%); Total electricity consumption 55 TWh	Share of imports from Russia at 15.5% for natural gas, 37% for crude oil and nearly 12% for coal	Transform the country's energy infrastructure and energy mix
Slovakia	Total electricity consumption 27 TWh. Major sources of electricity production - Nuclear 54%, Gas 15%, Hydro 14%	Imports approximately 87% of its natural gas and two-thirds of its oil from Russia	LNG and nuclear power boost - following the launch of a new pipeline with Poland and the green lighting of a nuclear power plant
Slovania	Roughly one-third of Slovenia's electricity comes from hydroelectric sources, one-third from thermal sources, and one-third from nuclear power. Total electricity consumption 15 TWh	Slovenia gets 25% of oil and 80% of gas from Russia	Slovenia continues to be in search of alternatives to Russian gas; VAT reductions
Spain	Wind 23%, Nuclear 21%, Hydro 11%. Total electricity consumption 241 TWh	Russia provided 10% of Spain's gas imports	Subsidies to consumers
Sweden	Most of Sweden's electricity supply comes from hydro and nuclear, along with a growing contribution from wind. Total electricity consumption 127 TWh	8% crude oil import, 30% LNG import from Russia	Cut excise duty, VAT
UK	Oil 43%, Natural Gas 30%. Total electricity consumption 293 TWh	4% of gas and 8% of oil comes from Russia	Payments to consumers ; Market stabilisation measures
Switzerland	Dominated by hydropower (more than 60%) and nuclear, Total electricity consumption 63 TWh	47% gas imports from Russia	Deals with France and Germany for gas supply; households and business to curb gas consumption and could oblige dual-fuel plants to switch to heating oil

Source: Economist, Capgemini Analysis

https://www.statista.com/statistics/1235432/hungary-distribution-of-electricity-production-by-source/
https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/electricity/#:~:text=The%20amount%20of%20electricity%20generated,grid%20integration%20of%20wind%20generation.
https://www.reuters.com/business/energy/italy-must-reduce-reliance-russian-gas-lift-domestic-production-draghi-2022-02-25/
https://renewablesnow.com/news/italys-2021-renewables-share-at-36-775794/
https://www.politico.eu/article/russia-put-gas-squeeze-france-italy/
https://eng.lsm.lv/article/economy/economy/latvias-dependency-on-russian-energy-is-overstated-says-em.a446689/
https://www.reuters.com/business/energy/russia-resumes-natural-gas-supplies-latvia-2022-08-09/
https://www.iea.org/countries/lithuania
https://www.pbs.org/newshour/world/lithuania-severs-russian-gas-imports-encourages-eu-to-follow-suit
https://www.nytimes.com/2022/04/02/world/europe/lithuania-russia-gas.html
https://chronicle.lu/category/at-home/39837-luxembourg-adopts-measures-to-limit-impact-of-rising-energy-prices-on-households
https://www.iea.org/countries/malta
https://timesofmalta.com/articles/view/malta-not-dependent-on-russian-gas-energy-minister.939906
https://www.trade.gov/country-commercial-guides/netherlands-energy
https://www.iea.org/countries/the-netherlands
https://www.dw.com/en/russias-gazprom-cuts-supplies-to-netherlands/a-61982602#:~:text=The%20Netherlands%20relies%20on%20Russia,over%20its%20war%20in%20Ukraine.
https://www.romania-insider.com/ro-energy-dependence-russia-mar-2022
https://www.eceee.org/all-news/news/romania-aims-for-energy-independence-in-response-to-ukraine-war/
https://www.aa.com.tr/en/europe/europe-urges-energy-savings-amid-gas-crisis-from-russia-ukraine-war/2648941
https://www.trade.gov/country-commercial-guides/slovenia-energy

How to address the challenge: Energy supply, energy markets, and energy transition

Governments have several levers available to them to reduce reliance on fossil fuels and on Russian commodities. They can limit Russian commodity share in their supply, transform energy markets and affect the energy transition to low carbon sources. None will work in isolation; all are long-term structural changes that require massive investment and the political will to push through market reforms.

Part 1: Limit Russian commodities dependency in energy supply

Placing an immediate stop on Russian oil and coal when worldwide markets exist is a no regret decision, especially since there is no need for specific transportation infrastructure. For gas, Europe's options are more limited: Immediately stopping the purchase of Russian gas is impossible for some countries (Germany, Italy, Austria, and others) and there are no easy options to buy U.S. LNG for these countries. Europe is looking to drastically limit its dependence on Russian gas, the faster the better. Realistic options include:

- Putting taxes on imported Russian gas. This will limit volumes and can bring money to help Ukraine (and refugees), but will increase inflationary pressures.
- Continuing to buy from Russia, but put money in an escrow account (in dollars or euros) until the war is over and a normal diplomatic situation has been restored.
- Buying gas at European level (cartel) to drastically reduce prices and manage volumes reduction accordingly.

Part 2: Energy market mechanism reform

European energy markets are mostly linked to the global price of oil and decisions on energy sources. They use a 'merit order' to decide how to produce electricity. This means that the cheapest sources are used first and the more expensive sources are used later. Spot prices are linked to the price of the next available electricity production source, generally a coal or gas plant in Germany, which makes high and volatile spot prices and endangers or impacts heavily the ones who are buying electricity on these markets (alternative suppliers). This mechanism also places little regard for carbon pollution. Consequently, coal-fired electricity generation is dispatched since the marginal cost of additional generation is low once the plant is up and running. In some energy markets (including the U.K., France, Germany, Poland, and Greece), the price paid to producers is the same nationally for each 30-minute billing period of the day. This further distorts the market and does not incentivize carbon efficiency.

Governments have already implemented some mechanisms to reform markets. Carbon pricing has been used by many governments to disrupt the merit order and to push gas and coal generation down the list. At the same time, contracts for difference (CFDs) have been used to guarantee renewables generation, such as windfarms where they achieve the same price for the energy that they produce encouraging them to produce energy whenever the wind is blowing.

Renewable energy has a different economic model to fossil fuels. In the coal-fired plant example noted earlier, once the plant is up and running there is still the cost of coal required to keep the plant operating. For renewable energy, the marginal cost of energy approaches zero once the windfarm or solar park has been established and there is no additional cost of producing energy.

In April 2022, some European countries, notably Spain and Italy, have been approved by the European Commission to set their domestic wholesale prices outside of the European market mechanisms. Other countries may follow, obliging Europe to reform completely the market mechanism.

Energy markets are not perfect; there are a confusing array of mechanisms, including capacity payments, energy costs, interconnectivity agreements, subsidies, taxation, and price limits, that result in complex markets that do not provide clear signals to either energy users or investors. Current prices suggest that the market is also pricing in significant further energy shocks and risks.

Market changes are needed: Updated markets need to stimulate billions of euros of investment in green renewables and nuclear energy, reduce the importance of fossil fuels in the economy, connect wholesale and retail markets, provide incentives for energy efficiency, and provide affordable energy to meet people's basic needs and protect disadvantaged people.

References from

https://www.drax.com/power-generation/market-decides-great-britain-gets-electricity/#:~:text=What%20is%20the%20merit%20order,are%20brought%20onto%20the%20system

https://www.nationalgrideso.com/how-electricity-priced

Part 3: Energy transition

Transitioning energy use away from fossil fuels is a key part of the solution to the European energy crisis. Once installed, renewable energy is locally sourced, reliable, and sustainable.

The price of renewable energy has been falling for many years. Over the past decade, the costs of solar energy and onshore wind have fallen 89% and 60% respectively. Unfortunately, these downward trends have ceased and, due to increased demand and a shortage of raw materials, prices for renewable energy have stabilized or increased. Transportation costs for imported goods (solar panels) and cost of capital are reinforcing this trend.

The energy transition actions that governments and energy system operators can take are listed here, with the shorter term, less structural changes listed first followed by longer and deeper changes towards the end of the list:

FIGURE 4

Energy Transition Actions and Impact

Action	Description	Imact on Transition	Impact on Costs
Solar	Accelerate approvals for solar farms and support supply chain	Positive	Positive, cheaper than fossil fuels, although raw materials costs increasing
Accelerate Onshore Wind	Accelerate approvals for wind farms and support supply chain	Positive	Positive, cheaper than fossil fuels, although raw materials costs increasing
Extend life of existing gas and coal plants	These are needed for peak demand when there is insufficient renewable energy available	Negative - need to remove all coal plants as fast as possible	Neutral, although may help to smooth price spikes
Extend life of existing nuclear plants	Careful safety assessment and risk analysis needed	Positive	Positive, likely to be cheaper than building and operating new nuclear plants (EPRs, SMRs or even fusion)
Energy efficiency measures	Particularly insulating homes and buildings, and helping industries to be more energy efficient	Positive	Positive – although payback period greater than 5 years
Heat pump roll out	Support installation costs and foster supply chain	Positive - reduces reliance on gas for domestic heating	Negative in the short term – likely to be more expensive than gas
Accelerate Offshore Wind	Accelerate approvals for wind farms and support supply chain	Positive	Positive, cheaper than fossil fuels, although raw materials costs increasing
Smart Grid	Ability to switch energy sources at the distribution level and keep the supply – demand balance with flexibility resources	Positive	Negative – substantial investment needed, but essential to supporting a high renewables system
Electrification of the economy	Particularly for transport and industry	Positive	Negative – high costs of transition, some can be absorbed in natural replacement costs
Increase LNG gasification plant capacity	New terminals and increased capacity at existing terminals	Neutral – continues reliance on fossil fuels, but creates greater independence	Negative / Neutral – less exposure to existing suppliers, but cost of assets and transport pipelines
Increase Natural Gas storage	Use of depleted oil wells and mines	Neutral – increases resilience	Negative – due to cost of asset Possible positive as less exposure to volatile market costs
Increase energy interconnectivity	Creation of Europe highway grids for electricity and gas and hydrogen	Positive – increases ability to use renewable energy	Negative – cost of asset
New nuclear build	Development of large and SMR plants	Positive – low carbon energy	Negative – high investment cost
Development of a Hydrogen economy	Particularly for Industrial Hubs and processes, as well as heavy transportation A new storage capacity	Positive at scale Uncertain in the short term	Uncertain - like renewables in the past, depends on market size and electrolysers production industrialization

Source: Capgemini Analysis

As seen in the above measures, there is clearly a significant cost involved in energy transition. Bloomberg has estimated that renewables investment will cost $5.3 trillion through 2050, which is over $150 billion per year for the next 30 years; the cost of all energy transition will be far higher. This leads to the obvious question of who is going to pay for this. Since the consumer always pays eventually, the real question is how are they going to pay? The answer is in higher energy bills, higher taxes, and higher costs for goods and services. This raises the question of making energy transition investment the highest priority at the local, national, and Europe region levels, even as compared to education, health, security or even defense. Is this politically realistic?

The business case for renewable energy remains finely balanced and today's figures require the polluter to pay the principle to be applied to carbon emissions to make a positive case for renewables. This will require significant political support. Protests of fuel prices in France and the U.K.'s reluctance to increase fuel duties show how hard this will be.

Political will is also needed to push through the European Union's Fit for 55 package which contains the mechanisms for some of the structural changes that are needed to accelerate energy transition. Most of the measures included are controversial or hard to accept for some countries, however voting this package is considered to be a European political stress test.

Conclusion

Below we list some of the key actions needed to address the European energy crisis and support longer-term transformation of the energy system:

1. Encourage investment and stimulate the billions of euros that will be required to transition Europe's energy system to a clean, affordable, and resilient system.
2. Adapt market structures. An updated blueprint for energy markets is needed, a new way of pricing low-carbon energy is needed, demand side management must be valued, and investment must be encouraged.
3. Address Russian commodity dependence. Lower it fast, starting with coal and oil and move to gas as European infrastructure projects are built.
4. Full lifecycle actions and circular economy. Our linear economy must be replaced by a circular one, with particular focus on the way that we use energy and products of the oil industry, such as plastics.
5. Accelerate the energy transition to low-carbon sources. (The table above shows the measures that are needed.)
6. Accelerate energy efficiency measures that have the potential to save billions of euros, eliminate millions of tonnes of CO2 emissions, and create millions of jobs. This requires investment to be stimulated by governments.
7. Measurement is needed. We lack the basic accounting mechanisms for CO2 emissions, use of energy (for example is our common language and measurement of energy expressed in talking MWH, Barrels of Oil Equivalent, Therms, or BTUs). Standards are needed and they need to be enforced.

Finally, everyone needs to prepare for winter 2022/23. At the time of publication, we have just a few weeks to mitigate the greatest risks of price shocks and supply issues.

https://ourworldindata.org/cheap-renewables-growth
https://www.weforum.org/agenda/2022/04/bnef-european-energy-transition-2022/

EUROPEAN ELECTRICITY PRICES

MAXIME GARDELLIN
LAURE REOSENBLIEH
SANDRA HAHN DURRAFFOURG
ZOE BERCHEM
CHRISTINE LE BIHAN-GRAF

EU Member States' responses to the European electricity market crisis

European countries have been facing an energy market supply squeeze and are experiencing an electricity market crisis.

Gas and electricity prices have reached record levels in 2021 and hit all-time highs in the first few weeks of March 2022. European gas prices, historically below €30/MWh, were recently around €100-200/MWh. They peaked at the end of August 2022 at more than €300/MWh.

Energy prices are expected to remain high for the rest of 2022, since the surge of electricity is linked to gas supply constraints and to rising gas prices. This is because gas is currently the marginal price setting energy.

- The surge in gas prices in 2021 largely explains the rise in wholesale electricity prices.

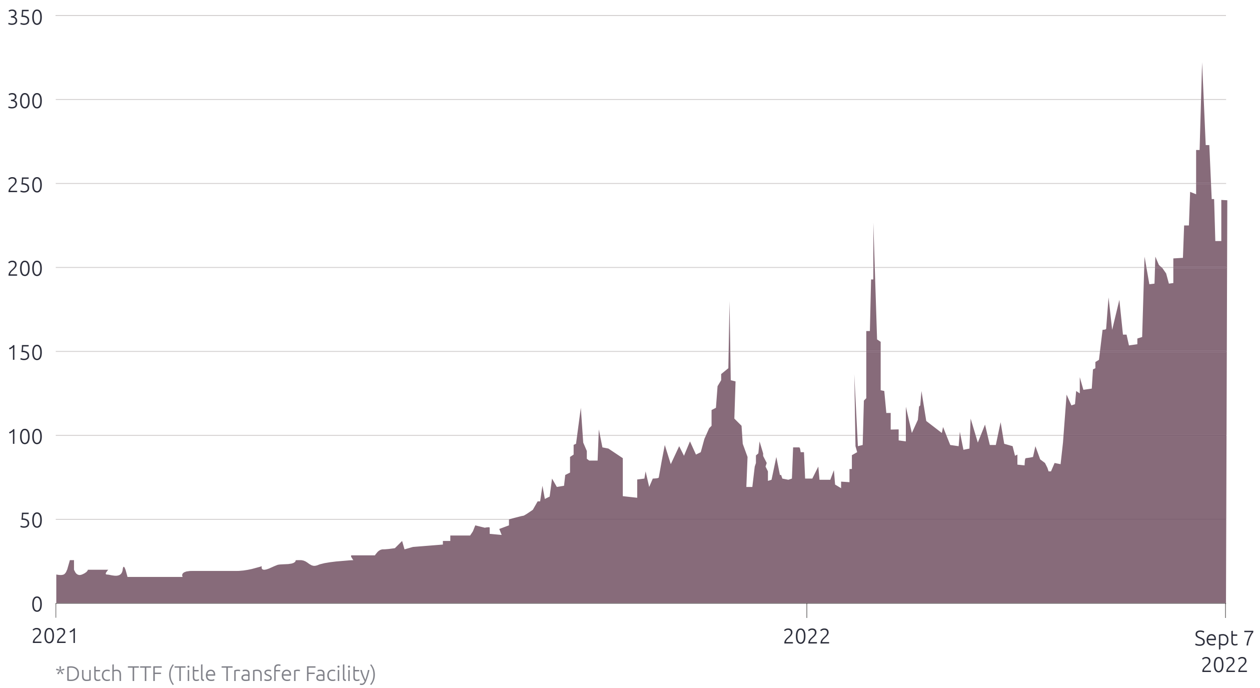
On the wholesale electricity market, the equilibrium price is set every hour on the basis of the marginal cost of the last power plant called, which is generally a gas-fired power plant. Gas prices have spectacularly increased due to cyclical factors: supply constraints; an increase of demand due to the economic recovery following the Covid-19 health crisis; increases in carbon and ETCS prices; and weather events in Europe (late cold winter, low rainfalls).

- **The price increase was reinforced by Russia's invasion of Ukraine and Europe's dependence on fossil fuel and gas imports from other countries, and especially from Russia.**

Russia is indeed the main EU supplier of natural gas. In 2020, 27% of natural gas was imported from Russia. In Germany, the situation is all the more critical as Russia accounted for 55% of Germany's gas imports in 2021 and 40% in the first quarter of 2022. Further disruptions of Russian gas supplies to the EU in the forthcoming weeks or months may result in higher levels of gas prices.

FIGURE 1

Natural gas prices in Europe
in euros per MWh on the reference market*



*Dutch TTF (Title Transfer Facility)

Source: Bloomberg, closing prices except September 7 at 08:00 GMT

- **Electricity price increases could also be explained by the French nuclear plants' unavailability and the price spread between French and German prices.**

The shutdown of several nuclear reactors in France due to corrosion issues has contributed to the French electricity price increase as power production has decreased. Only 31 of the 56 reactors operated by EDF were online on September 5, 2022. The security of supply is also affected by the closure of three German nuclear power stations at the end of 2021, as well as the foreseen closure of the remaining nuclear power stations at the end of this year. This is in addition to the low levels of the Rhine and other rivers, which affected the transport of coal.

The rise of electricity and gas prices also has a significant impact on overall European economies in the context of high food and commodities prices.

In the energy sector, the first victims of the energy crisis are the suppliers. In the U.K., 31 energy companies have ceased their activities since February 2022 due to high gas prices and the cap set by the regulator, Ofgem, that obliged them to set prices below what it costs to buy energy on the markets. In France, many suppliers did the same by ceasing their supply activities or now have severe cash difficulties. In Germany, facing financial difficulties, Uniper, one of Germany's biggest utilities, recently asked for a €4 billion increase to an existing €9 billion credit line from a German state-owned bank to help secure its short-term liquidity.

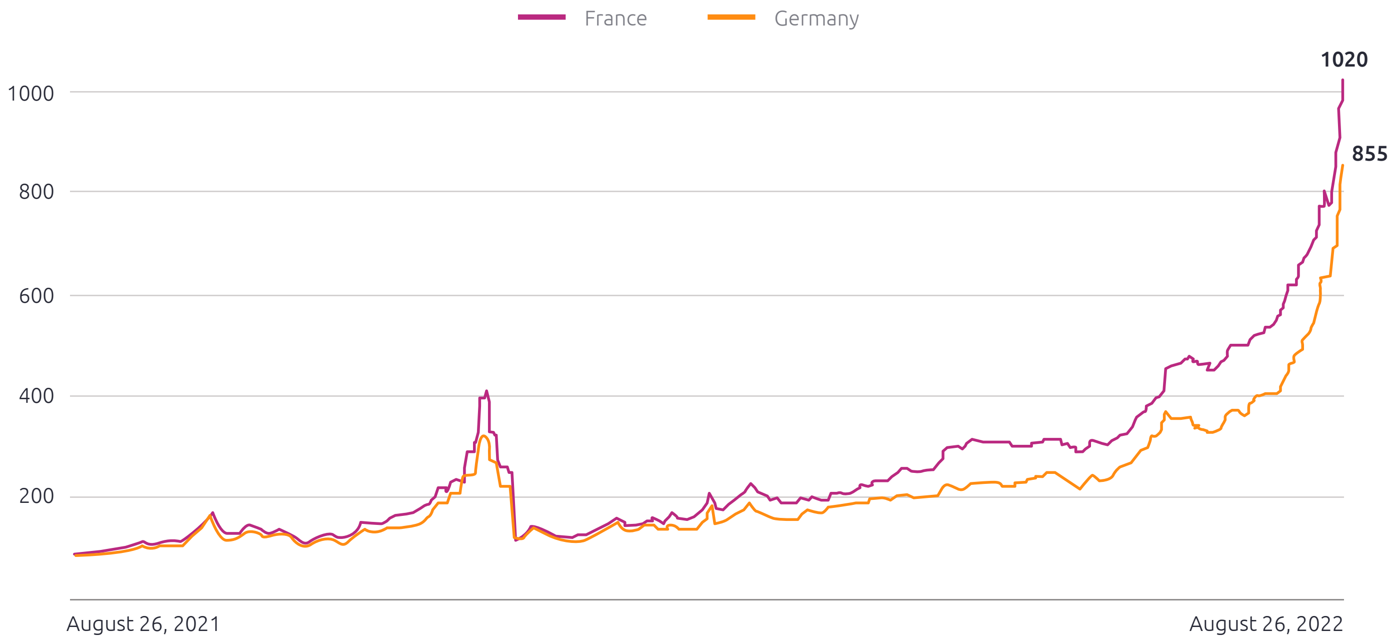
However, additional upward pressures put on energy and food commodity prices are feeding global inflationary pressures, eroding the purchasing power of households and the economy as a whole. In the Eurozone area, inflation grew strongly in the second quarter of 2022, from 7.4% in March (YOY) to a new all-time high of 8.9% in July (In EU area, from 7.8% in March to 9.8% in July).

European countries fear serious economic imbalances (high inflation, combined with a declining job market and a widening current public deficit) that can lead to an economic downturn at the end of 2022 or the beginning of 2023.

This economic context required a coordinated and dual response from the EU Commission and the Council of the EU. Their work focused on supply constraints and the market electricity price design.

FIGURE 2

New records for electricity prices
Prices for 2023 delivery on the European reference market, in Euros per MWh



*European Energy Exchange (EEX)

Source: Bloomberg, closing prices except for August 26 (11:15 GMT for France), 12:08 GMT for Germany

1. The first part of the EU response to the current price crisis involves lowering Europe's dependency on Russian fossil fuels imports and ensuring security of supply and affordable energy prices.

In March 2022, EU leaders agreed to lower the **EU's dependency on Russian fossil fuels** in light of Russia's acts of aggression against Ukraine and several gas interruptions to Member States by Russia.

On March 8, 2022, the Commission proposed the first version of a plan to make Europe independent from Russian fossil fuels well before 2030. At the European Council, held March 24-25, EU leaders agreed on this objective and asked the Commission to present a detailed plan.

The main ambition of the REPowerEU Plan, presented on May 18, 2022, is to end EU reliance on Russian gas by 2027 and accelerate the green transition. This is in line with the European Green Deal, which is the EU's long-term growth plan to make Europe climate neutral by 2050.

This European Green Deal target is a legally binding commitment of the European Climate Law. The region also aims to reduce net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. The Commission also presented its Fit for 55 package in July 2021 to implement these targets; these proposals would lower gas consumption by 30% by 2030, with more than one-third of such savings coming from meeting the EU energy efficiency target.

Following the IEA's conclusion on the recent price crisis, the EU is working towards **climate neutrality** as a way to strengthen its independence from fuel imports, as well as reaching its climate goals.

> *Clean energy policies are not to blame for recent spikes in gas and electricity prices, and the soaring prices should not derail Europe's green transition"*
>
> **Fatih Birol**
> Executive Director, International Energy Agency

Alongside the presentation of the REPowerEU plan of the Commission, the Council of the EU adopted several measures:

- At their Special European Council meeting in May 2022, leaders decided to **ban almost 90% of all Russian oil imports** by the end of the year. A temporary exception for crude oil delivered by pipeline will be made. The European Council also called on the Council to rapidly examine the Commission's proposals to deliver on the REPowerEU objectives, including their financing.
- On June 3, 2022, the Council adopted **the sixth package of sanctions** against Russia, which includes the ban of oil imports, as agreed by EU leaders in May 2022.
- On June 27, 2022, the Council adopted n**ew rules to improve the EU's security of supply** in the context of the war in Ukraine by definitively adopting **the gas storage regulation.** EU member states will ensure their gas storage facilities are filled before winter and share storage facilities in a spirit of solidarity.
- On July 26, 2022, the EU energy ministers reached a **political agreement** on a **reduction of natural gas demand by 15% for the coming winter.** This reduction is voluntary but could become mandatory if a security of supply alert is triggered.
- On August 5, 2022, the Council **adopted the regulation on reducing gas demand by 15% through a written procedure.** The adoption follows the political agreement reached in July 2022 by the Council.

1.1 The REPowerEU Plan covers five main areas of actions: energy savings, energy supply, clean energy generation and investments, and contingency measures for supply disruptions.

- **Energy savings**

The first proposal of the REPowerEU plan is to enhance energy efficiency measures, primarily through requirements for new buildings and regulatory measures to increase energy efficiency within the transportation industry. (For example, reduced VAT rates on energy efficient heating systems, building insulation and appliances, and products fiscal measures).

The plan also increased the binding Energy Efficiency Target from 9% to 13% under the Fit for 55 package of European Green Deal legislation.

In addition, the Commission also published an "EU Save Energy Communication," detailing short-term changes which could cut gas and oil demand by 5% and encouraging Member States to start communication campaigns.

- **Energy supply diversification**

The EU institutions have been working with international partners to diversify gas supplies. This component corresponds mainly to the newly-created EU Energy Platform for the purchases of gas, LNG, and hydrogen by pooling demand, optimizing infrastructure use, and coordinating the suppliers.

The plan also proposes that the Member States consider the development of a "joint purchasing mechanism" which is similar to the mechanism set up for the purchase of Covid-19 vaccines. It will allow the Commission to negotiate gas contract purchases on behalf of participating Member States.

In line with this REPowerEU's component, the EU External Energy Strategy also aims to facilitate energy diversification and building long-term partnerships with suppliers, including cooperation on hydrogen or other green technologies.

- **Accelerating renewable energy deployment**

The Commission proposes to increase the 2030 target for renewables from 40% to 45% under the Fit for 55 package.

To reach this objective, the plan focuses on several proposals, including: a new EU Solar Strategy, which includes an initiative for phasing-in legal obligation to install solar panels on new public and commercial buildings; doubling the rate of deployment of heat pumps; measures and incentives to create faster permitting for major renewable projects; establishing a target of 10 million tons of domestic renewable hydrogen production and 10 million tons of imports by 2030; and creating a biomethane action plan, including incentives to increase production to 35ncm by 2030.

- **Smart investments in European interconnection and infrastructure needs**

The Commission also proposes to implement several long pending projects in order to complete the European infrastructure, by complementing the existing list of projects of common interest (PCIs).

The plan outlines that limited additional gas infrastructure, estimated at around €10 billion of investment, is needed to fully compensate for the future loss of Russian gas imports.

The implementation of the electricity PCIs will also be essential to adapt the European power. Alongside the publication, the Commission has launched a call for proposals with a budget of €800 million and another one has been announced in early 2023.

- **Emergency measures in case of interruption of Russian gas supplies**

The Commission also suggests two main contingency measures in case of severe supply disruption. The first measure is the creation of a coordinated EU demand gas demand reduction plan. The second measure is the upcoming issuance of a guidance on the prioritization criteria of non-protected customers, in particular of industry, in case of sudden interruption of gas supply.

1.2 The success of the REPowerEU plan will require coordination between Member States, given that it may be implemented on a voluntary basis.

Success of the plan will largely depend on Member States' involvement and coordination, given that the plan is not a legally-binding commitment and may be implemented by the EU Member States on a voluntary basis.

The determining success factor of this component of the REPowerEU plan will be whether Member States will implement the measures proposed by the EU Commission.

For example, many European countries, such as France, Germany, Italy, and Spain have set expansive measures to protect consumers against the impact of rising gas and electricity prices. In France, gas and electricity prices shield aims to protect the consumers until the end of 2023. The French government also increases the amount of historical nuclear electricity to be sold by French major electricity producer, EDF, to the other suppliers at a regulated price (from 100 TWh to 120 TWh).

The challenge of these countries is now to switch from universal energy subsidies to targeted measures for poor households and vulnerable small- and medium-sized companies; they must also ask the rest of consumers to consume less energy.

The challenge would also be to create special protection measures for electricity or gas consumers from the industry sector in case of large interruption of gas supplies.

Regarding the accelerated development of renewables, the countries must fix long-lasting administrative inefficiencies and implement the necessary changes quickly. In France, a project of bill provides several improvements of administrative procedures for the implementation of renewable energy projects in order to mitigate the length of these procedures in France.

The success of the plan requires Member States' coordination, as well as capacities of the EU to fund the measures proposed.

The Commission indicated that REPowerEU objectives require an additional investment of €210 billion until 2027, while cutting Russian fossil fuel imports can also save almost €100 billion per year. These investments must be met by the private and public sector, and at the national, cross-border and EU level.

The EU Commission also proposed to invest €300 billion by 2030 (€72 billion in grants and €225 billion for loans). The investments will include €10 billion for gas infrastructure and €2 billion for oil, with the rest for clean energy. This plan relies on phasing out Russian gas imports and on setting more ambitious EU energy-efficiency and renewable targets for 2030.

Conclusion

The REPowerEU Plan is an application of the long-term EU energy policy, as it contains proposals to accelerate the achievement of ambitious objectives in terms of green transition outlined in the European Green Deal. In other words, Russian's invasion of Ukraine has suddenly raised the level of the challenge on a short-term scale as it relates to energy security of supply and green transition.

REPowerEU Plan also shows that solidarity and coordination between Member States are the EU's strongest asset to respond to the energy crisis. However, EU countries must decide to what extent to engage in this cooperation.

The achievement of security of supply and diversification of supply sources will indeed depend mostly on the implementation of the proposed measures by the Member States themselves. Due to the market integration of the EU economies, a fragmented response to the EU energy crisis would likely lead to disappointing results in terms of security of supply and affordable energy prices.

2. The second part of the EU response to the current electricity market crisis focused on the improvements to be made to reform the European electricity market price design.

2.1 The first work of the EU Commission was not very conclusive on a reform of electricity price market design.

On May 18, 2022, following the publication of the REPowerEU, the Commission issued a communication on Short-Term Energy Market Interventions and Long-Term Improvements to the Electricity Market Design.

This communication presents a first package of measures that could be understood as possible reforms of the European electricity market design.

The first part of the package focuses on short-term intervention measures on the gas market to address the price crisis and to anticipate a full disruption of Russian gas supplies.

- Regarding the gas price crisis, the Commission proposes to Member States to implement three types of measures: (i) the extension of the price regulation for natural gas to the industries; (ii) emergency liquidity support measures for the benefit of commodity traders and energy companies if such measures comply with State aid rules and do not undermine the sanctions regime imposed on Russia; (iii) to impose internal trading rules that limit short-term volatility of gas prices in the European gas exchanges (e.g. TTF).
- Regarding the solutions in case of an interruption of Russian gas supplies, the Commission mentions the potential need to set an EU price cap for gas delivered to European consumers and companies. The communication notes that the duration of that measure should be strictly limited and proportionate to the objective of the damaging price of a sudden interruption of Russian gas supplies for consumers.

The second part of the package includes several proposals for short-term measures related to the electricity market; this includes **the taxation or regulatory measures that could remove infra-marginal rents of certain baseload electricity generators created by the current crisis.**

It also includes measures of protection for small and medium-sized enterprises (for example, extension of regulated retail prices to for small and medium-sized enterprises) or for producers (subsidies to producers to cover gas costs for electricity generation).

However, long-term interventions proposed by the Commission in its communication are less convincing and ambitious since they were based on the conclusions of the ACER Report from April 29, 2022, which was very protective of the current electricity market design.

Following the ACER Report conclusions, the Commission has listed several improvements of the current functioning rules of the market without modifying the fundamentals of the European electricity market design.

For example, the Commission indicates that possible market reforms could be to protect vulnerable consumers and to provide them with an affordable electricity price in the short- and long-term. It also suggests: generalizing the conclusion of supply agreements at fixed prices; giving incentives to the actors for ensuring investments in new generation and low carbon capacities; reducing electricity demand and enhancing flexibility in case of peak prices; removing existing barriers to innovation on electricity and gas infrastructure; reducing costs and exceptional profit through local regulated pricing systems; and enhancing market surveillance and transparency (by reinforcing REMIT compliance).

Conclusion

The Commission was initially not very supportive to possible reforms of the European electricity market design. Based on the ACER report, it considered that the "current electricity market design delivers an efficient, well integrated market, allowing Europe to reap all the economic benefits of a single energy market, ensuring security of supply and sustaining the decarbonization process."

Accordingly, the Commission asked Member States to ensure a full implementation of the electricity market legislation and the REPowerEU Plan. The Commission proposals on market design were limited to small improvements of EU energy regulations. This discourse had changed at the end of August 2022 due to a strong political revival of EU Member States in order to tackle the current electricity market crisis.

2.2 The EU started to assess possible emergency market reforms of the European electricity single market design.

The energy crisis will continue to dominate EU's agenda in autumn and winter.

At the end of August 2022, many Member States observed that the economic context required a rapid and coordinated EU-wide response to mitigate the peaks in electricity prices and to ensure security of supply at the European level.

Therefore, some members, such as France and Germany, urged the Council of the EU and the Commission to prepare emergency measures to curb the price of electricity by separating it from the soaring cost of gas.

In a framework note dated September 4, the Presidency of the Council of the EU also asked the EU delegations what they could do to limit the price explosion. Among the measures envisaged:

- Capping the price of gas (depending on its origin or use)
- Excluding gas-fired power plants from the price-setting system (the "merit order")
- Coordinating the reduction of electricity demand; or
- Capping the prices of certain electricity production, in particular the less expensive ones (renewable, nuclear, etc.)

The Presidency of the Council of the EU also proposed to increase market liquidity by suspending electricity derivatives markets or by providing specific credit lines for certain market players.

A consensus may be rapidly reached between the EU Member States.

Some form of consensus seems to have been reached between several EU Member States on a possible separation of electricity and gas prices, a position that is directly in conflict with the marginal cost system. For example, Czech industry minister Jozef Sikela said: "We have to separate electricity prices from gas prices," and suggested that gas prices used for electricity production should be capped. Germany's economy minister Robert Habeck also gave his support to a "fundamental reform" to decouple the two markets, as have other EU leaders such as Mario Draghi, Prime Minister of Italy, and Pedro Sánchez, Prime Minister of Spain, both of whom have called to cap European electricity prices.

In opposition to its precedent Communication dated May 2022, the EU Commission is working on fundamental market design reforms.

Despite the findings of the ACER Report on the benefits of the current market design, the Commission has admitted the weaknesses of the European electricity market design in the current crisis. In a non-official document unveiled in September 2022, which is a preliminary assessment, the EU Commission presented a first package of measures to optimize the functioning of EU common electricity market and to lower the impact of gas prices on electricity prices. This package contains three main interventions.

a. The first intervention would be inspired by the mandatory demand reduction for gas and focus on achieving a similar type of demand reduction for electricity.

b. The second intervention would introduce a price limit for inframarginal electricity generation technologies, which have lower operating costs than gas-fired power plants (as renewables or nuclear plants), with the aim of making the commercial returns of these technologies independent of the marginal electricity price.

c. The inframarginal price cap would provide Member States with financial resources to finance retail price interventions. In this respect, the Commission would provide greater legal certainty for Member States' efforts to protect certain consumer types from the impact of high electricity prices via regulated tariffs.

The 27 energy ministers of the Member States will discuss these proposals and those of the Commission on September 9, at their extraordinary meeting in Brussels.

> *Currently, gas dominates the price of the electricity market… with these exorbitant prices, we'll have to decouple (…). We'll have to ensure renewable energies are generated at lower costs, that those costs are transferred to consumers and windfall profits used to help vulnerable households"*
>
> **Ursula Von Der Leyen**
> President of the EU Commission

NUCLEAR ENERGY

DAVID STEIGER
COLETTE LEWINER

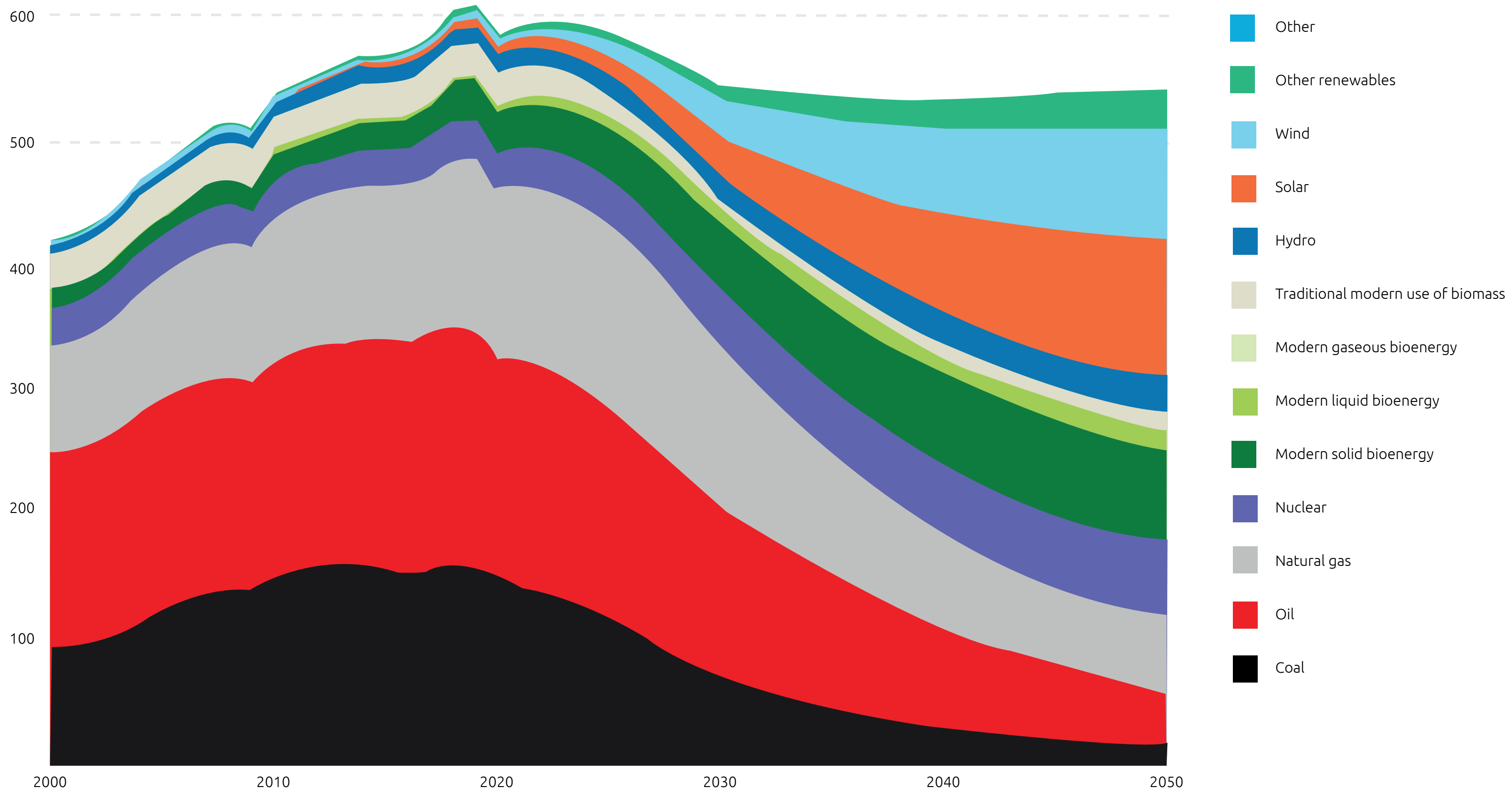
1. Nuclear energy renaissance

a. The nuclear energy benefits are now clearly brought to light. This is driven by the global communities' commitment to reach net zero carbon emissions.

- On February 3, 2022, the European Commission published the final version of the "European taxonomy delegated act" dedicated to gas and nuclear. For the first time, a European text acknowledges the role of nuclear in the fight against climate change. The act was approved on July 6 by the European Parliament and on July 11 by the EU Council. From now on, nuclear power and gas will be able to benefit from European funding linked to the Green Deal, which represents more than €1000 billion. Thus, nuclear power will be able to take advantage of these investments to finance its development until 2045.
- As promises for carbon neutrality targets increase, the International Energy Agency (IEA) published in 2021 a global roadmap (net zero roadmap) for the decarbonization of the energy sector. One of its conclusions is that nuclear energy production, a low-carbon, reliable, flexible, and schedulable energy source, must double by 2050 to meet the net zero carbon objectives. It is an indispensable complement to renewable energies.
- Similarly, at COP26 in November 2021, IEA Director Fatih Birol called for accelerating three areas: the extension of the operating life of nuclear reactors; new plant construction that must be increased five-fold; and finally, innovation, including small modular reactors.

FIGURE 1

Total energy supply in the NZE (Net Zero Emissions by 2050 scenario)



Renewables and nuclear power displace most fossil fuel use in the NZE

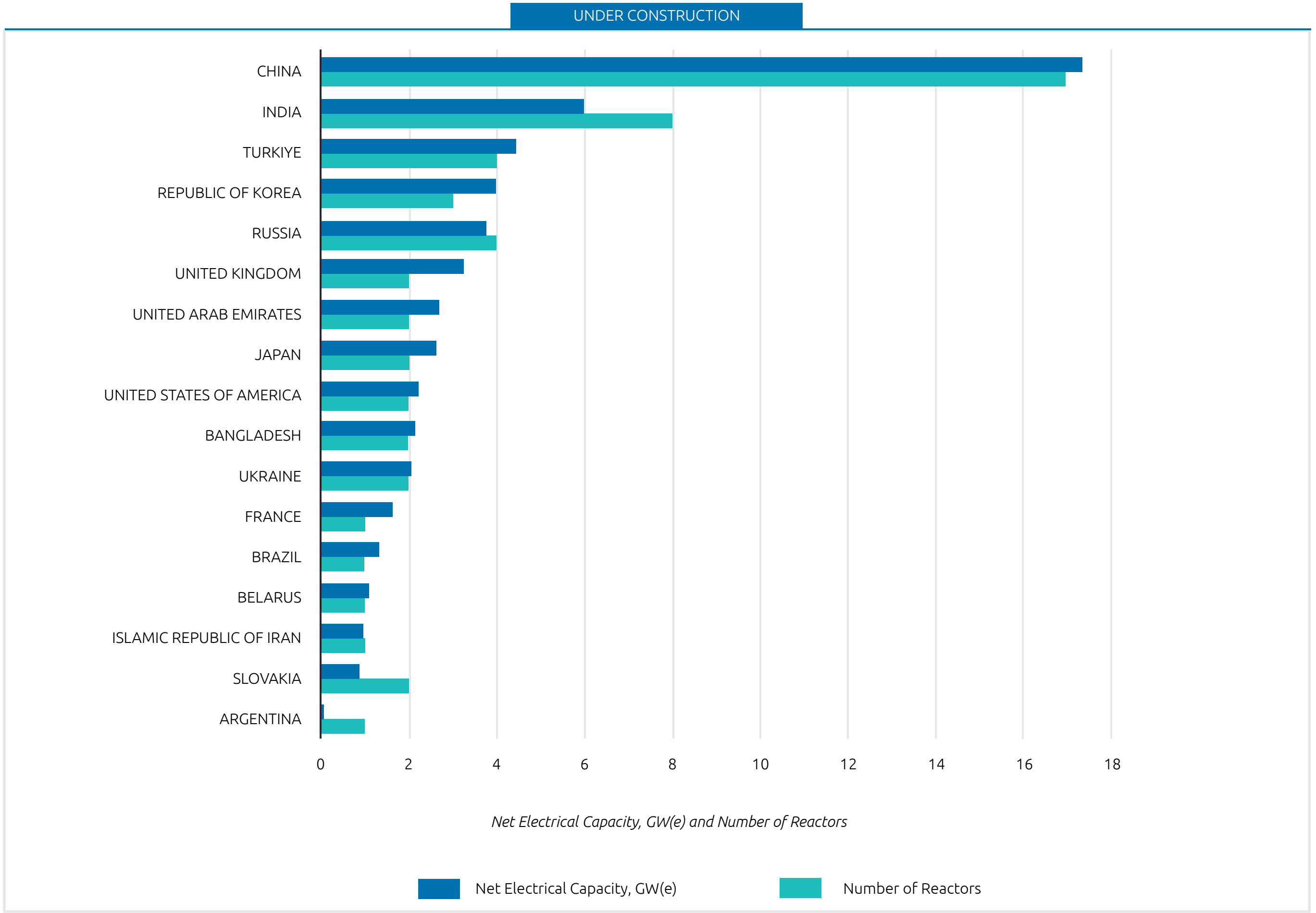
Source: IEA

b. The number of new nuclear projects is increasing while utilities extend their existing reactors' operating lifetime.

- Asian countries, whose economies are growing the fastest, are currently building the most new reactors.
- China remains well ahead with 17 projects for a total capacity of more than 17 GW. The country plans to build 150 reactors in 10 years. In 2021, about one-third of the new nuclear reactors under construction were in China (18 out of 53).
- The Middle East and South Asia follow, with eight reactors under construction in India and two in the United Arab Emirates, the first in the Arabic world.
- While some European countries have announced their intention to close their nuclear power plants, others continue to expand their fleet. The United Kingdom is building two reactors, Slovakia two, Belarus one (the country's first), and France one.
- On February 10, 2022, the French President announced a construction program of six EPR2, followed by eight additional reactors and the extension of the operating life of the existing fleet. In 2022, the French Nuclear Safety Authority agreed to the 900 MW reactors' lifetime extension (32 reactors in total).

FIGURE 2

Reactors under construction



Source: IAEA PRIS (Power Reactor Information System) Database

c. The perception of nuclear energy is improving.

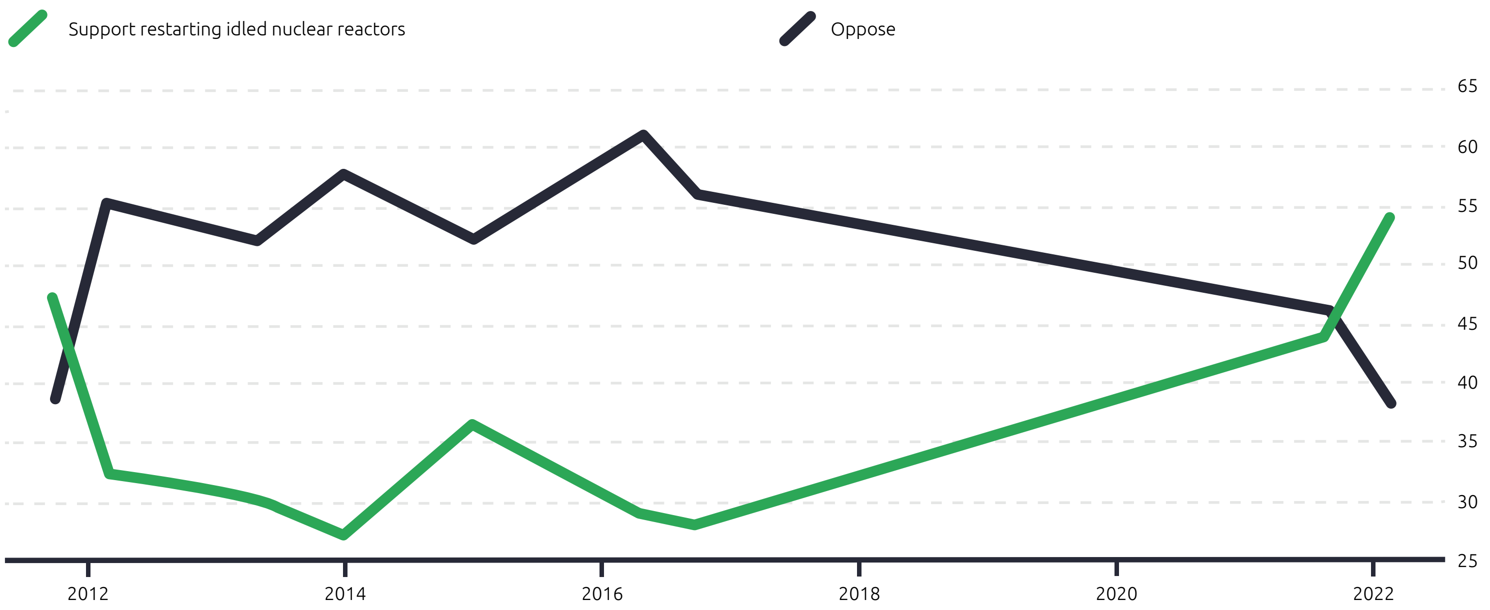
- Japan, deeply marked by the Fukushima accident, has confirmed the priority of nuclear power. In 2022, a majority of Japanese (53% vs. 44% in Sept 2021) are in favor of restarting closed reactors to reduce the archipelago's energy dependence and meet its climate goals.
- In France, nuclear energy is perceived by half of the French people as an asset for France[1] (50% in favor in 2022 vs. 47% in 2020).
- According to the 2021 International Climate and Public Opinion Observatory covering 30 countries, a majority of those interviewed (60%) consider it acceptable to replace oil and coal-fired power plants with nuclear power plants.

d. Despite politics' revival of nuclear power, the industry is struggling to attract young talent with the needed key skills.

- For several years, western countries' politicians, usually to attract the "green" votes, have neglected nuclear energy. This has led to a decline in the number of young people studying and wishing to work in this sector[2].
- This matter has been tackled by the industry, which is multiplying its initiatives, including cooperation with the academic sector, communication campaigns on the benefits of nuclear power in mitigating climate change, career prospects, etc.
- More diverse profiles, including those from smaller companies, should contribute to the nuclear sector's innovations. In this respect, the growing number of start-ups is promising.

FIGURE 3

Majority of Japan supports reactor restarts for first time in a decade



Note: there were no polls between oct. 2016 and sept. 2021

Source: Polls conducted by the Nikkey

1 Recent BVA survey for Orano
2 Global Energy Talent Index 2021 Survey

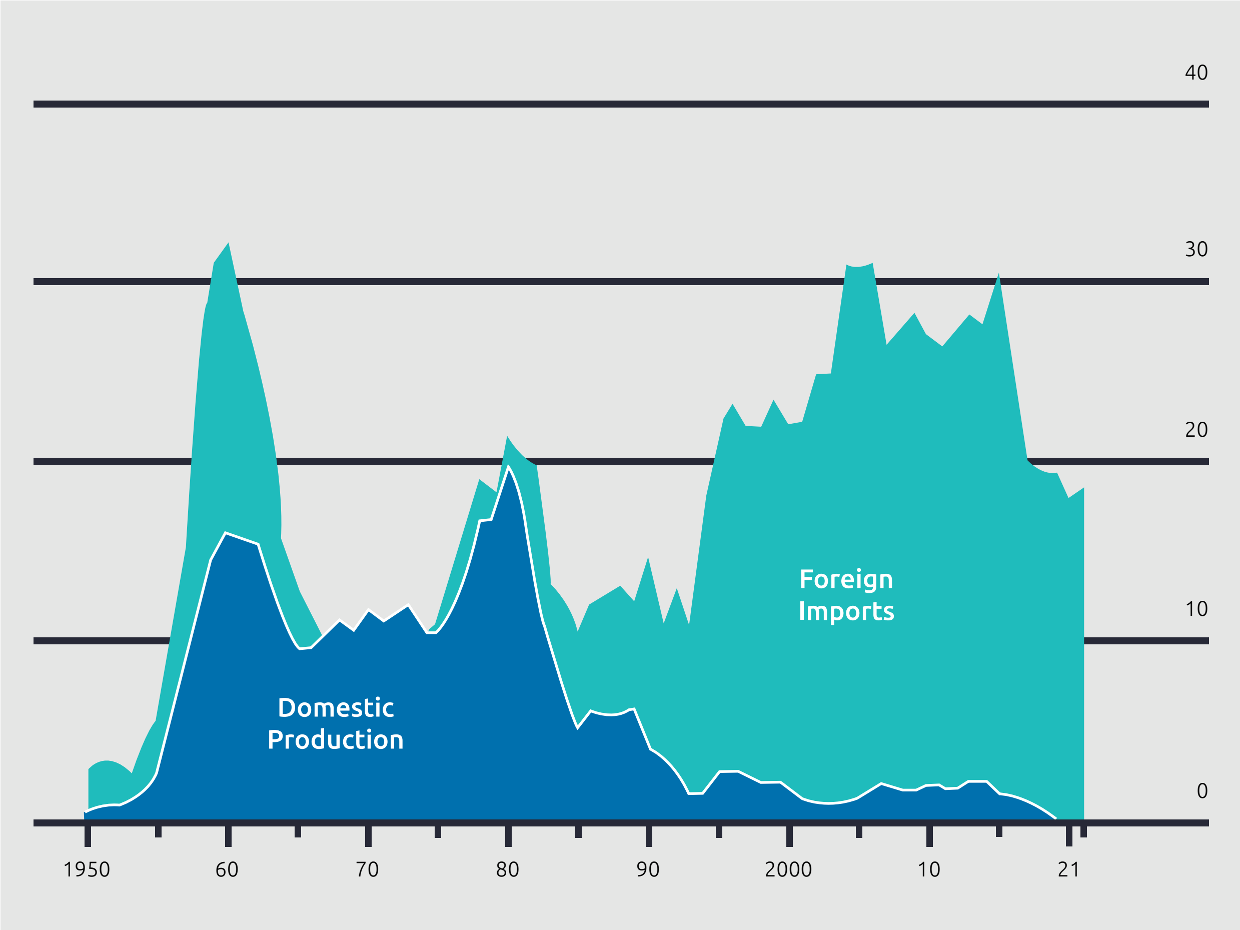
2. A market in a bipolarization phase

a. Because of Russia’s invasion of Ukraine, the European market has closed for Rosatom (the Russian nuclear equipment supplier and the largest exporter). Rosatom will probably intensify its commercial efforts in other geographies, including developing countries.

- The Rosatom construction contract for the Finnish Hanhikivi-1 reactor was cancelled in May 2022 due to the risks inherent to Russia’s invasion of Ukraine. This decision stops one of the main EU industrial projects (more than €7.5 billion with €600 million already invested) involving a Russian company.
- Although the European sanctions do not apply to Russian nuclear power (including the delivery of enriched uranium), the future relationship between Russia and Europe in this sector is questioned.
- The White House is considering sanctions against Rosatom. In retaliation, Russia could stop its uranium and enrichment exports. Globally, the nuclear operators depend on Russia for about 14% of its supply of uranium concentrates, 27% of its supply of chemical conversion, and 39% of its enrichment needs (in 2020, 20% of the uranium consumed in European power plants came from Russia, 16.5% in the U.S.).
- Uranium spot price increased by 38% since the beginning of 2022; however, this increase does not significantly impact the nuclear electricity cost as uranium accounts for around 6% of it.

FIGURE 4

United States uranium concentrate origin (for use in nuclear plants)



Source: EIA

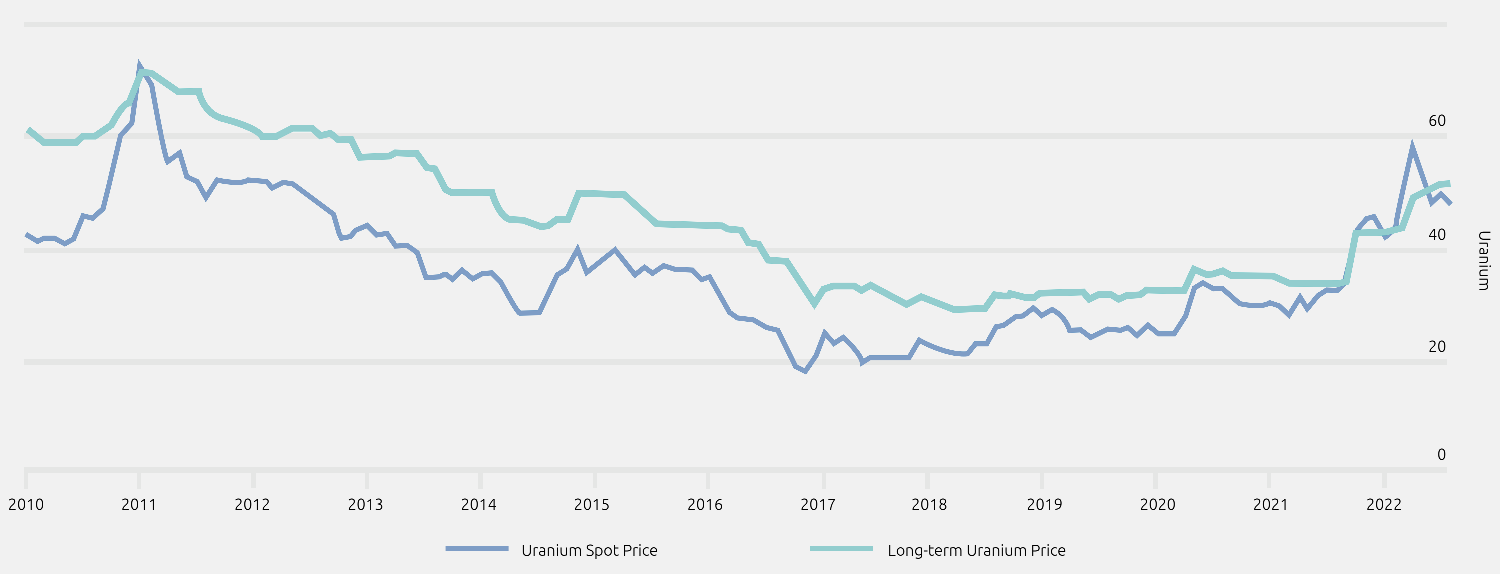
- Moreover, uranium has a very high energy density (the fission of 1g of uranium releases as much energy as 1 to 2 tonnes of oil), which allows operators to have strategic reserves of nuclear fuel in a limited space. Thus, nuclear power plants generally have enough fuel on site to continue operating for a few years in the case of uranium embargos.
- Taking into accord the small share of the uranium cost in the total nuclear electricity cost and those strategic reserves, nuclear electricity can be considered as a domestic source of electricity.

b. Tensions between China and the western world negatively impact Chinese nuclear projects in the west.

- Since the China take-over of Hong Kong, the government of Boris Johnson decided to exclude the Chinese from its new nuclear programs and wants to revise the Sino-British partnership signed in 2015. China General Nuclear Power Group (CGN) had big ambitions in the U.K. It planned to build a Hualong One reactor at Bradwell. To acquire the experience of working with the British Safety Authority and to be accepted as a nuclear operator in the UK, it entered into a long-term alliance with EDF, with whom it was building two EPRs in Taïshan (China). It started by investing with EDF in the two Hinkley Point C EPRs in the U.K. It also invested in the Sizewell C EPRs project alongside EDF. However, the Bradwell project has been canceled and, under the U.K. government's pressure, CGN should exit the Sizewell C project. It should keep its 30% share of Hinkley Point C.
- Similarly, in 2019, US President Donald Trump blacklisted CGN and its subsidiaries over the theft of military technologies.

FIGURE 5

Uranium price trend



Note: Cameco calculates industry average prices from the month-end prices published by UxC and TradeTech.

Source: Cameco

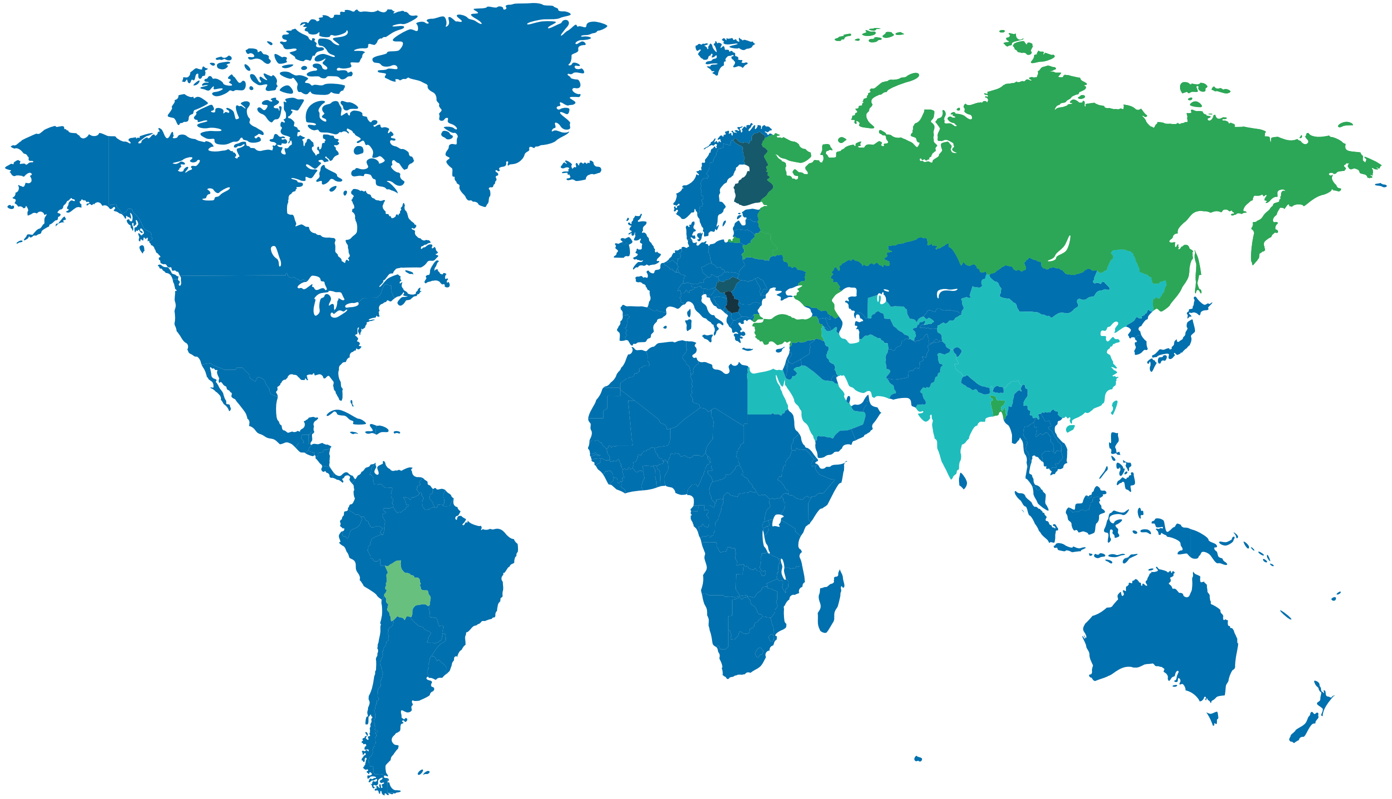
c. In the present political situation, American (sometimes teamed with South Koreans) and French nuclear companies could gain market share in Europe while Russian and Chinese companies will fight for new nuclear countries' projects.

- American nuclear equipment manufacturers could enter central and eastern Europe, helped by intergovernmental agreements that paved the way for American industries.
- Russian and Chinese manufacturers' exclusion from pre-qualification for constructing a reactor in Dukovany (Czech Republic) paves the way for U.S. or French companies.
- In Europe, the opposition to nuclear power by some countries, including Germany, deprives France of European support for its export policy.
- Nevertheless, considering that two-thirds of the cost of a power plant comes from the cost of capital, Russia and China retain real advantages with the allocation of generous export credits. The other supplier countries are not allowed to because of the international trade rules that Russia and China have not signed.

FIGURE 6

Rosatom construction or research projects (April 2021, prior to contract cancellation in Finland)

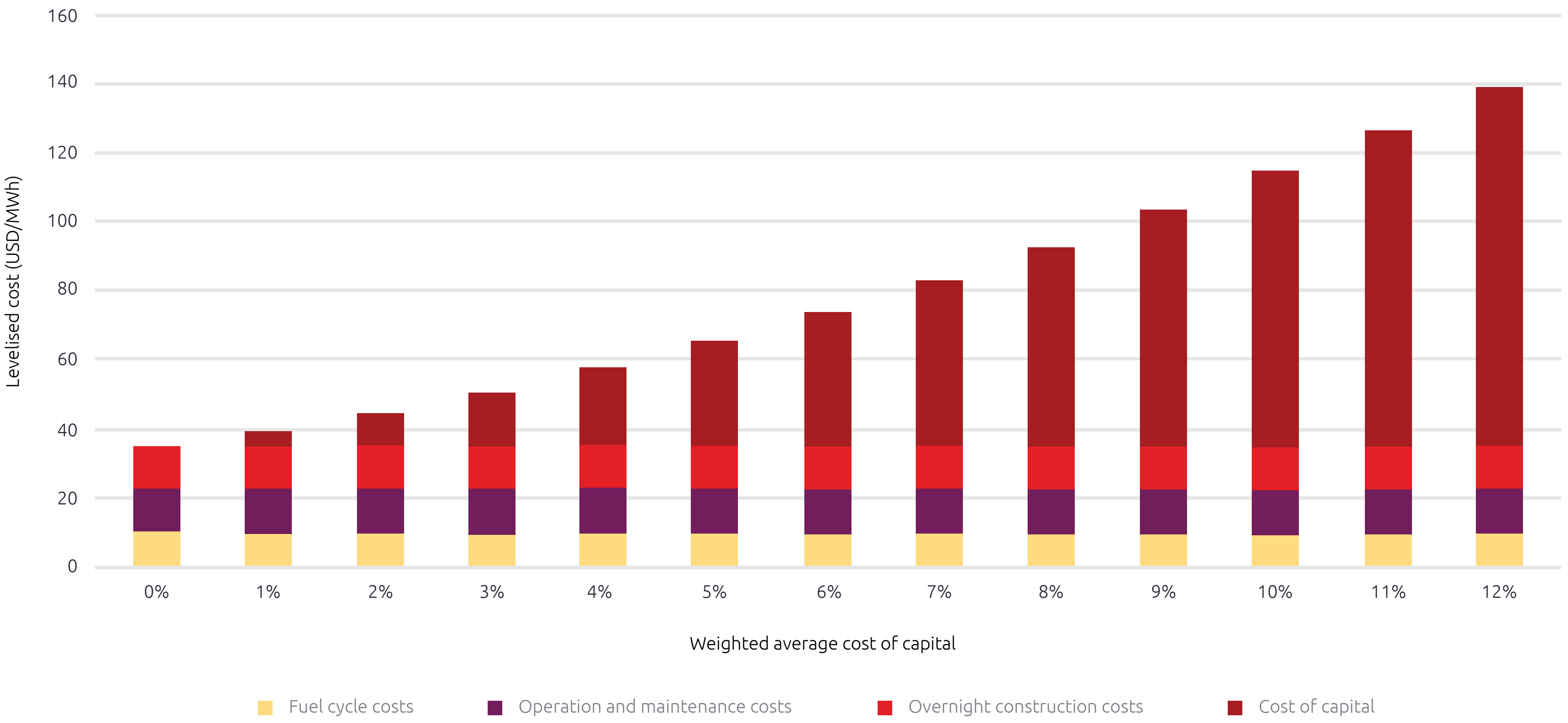
Ongoing nuclear research centers' construction
Plant construction project
Ongoing plants construction
Construction of suspended plant
Nuclear research center project



Source: Usine Nouvelle

FIGURE 7

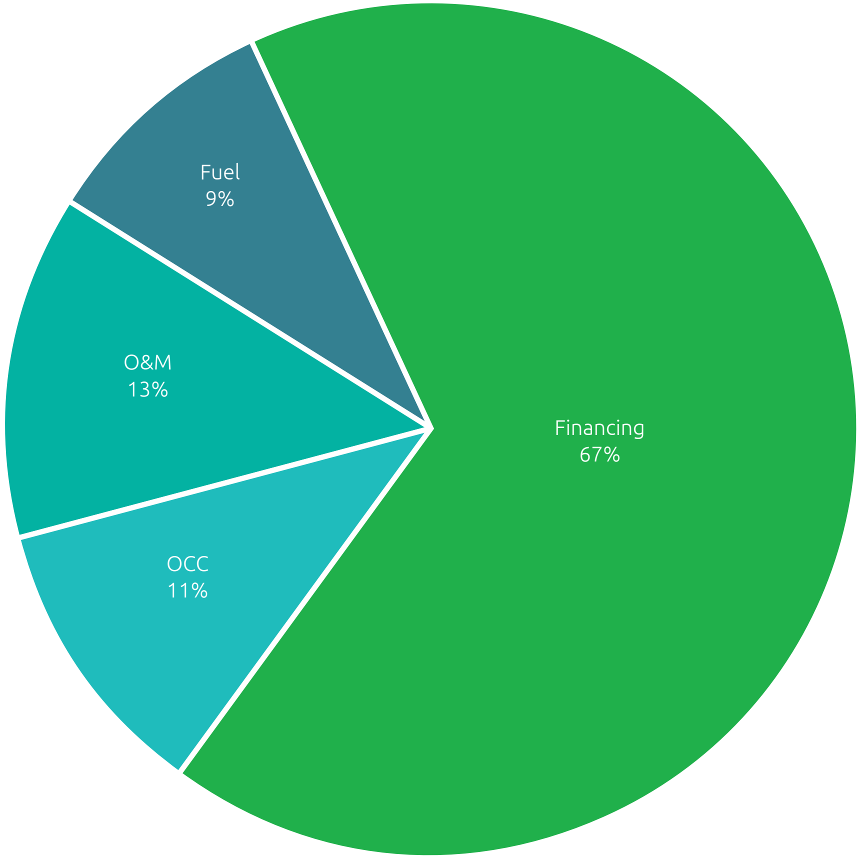
Capital cost impact on the LCOE of a new nuclear power plant



Source: Nuclear Energy Agency

FIGURE 8

Cost breakdown for nuclear power LCOE



LCOE: Levelized Cost Of Electricity

Source: Nuclear Energy Agency

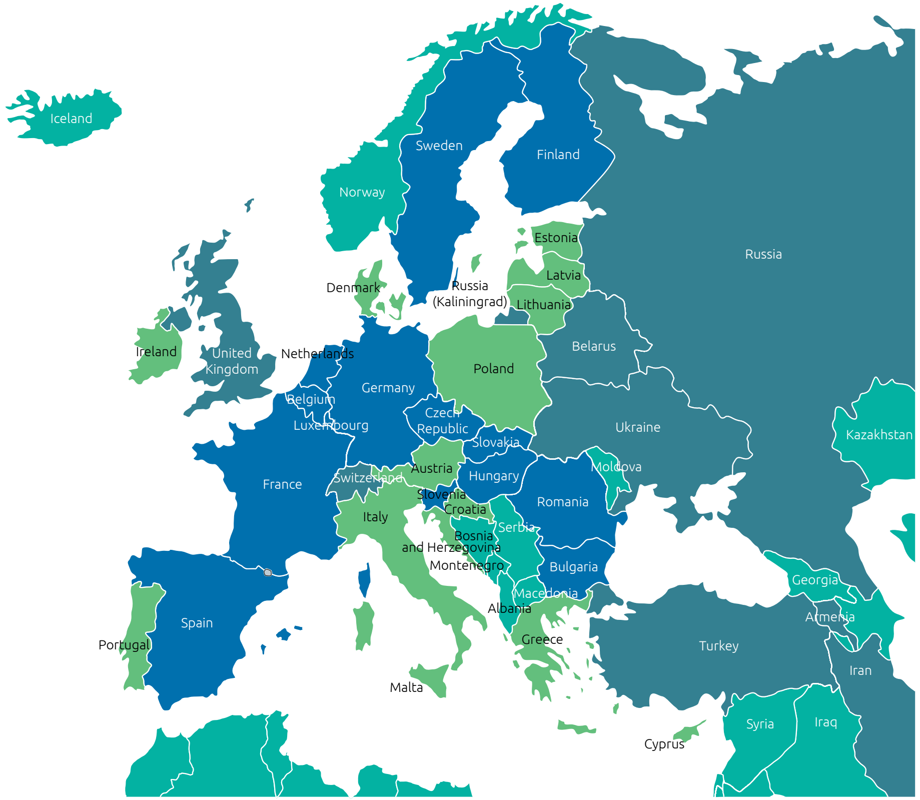
3. The Ukrainian war related crisis is revealing the strengths and weaknesses of nuclear power

a. The energy crisis world has highlighted the importance of ensuring the security of energy supply. In this respect, low-carbon domestic nuclear electricity is a key asset.

- While the closure of nuclear plants in 2025 was approved 19 years ago in Belgium, the Belgian federal government finally decided in March 2022 to extend for ten years the operation lifetime of the Doel 4 and Tihange 3 nuclear reactors (2000 MW in total), citing the need to strengthen Belgium's energy independence in a tense geopolitical context.
- In the context of missing Russian gas supplies, the German government could revise its nuclear exit policy decided in 2011 after the Fukushima nuclear accident. The debate is still pending on whether to close the last three nuclear power plants[3] still in operation.
- In France, the stress corrosion cracks discovered in the 1400 MW and 1300 MW reactors have led to unplanned closures for inspections and repairs, resulting in a significant decrease in the French reactor's output for winter 2022-2023.
- The lack of electricity supplies combined with the threat on Russian gas could result in energy shortages in Europe if the winter is very cold.

FIGURE 9

Nuclear power plants in Europe



- EU member states with operating and / or under construction nuclear power plants (as of February 2020)
- EU member states without nuclear power plants
- Non-EU countries with operating and / or under construction nuclear power plants
- Non-EU countries without nuclear power plants

Source: World Nuclear Association

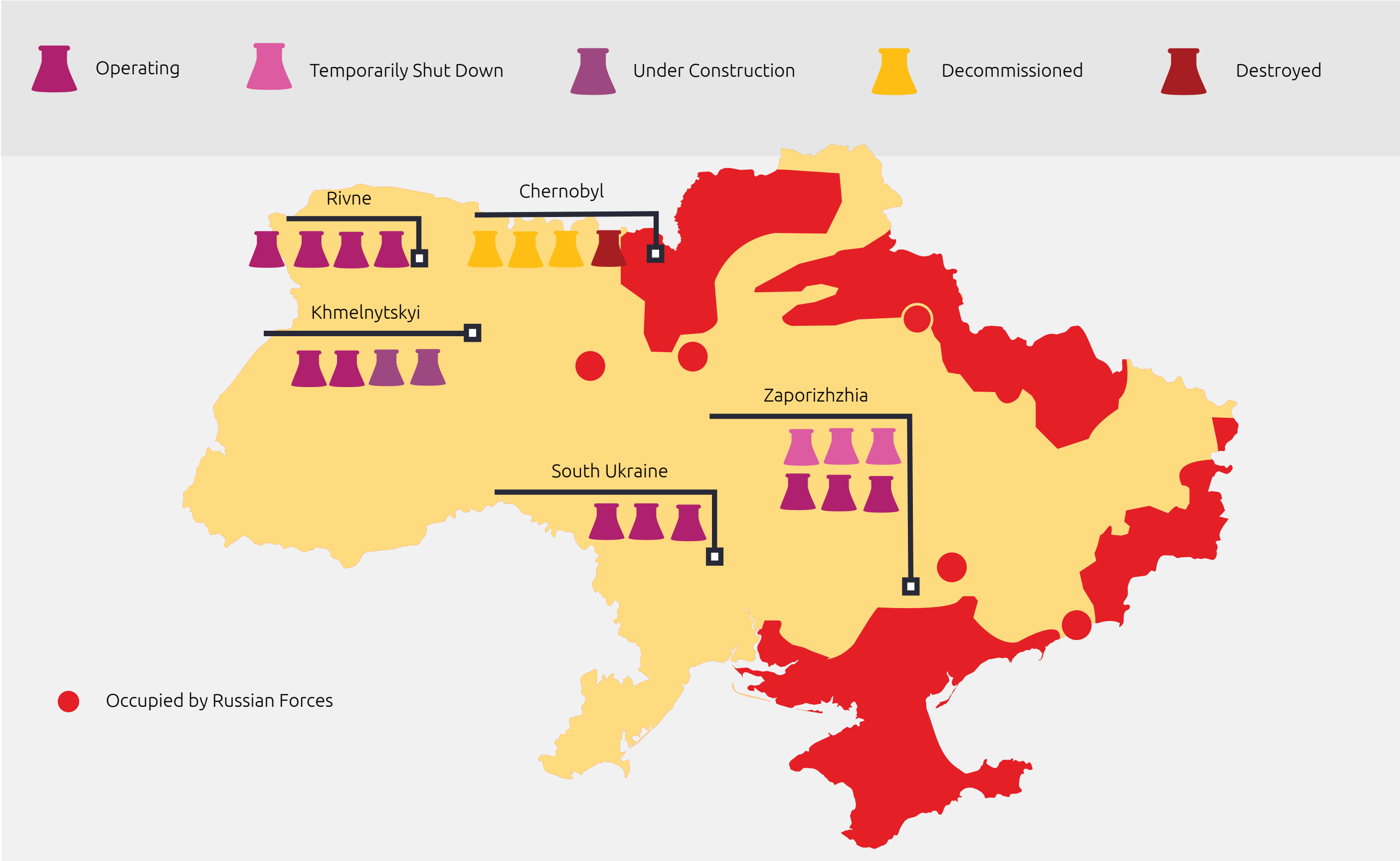
3 These three power plants, Neckarwestheim 2 in Baden-Württemberg, Emsland in Lower Saxony and Isar 2 in Bavaria, still provide 30 TWh this year, i.e. 6% of German electricity production

b. The war in Ukraine highlights the fact that nuclear power plants are not designed to withstand a missile attack and such an event would have significant consequences, particularly if large amounts of radioactivity were released. This questions the choice of this technology in areas where wars can occur.

- Zaporzhia, located in the south of Ukraine, is the largest power plant in Europe, with six VVER reactors. It was bombed and taken by Russian troops in early March 2022 at the beginning of Ukraine invasion. A projectile hit an administrative building near one of the reactors. According to the International Atomic Energy Agency (IAEA), no reactor was damaged, and radioactive material was not released. However, since the end of July, several strikes have targeted the site, raising fears of a nuclear disaster.
- This risk relates to vital auxiliary systems (providing notably electricity) and supplies (water, fuel, oil), which are much more exposed than the reactor itself located in a solid building. They ensure, among other things, the reactor cooling when this latter is shut down.
- Another risk is related to the stressed environment in which the operators (that are present 24 hours a day and seven days a week) operate.
- Even if it is not in the interest of a country, wishing to annex another, to provoke a nuclear accident that could damage the surrounding agricultural areas and cities, a vital organ of the power plant could be hit by an uncontrolled shot.

FIGURE 10

Nuclear power plants in Ukraine, by operational status



Note: As of March 4, 2022

Source: Statista Research

Conclusion

- There is a nuclear renaissance in western countries triggered by concerns over climate change. China is continuing to build new reactors at a steady pace, and some emerging countries, often «first-time buyers», are seeking to acquire schedulable and low-carbon energy.
- The growing number of start-ups and the investments they are receiving are evidence of the sector's dynamic innovation.
- In the present geopolitical context, the nuclear market could shift to bipolarization with Chinese and Russian nuclear equipment manufacturers on one side and the western countries' nuclear companies on the other.
- The emerging economies that wish to build reactors must establish an independent safety authority, create a local industry, recruit skilled people, train younger ones, and comply with the rules of non-proliferation.
- The Ukrainian conflict has revealed the strengths of nuclear power in terms of energy sovereignty and strategic resilience, but also its weaknesses, as the presence of nuclear plants in the battlefield is a real danger.

RENEWABLES TECHNOLOGY

DAVID PEREZ LOPEZ

Onshore Wind

In most cases globally, onshore wind and solar PV are the best lower-cost options for new electricity generation. In 2021, China's onshore wind market was dominated by five manufacturers and captured 93% of the global market share[1].

Provide energy flexibility will be likely the main challenge for unpredictable renewables sources to substitute completely fossil fuel technologies, requiring enablers like storage, hybrid projects with solar, green hydrogen or power to X where digitalization will play a crucial role with real time smart power plants, AI data-driven, new generation of SCADAs and full IT/OT integration, advanced networks and communications, and cybersecurity to make fully reliable.

Advanced digital technologies (powered by data and AI) will boost turbine performance and enable new control of wind turbines, leading to an increase in production output. Proliferation of new digital technologies provide many benefits to the grid, its electrical system, and consumers. This will also enable operators to extend the wind turbine's lifespan, enhance its power yield, reduce downtime, and decrease operation and maintenance costs.

Unfortunately, profitability has been hampered by disruptions to supply chains, lack of raw materials, logistical oversight, cost inflation, and the Covid-19 recovery, all of which impacted timelines and increased costs.

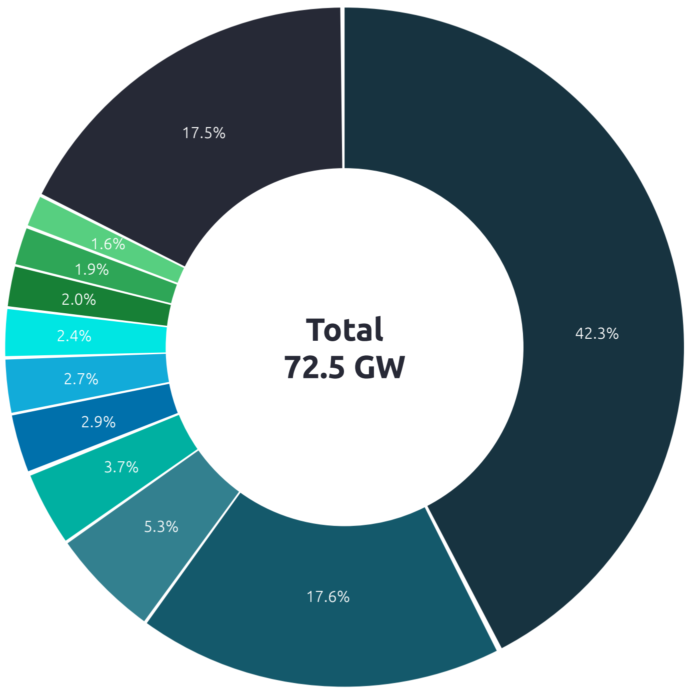
A new generation of onshore wind turbines is being developed that increases efficiency and power output and, therefore, reduces costs. The construction of bigger and higher turbines have a rotor diameter of ~170 meters and a power capacity to between ~5 MW and 7 MW.

1 BNEF's 2021 Global Wind Turbine Market.

More complex modular design concepts and logistics have resulted in improved performance, land use, less impact on birds, and reduced noise. Repowering the oldest wind parks has led to new and more advanced grid codes. There have also been greater focus on eco-designs and recycling components, especially in blades and composites materials. Rebuilding the new future supply chain has leveraged synergies and scalability between platforms, and effectively addressed challenges on procurement, manufacturing, and logistics.

FIGURE 1

New onshore wind installations, 2021 (GW)



Source: Global Wind Energy Council (GWEC) report 2022

In 2021, wind experienced record growth in renewable generation, increasing installed capacity to almost 17%. In 2020, China and the U.S. jointly accounted for more than 55% of global wind output[1].

Between 2010 and 2020, the global weighted-average levelized cost of electricity from onshore wind fell by 56%[2].

In 2021, 93.6 GW of new installations brought the global cumulative wind power capacity to 837 GW, with a year-over-year growth rate of 12%[3]. In the same year, the onshore wind market added 72.5 GW, making up 77.5% of global wind installed. Due to a slowdown in China and the U.S. (the two largest wind markets worldwide), the total global wind installed was 18% lower than in 2020.

In 2021, Asia-Pacific and North America represented more than two-thirds of global new onshore installations. In Europe, Latin America, and Africa and Middle East, installations increased by 19%, 27%, and 120% respectively[4].

Over the next five years, onshore wind is projected to grow at a CAGR of 6.1%, with average annual installations of 93.3 GW. Between 2022-2026, a total of 466 GW is likely to be built. Current rates of installation will have less than two-thirds of the wind energy capacity required to meet the 1.5°C target and achieve a net zero pathway by 2030. The wind market growth rate will need to quadruple to meet net-zero goals[5].

Wind manufacturers are competing against each other specially under auctions schemes, resulting in a 'race to the bottom' in costs and even against other technologies like PV in agnostic auctions. Consequently onshore wind turbine manufacturers are facing gigantic market complexities causing financial losses issues in manufacturing business units but on the other side relevant profits are being made from services and maintenance units.

1 Global Energy Review 2021: IEA
2 IRENA WORLD ENERGY TRANSITIONS OUTLOOK 2022 1,5°C Pathway Exec Summary
3 Global Wind Energy Council (GWEC) report 2022.
4 Global Wind Energy Council (GWEC) report 2022.
5 Global Wind Energy Council (GWEC) report 2022.

Offshore Wind

The momentum for offshore wind farms is mounting worldwide. Over the next five years, the CAGR for offshore wind is expected to be 8.3%, while the market share of new global wind installations is expected to increase from 23% in 2021 to at least 30% by 2031[1]. Between 2010 and 2020, the global weighted-average levelized cost of electricity (LCOE) for offshore wind fell by close to 50%[2]. In 2021, revenues on a €/MWh basis were, on average, 55% lower than in 2014[3].

A total of 21.1 GW of offshore wind capacity was commissioned in 2021 – three times more than in 2020. This makes 2021 the best year for offshore wind[4] on record. As a result, the outlook for 2030 was raised by 16.7% to 316 GW. Expanding government support and digital technologies are also expected to increase growth in the offshore wind market. Global offshore wind capacity quadrupled in the first half of 2022 reaching 6.8 GW, with China leading the market with 5.1 GW[5].

A new generation of digital technologies will enable an increase in performance and efficiency, resulting in a decrease in construction and operational costs in complex environments. Examples of these technologies are AI for predictive maintenance, analytics, smart self-maintenance, a new generation of SCADAs, full IT/OT integration, 5G, and cybersecurity.

1 Global Wind Offshore Energy Council (GWEC) report 2022.
2 IRENA WORLD ENERGY TRANSITIONS OUTLOOK 2022 1,5°C Pathway Exec Summary
3 Wood Mackenzie
4 Global Wind Offshore Energy Council (GWEC) report 2022.
5 Global Offshore Wind Report HY1 2022 report

Offshore wind energy could be a promising enabling technology for generating competitive green hydrogen and power-to-X. This is due to higher hours of electricity generation which can maximize electrolyzer production through seawater.

Offshore plants located on oil and gas platforms could produce green hydrogen that mixed up to 20% of gas could be transported to land via the existing gas pipeline infrastructure.

Since the early 2000s, offshore wind turbines have grown in power, size, height, and blade length. A new generation of offshore wind turbines are currently being developed, reaching a power capacity of between ~14 MW and 17 MW. With rotor diameters above 200 meters, blade lengths over 100 meters, and height close to 300 meters, this level of magnitude is comparable to that of the Eiffel Tower. Increasing the size of wind turbines will reduce costs, as well as raise efficiency and economies of scale. This will inevitably result in a higher energy output and a reduction of cost of energy per MWh. By 2030, the next generation of offshore wind turbines could reach a power capacity of ~20 MW and a rotor diameter of ~275 meters. Over the past 10 years, these super scale designs have been a key contributor to dropping wind offshore LCOE by more than 65%[6].

6 BNEF.

FIGURE 2
New offshore wind installations, 2021

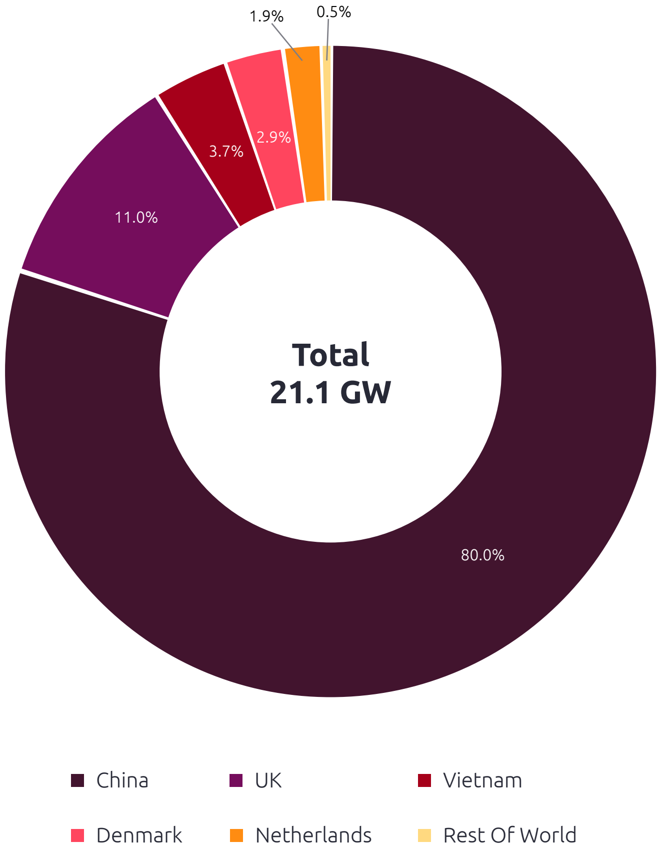
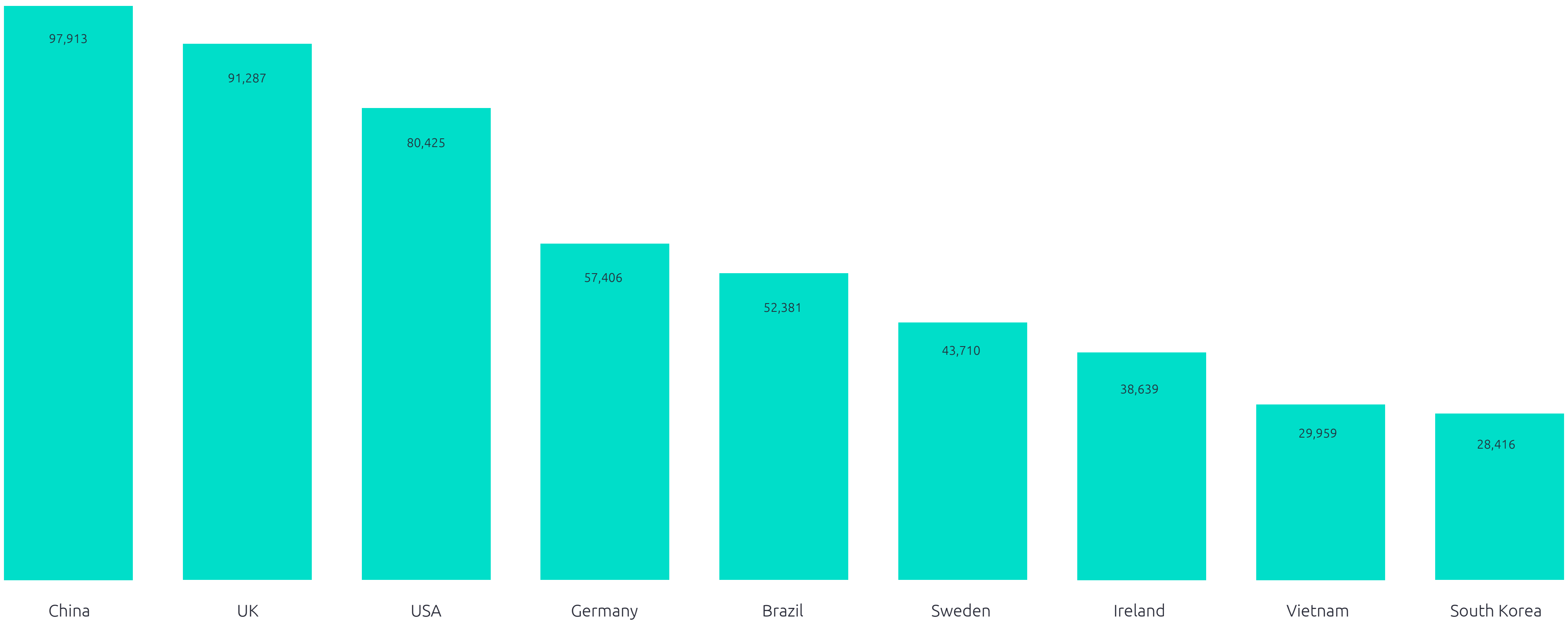


FIGURE 3

Global Total Programme Portfolio by Country (MW)



Source: Global Wind Offshore Energy Council (GWEC) report 2022

In 2021, China accounted for 80% of the global total offshore wind power, followed by the U.K., Denmark, Vietnam, and The Netherlands. The market in China is dominated by four main Chinese manufacturers[1]. The rest of the market is mostly served by two Danish manufacturers and one American manufacturer.

The expected global portfolio of new offshore parks in 2022 has increased significantly. Compared to the last 12 months, the global portfolio is expected to double. Last year's global offshore wind power totaled 429 GW and is predicted to reach 846 GW in 2022. This activity has been led by China, U.K., U.S., and Germany.

Reaching such growth targets will require certain measures to be in place. In the short-term, there needs to be an acceleration in permitting procedures that work in harmony with nature and marine spaces. In the medium-term, structural policy and regulatory frameworks must be adhered to, as well as early and sustained investment in supply chain and infrastructure.

The offshore wind supply chain will face the same pressures on commodity costs and supply chain bottlenecks than onshore wind. Special advantages will be given to companies with strong competences in marine environments. Companies will need to invest in new equipment so they can meet growing demand and deliver bigger projects using larger turbines.

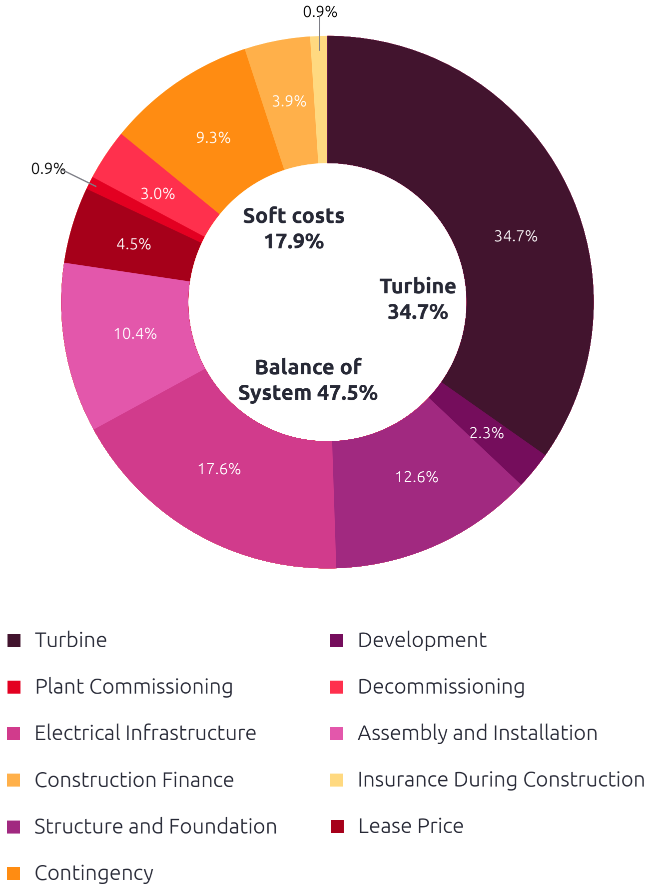
In comparison to onshore wind, the global supply chain (which sits behind offshore wind) is more diverse. Not only does it include OEMs and key component suppliers of nacelles, blades, generators and converters, gearboxes, bearings and control equipment, it also includes suppliers of cabling, foundations and substations, as well as suppliers to EPCs in marine conditions. Two-thirds of the value from offshore wind comes from non-turbine elements, such as substructure and foundations, electrical infrastructure, and assembly and installation.

The two primary drivetrain technologies used by the OEMs in China are direct drive (DD) turbines and medium-speed turbines – both of which have permanent magnet synchronous generators. The advantages of using these turbines include: improved energy efficiency; easier installation; and lower maintenance costs. The design and performance of components (such as blades, nacelles, engines, yaw and pitch control) are also enhanced. Technology innovation is a key differentiator in tackling challenges related to the supply chain, logistics, infrastructure, drivetrain, foundations, materials, and coatings.

1 Global Wind Offshore Energy Council (GWEC) report 2022

FIGURE 4

CAPEX for typical fixed-bottom offshore wind farm, 2020



Source: 2020 Cost of Wind Energy Review, Tyler Stehly and Patrick Duffy, National Renewable Energy Laboratory, 2021

Technological advancement in floating foundations has significantly contributed to the positive outlook for offshore wind. Floating offshore wind has moved from the pre-commercial phase, to adding 57 MW in new installations globally. This number has been growing exponentially, increasing the expected global portfolio to more than three times what it was during the past year and a half[1]. The floating offshore wind market is still maturing. However, multiple players and more than 100 concepts are readily approaching the floating designs with state-of-the-art technology, though there is little clarity over which concepts or manufacturing processes will be used in commercial projects. As a result, different industry players have joined forces, fueling growth in the floating offshore wind market in the latter half of this decade.

France has completed a tender for a 250 MW floating offshore wind project, which will take place in an area off the South Brittany coast. Italy has identified more than 17 GW of offshore wind potential, 70% of which lies in deep waters and therefore requires floating foundations. Although much of the activity in the U.S. is taking place on the East Coast, areas in California, the Gulf of Mexico, Alaska, and Hawaii also are starting to recognize the potential in utilizing offshore wind and floating technologies[2]. The U.K., Ireland, South Korea, Japan, Australia, Spain and China are also expected to drive growth in the floating offshore wind market.

Floating offshore wind unlocks an array of advantages:

- Due to sea installations with depths of between 50-60 centimeters, there will be less invasion of seabed and marine ecosystems, and therefore a reduction in environmental impact
- The installations will not be seen from the coast, minimizing visual impact
- There will be a larger surface area in which to build
- Wind resources will have greater and more regular power
- Construction will be cheaper, as floating turbines and platforms can be built and assembled on land and towed offshore using tugboats and cables (as opposed to using more expensive, fixed foundations)

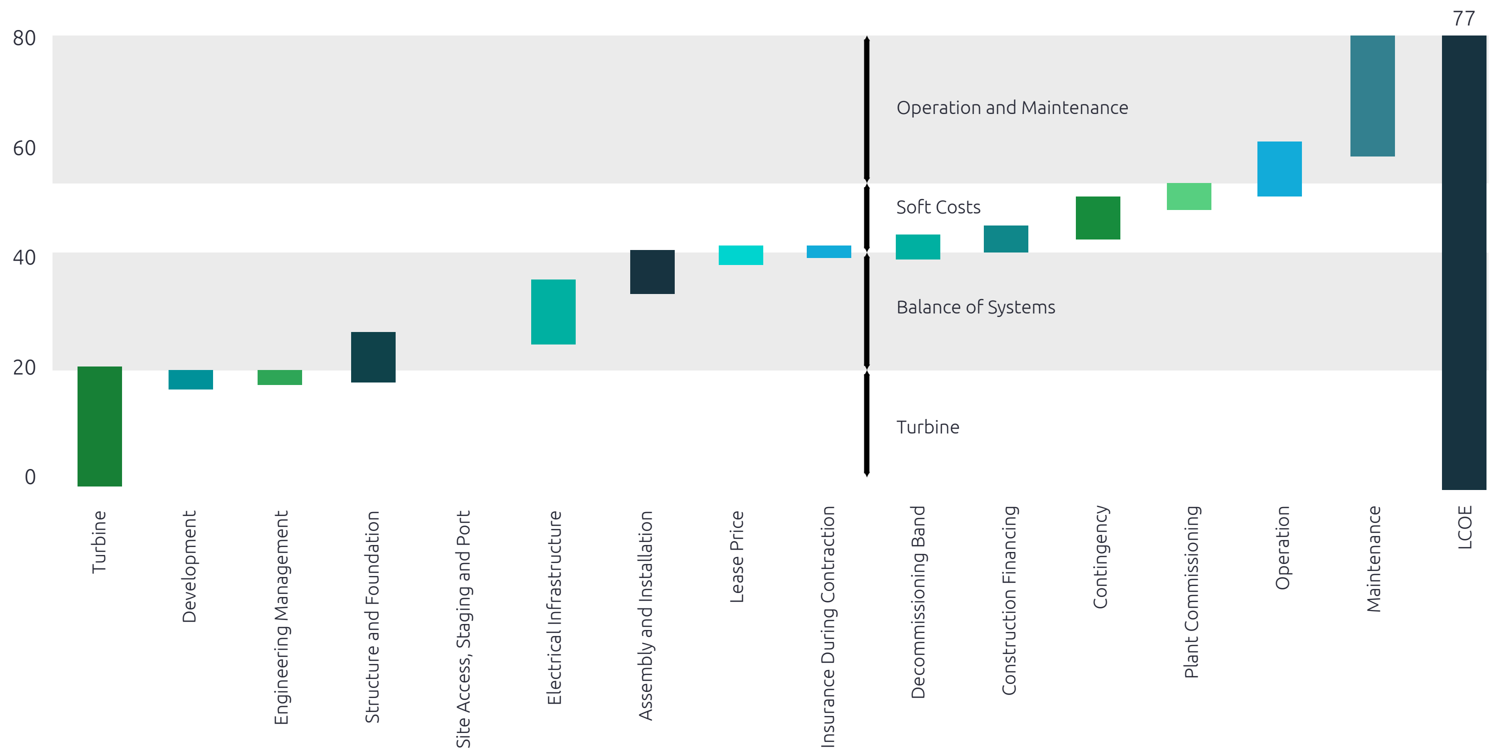
1 Global Wind Offshore Energy Council (GWEC) report 2022
2 McKinsey Insights: How to succeed in the expanding global offshore wind market

Deploying floating offshore wind at a large scale will face challenges:

- High-voltage cables and dynamic design provide underwater protection and insulation, but make lengthier transportation distances more complex
- Higher-voltage export cable technology, while innovative, is not yet mature enough to support floating substations on a large scale
- The power grid needs enough reliability to transport and distribute large amounts of power
- Materials need to be suitable for varying conditions in different sites (such as temperature, flotation and wind)
- Heavy maintenance could be required for longer time periods (such as 10 years)
- Transport wind turbines to a port for maintenance can be complex

FIGURE 5

Component-level LCOE breakdown for typical fixed-bottom offshore wind farm operating for 25 years, 2020



Source: 2020 Cost of Wind Energy Review, Tyler Stehly and Patrick Duffy, National Renewable Energy Laboratory, 2021

Solar PV & CSP

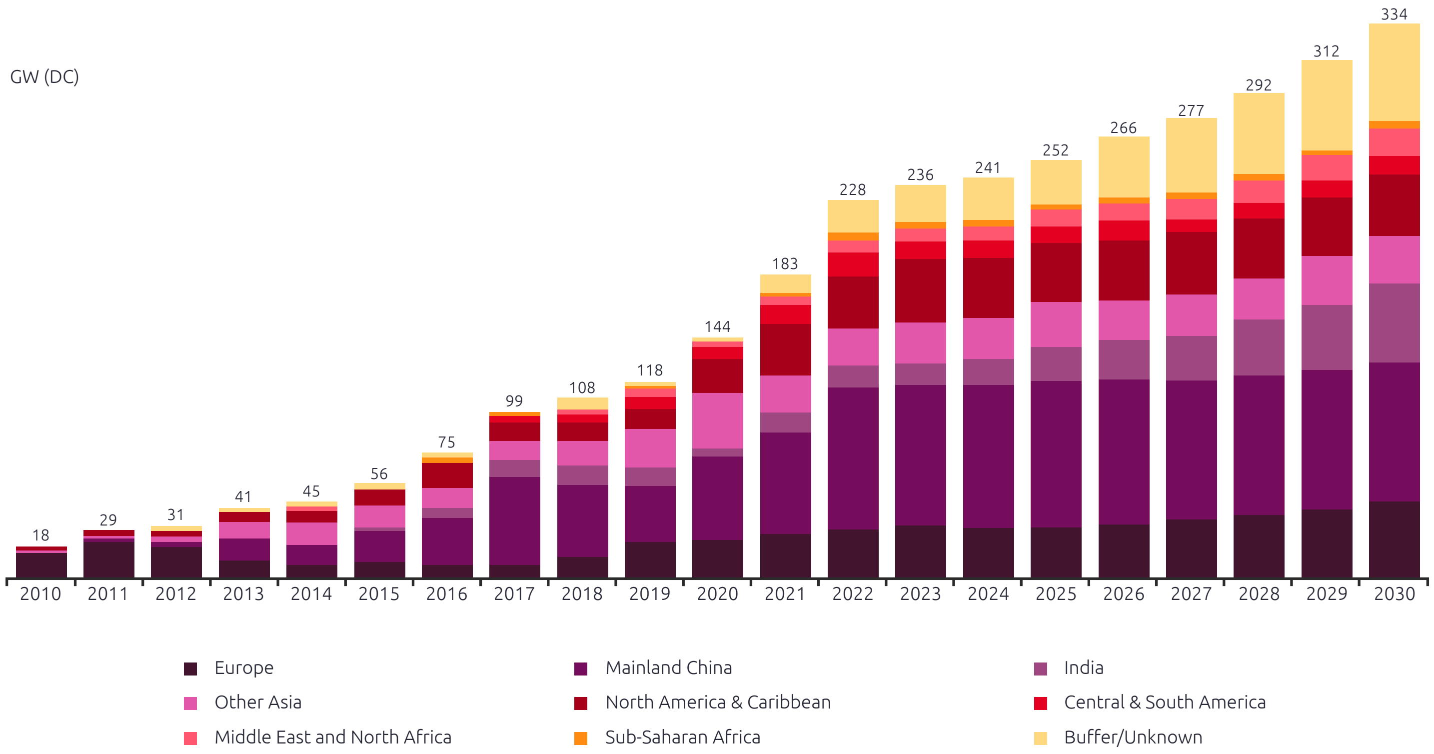
From 2010 to 2020, the worldwide weighted-average levelized cost of electricity (LCOE) from concentrated solar power (CSP) declined 68% while utility-scale solar photovoltaics (PV) dropped by 85%[1]. Global installed capacity of solar PV is expected to reach 5200 GW by 2030, a seven-fold increase compared to 2020[2] under 1.5°C scenario.

Newly installed PV capacity in 2021 reached 183 GW, 40 GW more than in 2020; new investments are estimated to cross the 200 GW mark for the first time in 2022, reaching between 204 and 252 GW[3]. Solar PV is leading the power sector investment, with positive investments for transmission and distribution networks and speeding up the global energy storage market for a 30% annual growth to 2030[4].

Solar PV panel prices increased by around 20% over the last year, as driven by higher polysilicon prices and bottlenecks within the manufacturing supply chain. High PV module prices (e.g., 166 mm monocrystalline solar module prices increased up to $0.28 per watt) are expected to decline in near future, as polysilicon production is likely to increase by 39% as new manufacturing facilities in China come online. The price of polysilicon has declined since October 2021, dropping to $32 per kg (down from $37) by the end of 2021; prices are expected to remain between $20 and $25 per kg in the second half of 2022[5]. Increasing efficiency in the production of large wafers of 210 mm is also expected to reduce module costs between 11% and 15%, with prices dropping to $23/24 per watt by the end of 2022[5].

FIGURE 6

Global PV annual installed capacity and forecast, January 2022 GW (DC)



Source: BloombergNEF

1 IRENA WORLD ENERGY TRANSITIONS OUTLOOK 2022 1,5°C Pathway Exec Summary
2 IRENA
3 BloombergNEF
4 IRENA WORLD ENERGY TRANSITIONS OUTLOOK 2022 1,5°C Pathway Exec Summary
5 BloombergNEF

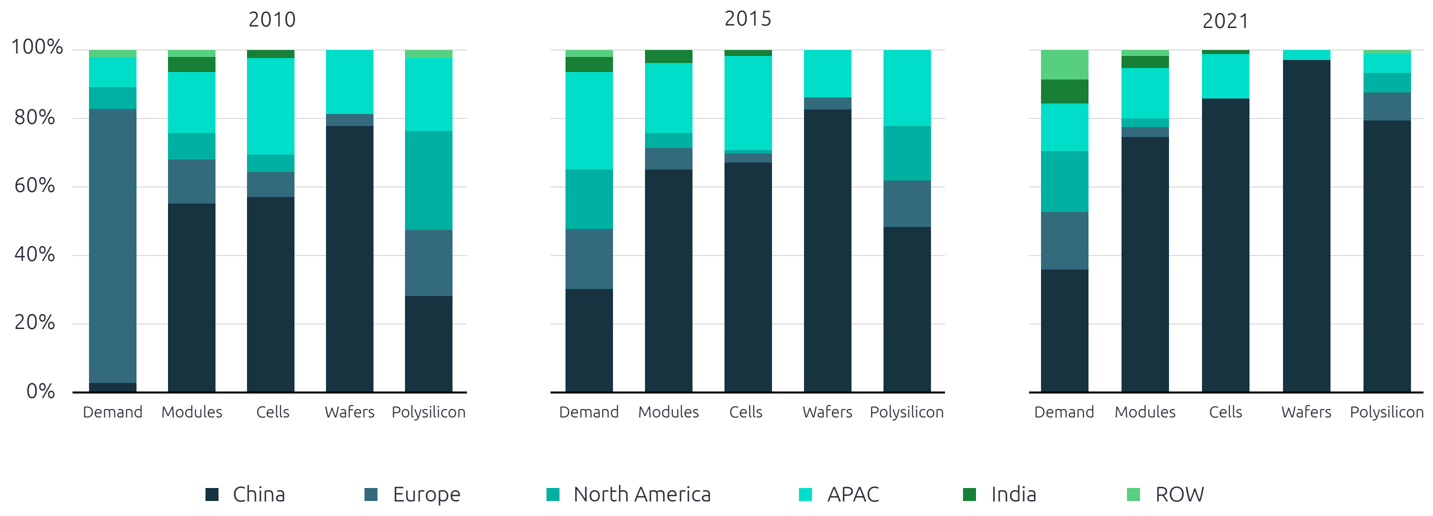
The current unbalanced situation between supply and demand, together with the ambitious path of decarbonization in many countries, will boost new production capacities for solar cells and solar modules. Production is increasing outside of China, particularly in India, U.S., Japan, and Europe, albeit at a slower speed. Diversification is one of the key strategies to ensure security of supply, reduce supply chain risks worldwide, and create local job opportunities. Under a 2050 net zero roadmap, global capacity of PV modules will double with investments totaling an estimated $120 billion in this industry. Meanwhile, PV panel manufacturing is expected to quadruple by 2030.

Over the last decade, China invested almost $50 billion in building a PV industry, 10 times more than Europe. Today, the top 10 PV module manufacturers are from China and the country's total market share in manufacturing of solar panel exceeds 80%. China also dominates polysilicon manufacturing. Polysilicon is the main bottleneck in the supply chain and prices quadrupled in 2021. Considering that current manufacturing capacity under construction is expected to rise in the coming years, China is likely to continue to dominate this industry, achieving an estinamed market share of 95% by 2025[1].

Crystalline silicon is the industry standard for PV modules with approximately 95% of the global market taken over by silicon technologies. The efficiency of this type of cell has increased in the last decade from 17% to 26.7% for monocrystalline silicon and 23.2% for polycrystalline[2].

FIGURE 7

Solar PV manufacturing capacity by country and region, 2010-2021



Notes: APAC = Asia-Pacific region excluding India. ROW = Rest Of World
Source: IEA, BNEF, SPV Market Research, PV Infolink

Current technological research and development in alternative materials, such as cadmium tellurium (CdTe) known as thin film type, are the most efficient with 19.2%. Perovskite is an abundant and versatile material with low production costs and high efficiency; it reached 17.9% efficiency in just 11 years. When used in combination with silicon, known as tandem cells, it achieved record efficiencies of 29.15%. Organic cells have also made enormous progress, reaching efficiencies of 11.7%. Current technological research and development in alternative materials, such as cadmium tellurium (CdTe) known as thin film type, are the most efficient with 19.2%. Perovskite is an abundant and versatile material with low production costs and high efficiency; it reached 17.9% efficiency in just 11 years. When used in combination with silicon, known as tandem cells, it achieved record efficiencies of 29.15%. Organic cells have also made enormous progress, reaching efficiencies of 11.7%.

1 6 IEA Special Report on Solar PV Global Supply Chains 2022
2 IEA Special Report on Solar PV Global Supply Chains 2022

Larger modules with bigger wafers (those having a side length between 182 mm and 210 mm) are becoming mainstream products and are expected to experience a drop in module prices. Manufacturing techniques and technologies of Black Surface Field (BSF) is expected to decline and gradually leave the market within five years. PERC/PERL/PERT/TOPCON type joints are the current market standard, capturing 80% of the market – a trend that is expected to continue. This type of cell is capable of capturing sunlight through its rear face. Reduced costs and increased efficiency in recent years has enabled the manufacturing of bifacial modules with performance gains of around 4-8%, depending on albedo conditions. This cell type has reached a market share of more than 30% and is expected to rise to about 80% in the next 10 years.

New tracker innovations have increased the performance of plants between 20%-35% with a single axis; this number is even higher when using bifacial modules, designs tailored to new PV modules, structural optimizations, new control algorithms based on AI, lower maintenance costs etc. Power inverters are decreasing costs while also increasing efficiency, power density and the flexibility of the equipment. incorporating monitoring and digital communication systems, mainly for central inverters and string inverters for utility-scale plants. Innovative trends focus on providing inertia and flexibility to the grid thanks to grid-forming inverters.

Environmental integration, agrovoltaic, solar floating, building integration, storage systems, green hydrogen or Power-to-X integrating PV, are some other inventions under development. Specialty storage solutions are growing and had a record-breaking year in 2021. Macroeconomic and market constraints will continue to present challenges and price pressures caused by spikes in costs for materials like lithium, graphite, and cobalt, which may not begin to ease until 2023. Battery pack prices are expected to fall below $100/kWh across the industry by 2024. Prices have fallen by about 89% between 2010 and 2021.

New PV generation of digital asset management and monitoring systems will optimize the return of the installation. This includes cybersecurity, AI and ML tools for predictive maintenance; drones to supervise installations with thermal cameras, plus automatic visual inspections; and smart control solutions to integrate to the grid and combine in hybrid installations with wind or storage.

Global CSP market growth deteriorated in 2021 despite reductions in the technology cost. The CSP market contracted to a total cumulative capacity of 6 GW; this decline of CSP in the past decade has resulted from competition with solar PV. By the end of 2021, 23 GWh of thermal energy storage in conjunction with CSP plants was operating, representing almost 40% of the global energy storage capacity outside of pumped hydropower.

CSP with storage is expected to play a key role in the energy transition process, not just for electricity production during daylight hours but also during night hours[1].

Thermal energy storage systems can be designed to store energy from 4 to 12 hours daily, and even for 24 hours. Next generation of CSP and TES plants are being developed with low-cost heat transfer fluids that can reach higher temperatures to increase the thermal cycle efficiency, while new materials, such as molten salts, rocks, sands, or concrete, and new tanks systems design, can improve energy storage.

1 Concentrating Solar Power Clean Power on Demand 2477 - Protermosolar The Spanish Case

HYDROGEN

RICHARD BIAGIONI
BENOIT CALATAYUD
JEAN-LUC CHABAUDIE

The European Union (EU) has set ambitious strategies to develop the production and use of hydrogen

Because hydrogen has been identified as a crucial enabler of the energy transition, the European Union has begun to build a legal framework conducive to its emergence.

To achieve the energy transition objectives, the EU is interested in the production and use of hydrogen because renewable or low-carbon hydrogen emits minimal carbon dioxide and almost no air pollution. Russia-Ukraine war is also accelerating the development of hydrogen economy in Europe particularly for hard to abate industries, as well as heavy transportation.

Renewable or low-carbon hydrogen is, therefore, a central lever for reaching the goal of carbon neutrality in 2050, which both the European Union and France have committed to.

Hydrogen produced from renewable or decarbonated sources is considered one of the available and efficient solutions to meet energy transition goals. It can be used as a raw material, fuel, energy carrier, and storage solution for electricity.

The European strategy specifically aims to use hydrogen to help decarbonize other industrial sectors (such as the steel industry), ensure the storage of electricity, or power the transportation sector.

The development of the hydrogen sector is also of interest to the European and EU countries economic recovery plans designed to contribute to remedying the immediate economic and social damage caused by the pandemic.

Indeed, it is estimated that the hydrogen sector could create up to one million high-quality direct jobs by 2030 and 5.4 million by 2050.[1]

However, the implementation of hydrogen technologies requires overcoming a certain number of barriers. Today, renewable hydrogen and low-carbon hydrogen are not cost competitive when compared to hydrogen from fossil fuels.

1 European Parliament resolution of May 19, 2021, on a European strategy for hydrogen (2020/2242(INI))

Estimated current cost of fossil hydrogen	Estimated cost of low-carbon hydrogen	Estimated current cost of renewable hydrogen
€1.5/kilogram	€2/kilogram	€2.5 - €5.5/kilogram

Therefore, public support and an appropriate legal framework are necessary to support the development of this new sector and match European ambitions. These support mechanisms will also need to include sufficient flexibility and clarity to provide legal certainty to investors.

Recently the European Commission announced the creation of a European Hydrogen Bank with €3 billion investment to make the most of the rapidly developing clean hydrogen economy.

Since the European legal framework is still in the process of being built, it is too early to say how efficient it will be. However, the main lines of these legal frameworks have already been drawn. The purpose of this article is to present the first steps taken by the European Union to create a legal environment favorable to the development of the hydrogen industry.

Hydrogen needs strong support to become profitable and competitive. Public support, including financial support mechanisms and appropriate legal framework, is necessary to achieve the rapid and large-scale deployment of hydrogen.

The first steps of the European legal framework for the development of the hydrogen sector have been taken

In a communication from the European Commission dated July 8, 2020, the European Union adopted a strategy to develop clean hydrogen, which provides several measures to promote and support the hydrogen sector.

The ambitious European roadmap to develop clean hydrogen is divided into different phases allowing the measures to be adapted to the maturity of the sector.

The European Union has chosen to prioritize the development of renewable hydrogen and low-carbon hydrogen in the short- and medium-term.

To do so, it has set quantified objectives, which are spread over three phases corresponding to the different stages of maturity of this new sector:

From 2022 to 2024	From 2025 to 2030	From 2030 to 2050
The European Union aims to install at least 6 GW of renewable hydrogen electrolyzers and produce up to 1 million tonnes of renewable hydrogen per year. During this phase, public support should be quite significant since the hydrogen sector will still be relatively young.	The European Union aims to install at least 40 GW of renewable hydrogen electrolyzers and produce up to 10 million tonnes of renewable hydrogen. It is expected for hydrogen to become a fully incorporated part of the integrated energy system and its cost will gradually become competitive compared to other forms of energy production. During this transitional phase, it will be necessary to start preparing for the gradual withdrawal of public support mechanisms.	The European Union aims for renewable hydrogen technologies to reach maturity and be deployed at a large scale.

The identification and coordination of viable investments will be carried out by the European Clean Hydrogen Alliance.

Achieving the roadmap's objectives requires a robust and coordinated investment program while avoiding over-support.

In this respect, the European Union has launched the European Clean Hydrogen Alliance (the Alliance), which brings together leading actors from the sector, national and local governments, civil society representatives, the European Investment Bank, and other stakeholders.

This Alliance aims to build a pipeline of investment projects to increase the production and support the demand for clean hydrogen in the European Union; it will also identify and coordinate viable investment projects since effective coordination of investments is essential to the success of the sector.

At the occasion of the forum held on June 17-18, 20211, the Alliance presented 997 projects out of the 1,052 submitted. The eligibility of the selected projects was based on the following criteria: Alliance membership, geographic location, project maturity, and CO_2 emission threshold.

Several European funds are mobilized to financially support hydrogen projects, as well as enable small- and medium-sized companies and less developed Member States to take part in the development of the hydrogen sector

The European Union intends to mobilize different funds to help finance hydrogen-related projects and encourage the emergence of the sector. These funds should enable hydrogen sector operators, especially small businesses, to find the financial assistance adapted to the nature and scale of their project.

A plurality of existing European funding instruments is suitable to fund the development of hydrogen projects because a wide scope of hydrogen-related activities must be developed to enable the sector to emerge. These activities range from the production of renewable and low-carbon hydrogen, to its transportation and distribution, as well as its application in industry and mobility purposes.

As an example, it is estimated that funding in electrolyzers alone is expected to represent between €24 and €42 billion by 2030.

To facilitate access to relevant information on financial support, the European Commission has launched the Hydrogen Public Funding Compass, which is an online guide for all interested stakeholders to identify public funding sources for hydrogen projects.

This funding compass not only contains information on European funding programs and funds, but also on programs implemented at the national level by Member States.

The significant budgets contributing to the financing of clean hydrogen projects will be guided by the sustainable finance strategy adopted on July 6, 2021, the EU Taxonomy on Sustainable Finance adopted on April 21, 2021, and the Alliance.

About 15 European funds and programs are mobilized. Their purpose is to finance innovative technologies, research, sustainable energy infrastructures, small and medium-sized companies, sustainable development, and energy beneficial to the environment.

For instance, the Innovation Fund is dedicated to financing innovative low-carbon technologies. The focus of this program is not to fund research, but to promote the market introduction of highly innovative technologies. Therefore, this fund will be available to finance demonstration projects on the innovative production and use of renewable and low-carbon hydrogen on a pre-commercial scale.

European funding instruments offer five different types of financing. Depending on the case, hydrogen projects can benefit from: grants, loans, guarantees, equity, or trust fund prizes.

As an example, the Invest EU Fund mobilizes public and private investments through a €38 billion budget guarantee to support the investment projects of the European Investment Bank Group (EIB) and other financial partners.

Certain European funding instruments, such as the European Regional Development Fund and the Cohesion Fund, specifically target small and medium-sized enterprises and least developed Member States, so they can take part in the process of supporting the emergence of the hydrogen sector.

Hydrogen projects may receive funding from multiple European funding instruments, provided that these funds are not intended to cover the same costs.

The EU launched an important project of common European interest (IPCEI) specifically dedicated to hydrogen. 41 projects were announced in July 2022 with €5.4 billon from 15 Member States.

Important projects of common European interest consist of gathering the know-how and financial resources of the European Union's private and public actors to implement cross-border and large-scale projects that benefit the Union and its citizens.

By exception to the principle of the prohibition of state aids, the promotion of IPCEIs may be considered compatible with the internal market.[2]

To ensure that an IPCEI is compatible with the internal market, the European Commission assesses each project on its communication, dated November 25, 2021. It assesses the criteria relating to the analysis of the compatibility with the internal market of state aid to promote the execution of an IPCEI. **Projects that meet the criteria are exempt from competition and state aid rules.**

Pursuant to this communication, three categories of projects can be qualified as IPCEI:

- RDI projects with a major innovative character (Article 22)
- Projects involving industrial deployment for the development of a new R&D-intensive product (Article 23)
- Projects in the fields of environment, energy, and transport with a major impact on European strategies (Article 25).

In July 2022, the European Commission has authorized public support of up to €5.4 billion from 15 Member States for an IPCEI in the hydrogen technology value chain. An additional €8.8 billion of private investment may also be mobilized. 41 projects proposed by 35 companies, including 10 French ones, have been selected.

The coordination of the investments in the framework of these projects are operated in light of the recommendations set out in the Strategic Forum for IPCEI report.

IPCEIs are particularly well-suited to the development of the hydrogen sector since it requires significant research and innovation efforts across the entire value chain.

This legal instrument will also encourage synergy between member states because the projects selected in this framework **must involve more than one Member State and benefit a significant part of the Union** without being limited to those who have contributed to its financing.

The major advantage of IPCEIs is they secure the flow of public money to investors at an early stage of the project.

2 Article 107 (3) (b), Treaty on the Functioning of the European Union.

Supply is beginning to be structured but support for demand is key to the emergence of a competitive industry, in the context of the Ukrainian war

In the context of the Ukrainian war, REPowerEU plan, plan places hydrogen as a key element in achieving affordable, secure, and sustainable energy for Europe.

While the Fit for 55 package set a target of 5.6 million tons (Mt) of decarbonized hydrogen per year by 2030, the European Commission has decided to increase this target by 14 Mt. Of this total consumption, 8 Mt of hydrogen would replace 27 billion cubic meters of natural gas imported from Russia and 3.9 Mt of Russian oil.

In order to reach these new objectives, 9.6 Mt of renewable hydrogen will be produced within the Union, while 10 Mt will be imported. Hydrogen imports (6 Mt) would be done by pipeline, while the ammonia imports (4 Mt) would be done by ships.

Three import corridors are selected: the southern Mediterranean (with Morocco and Egypt as priority partners); the North Sea (United Kingdom and Norway); and Ukraine, if conditions permit.

In February 2022, Europe decided to invest €300.5 million in clean hydrogen technologies to boost renewable hydrogen production, reduce its costs, develop its storage and distribution solutions, and stimulate the use of low-carbon hydrogen in hard-to-abate sectors, such as energy-intensive industries like aviation or heavy-duty transport.

A novelty is that it foresees several “flagship projects”, which are expected to have a significant impact in accelerating the transition to a hydrogen economy.

In May 2022, the announcement of a European Electrolysis Alliance, which brings together the main players in electrolyzer production, aims to increase electrolyzer construction capacity tenfold by 2025.

This increase will allow for an annual production of 10 million tons of renewable hydrogen in the EU by 2030, which is the target set in the REPowerEU Communication of March 2022.

While public support is important and supply is beginning to be structured, the challenge now is to shift it to demand-side support. Indeed, the supply of hydrogen produced must be secured by the uses (industries, mobility in particular) through their aggregation in identified geographical basins.

Commission approves up to €5.4 billion support by 15 Member States for an Important Project of Common European Interest (IPCEI) in the **Hydrogen Technology value chain** “IPCEI Hy2Tech”

Hydrogen Generation Technology	Fuel Cells Technology	Storage, Transportation and Distribution Technology	End User Technology
1st Energy*	1st Energy*	Arkema	Alstom FR
Advent*	Advent*	B&T Composites*	Alstom IT
Ansaldo	Alstom	Daimeler Truck	Bosch AT
AVL	Ansaldo	Enel	Daimler Truck
Christof Industries	Arkema	Faurecia	Fincantieri
De Nora	Bosch DE	NAFTA	HYVIA
Elcogen*	Daimler Truck	Neste	Iveco CZ
Elogen	De Nora	Ørsted	Iveco ES
Enel	EKPO	Plastic Omnium FR	Iveko IT
Genvia	Elcogen*		Neste
H2B2*	Fincantieri		Ørsted
Cummins	Genvia		Plastic Omnium AT
John Cockerill	HYVIA		Plastic Omnium FR
John Cockerill	Iveco		
McPhy*	Nedstack*		
Nordex	Plactic Omnium AT		
Ørsted	Symbio		
Sener			
Startgate			
Sunfire*			
Synthos			

*SME

Source: European Commission, July 2022

France adopted the Hydrogen Ordinance, which outlines the main support mechanisms for developing the hydrogen sector. However, the regulations specifying the applications have not yet been adopted

The first milestones of the French legal framework for hydrogen were laid out in the Ordinance n° 2021-167 dated February 17, 2021. The Ordinance resulted in the creation of a new section in the French energy code. The government stepped in to define the framework of the support of renewable and low-carbon hydrogen.

The Ordinance distinguishes between renewable, low-carbon, and carbon-based hydrogen, and provides definitions based on the primary source used for hydrogen production. In France, public support exclusively concerns the production of renewable and low-carbon hydrogen.

The establishment of clear terminology is important for investors. **However, the sector's professionals are still waiting for the issuance of a decree of the French Ministry of Energy containing the thresholds above which hydrogen can be considered as renewable or low carbon.**

The eligibility of projects for public support will depend on this qualification (Article L. 811-1, French energy code).

The Ordinance provides public support for the production of renewable or low-carbon hydrogen by electrolysis of water (Article L. 812-1, French energy code). This support is open to any person established in the territory of a Member State of the Union or the European Economic Area. Depending on the case, this public support will take the form of:

1. **Financial aid for investment**
2. **A combination of financial aid and operating aid (Article L. 812-2, French energy code).**

Clean hydrogen projects eligible for support will be selected following a tender procedure that complies with the principles of transparency and equal treatment, the terms of which will be specified by a decree of the conseil d'Etat (Article L. 812-3, French energy code).

The French National Energy Regulator, which was consulted to give its views on the Ordinance draft, expressed reservations about the use of calls for tenders to support renewable and low-carbon hydrogen produced by electrolysis.

The regulator questions the level of maturity of the hydrogen sector and its capacity to meet the prerequisites necessary for the proper functioning of a call for tenders, such as:

1. **A sufficient number of projects to maintain the competitive pressure and the effectiveness of the tender**
2. **Knowledge of the operating costs of the projects, so public authorities can define the specifications and a suitable support mechanism**

The operating aid granted will be subject to a contract with the state, with a maximum duration of 20 years, setting out the terms and conditions for the payment of the aid, its duration, the frequency of payments, and the conditions for receiving the aid (Article L. 812-4, French energy code).

To avoid reproducing the same situation as photovoltaic energy, which had such significant public support that it led to a windfall effect, the Ordinance contains provisions to ensure hydrogen-related projects are not overly supported.

Two articles of the Ordinance provide mechanisms to avoid the risk of excessive remuneration of hydrogen project managers who benefit from operating aid:

1. The amount of operating aid granted must not result in the total return on capital exceeding a reasonable level, considering the risks inherent in the activities supported by the aid (Article L. 812-5, French energy code).
2. The contract concluded that the French State may subordinate the benefit of the operating aid to the renunciation, by the producer, to some of his financial or taxation aids (Article L. 812-5, French energy code).

Moreover, since this support mechanism is transitory, the operating aid may be partially or totally suspended by the competent administrative authority if it no longer meets the objectives of the French Annual Energy Programs (Article L. 812-7, French energy code).

While the broad outlines of the French support system for the hydrogen sector have been outlined in the Ordinance, the **precise rules still must be specified** by a decree after the consultation with the conseil d'Etat.

Conclusion

The European Union, faced with the emergency of climate change, has fully seized the challenge of hydrogen.

They have set ambitious objectives and adopted the fundamentals of a legal framework that seems promising for a rapid and large-scale deployment of the hydrogen sector.

However, these legal frameworks are still in the process of being completed. Therefore, investors and hydrogen project managers are still waiting for the complete European legislation that will be adopted after the debates with the Member States on the European Commission's strategy, as well as the French regulatory framework.

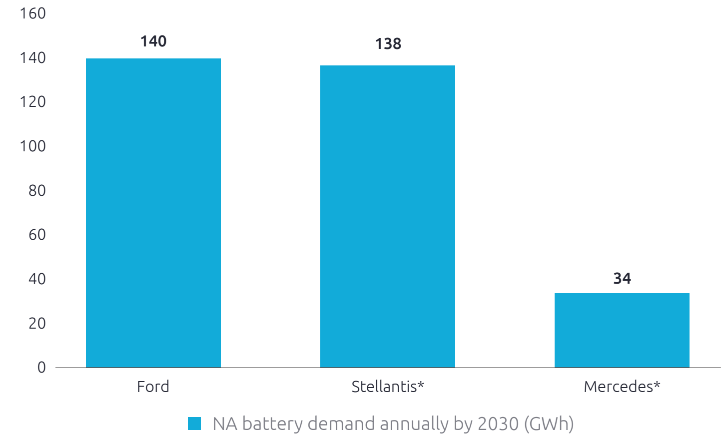
In addition, the implementation of support mechanisms for hydrogen projects, especially on the demand side, is essential but not sufficient to guarantee a substantial take-off of the hydrogen sector. It is necessary to also put in place a coherent regulatory framework that offers visibility to investors apart from the financial circuit.

GIGAFACTORIES

RICHARD BIAGIONI
PIERRE BAGNON
SIMON SCHÄFER
DAVID MANDRYSCH

FIGURE 1

Battery Demand in NA as declared by some car manufacturers by 2030



*Demand declared at global level. Extrapolating it based on current NA sales share

Source: insideevs, theicct

FIGURE 2

EV sales target as a percentage of overall sales in NA as declared by some car manufacturers

Car Manufacturer	2030	2040
Ford	40%	--
General Motor	40% (US)	100% (US)
Volkswagen	50%	--
Honda	40%	100%
Stellantis	40% (US)	--
Toyota	15% (US)	--
Mercedes	50% (US)	--

*Data is for NA. US specific targets are mentioned in brackets

Source: insideevs, theicct

Observations and insights: North America (NA)

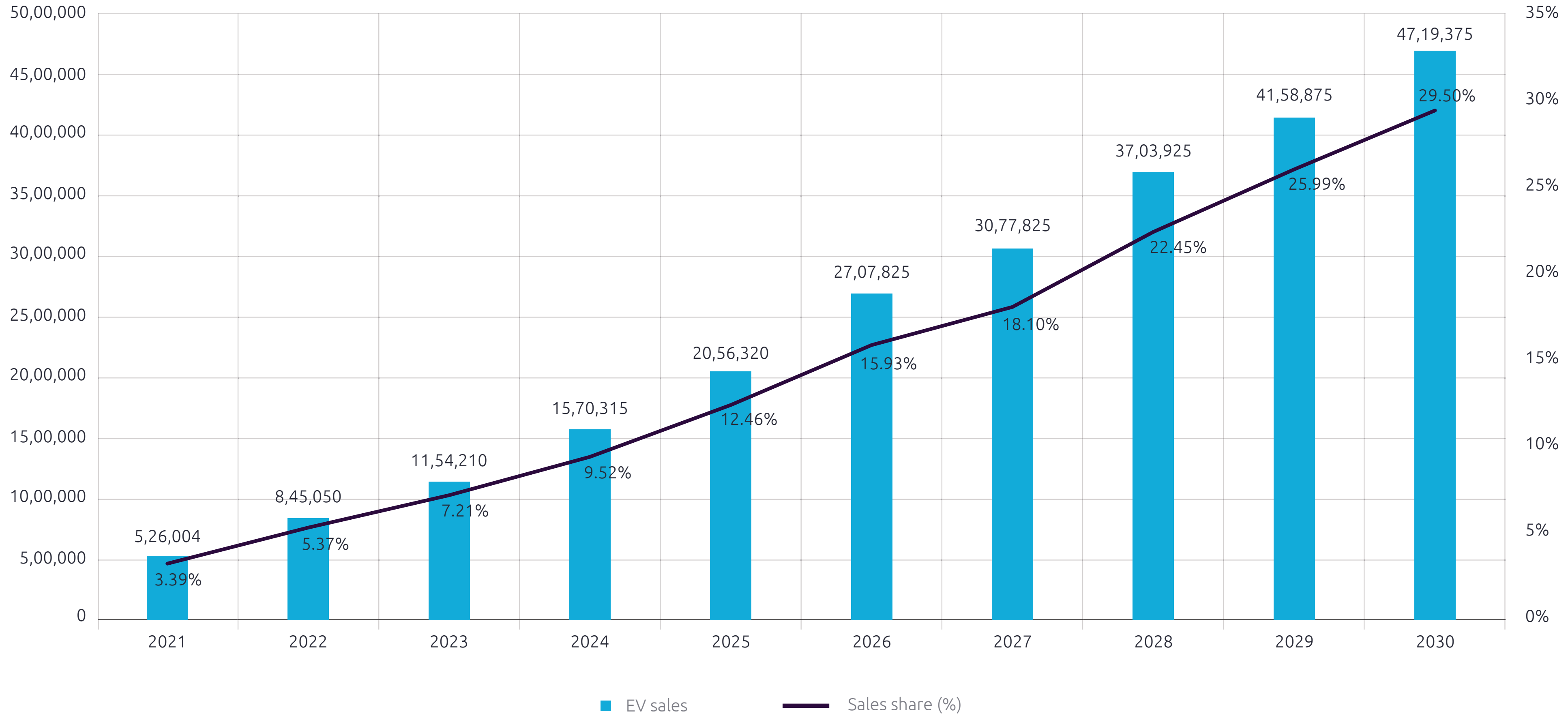
Highlights:

- Q1 2022 registered nearly 160,000 EVs – a 60% increase from the previous year.
- By 2030, EV sales are forecasted to reach approximately 29.5% of all new car sales, up roughly 3.4% from 2021. This would also see sales increase to 4.7 million in 2030, up from just over 500,000 in 2021.
- About 15% of approximately $345 billion in global automaker EV investments appear to be destined for the U.S.[1].
- About 10% of the 22 million EV sales (2.3 million) are expected to be manufactured in the U.S. across automakers by 2025[2].
- Seven of the 44 major U.S. vehicle assembly plants are slated to be making all EVs by 2025 (three owned by General Motors, two by Tesla, and one by each emerging EV company, Rivian and Lucid Motors)[3].

1 https://theicct.org/sites/default/files/publications/us-position-global-ev-jun2021-1.pdf
2 https://theicct.org/sites/default/files/publications/us-position-global-ev-jun2021-1.pdf
3 https://theicct.org/sites/default/files/publications/us-position-global-ev-jun2021-1.pdf

FIGURE 3

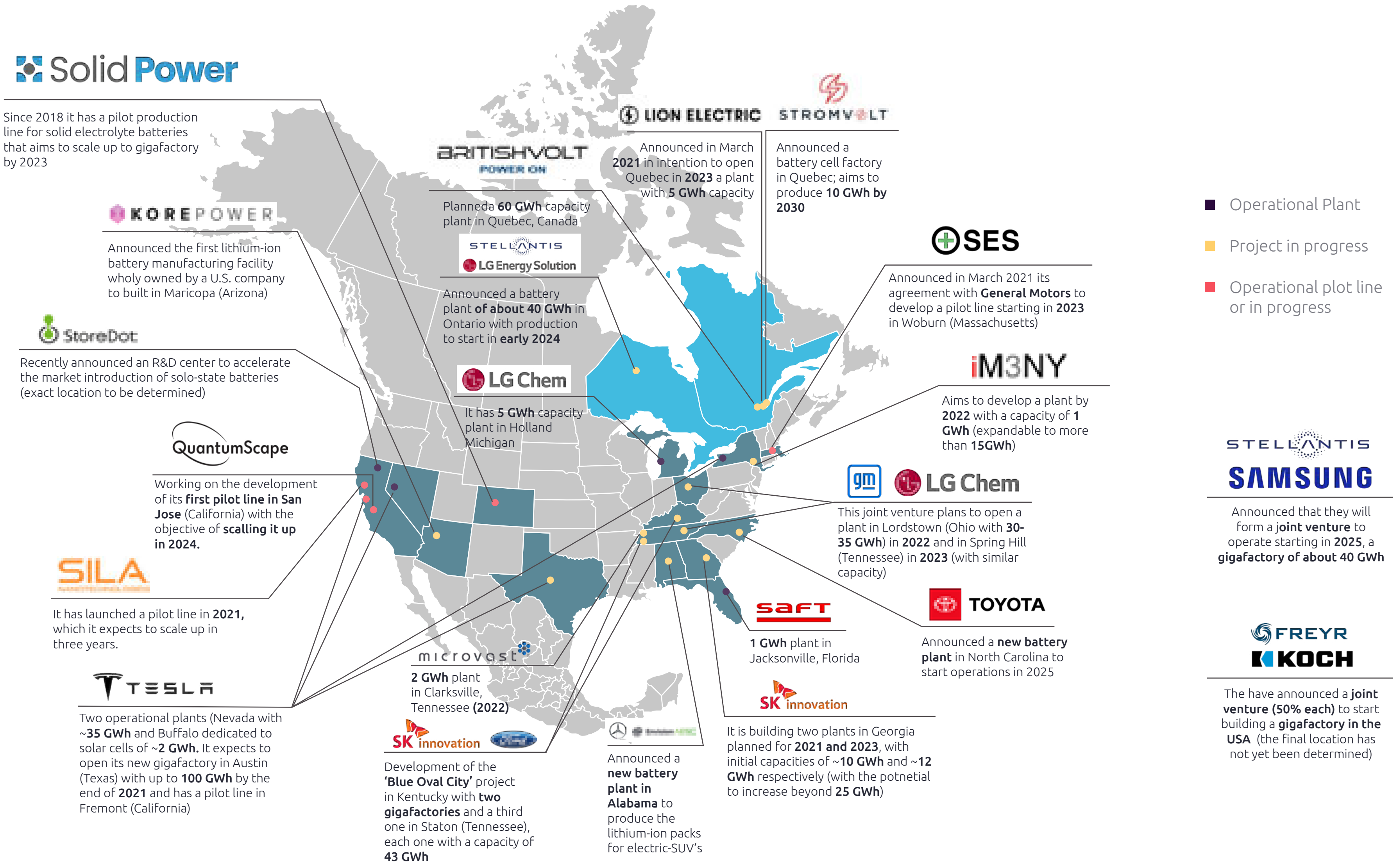
US EV Sales and Sales Share Forecast 2021-2030



Source: EV Adoption, GoodCarBadCar.net, Inside EVs, Deloitte Insights

FIGURE 4

North American Battery Initiatives



Source: CIC Energigune

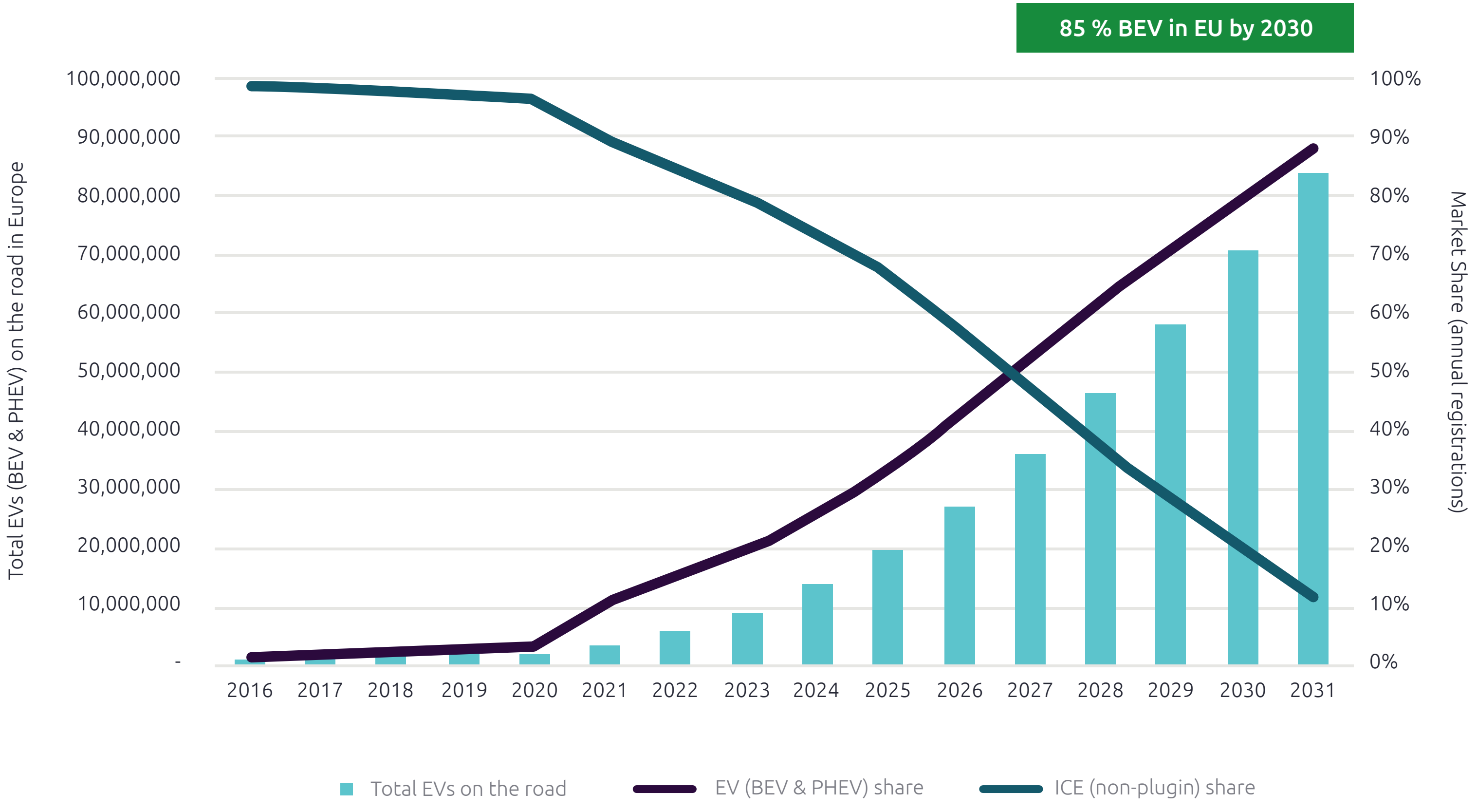
Observations and insights: europe

Major market drivers pulling in the same direction will result in:

- EVs clearly dominating European car sales in the coming decade
- The market share of all EVs (including BEV and PHEV) representing almost 90% of the market in Europe by 2030
- Approximately 80-90 million EVs in Europe by 2030
- Access to sustainable raw materials is required to fuel this market and the key to developing the battery industry in Europe

FIGURE 5

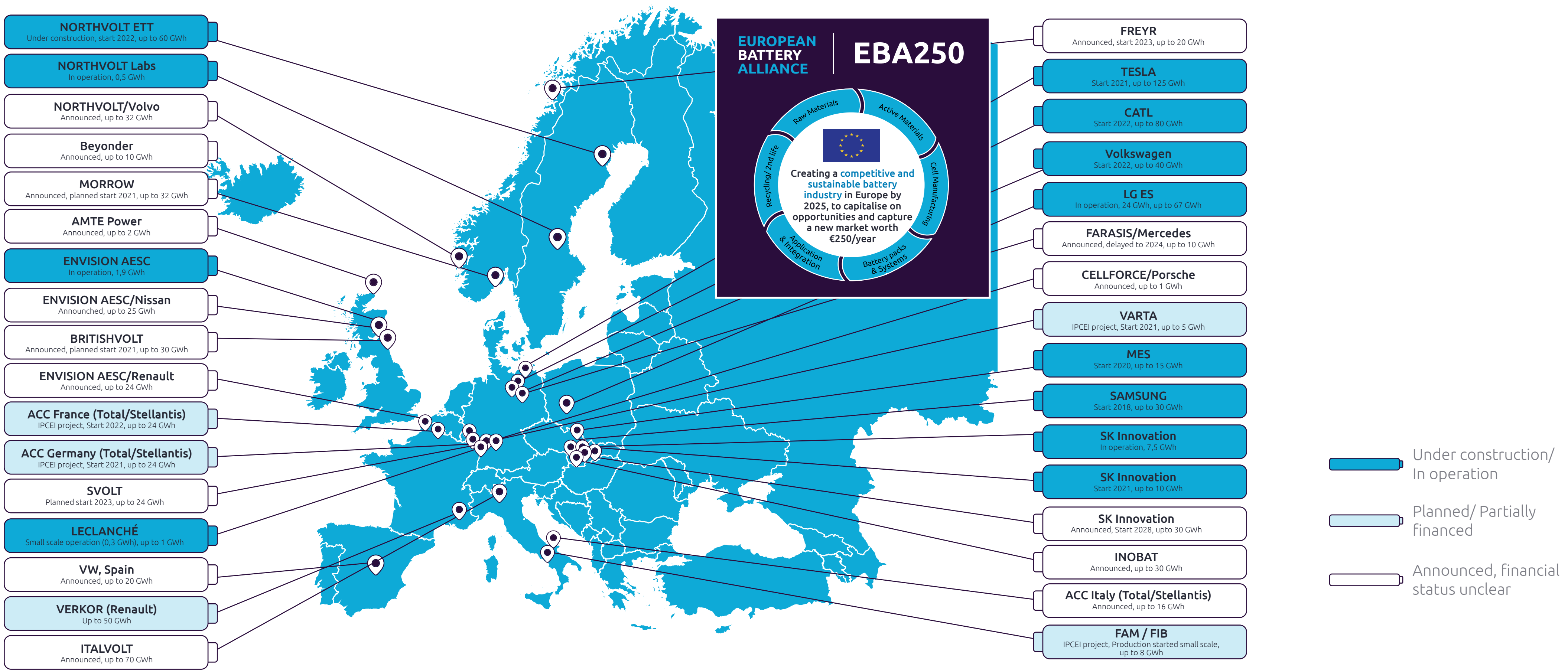
European EV Uptake Rates to 2030



Source: Delta-EE & ACEA | Europe: EU + EFTA + UK | EVs, BEVs, PHEVs & eLCVs | Actual data: 2015-2020. Forecast data from 2021.

FIGURE 6

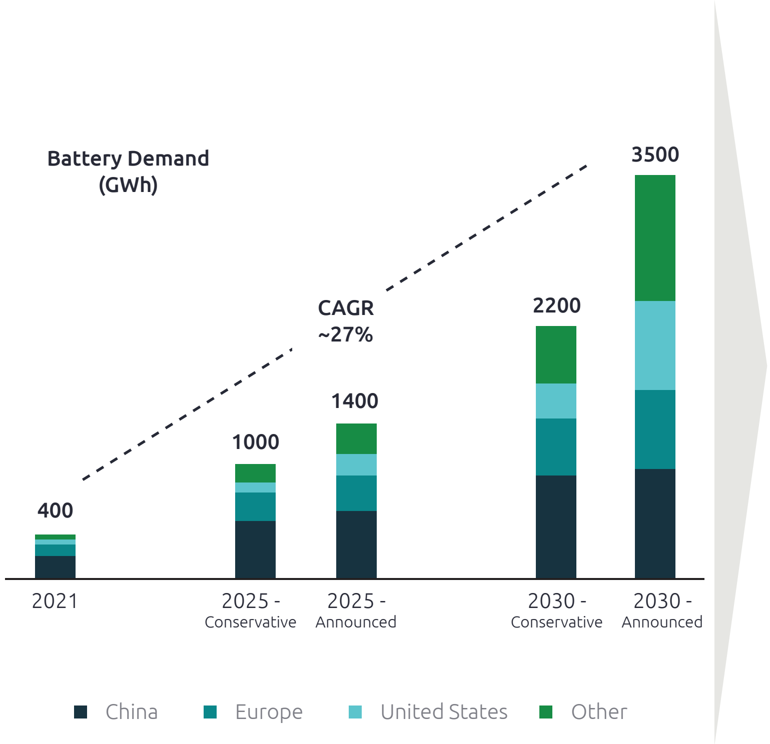
Ongoing and planned Li-ion battery cell factories in Europe



Source: The EBA, 2021

FIGURE 7

The increasingly vibrant market for EVs is analogous to the rise in demand of batteries by 2030



Startups	**northvolt** • Backed by EIB • Aims for 150 GWh by 2030	**VERKOR** • Backed by EQT Ventures, Renault • Increase capacity from 16 GWh (2025) to 50 GWh (2030)	**QuantumScape** • Solid state battery • Planned capacity of 21 GWh by 2030	**FREYR** • Increase capacity from 43 GWh (2025) to 200 GWh (2030) • $3 billion supply deal with Japanese Nidec
Incumbents	**SAMSUNG** • $1.48 billion investment in Hungary for 60 GWh • $2.5 billion plant in U.S. with Stellantis	**Panasonic** • Exploring EU with Nordic Equinor • A second $4 billion EV battery plant in U.S.	**CATL** • Partnership with Mercedes for $7.6 billion 100 GWh factory in Hungary	**LG** • Investing $11 billion in cell manufacturing in U.S. • Investing €1 billion in Poland
OEMs JV/ Subsidiary	**Mercedes-Benz, STELLANTIS, saft** • JV (ACC) to increase industrial capacity to at least 120 GWh by 2030	**Volkswagen, BOSCH** • Exploring the establishment of an EU battery equipment solution provider	**STELLANTIS, SAMSUNG** • Announced a $2.5 billion JV to build an EV battery plant in U.S.	**HONDA, LG** • To build a $4.4 billion lithium-ion plant in the U.S. • Estimated capacity of 40 GWh

Source: International Energy Agency 2022, International Energy Agency Gobal Supply Chains EVBatteries 2022 Including PHEV and BEV; Summarizing Light-duty Vehicles (i.e., Passenger Cars), Bus and Trucks Sales, assumptions consider growing average battery size per vehicle within the next years; sales are based on the International Energy Agency STEPS Scenario, STEPS is the Stated Policies Scenario

Trends in Technological evolutions will impact the product and production strategy of gigafactories

“New gigafactories, need to be flexible and scalable to not only meet future demand but to be capable of shifting future battery technology requirements, including the need to integrate circularity requirements.”

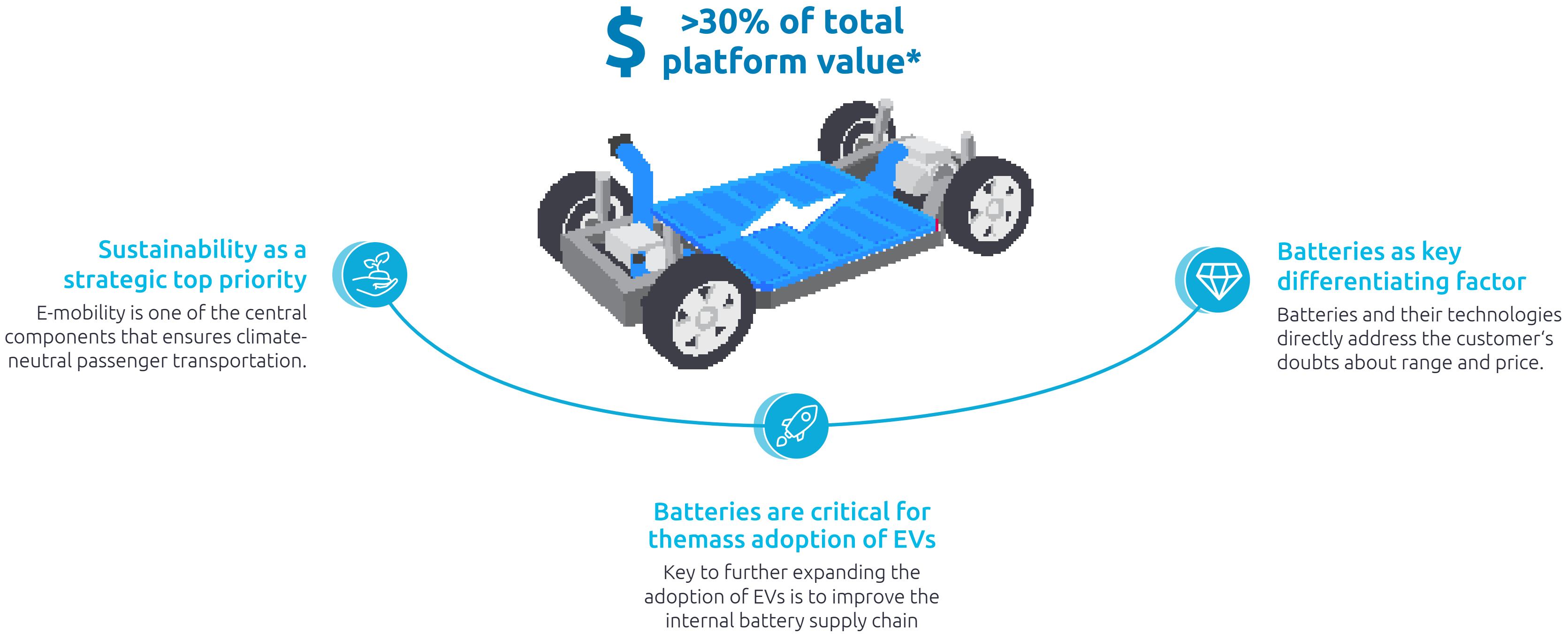
FIGURE 8

	Trend	Description
	Alternatives in chemical battery design	Battery manufacturers and scientists are researching battery solutions that do not contain critical raw materials (e.g., moving from cobalt to nickel).
	Cell-to-pack (CTP) and cell-to-chassis (CTC)	Suppliers are working on the development of cell-to-pack and cell-to-chassis with optimized pack structure, enabled by LFP technology.
	LFP in entry level models	LG Energy Solution plans on building a pilot line for the LFP batteries in 2022. Unlike other LFP batteries, these will be of a pouch type.

FIGURE 9

The battery value chain is a key contributor to the large-scale adoption of EVs

Batteries represent a major stake of the total value of an EV. With sustainability as a strategic priority, e-mobility and batteries are critical and differentiating factors for the mass adoption of EVs and improvement of the supply chain.



Based on calculation on C Segment vehicle 2025 varying between BEV modified or dedicated platform, source: Bloomberg NEF 2021, T & E | Battery prices rose the first time since 2010, Bloomberg NEF forecasts the average battery price will climb to $135/kWh in 2022 bnef 2022

Trends n Raw material and active components (as well as equipment) are increasing the need to secure supply chainst

"…a shortfall in raw materials critical to battery production, as EV demand rises, could result in OEMs struggling to fill orders."

FIGURE 10

Trend	Description
Raw material shortages impacting the battery supply chain	Delivery shortages pose a major risk to the OEM's battery supply chain, especially for nickel, lithium, and cobalt, as well as graphite. Geopolitical developments will increase uncertainty.
The evolution of battery composition	The next generation of batteries may result in a decrease of nickel and cobalt demand.
Production challenges due to raw material supply chain constraints	Variabilities in raw material deliveries require an adaptation of formulations, which leads to the adaptation of production processes.
The need for transparency, data and risk management	More effective tracking and tracing of materials can assuage concerns of potential investors towards meeting the ESG criteria.
Price volatility in material markets	Volatile markets impact everyone, from raw material producers to those considering starting such operations. OEMs are intending to ramp up EV production.

Challenges in battery manufacturing are diverse, impacting stakeholders both strategically and operationally

FIGURE 11

- **China** has a coherent industrial strategy for **battery production.**
- **Europe** and **U.S.** are **regaining** through government acts.
- Startups supported by established battery manufacturers and OEMs

- **High volume of investments are required** to build-up EV battery production.
- **Attractive returns on investments** are only mid- to long-term.

- **Fierce competition** for material supply.
- **Scarcity** of lithium, cobalt, and nickel.
- **Concentration of mines** in China.
- **Raw material supply** variations.

- **Lack of solutions for circular battery supply chains.**
- **Meeting net zero targets** set by OEMs is essential.

- **Significant lack** of skilled **employees** that can operate a gigafactory.
- **Skilled labor shortage** in the battery value chain.
- **Existing** OEM **workforce is not yet equipped** with relevant skills.

- The **race** for **battery manufacturing,** commissioning, and production is being ramped up.
- **A high-quality manufacturing process and automation** is essential.

In Gigafactories, Managing people is as important as managing the technology

FIGURE 12

Identify matching talents

Find qualified employees in the battery sector through:

- Special recruitment measures, like tech fairs
- Incentives for existing employees to re-educate
- Qualification

Retain talents

Employees must be managed, motivated, retained, and supported by:

- Modern leadership structures
- Attractive training measures and development programs
- Retention and benefit programs

Support from Digital tools

The use of modern HR cloud software plays a crucial role in HR transformation and is an effective support for achieving people goals.

People Challenge

Gigafactory already has a very tight labor market. Very few engineers have the right qualifications. Furthermore, operators who have the right experience are hard to find. It is important to consider:

- How to motivate people from other production fields to qualify for gigafactory work.
- How to provide high quality re-education at scale.
- How to retain and further grow every team member after hiring or re-educating.

2022
350 employees

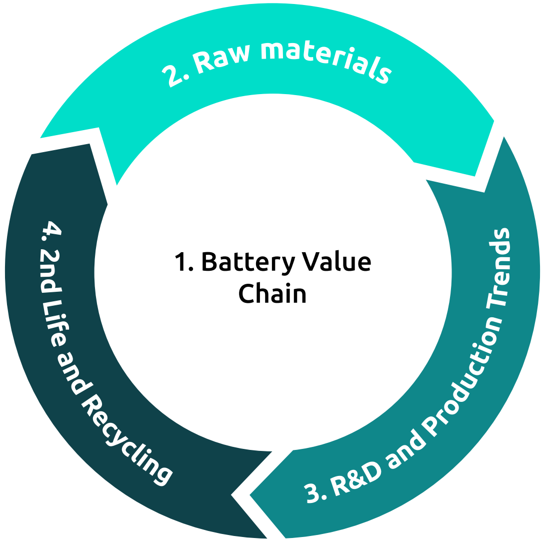
until 2030
20,000 employees

OEMs must act now to secure a successful e-mobility ramp-up, build a battery ecosystem, and consider second life scenarios

FIGURE 13

The battery value chain for a more sustainable future

- OEMs must diversify their battery supply chain
- Production facilities must be set up to meet growing demands
- OEMs must build a strong battery network



Recycling and second life solutions as success factors and business opportunities

- Players must consider battery end-of-life scenarios now
- No one-size-fits-all solutions – individual strategies implemented depending on targets
- Relevance of a strong partner ecosystem to tackle challenges

Raw materials are crucial for battery supply

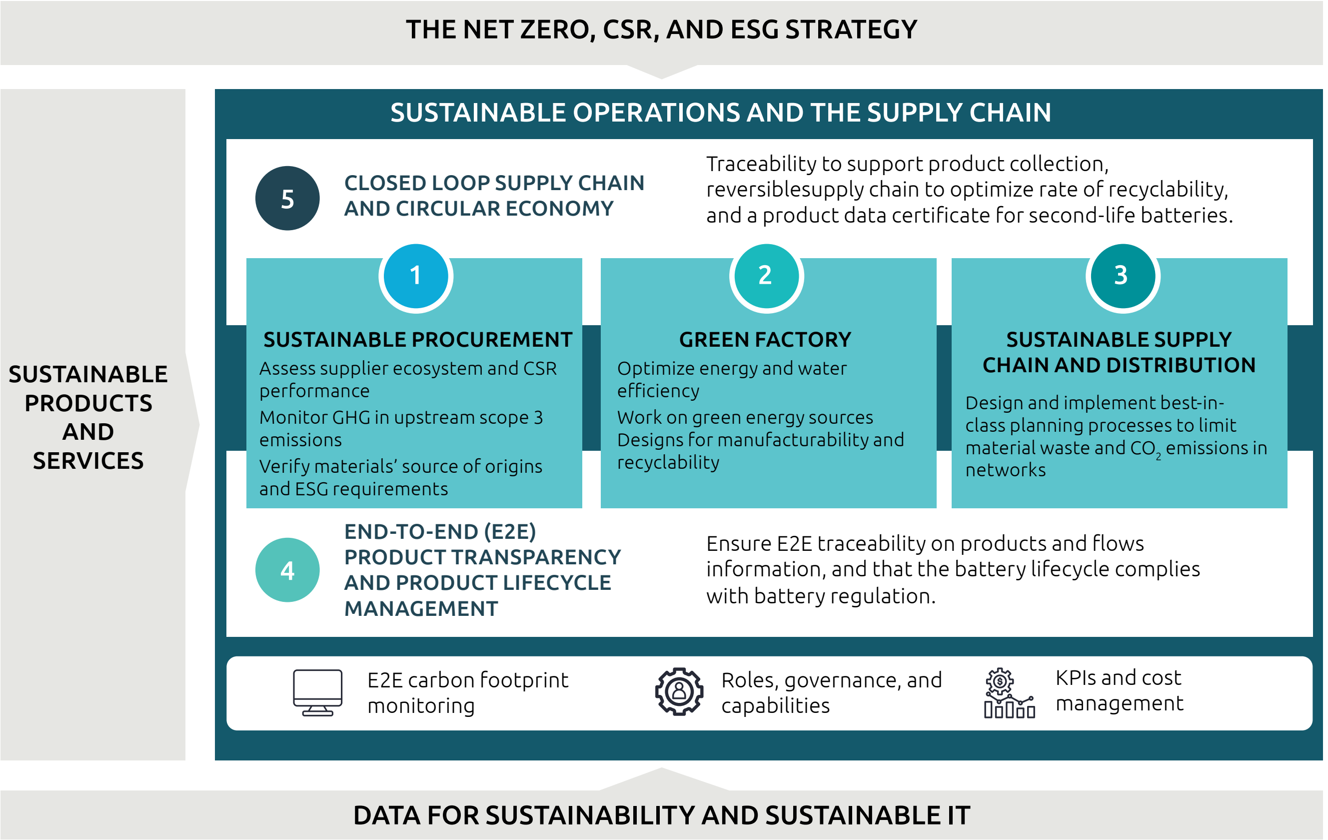
- React to the materials market's price volatility
- Uncertainty over future battery compositions
- The need for transparency, data, and risk management

Research and development (R&D) and production trends enable continuous improvement

- Flexible production to scale up for future technologies
- Battery design must meet recycling standards
- Production must reach full digitalization potential

In order to be a key component of AUtomotive Sustainability, the Gigafactory must be sustainable as well

FIGURE 14



PATH TO SUSTAINABILITY

Life cycle assessments and contributions to the environmental burden of different battery chemistries

"Cradle-to-gate" investigation of energy consumption, gas emissions, and water consumption.

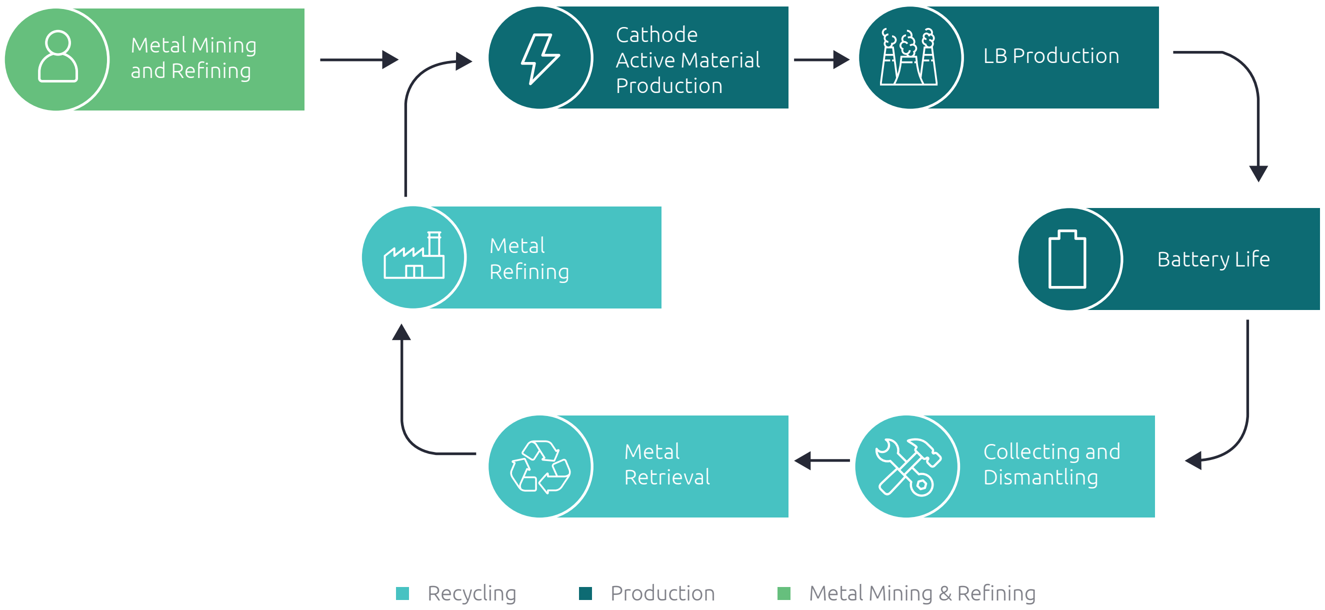
Pushing the value chain stakeholders to redesign the way they think, hire, and construct.

Recycling Batteries

- EV batteries are important for second-life use cases that have reduced energy or capacity and are therefore no longer an option. The disposing of batteries should be avoided at all costs, as this has an extremely hazardous effect on our surroundings. Large quantities of electronic waste containing lead and other toxic chemicals can pose a danger to both people and the environment.
- Disposing batteries wastes valuable and expensive materials that are used in their production. The same applies to metals that have highly fluctuating prices (like cobalt or nickel). Batteries and metals should be recovered, rather than wasted. In this way ,we can avoid relying on unstable deliveries and questionable companies that carry out ethically problematic practices and plague large parts of the mining industry. Recovering metals also gives European OEMs more autonomy on raw materials. This is a valuable advantage, considering their common geographical disadvantages.
- When it comes to sustainability, recent cases show improvements in the circular economy and supply chain; materials from EV batteries are more often reused, repaired, refurbished, and recycled, creating a closed loop. This has resulted in a decreasing need for new materials and an increase in second life batteries.
- Focusing largely on sustainability can work wonders for the quality of lives for local communities, particularly in areas where many of the materials for battery production are mined. Good practices avoid involuntary resettlement and artisanal mining and protects the indigenous people. If we maintain the successful implementation of these practices, we can minimize damage to these communities, while making everything more cost-efficient in the long-term.
- Manufacturers are currently collaborating to identify a sustainable and economically feasible approach by exploring the most promising recycling methods.
- The main challenge in the entire process is that recycling batteries is simply not yet profitable. This is due to inefficiencies, safety hazards, and logistical challenges related to the collection, transportation, and evaluation of battery SOH – the prerequisite for recycling cell materials.
- According to current estimations, EV battery recycling indicates profitability from 2025 onwards, largely due to effects of widespread adoption and scaling. Countries like China are already showing great promise in that regard.

FIGURE 15

General process of recycling



Recycling Batteries: Regulations

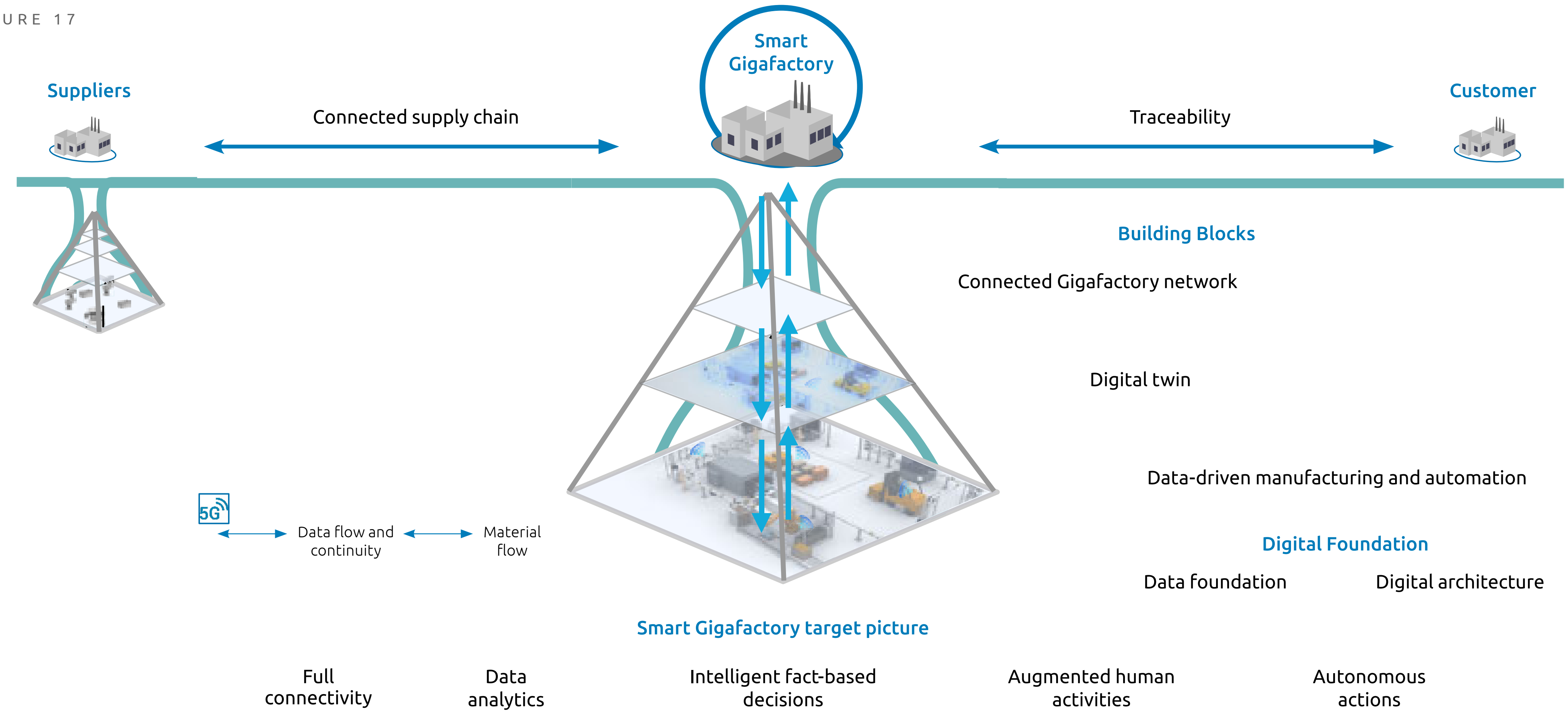
- Even though China is one of the world's leading markets, there is huge potential for the future of Europe and North America, if countries act now.
- Establishing all necessary structures and systems is vital to avoid falling behind in battery recycling, and to have a chance at becoming future leaders.
- Before looking at different recycling alternatives and initiatives, let us highlight geographical differences, with a focus on the U.S. and the EU from a regulatory perspective.

FIGURE 16

Topic	U.S.	E.U.
Directives	Directives in first, selected states regarding recycling	Overarching batter directive 2006/66/ EC that covers collection rates, recycling efficiences and mandatory usage of recycled material (directive to be approved by parliament in 2022)
Current Recycling Efforts	No/limited effort in the U.S. only specific states are putting policies in place and supporting the circular economy of batteries (e.g. California, Hawaii, North Carolina) important is that of the states, e.g. California (100% recycling and reuse) are showing effort, which is by far the most prevalent state in terms of EV adoption support and budget for research initiatives in recycling design for recycling and reuse is explored by leading manufacturers (e.g. Tesla, Ford, GM) but vast majority of battery manufacturers follow liner economic models (no circularity); but mostly driven by federal funded initiatives and pilot projects	Limited recycling due to cost and technological challenges (e.g., only 12% Aluminium, 22% Cobalt, 8% Manganese and 16% Nickel are recycled) investment and regulations are in place or being developed for infrastructure building the base to enable growth and stability of the market extended producer responsibility (ERP); battery and component manufacturers are already resposnsible for waste management (particularly funding of collection and recycling programs)
Mandatory Recycling Efficiencies	---	2025 Recycling efficiency lithium-ion batteries: 65% by 2025 Material recovery rates for Co, Ni,Li Cu: resp. 90%, 90%, 35% and 90% in 2025 -------- 2030 Recycling efficiency lithium-ion batteries: 70% by 2030 Material recovery rates for Co, Ni,Li Cu: resp. 95%, 95%, 70% and 95% in 2030
Mandatory Recycling Efficiencies	---	2030 and 2035, with 12% Cobalt; 85% Lead, 4% Lithium and 4% Nickel from January 1st, 2030, incrementing up to 20% Cobalt, 10% Lithium and 12% Nickel from January 1st, 2025, 2030

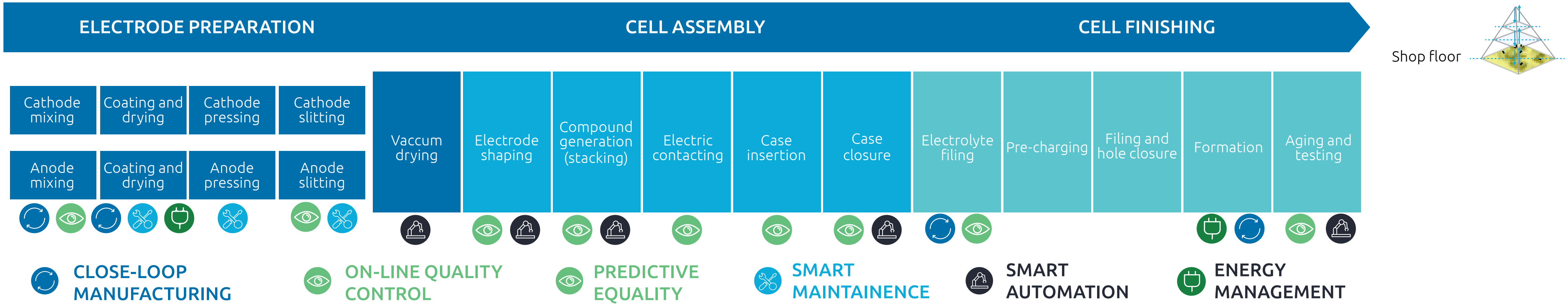
New Gigafactories should be natively digital to fully utilize the potential of industry 4.0 and data

FIGURE 17



Data-driven manufacturing is fundamental to improving Yield and quality, as well as driving production costs down

FIGURE 18



WHAT IS THE NEED?

- Improve quality and yield
- Real-time, on-line quality control
- Closed loop to adjust formulations and parameters to raw materials
- Higher automation with connectivity

KEY COMPONENTS

- **Smart automation**
  Cooperation with equipment manufacturers for automation
- **Data acquisition**
  Collect data from machines and processes and make them available to other systems
- **Data analytics**
  Draw insights from process optimization and edge computing for real-time process monitoring and adjustment

EXAMPLES OF USE-CASES

- Slurry quality: Variation in viscosity and the aggregations of powder
- Coating: Speed variations and variations in temperature
- Roll pressing: Variation in thickness of the electrode
- Cutting: Variations in length, alignment, and generation of particles and dust in the air

ELECTRIC HEATING
HEAT PUMPS

LARS FALCH
TOM ERDKAMP
SIMON BROD
THOMAS SCHOOT
IGOR LELIEVELD
EVA HOFTIJZER
KIM SILLEKENS
DEBARGHYA MUKHERJEE

What are heat pumps?

A heat pump is an efficient heating and/or cooling system. Typically powered by electricity, a heat pump transfers heat from one place to another. The heat source can be the outside air (air source heat pump) or the ground (ground source heat pump). Heat is transferred with the help of a refrigerant fluid, compressor and expansion valve – the same principle by which a refrigerator operates. By taking heat from the outside (even in colder weather) and transferring it to the heating circuit in a building, the heat pump can replace the boiler and remove the need to burn gas or oil for heating.

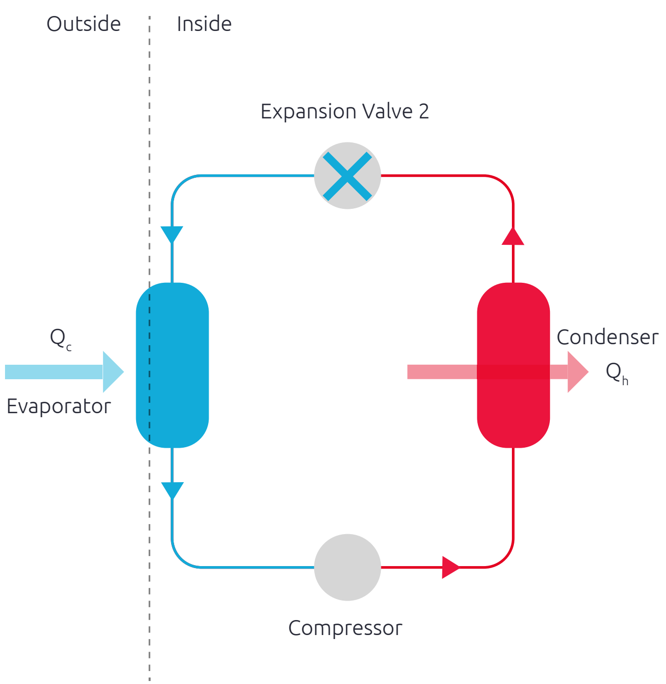
Some heat pumps are equipped with a reversing valve, which can change the flow of refrigerant and either heat or cool a home.

When used in residential settings, air source heat pumps – the most common type – can save more than 2 tonnes of carbon per year per heat pump, contributing up to 20% less CO_2e than gas boilers. No gas needs to be burned, but electricity gets consumed, which may (partly) come from fossil sources.

In recent years, we have seen several initiatives, particularly in Finland, Germany, the United States, and Japan, to promote heat pumps in the replacement market, accompanied by government incentives at national and local levels. Simultaneously, technology has developed to help make heat pumps more appealing than gas boilers.

FIGURE 1

Heat pump schematic



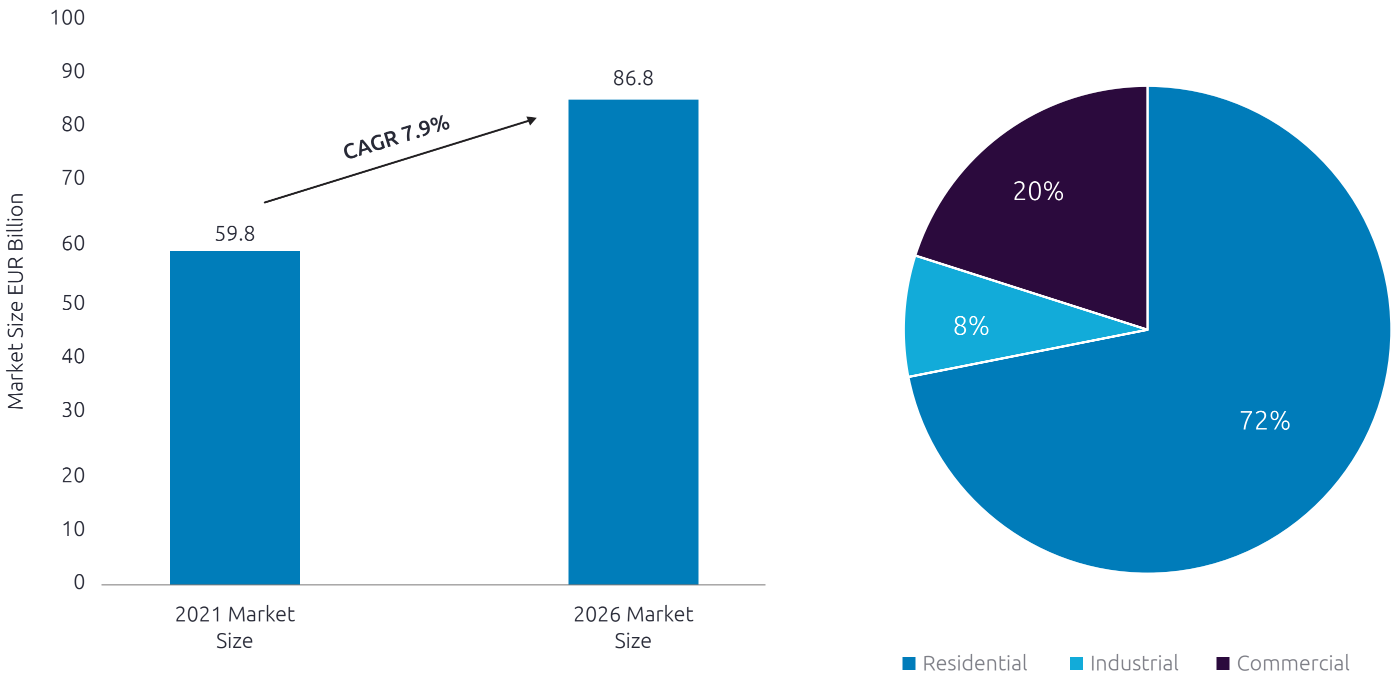
Source: Secondary research

Market size, market share and growth estimate

- The heat pump market is segmented (by end-user) into residential, commercial, and industrial. The residential segment is estimated to account for the largest share – 72% of the market.
- Heat pumps are currently used in 7% of heating systems worldwide. Almost 177 million heat pumps were used for heating in 2020. International Energy Agency (IEA) data shows the global heat pump market grew by around 10% per year in the last few years. Growth is evident across all primary heating markets – North America, Europe and Northern Asia.
- The IEA's net zero pathway (Net Zero Emissions by 2050 Scenario) requires global market growth of around 13% year-over-year to 2030, with the installed heat pump stock reaching 600 million, shown in the figure 3.

FIGURE 2

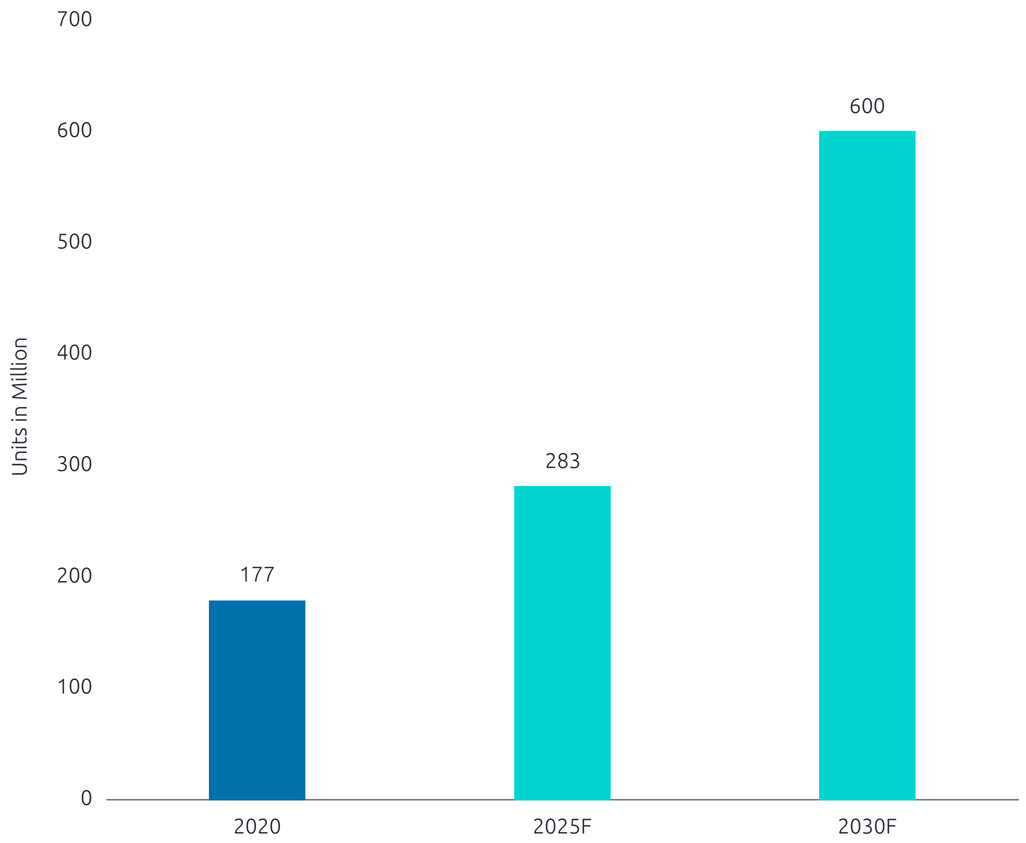
Market Size, Market Share and Growth estimate



Source: Secondary research

FIGURE 3

Installed heat pump stock: Global net zero scenario deployment, 2020-2030 (IEA)



Notes:
- F = Forecast
- IEA's net-zero scenario pathway requires market growth at a global level of around 13% year on year to 2030, with the installed heat pump stock expected to reach 600 million from 177 million in 2020

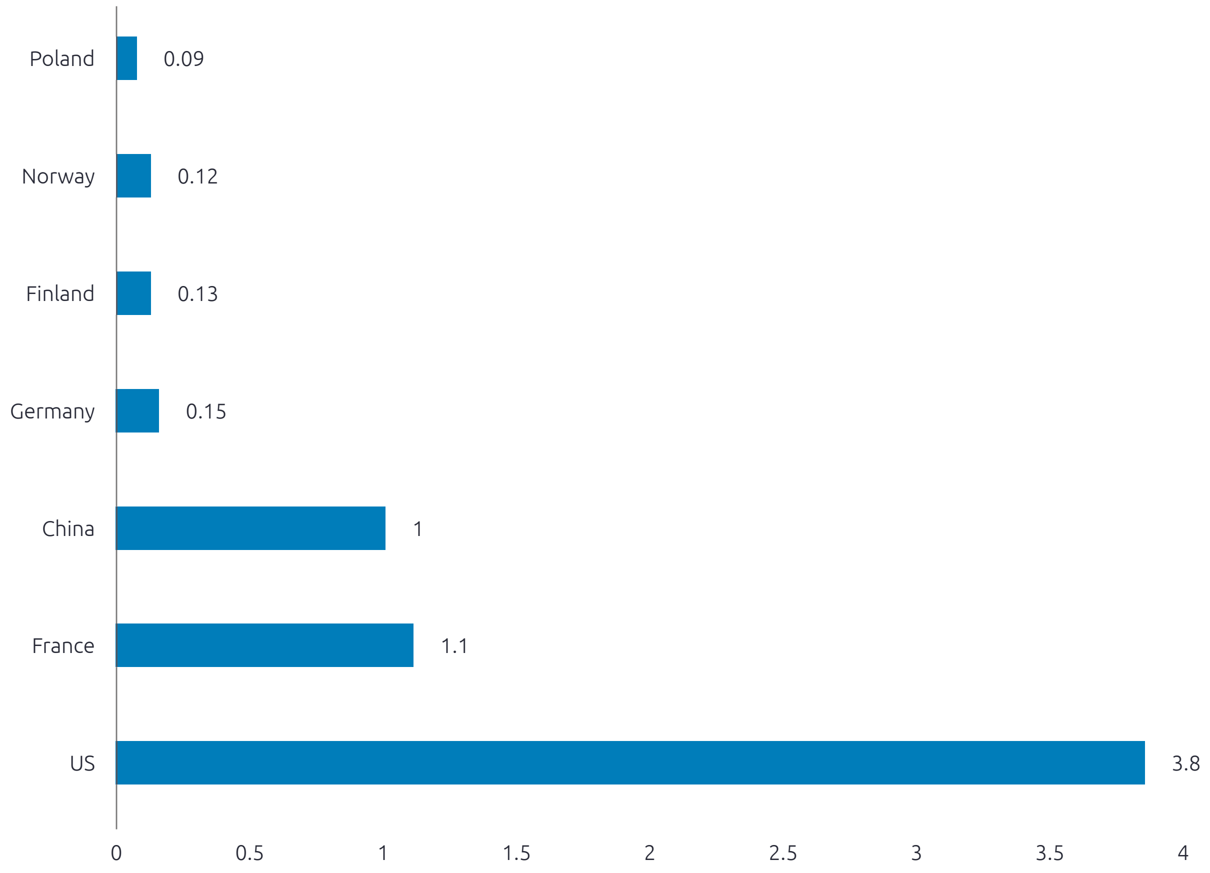
Source: IEA

Heat pump sales - some recent highlights

- According to the Finnish Heat Pump Association, in 2021, Finland showed similar growth to Germany, with an increase of 25% to 130,000 heat pumps installed. Given the country's small size in terms of population, this is remarkable, with almost 5% of all homes installing a heat pump in 2021.
- In Germany, the heat pump market grew by 28% in 2021, with 154,000 units sold – mainly because of the expansion of air source heat pump sales. The adoption of a carbon tax on heating fuels in 2021 partly explains the growth.
- The U.S., another global leader for air source heat pumps, gained 15% in 2021, capping a consistent yearly growth above 5% since 2015.
- The Polish Heat Pump Association, Port PC, reported an increase of 60% in heat pumps in 2021, mainly driven by regulations phasing out coal heating for single-family homes.
- Overall, the French heat pump market grew by 3% in 2021, but the air-to-water segment (chiefly used in space heating) rose by 53%. The French heat pump market is the largest in Europe, with more than one million units sold in 2021.

FIGURE 4

2021 Heat pump sales – major countries (million units)



Source: EHPA, Heat Pumping Technologies (HPT TCP), CarbonBrief

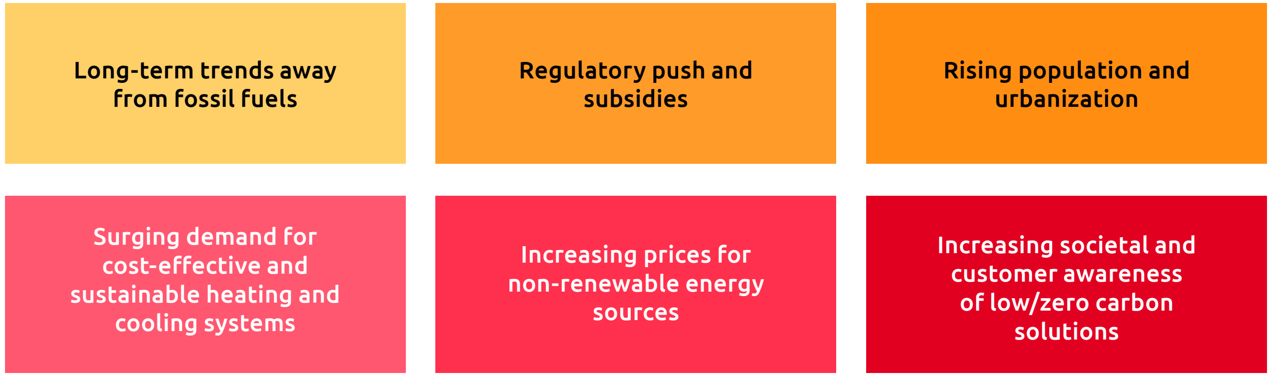
- Switzerland, another mature and long-established market for heat pumps, showed market growth of 20% in 2021, primarily in air-to-water systems. More remarkable is that 54% of all heating systems sold in Switzerland last year were heat pumps, making it the dominant heating technology, not only in new buildings, but also in existing buildings.
- In 2021 in China, initial estimates of residential air source heat pump sales saw market growth of 10% to more than one million units. Additionally, there were hints of a more significant increase in non-residential sales.
- In Norway, 125,000 heat pumps were sold in 2021, similar to Finland. This represents a growth of 36% over 2020.
- Assoclima, the Italian association of manufacturers of HVAC systems, reported heat pumps and air-cooled refrigeration units grew by 120% in volume and 130% in value in the size segment below 17 kW in 2021.

Market growth drivers

- In recent years, particularly in Finland, Germany, the U.K., the U.S., Japan, and Netherlands, we have seen several initiatives to make heat pumps compulsory in the replacement market (replacing gas-fired boilers), accompanied by government incentives at the national and local levels.
- Europe is one of the fastest-growing markets for heat pump sales, as many countries strive to decarbonize and seek alternatives to natural gas for space heating purposes. Heat pumps play an important part in reducing carbon emissions from space heating and, therefore, reaching ambitious net zero targets at the national level. For example, in the U.K., if net zero targets are to be achieved by 2050, no new gas boilers can be sold after 2025.
- In Japan, Korea, Europe, the U.S., and Australia, reversible heat pumps are commonly used for heating and cooling.
- Globally, over 50% of the population already lives in urban areas, and by 2045, the world's urban population will increase from four to six billion. City leaders must move quickly to plan for growth and provide the basic services, infrastructure, and affordable housing their expanding populations need.
- Gas, coal, and electricity prices have recently risen to their highest levels in decades. A combination of factors has caused these increases. However, the sharp increase is causing many energy consumers to explore new choices. In Europe, gas consumption may be forced to be reduced in the face of supply disruption from Russia.

FIGURE 5

Heat Pump Market Growth Drivers



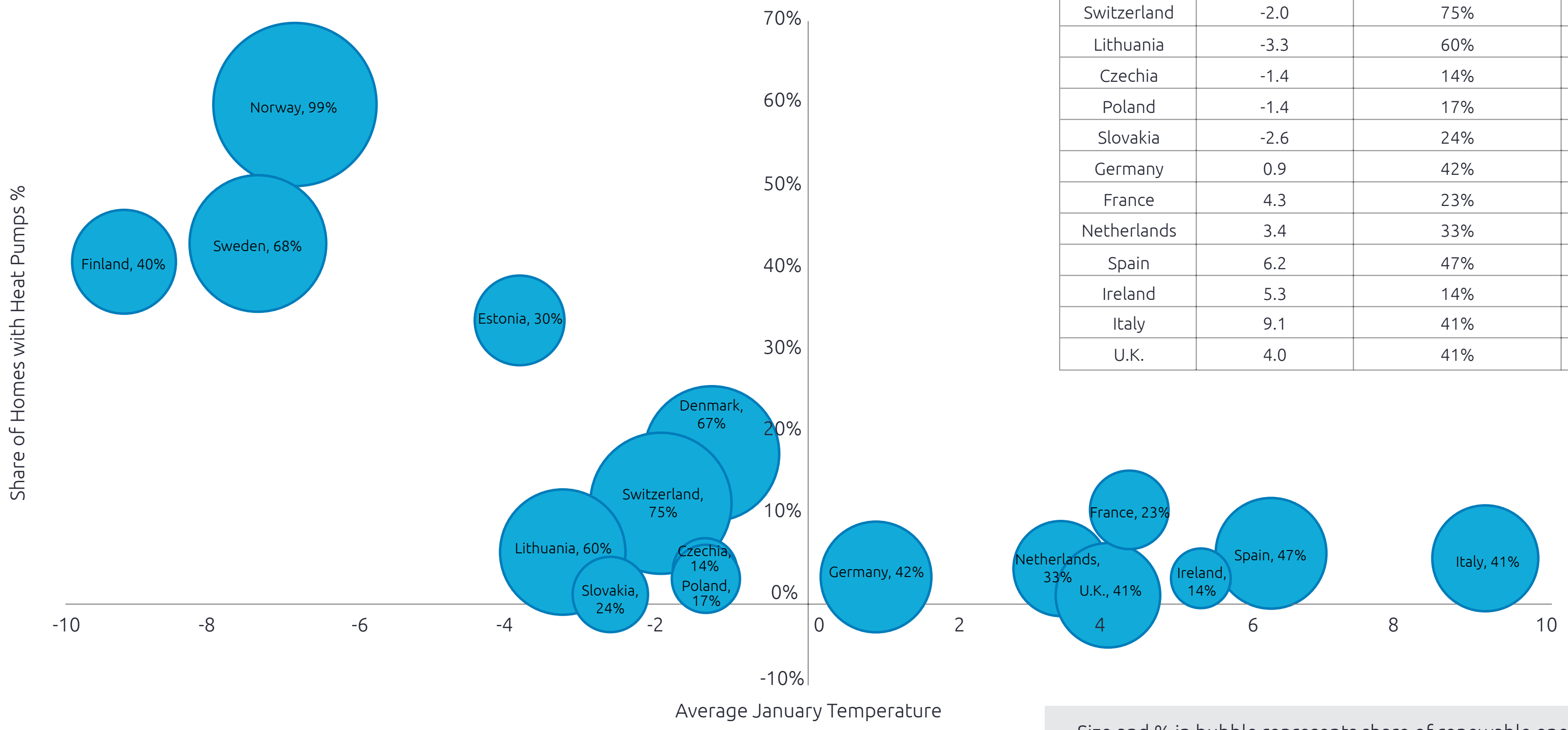
Source: energy.gov, NRCAN, EPA, IEA, Capgemini Analysis

The highest penetration of heat pumps can be found in the coldest climates, as the chart below shows. Perhaps unsurprisingly, these countries have abundant renewable electricity and never developed gas as a widespread energy source.

FIGURE 6

European countries average January temp vs. share of homes with heat pumps

Country	Avg. January Temperatures	Renewables share in power generation	Share of homes with heat pumps
Norway	-6.9	99%	60%
Sweden	-7.4	68%	43%
Finland	-9.2	40%	41%
Estonia	-3.9	30%	34%
Denmark	-1.3	67%	18%
Switzerland	-2.0	75%	12%
Lithuania	-3.3	60%	6%
Czechia	-1.4	14%	4%
Poland	-1.4	17%	3%
Slovakia	-2.6	24%	2%
Germany	0.9	42%	3%
France	4.3	23%	11%
Netherlands	3.4	33%	4%
Spain	6.2	47%	6%
Ireland	5.3	14%	3%
Italy	9.1	41%	5%
U.K.	4.0	41%	1%



Size and % in bubble represents share of renewable energy in power mix of that country

Source: EHPA, Enerdata, Statista, CarbonBrief

Main challenges for residential and commercial space heating applications

Customer perspective – households

- Heat pump price and installation costs can significantly strain a household budget. However, a properly installed heat pump will help reduce energy costs, with a payback period spanning five to seven years (assuming the heating system being replaced runs on oil, liquified petroleum gas, solid fuel, or electricity).
- The price is higher than a typical electric or gas-fired boiler or air conditioning system. In the U.K., one might expect to pay between £8,000-£18,000 (€9,600-€21,600) to buy and install an air source heat pump and between £20,000-£35,000 (€24,000-€42,000) for a ground source heat pump. In the U.S., the price to install a heat pump is usually between $5,000-$9,000 (€5,000-€9,000).
- Currently, delivery times are more than 12 months and are subject to global supply chain bottlenecks.
- A broad customer survey by DG Cities in the U.K. concluded that customers lack knowledge about the pros and cons of heat pumps:
  - Awareness is moderate, but knowledge is low. For example, 82% had heard of heat pumps, but nearly half (46%) knew only a little about them. Almost one in five (15%) had heard of them but didn't know what they were.
  - The cost of purchase and installation is too high, according to more than half (53%) of respondents. And although the government is now offering the new Boiler Upgrade Scheme, which provides up to £6000 (€7,200) in subsidy, less than half (46%) of the respondents knew about the grant, and the majority (60%) would not use it.
  - Perceived effectiveness is also an obstacle.

FIGURE 7

Main challenges for residential and commercial space heating applications

- High upfront purchase prices and installation costs
- High electricity prices in some markets
- Varying consumer perspectives
- Supply chain issues
- Installation needs qualified personnel and knowledge

Source: IEA, DG Cities, , BBC, Capgemini Internal analysis

A further challenge is installation requiring significant modifications to the home:

- If there is inadequate heat insulation, this should be rectified before installing a heat pump.
- Existing heating systems have been designed around boilers, which deliver water at 80-90°C. Heat pumps typically deliver water at lower temperatures, which means adjustments are needed to the home heating system.

Alternative solutions are:

- High-temperature heat pumps, which deliver water at a similar temperature to a boiler.
- Hybrid heat pumps which work alongside an existing boiler. The heat pump reduces the use of the boiler, saving approximately 60% of fuel, and is easier to install.

Customer perspective - commercial buildings

- Heat pumps can be an attractive heat source for larger buildings, with similar or shorter payback periods than residential buildings.
- Price depends on the size of installation. Generally, there are economies of scale; it will be most attractive for buildings with higher heating loads.
- Buyers are typically facilities managers with broad responsibility and cannot devote much time to energy matters. Therefore, it is essential for clear advice to be readily available and for the buyer to be able to purchase a complete, hassle-free service, including equipment specification, design, delivery, installation, maintenance, and a performance guarantee.

Since a significant up-front investment is required, financing is an additional key piece of the puzzle. The result is a heat-as-a-service product that is simple for the customer.

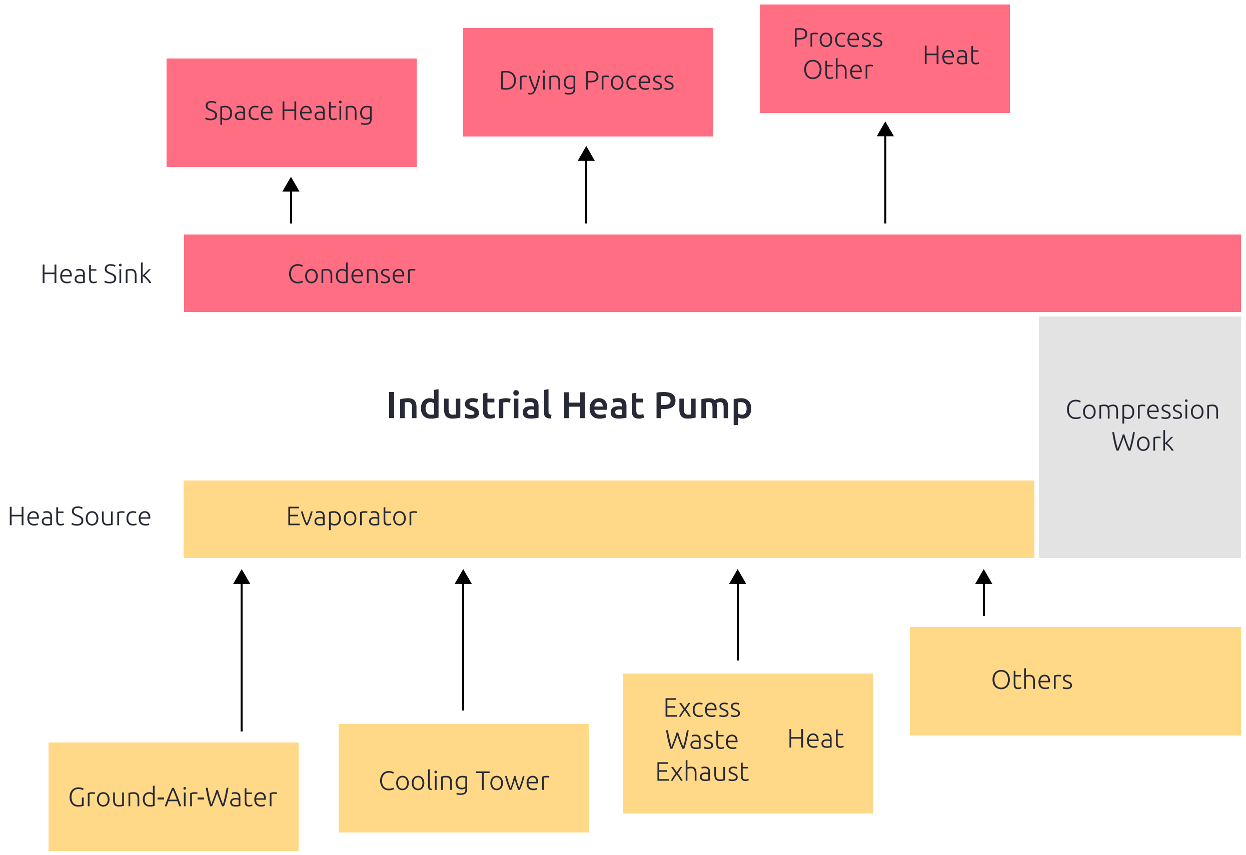
- Often, the building's energy supplier is best placed to coordinate this service. It has a pre-existing customer relationship with the buyer and potentially stands to lose from the reduced energy consumption of the building. By taking a proactive role, energy suppliers can ensure a viable business model into the future, based on services rather than purely supplying energy.

Industrial heat pump applications

- Industrial heat pumps enable the recovery of waste process heat. The potential amount of industrial waste heat is difficult to quantify, but various studies have estimated as much as 20% to 50% of industrial energy consumption is ultimately discharged as waste heat and that between 18% and 30% of this waste heat could be utilized.
- As visualized in figure 9 main applications for heat pumps are in the food, paper, metal, and chemical industries, especially in drying, sterilization, evaporation, and steam generation processes. High temperature heat pumps with heat sink temperatures in the range of 100°C to 160°C are under development, opening up new applications. A growing trend is the integration of industrial heat pumps in district grids, enabling heating and cooling from currently wasted heat sources.
- The market for industrial heat pumps was estimated at approximately €4.8 billion in 2021 and could reach €6 billion in 2026. However, adoption is being held back by low awareness of heating and cooling demands, heat wastage, and lack of knowledge of heat pump capabilities.
- The figure 9 shows the current and future fields of application for industrial heat pumps.

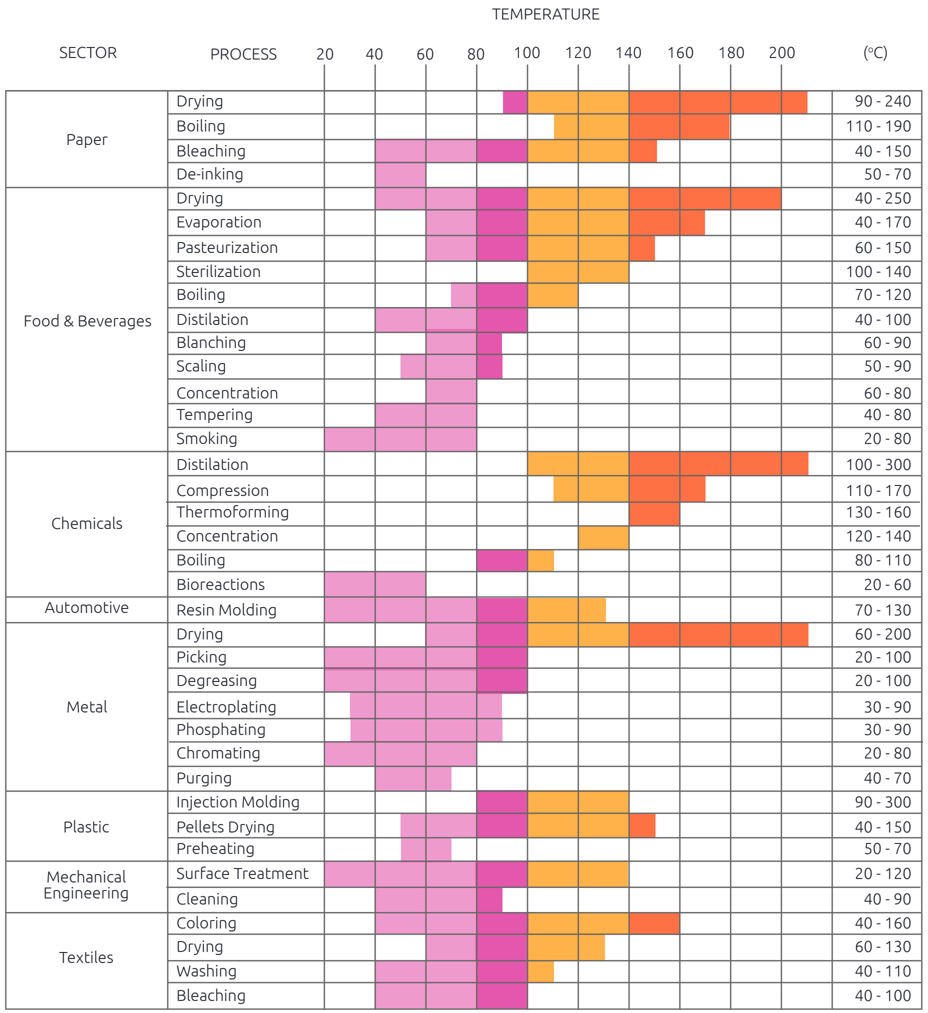
FIGURE 8

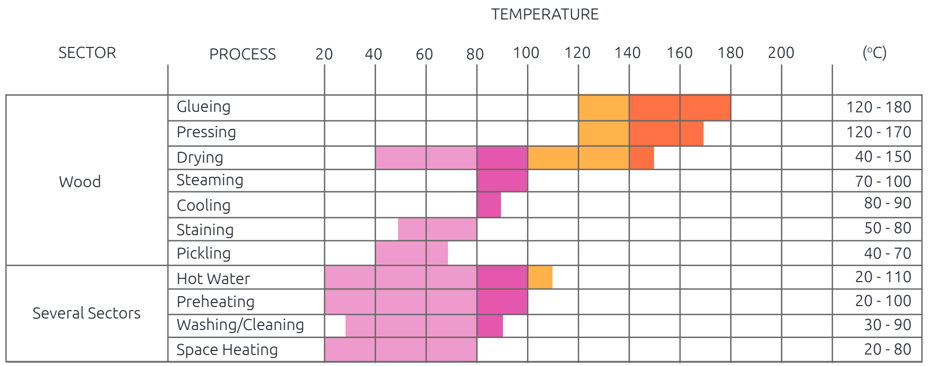
Industrial Heat Pump Applications



Source: EHPA, Heat Pumping Technologies (HPT TCP)

FIGURE 9 Technology readiness level: Industrial heat pump applications





Technology Readiness Level (TRL):

- Conventional HP <80°C, established in industry
- Conventional available HP <80°C, established in industry
- Prototype status, technology development, HTHP 100 - 140°C
- Laboratory research, functional models, proof of concept, VHTHP > 140°C

Source: EHPA, Heat Pumping Technologies (HPT TCP)

Effect of energy prices on deployment of heat pumps

- One of the main barriers to the deployment of heat pumps is the energy prices in some countries. The investment case is especially sensitive to the ratio of electricity price to gas price. A heat pump uses less energy (in kWh) than a boiler, but that energy is in the form of electricity rather than gas and typically costs more per kWh. A favorable investment case typically requires the ratio of electricity price to gas price to be around 2 or 3 to one, at most.
- Electricity and gas prices tend to be correlated in most countries. Recent high energy prices have made heat pumps more attractive in some places, especially where the electricity price is not closely linked to the gas price.
- Energy prices are volatile, and these ratios can change fast. The table to the right shows a snapshot from the first half of 2022.

FIGURE 10

Ratio of Electricity price to Gas price: Europe, USA and China - H1 2022

Note: This figure is a general guide and is a function of typical heat pump efficiency and energy prices. The individual circumstances of a building may mean that a heat pump makes sense at higher electricity prices.

↑	0-2
→	2-4
↓	>4

Country	Ratio of electricity price to gas price – household		Ratio of electricity price to gas price – non-household	
Finland	↑	1.4	↑	1.2
Sweden	↑	1.4	↑	1.5
Lithuania	→	3.6	→	2.5
Luxembourg	→	3.1	→	2.5
France	→	2.6	→	2.8
Estonia	→	2.6	→	2.9
Hungary	→	3.3	→	3.0
Slovenia	↓	4.0	→	3.0
Czechia	→	3.4	→	3.3
Poland	↑	2.0	→	3.4
Liechtenstein	→	2.9	→	3.4
Croatia	→	3.3	→	3.5
Romania	→	2.7	→	3.6
Latvia	↓	4.4	→	3.7
Austria	↓	4.8	→	3.7
Bulgaria	↑	1.5	→	3.8
Netherlands	↑	2.1	↓	4.1
Ireland	→	3.8	↓	4.2
Denmark	→	2.8	↓	4.2
Portugal	↓	4.6	↓	4.5
UK	↓	4.0	↓	4.7
Greece	↑	1.9	↓	5.0
Slovakia	↑	0.9	↓	5.1
Spain	→	2.6	↓	5.3
Belgium	↓	4.4	↓	5.3
Italy	→	2.3	↓	5.7
Germany	↓	4.7	↓	7.7
European Union	→	3.0	↓	4.8
China	↑	0.9	↑	1.0
USA	→	3.7	→	2.9

Source: EHPA, Eurostat, EIA, Bloomberg

Key points

- Heat pumps are an important technology in the transition to clean energy as they enable space heating applications (often fossil-fueled today) to be electrified. On a global net zero pathway, heat pumps will account for more than 1 billion tonnes per year of avoided CO_2 emissions by 2030.
- Heat pumps consume electricity and move heat from the outside air or ground to the inside of a building – even in colder weather. They provide an alternative to gas, coal, or oil-fired heating boilers. Emissions are reduced because moving heat takes less energy than producing it and because electrification means zero-carbon energy can be used in place of fossil fuels.
- For an attractive investment case, the electricity price at the point of use should be no more than 2 or 3 times the natural gas price (per kWh).
- Heat pumps are suitable in a wide variety of settings but always need to be considered in light of other possible solutions (for example, direct electric heating, geothermal, or combustion of green fuels). Heating (and cooling) systems are technically complex. Suitability depends on local climate, demand patterns, and existing energy infrastructure.
- Large scale household deployment requires careful planning and orchestration by governments and local authorities. Points for attention are:
  - deployment as part of a wider heating and cooling strategy that maximizes CO_2 savings (considering a broad view of which technologies are suitable for which situations);
  - availability of heat pumps and skilled labor for installation;
  - adequacy of the local electricity grid; and
  - investment support and financing.
- Householders wanting to convert to a heat pump might have to modify their home heating system since heat pumps produce heat at a lower temperature than boilers. Attractive alternatives are hybrid heat pumps (which act as an addition to an existing fossil-fueled system) and high temperature heat pumps (which produce heat at a comparable temperature to boilers). Each has its pros and cons.
- Commercial buildings are likely to benefit from a heat pump but often are not considered as the facilities manager has broad responsibilities and is not an expert in energy matters. As a result, heat-as-a-service offerings are emerging to provide hassle-free service to such customers.
- In addition, heat pump technology can be deployed in industry to capture and re-use waste heat, especially where there are drying, sterilization, evaporation, or steam generation processes. Many companies are unaware of their heat waste, so creating a business case starts with measurements. Studies estimate that between 3.6% and 15% of industrial energy consumption could be re-used, representing hundreds of millions of tonnes of CO_2 emissions per year.

Source: IEA, EHPA, Heat Pumping Technologies (HPT TCP), McKinsey

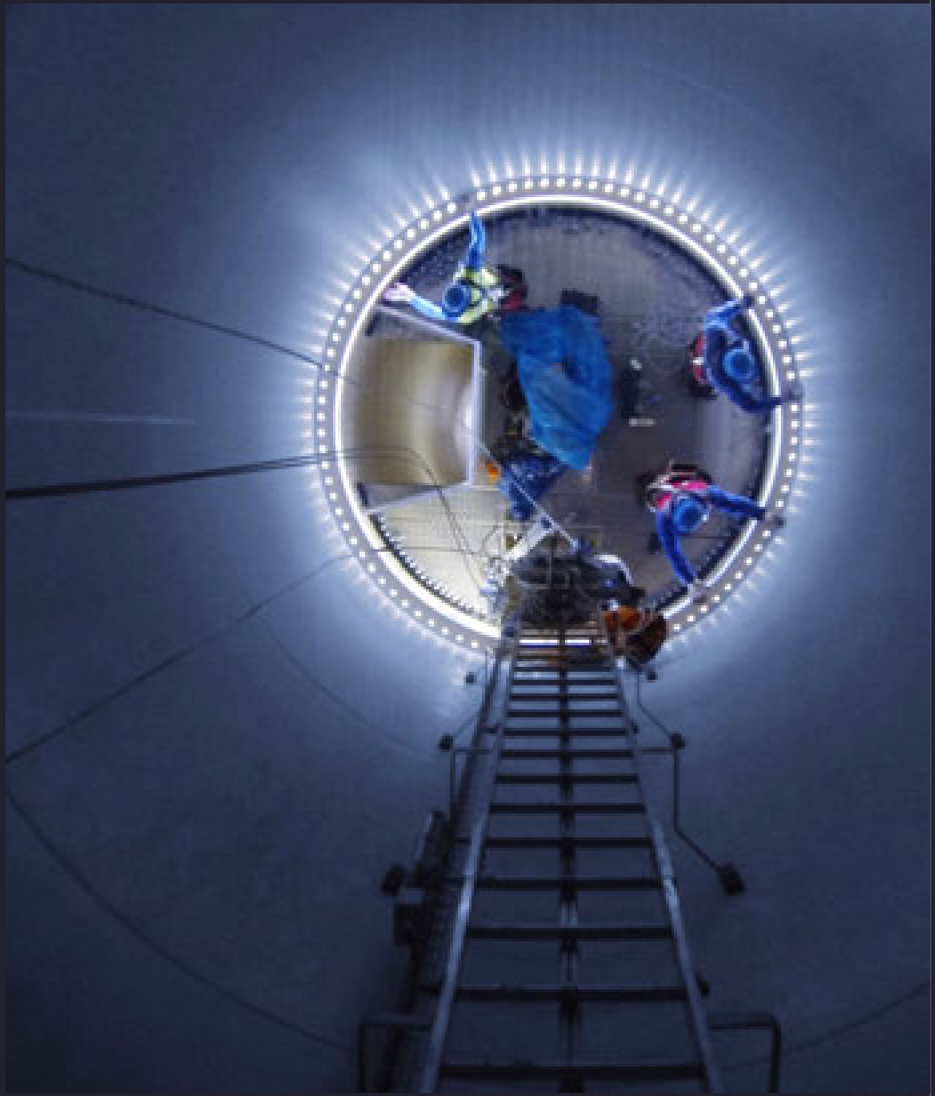
Recommendations

- Governments should implement an overall energy strategy that leads to decarbonization as rapidly as possible. Decarbonizing heat is an essential part of this and will be powered by renewable electricity. Heat pumps are an important technology enabling heating systems in the existing building stock to be electrified. The government has a role in setting strategy, creating incentives, and ensuring a large-scale roll-out is properly coordinated.
- Building owners and managers should seek expert advice on energy saving, including the suitability of heat pumps for their situation. Heat pumps should be explored when replacing a heating system, and may also be viable as a retrofit, especially as part of a package of energy efficiency measures.
- Energy grid operators should communicate clearly how they will accommodate new electrical load from heat pumps. An advantage for the grid is that if individual homes and buildings allow remote control of their heat pump, the grid can modulate the load. With smart grid technologies, this is possible – within limits – without affecting the customer's comfort and promises to reduce the need for capital-intensive projects to increase grid capacity.
- Energy retailers should develop heat-as-a-service that combines delivery and installation of a heat pump, financing, and energy supply. This type of bundled service speeds up adoption by removing the need for the customer to master the complexity of the system and the need to finance the heat pump installation up-front.

Source: Capgemini Internal analysis

03

REGIONS DESCRIPTION



EUROPE ENERGY ID CARD

MARIE VERMERSCH
DEBARGHYA MUKHERJEE

Country Description

Country profile

- **Region:** European Union (All data is for EU27+U.K. unless otherwise specified)
- **Population:** 446.8 million
- **GDP:** € 14.4 trillion

Energy

2021 total energy consumption: **1787 Mtoe**

Gas

Total gas production: **50.6 bcm**

Total gas consumption: **412 bcm**

Environment

Total CO_2 emissions: **2,730 Mt CO2**

GHG emissions growth rate: **7.3% (2021)**

EU is set to adopt the Corporate Sustainability Reporting Directive (CSRD), amending the previously applicable Non-financial Reporting Directive (NFRD) supporting the European Green Deal, to combat the climate crisis with no net emissions of greenhouse gases by 2050.

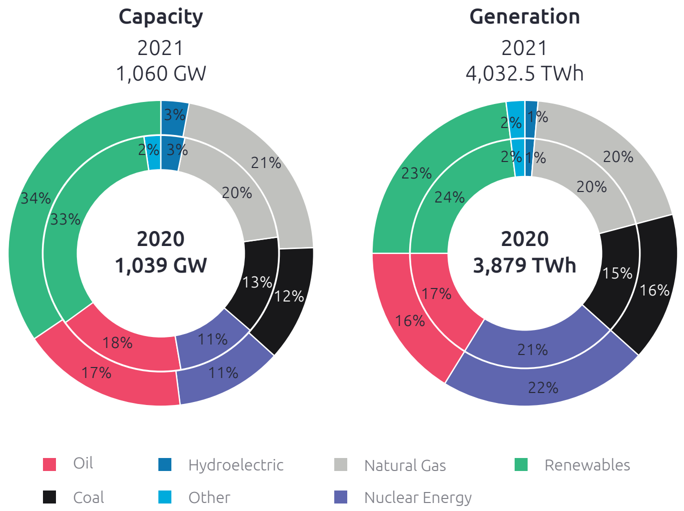
Renewable Energy

Share of renewables in primary energy consumption: **12%**

2021 added wind capacity: **16 GW**

2021 added solar capacity: **24 GW**

Electricity



EU average electricity price by household consumers: €0.2369 per kWh (H22021)

Network

Electricity grid investments in Europe was estimated to reach $57 billion in 2021; grid expansion plans for 2021-2030 provide the foundation for increased investment, supported by economic recovery schemes.

The Nord Stream 2 gas project was halted due to the Russia-Ukraine war.

Electric Vehicles (EVs)

- In Europe, electric car sales continued to grow in 2021 by more than 65% YOY to 2.3 million.
- According to IEA, over the 2016-2021 period, EV sales in Europe increased by a CAGR of 61%.
- Overall, electric cars accounted for 17% of Europe's auto sales in 2021.
- The highest market share for new electric car sales in 2021 in Europe are Norway (86%), Iceland (72%), Sweden (43%), and the Netherlands (30%), followed by France (19%), Italy (9%), and Spain (8%).

Energy Players

Power: Centrica, CEZ, E.ON, EDF, EDP, Enel, ENBW, Engie, Fortum, Iberdrola, Naturgy, Ørsted, RWE, SSE, Uniper, Vattenfall

Oil and Gas: BP, Eni, Equinor, Repsol, Shell, TotalEnergies

Region Highlights

- As part of CSRD, companies are required to start reporting from 2024. Reporting must comply with mandatory EU sustainability reporting standards and be accompanied by external verification.
- Utilities' growing focus on renewable capacity development continued during this period, along with increased activity around mergers, acquisitions and new capacity additions, which added to the marginal decline in the EBITDA margin in 2021 for Europe.
- EU ETS reached an average 2021 price of €52 per tonne; it approached almost €90 per tonne in Dec 2021.
- 23 countries are expected to be coal free by 2040.

US ENERGY ID CARD

ISHANDEEP
NUPUR SINHA

Country Description

Country profile

- **Region:** U.S.
- **Population:** 333,070,544 (September 2022)
- **GDP:** $22,996.10 billion (2021)

Electricity

- Total electricity generation: **4,146 TWh (2021)**
- Average electricity price: **11.18 cents/KWh (2021)**
- Electrification share (average): **100%**

Gas

- Total natural gas production: **934.2 bcm (2021)**
- Total natural gas consumption: **826.7 bcm (2021)**

Energy Players

Revenue for main players, 2021:

- Exelon: $36.3 billion
- Duke Energy: $25 billion
- Southern Company: $23.1 billion
- Pacific Gas & Electric: $20.6 billion
- NextEra Energy: $17.1 billion
- American Electric Power: $16.7 billion
- Edison International: $14.9 billion
- Consolidated Edison: $13.7 billion
- Sempra Energy: $12.9 billion
- FirstEnergy: $11.1 billion
- The AES Corp: $11.1 billion
- NRG Energy: $27 billion

Renewable Energy

- Renewables share in energy generation: **21% (2021)**
- Renewables generation in United States: **858 TWh**
  - Wind and solar contribution: **66 TWh (13%)**

Environment

- Total CO_2 economy-wide emissions: **6,263 MtCO_2 (2021)**
- Energy-related CO_2 emissions: **4.9 billion metric tons (2021)**

Country Highlights

- Renewables provided over 25% of total U.S. electrical generation in the first half of 2022, according to the U.S. Energy Information Administration (EIA).
- In August 2022, The Inflation Reduction Act was signed by President Joseph Biden to deliver $370 billion in the next decade to increase renewable energy production and reduce greenhouse gas emissions.
- In June 2022, DOE launched the Bipartisan Infrastructure Law's $8 billion program for clean hydrogen hubs across the U.S.
- In May 2022, the U.S. witnessed electricity shortages as summer approached; grid operators warned of the limits of renewable energy.
- A breakthrough of $105 billion in new capital went into new U.S. clean energy assets.

CANADA ENERGY ID CARD

ISHANDEEP
NUPUR SINHA

Country Description

Country profile

- **Region:** Canada
- **Population:** 38,478,845 (September 2022)
- **GDP:** USD$1,990.80 billion (2021)

Electricity

- Total electricity generation (2021): **641 TWh**
- Average electricity price: **USD$0.112/KWh for households and USD$0.096 for businesses**
- Electrification share (average): **100%**

Gas

- Total natural gas production: **172.3 bcm (2021**)
- Total natural gas consumption: **119.2 bcm (2021)**

Energy Players

Revenue for main players, 2021:

- Hydro-Québec: USD$11.6 billion
- BC Hydro: USD$6.1 billion
- Hydro One: USD$5.8 billion
- Ontario Power Generation: USD$5.5 billion
- ENMAX: USD$2.5 billion
- TransAlta: USD$2.2 billion

Renewable Energy

- Renewables share in energy generation excluding hydro: **7.8% (2021)**
- Renewables generation excluding hydro in Canada: **50 TWh (2021)**

Environment

- Energy-related CO_2 emissions: **527.4 million tonnes of CO_2**

Country Highlights

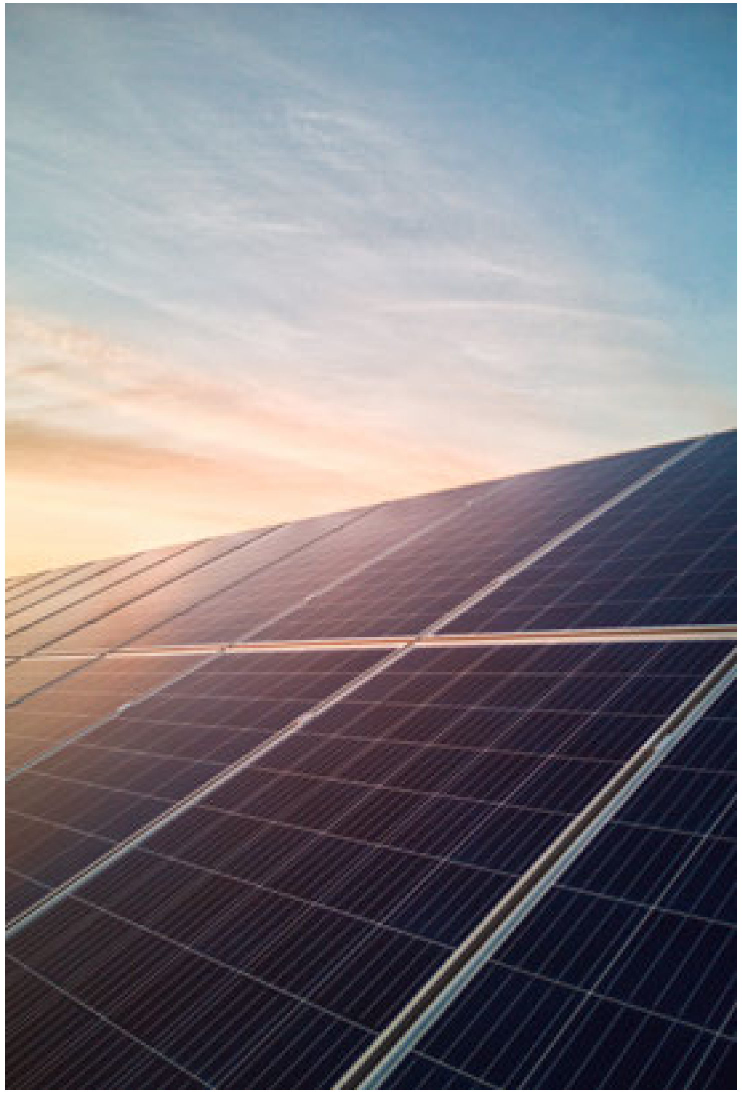
- In August 2022, Canada and Germany partnered to enhance German energy security with clean hydrogen.
- In May 2022, the Canadian financial regulator released draft guidelines to mitigate the risks of climate change as the country's financial institutions prepare for mandatory disclosures starting in 2024.
- In April 2022, Canada raised the federal carbon tax to CAD$50/t (USD$40/t), which may lead to higher prices of gasoline, diesel, and natural gas in the near future.
- In March 2022, Canada unveiled a $7.3 billion 2030 Emissions Reduction plan to meet its carbon emissions target, including reductions in the oil-and-gas sector.
- In February 2022, Mitsui invested in EKONA Power which has been developing a novel methane pyrolysis process for making clean hydrogen from natural gas.

REGIONAL EDITORIAL: NORTH AMERICA

ELFIJE LEMAITRE
CLAIRE GOTHAM
TYLER WILLIAMS

The upwards bounce energy markets experienced in 2022 after the disruption of the pandemic feel a bit like whiplash for North America. Energy prices hit new lows in 2019 and then remained low during the pandemic restrictions and limited production. However, now a post-pandemic surge in demand plus geo-political events impacting supply are boosting prices to new heights.

This profitability is not being matched by a rush to increase spending on infrastructure and technology to increase production. Historically, energy markets have been some of the most volatile. In contrast to prior high price environments, we are seeing North American energy companies be disciplined with their capital as they negotiate the energy transition to low- or no-carbon fuels and decide how best to invest improved cash flows. Renewables' share of the market continues to rise as their costs have decreased and as the world moves towards decarbonization. (Renewable energy is the fastest-growing energy source in the U.S., having increased 42% in 2020 from just ten years prior and 90% since 2000[1].) This leaves many companies evaluating whether it is the time to build additional oil and gas facilities or to instead look for investments that support the buildout towards a more integrated energy ecosystem.



1 https://www.c2es.org/content/renewable-energy/

The challenge of change

As society pushes forward on the energy transition, an "energy trilemma" begins to emerge, with competing demands between sustainability, affordability, and security. Tackling all three simultaneously will be a challenge, with tradeoffs being necessary in the near- to medium-term for producers and consumers.

Grid-scale solar and wind energy are not easily dispatchable, for example. Questions like how to integrate renewables into the existing system, increase reliability, and guarantee grid security need to be answered, as electricity demand is independent of hours of sunlight or calm days. Strain on an already constrained grid will only continue with further electrification of the transportation sector.

Geopolitical events are also making the industry reassess supply security and how much energy needs to be available to customers in North America. The U.S. and Canada are net exporters of energy but, with increased volatility and demand, domestic requirements need to be managed.

For example, the U.S. federal government is focused on the security of the supply that will drive decarbonization, but it is also looking for ways to be more self-reliant. (Self-reliance includes reliability of both the grid and that of the supply. The impact of winter storm Uri on Texas in February 2021 was just one event that highlighted this need.) More electric vehicles (EVs) and solar panels require raw materials, chips, etc. there is a push to produce more of these products at home.

The rise of renewables

Buoyed by state and federal regulations, renewables are expanding in North America despite supply chain, pandemic, and geopolitical challenges. Government recognizes that incentives are useful in the quest for carbon neutrality. For example, California recently introduced a plan to phase out gasoline-powered cars to reduce the demand for fossil fuels. By 2035, all new cars and passenger trucks sold in the state will be required to be zero-emissions vehicles.

The biggest push in the U.S. may be coming from the federal level. The current administration has passed multiple pieces of legislation to support sustainability and energy transition. The recent Inflation Reduction Act includes building an economy that promotes clean energy, strengthens climate resilience, and reduces greenhouse gas emissions, with billions in funding available. The renewable targets are sizable: 950 million solar panels, 120,000 wind turbines, and 2,300 grid-scale battery plants by 2030. It also includes credits for grid modernization projects, as well as $4 billion for projects located in "energy communities," which are defined as "an area that has had significant employment related to coal, oil or natural gas activities".

At the same time, the legislation also focuses on the security of the supply of semi-conductors, solar panels, and other key pieces of technology that were impacted during the pandemic. There is a push to rely less on a global supply chain and more on a domestic one. It will also push projects like battery and EV factories, which will have a big impact in a few years.

The American Jobs Plan was introduced earlier in 2022 and offers energy and utilities companies, as well as municipalities and new energy market entrants, access to funds to reenergize America's power infrastructure. This will help to build a more resilient electric transmission system to move cheaper, cleaner electricity. The goal of the infrastructure investment is to move to 100% carbon-free electricity by 2035.

At the same time, carbon-intensive energy procurement could become increasingly challenging. Investors, governments at all levels, and customers are pushing companies to adopt positive environmental, social, and corporate governance (ESG) ratings and move towards carbon neutrality. Customers are becoming savvier about their energy and how it is being generated. The SEC Climate Disclosure Policy will bring in sweeping new rules focused on climate-related risk disclosure, emissions reporting, and transition planning. Compliance will usher in a new level of transparency to the investor community across sectors.

This means commercial and industrial customers are actively procuring clean energy – and not just on paper. They are seeking power generated by renewable sources. As these companies explore energy options, they may turn from being customers to becoming competitors. If a company such as Google or Amazon enters the energy market as a provider, it will most likely bring further disruption. (Tesla has already declared such intentions in both the U.S. and the U.K. markets.)

More electrification needs more security

The average home is a good example of the growth of electrification, and projections point to continued demand. The U.S. grid has already faced challenges with demand in some major cities, and it is increasing. The infrastructure bills at the federal level should help fund some of the investment needed, but additional measures will likely be required to complete next-generation grid and storage options.

This future could include traditional storage, such as gas and oil reserves, but will also extend to battery storage and increased usage of battery systems as part of an overall renewable generation system. A battery system can help smooth the flow of electricity when the sun is not shining or the wind is not blowing.

The key will be bridging the gap between the requirement for a steady supply of power and the planned reliance on renewables. Regulations are opening to allow for Distributed Energy Resources (DERs) such as solar panels and batteries to be aggregated and connected to the wholesale power system. DERs may help to smooth the flow of power. They are an additional resource, but they may initially cause more disruption to the grid as ISOs/RTOs and utilities figure out how to integrate them into their load forecasting and dispatching.

In addition, companies are exploring the idea of the virtual power plant (VPP), which typically consists of a decentralized array of renewable generation plus battery storage. A VPP would provide the flexibility to pull power from the grid or add power back on in times of high demand without requiring extensive new infrastructure.

But with every point added to the grid comes considerations around cybersecurity and supply security risk. Connecting to an overloaded system is not the solution, so energy companies need to plan for the next phase of the grid infrastructure. Building a more resilient infrastructure includes security for risk mitigation to ensure the lights stay on.

Reconsidering nuclear energy

Energy companies are also starting to revisit nuclear energy. As the industry figures out the energy transition, a move to micro-nuclear plants may be worth considering, since nuclear is a low-carbon technology (same level of emissions as renewables) and shrewd in terms of critical resources. After decades of declining investment in new nuclear generation in the U.S., it may turn out to be the way to help transition to carbon neutrality.

Energy grids have always been complex systems that required a great deal of expertise to plan and manage, and that was true when the demands consumers placed on these systems amounted to two basic asks: consistent power at a reasonable price. But society is now asking for a third factor: environmental sustainability. That new requirement demands both environmental awareness and the inclusion of new generating processes, greatly increasing the complexity of modern grids. Which means that the future is bright and certainly more environmentally responsible, even if there are new challenges to face and technologies to deploy.

CHINA ENERGY ID CARD

SWETANTA LAHIRI
NUPUR SINHA

Country Description

Country profile

- **Country:** China
- **Population:** 1.4 billion
- **GDP:** $17.8 trillion (2021)

CO_2 footprint

- **Total 2021 CO_2 emissions:** 10,523.0 million tonnes
- **2021 CO_2/capita emissions:** 8.44 tons

Energy demand

- Demand for electricity in China increased by 10% in 2021 (equivalent to the total demand of all of Africa)
- Use of coal accounted for 56% of this increase in electricity demand

Renewable energy

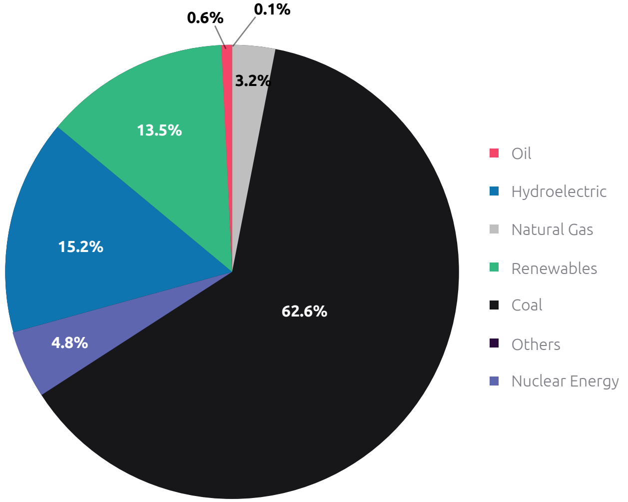
- China aims to achieve carbon neutrality by 2060. To reach that goal, the government has set a medium-term target to further increase renewables share to 25% by 2030.

Gas

- **China Natural Gas Production:** Organization of the Petroleum Exporting Countries (OPEC) Marketed Production was reported at 193,286.000 million cubic meters (Cub m mn) in Dec 2021

FIGURE 1

Electricity generation by fuel, 2021 – terawatt hours (TWh)



Source: BPStats 2022

Coal

- **China coal production:** 3,902.000 million tonnes (December 2020)

Electricity (2021)

- Total electricity generation: **8,534.3 TWh**

Oil

- Total oil production (2021): **3,994 thousand barrels** daily (4.4% of the world's total production)
- Total oil consumption (2021): **15,442 thousands barrels** daily (16.4% of the world's total)
- Oil refining capacity (2021): **16,990 thousand barrels/ day** (16.7% of the world's total)

Electric mobility

- Export of EVs in China (2021): **~500,000**
- Sale of EVs in (2021): **~3.3 million**
- According to the data published by the General Administration of Customs of China, the number of passenger EVs exported in 2021 rose by a factor of **2.6**
- **60%** of global EV production is concentrated in China
- Approximately **100,000** of the total EVs have originated from Tesla's Shanghai plant

Nuclear

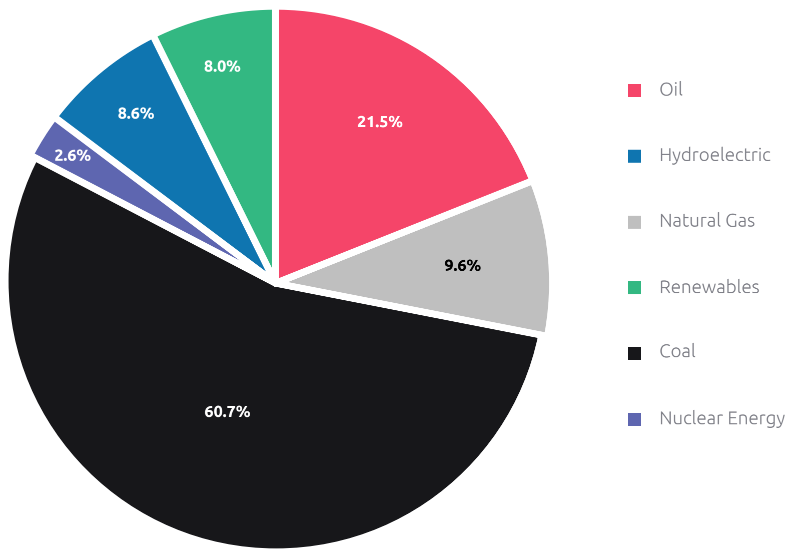
- Consumption: **3.68 Exajoules (EJ)**, (14.6% of the world's total production)
- As of December 2021, there were 53 nuclear plants in China generating approximately **55 gigawatts**

Country highlights

- **Key policies :** In the 14th Five-Year Plan, the country committed to climate and energy policies for the next 10 years to extend the current strategy

FIGURE 2

Primary energy consumption by fuel, 2021 (EJ)



Source: BPStats

- **Quick facts:**
  - China's principal energy consumption was 1.6 times greater than that of the U.S.
  - As of July 2021, there were around 2,990 coal plants operating in China
  - Three state-owned National Oil Companies (NOCs) dominate the oil and gas sector in China. The companies are China National Petroleum Corporation, Sinopec, and China National Offshore Oil Corporation
  - China currently implements a "dual control mechanism" under which provinces are given targets for total energy consumption and energy intensity
  - China has committed to achieving net-zero emissions by 2060

INDIA ENERGY ID CARD

SWETANTA LAHIRI
NUPUR SINHA

Country Description

Country profile

- **Country:** India
- **Population:** 1.38 billion (2020)
- **GDP:** $2.66 trillion (2020)

Electricity

- Total installed capacity of electricity: **402.9 GW** (CEA) (as of May 2022)
- Total electricity consumption (2019-20): **~1,227,000 GWh** (CEA)
- Average electricity price (as of September 2021): **0.077$/kWh** (household price) and **0.105 $/kWh** (business price)
- Average electrification share (2019): **97.8%** (IEA's electricity access rate)

Gas

- Domestic natural gas production (2021): **28.6 Billion Cubic Meters (BCM)**

Energy

- Total primary energy demand in India, 2020:
- Coal (**44%**); Oil (**25%**); Natural Gas (**6%**); Traditional Biomass (**13%**); Modern Renewables (**3%**); Other (**9%**)
- India's energy demand is set to grow by **50%** between 2019 and 2030. However, that figure has been revised to **25%** to **30%** as a result of the Covid-19 pandemic.

Renewable energy

- In 2020, the combined share of energy consumption for renewables increased from **3.9%** to **4.5%**. This can be attributed to a reduction in energy consumption from oil, gas, and coal, which decreased from **90.6%** to **89.7%**.
- Total investments in the renewable sector (2022): **$14.5 billion**

Environment

- Total CO_2 emissions (2020): **2.3 billion tonnes** (units in EJ unless otherwise stated)
- Total CO_2 emissions growth rate (2020): **-7.1%**

Electric mobility

- Electric charging stations: **1,742 public charging stations** (March 2022)
- Number of electric vehicles: **10,76,420** (March 2022)
- Type of electric vehicles: **BEV, PHEV and HEV**
- **Market growth:** Forecasted to increase at a CAGR of **94.4%** from 2021 to 2030

Network

- Total length: **458,258 circuit kilometer (ckt km)** (May 2022)
- Executive summary of target and achievement of transmission lines during 2022-23: **21,098 ckt km** (May 2022)

Energy Companies

- **Power:** NTPC Limited, Adani Group, Tata Power, JSW Energy, Torrent Power, etc.
- **Renewable Energy:** ReNew Power Ventures, Suzlon, Tata Power Solar Systems Ltd., etc.
- **Oil & Gas:** Indian Oil Corporation Limited, Oil and Natural Gas Corporation, Bharat Petroleum, etc.

Country Snapshot

- **Policy support:**
  - Under the Union Budget 2022-23, the Government of India announced the allotment of sovereign green bonds, recognized the energy storage systems as part of infrastructure projects, which includes grid-scale battery systems
  - The government also allocated INR 19,500 crore ($2.57 billion) for a Production Linked Incentive (PLI) scheme to strengthen manufacturing of high-efficiency solar modules
- **Growth in investments, as per the India Brand Equity Foundation (IBEF):**
  - April 2000-December 2021: Total foreign direct investments in the power sector reached $15.84 billion
  - NTPC announced its readiness to commence partial power generation of 10 GW from a 92 MW floating solar energy plant being set up at NTPC's unit at Kayamkulam in Kerala

AUSTRALIA ENERGY ID CARD

ISHANDEEP
NUPUR SINHA

Region description (AUS)

- Region: **Australia**
- Population: **25,739,256 (2021)**
- GDP: **USD$2 trillion (2021)**

Source: Australian Energy Regulator, BP Stats, World Bank, Australian Bureau of Statistics

Electricity

- National Electricity Market (NEM) is an interconnected electricity system that covers around 40,000 km of transmission lines and cables, supplying around 9 million customers.
- NEM interconnects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia. Western Australia and the Northern Territory are not connected to the NEM and have their own electricity systems and separate regulatory arrangements.
- Total electricity generation (2021): 267.5 TWh
- Average electricity price: 0.224 USD$/KWh (residential price)
- Electrification share (Average): 100%
- The Wholesale Electricity Market (WEM) in Western Australia commenced in September 2006 and established under the Electricity Industry (Wholesale Electricity Market) Regulations 2004 and is governed by the Wholesale Electricity Market Rules (WEM Rules). The WEM supplies electricity to more than a million households and businesses in the State's south-west via the Southwest Interconnected System (SWIS).

Gas

Australia's domestic gas market consists of three distinct regions, separated on the basis of the gas basins and pipelines that supply them – Eastern, Western, and Northern.

The Australian Energy Market Commission (AEMC) makes national gas rules.

- Total natural gas production: 147.2 bcm (2021)
- Total natural gas consumption: 39.4 bcm (2021)

Energy

Energy mix 2021:

- Fossil fuels contributed 190 TWh (71%) of total electricity generation.
- Coal accounted for 51% of total generation.
- Renewable sources contributed an estimated 78 TWh, making up 29% of total electricity generation.

Regulatory model: Australian Energy Regulator (AER) regulates the wholesale electricity and gas markets and is part of the Australian Competition and Consumer Commission (ACCC). ACCC enforces the rules established by the AEMC.

Source: Australian Energy Regulator, BP Stats, World Bank, Australian Bureau of Statistics

Renewable energy

- In 2021, 29% of Australia's electricity came from renewable energy, up from 24% in 2020. The largest source of renewable generation was solar (12% of total generation) followed by wind (10%) and hydro (6%). Bioenergy contributed around 4% of renewable electricity in 2021.

Emissions

- Total CO_2 emissions: 487.1 Mt CO_2-e (March 2022)
- CO_2 emissions growth rate: 1.54% (March 2021 vs March 2022)
- CO_2 intensity per capita: 18.9 t CO_2-e per person (December 2021)
- GHG emissions growth rate: 1.5% (March 2022 vs March 2021)

Electric mobility

- Electric charging stations: 1,871 (January 2022)
- Number of electric vehicles: 20,665 (2021)
- EV market growth (2020-2021): 199%

Network (regional sources)

- Electricity network: 918,000 km
  - 850,000 km of distribution grid and 45,000 km of transmission grid
- Tension: 216 - 253 V (households)

Energy players

- Generation and retail "Big Three": AGL, Origin Energy, and EnergyAustralia
- As of Q3 2022, in electricity retail market, Origin Energy caters to 2 million customers, followed by AGL with 1.6 million customers and Energy Australia with 1.1 million customers including residential, small, and large customers.
- Market share: Big Three hold 60% of small electricity and 89% of small gas market.
- Second-tier retailers have built significant market share in some states: Ergon Energy, Alinta Energy, and Red Energy have emerged as strong 'gentailers'.
- As of August 22, 2022, the top three energy generators in the WEM in Western Australian were Synergy (generating around 586 MW), followed by NewGen Kwinana (contributing around 184 MW), and then Alinta (generating approximately 178 MW).
- Per the report by the Energy Council of Australia, "Revenue Adequacy for Generators in the WEM" (April 2022), three generators (Synergy, Summit Southern Cross Power, and Alinta) accounted for 90% of electricity generated.

Country highlights

Key policies and initiatives:

- The 2022–23 budget includes AUD$1.3 billion of new investment which focuses on new clean energy investments, securing reliable and affordable energy, and putting Australia on track to achieve net zero emissions by 2050.
  - Energy and emissions reduction investment includes: AUD$300 million to support low-emissions LNG and clean hydrogen production; AUD$247.1 million for low-emissions technologies, including hydrogen; AUD$148.6 million to support affordable and reliable power; AUD$100 million to support the early readiness of hydrogen capability at Port of Newcastle.
- In June 2022, Prime Minister Anthony Albanese announced more ambitious climate targets and pledged to cut carbon emissions by 43% from 2005 levels by 2030, up from the previous government's target of between 26% and 28%.

Source: Australian Government, Australian Energy Regulator

Recent Developments

- In September 2022, Spanish utility Iberdrola pledged to double its energy generation and invest up to €3 billion (AUD 2.95 billion) in Australia, doubling the $2 billion already invested by Iberdrola Australia in solar and wind farm projects in New South Wales and a renewable energy farm in South Australia.
- In August 2022, Australian Energy Market Operator warned that without investment in new generation electricity storage and transmission, demand will outstrip supply and the so-called "reliability gaps" would emerge in South Australia during 2023-24 and in Victoria in the following year.
- In August 2022, to target carbon emissions from vehicles and boost the uptake of electric cars (which account for just 2% of new auto sales in the country) the Albanese government promised tax cuts for EVs.
- In August 2022, commonwealth, state and territory Energy Ministers established a new National Energy Transformation Partnership with an aim for national alignment and cooperative action by governments to support the smooth transformation of Australia's energy sector.
- In July 2022, as per Australian Energy Market Operator, wholesale electricity and gas prices tripled in Australia's main grid in the Q2 compared with a year ago, as failing coal-fired power plants and soaring global gas costs combined to create "unprecedented" market disruption.
- In June 2022, Australia's New South Wales state announced its plans to invest AUD$1.2 billion (USD$850 million) in new transmission lines over 10 years to speed up connections to the grid for new renewable energy projects.

REGIONAL EDITORIAL: AUSTRALIA

VINNIE NAIR
NICOLE ALLEY

In this sixth edition of dedicated Australian content in our World Energy Markets Observatory, we continue to monitor the evolving nature of Australia's energy transition.

In 2021-2022, climate change events in Australia were in stark contrast to previous years. In the last two years, Australia experienced 'once in 100-year' flooding events several times in parts of Sydney, Northern NSW, and Queensland. In 2019, Australia recorded its driest year in 119 years and experienced one of the longest and most intense bushfire seasons on record. This shows the extreme nature of climate, as many of the same areas that suffered through horrific bushfires in 2019 and 2020 also dealt with the severe flooding events of 2022.

In addition to most of the country being ravaged by fires, floods, and Covid-19, Australia also scored poorly from a climate change perspective[1]. This was due to a combination of factors such as climate denial by politicians, refusal to increase ambition, and refusal to recommit to international green finance mechanisms[2].

Australia: Renewable Energy Snapshot[3]

Despite the above impediments to installing renewables, the Australian renewable energy industry accounted for 32.5% of Australia's total electricity generation in 2021, which represented an increase of almost 5% compared to 2020.

In the past five years, the proportion of Australia's electricity that comes from renewables has almost doubled, increasing from 16.9% in 2017 to 32.5% this year. The growth in renewable energy generation has been most felt in the coal sector, which saw its share of total generation fall from 62% in 2020 to 59.1% in 2021. The growth of renewable energy in Australia in 2021 was again led by small-scale solar. The sector added 3.3 GW of new capacity during the year, representing the fifth year in a row that it has set a record for new installed capacity.

With a new Labor government now in office, the renewables targets are bolder and more ambitious, though they need to be backed up by policy changes and action. The Labor government's pre-election commitment was to cut Australia's greenhouse gas emissions by 43% below 2005 levels by the end of the decade, while boosting renewable electricity production to 82% of our electricity supply. At the time of writing this article, the federal government passed its Climate Change Bill in the lower house. This bill makes into law Labor's 2030 target of a 43% reduction in greenhouse gas emissions on 2005 levels[4].

A large proportion of baseline evidence for these targets comes from the Australian Energy Market Operator (AEMO) Independent System Plan (ISP) modelling and analysis. Each state has set its own individual targets with varying degrees of progress so far. Victoria and Queensland are both aiming for 50% renewables by 2030, while the NSW electricity roadmap is also consistent with a target of around 50%[5]. Tasmania has achieved 100% renewables in 2021 and South Australia is well on its way to 100% renewables[6].

1 https://www.abc.net.au/news/2021-11-10/australia-scores-zero-on-climate-policy-in-latest-report/100608026
2 https://www.sbs.com.au/news/article/australias-climate-policies-have-been-ranked-last-out-of-64-countries/jkydtxz0i
3 https://assets.cleanenergycouncil.org.au/
4 https://cosmosmagazine.com/technology/labor-government-energy-policy/
5 https://www.pv-magazine-australia.com/2022/07/14/labors-renewable-target-much-more-ambitious-than-it-seems-best-bang-for-buck-policy-needed/
6 https://www.pv-magazine-australia.com/2022/08/26/tasmania-reveals-25000-gwh-pipeline-of-renewable-energy-projects/

In 2021, South Australia met 100% of its operational demand from renewable resources for 180 days (49%)[7]. Western Australia and the Northern Territory are still largely fossil fuel dependant and have not set targets yet.

In 2022, across the Australian market there are some key trends we see continuing to evolve.

Market Convergence and Consolidation

- Key energy players are continuing to consolidate and acquire smaller players, therefore blurring the traditional lines of retail and wholesale businesses.
- Fossil fuel generators such as Ampol, bp, and Shell are aggressively positioning themselves as key players in the utilities market through expansion into energy retail and partnerships with grid operators. Ampol was granted an energy retail license in June 2022 by the Australian Energy Regulator (AER) allowing them to offer electricity and gas products to all jurisdictions in the National Electricity Market.
- Large telco players such as Telstra are also diversifying their portfolio through investment in energy, setting up a business to provide electricity retail services. Telstra acquired an energy retail license from the AER in October 2021 which, with the likes of Ampol and Shell entering this market, will significantly increase retail competition in Australia. This will no doubt be a good outcome for consumers with competition driving down energy prices.
- Some of the key impacts from large shifts in convergence and consolidation could mean we see the:
  - Emergence of strategic partnerships between DNSP's and "new" retailers. This would create a new type of commercial partnership not previously seen in Australian utilities, one which has the potential to create great disruption to the incumbent retail players.
  - New revenue streams and business models for traditional oil & gas players as well as DNSPs unregulated businesses, from EV charging to behind the meter solar and home battery bundled service offerings.
  - Injection of fresh capital into more of the traditional electricity retail businesses as well as new start-ups. We expect to also see, as a result of the large windfall these fossil fuel players have seen from recent global petroleum price spikes, a shift in capital to renewables and more investment in new energy services with investment diverted or divestment away from some traditional parts of the oil & gas operations.

Energy security

- Australia, like Europe, has been experiencing an energy supply crisis and shortage of electricity in the Australian NEM, albeit for slightly different reasons. This is largely due to several events preceding the crisis such as blackouts, years of underinvestment in electricity infrastructure, and energy reform that followed. On June 15, 2022, AEMO was forced to suspend the wholesale spot market and put a price cap on generators, protecting further crisis and ensuring security and reliability of supply[8].
- A cold start to winter and a reliance on ageing coal-fired power stations, many of which have unplanned outages in addition to several planned outages, are amplifying challenges facing the Australian energy market. Data from Australian Energy Market Operator – the national electricity market manager – shows nearly 25 per cent of coal capacity remains offline in June 2022, which has sent spot market prices skyrocketing and creating an unprecedented level of disruption to traditional generation.

7 https://www.energymining.sa.gov.au/industry/modern-energy/leading-the-green-economy

8 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf

Cheap capital and the role of the activist investor

- The increase of free-flowing, low-cost capital seen in Australia in the last year has had a significant influence on M&A activity and the ownership stakes of major utilities in Australia. Many major Distribution Network Service Providers (DNSPs), are now partly owned by private equity firms (along with Superannuation funds), delivering essential infrastructure with stable, inflation-protected cash flows. The most notable example in the market in the last couple of years includes cheap credit influencing the sale of a major Victorian network, AusNet Services, bought in excess of 1.5 times the regulated asset base (RAB) by Brookfield for $18.2 Billion AUD[9].
- Cheap capital has also given rise, along with climate action motivations, to the activist investor, largely tech billionaires who have made their money in software. One such example which caused major media attention in February for a number of months was a bid by Atlassian co-founder Mike Cannon-Brookes' Grok Ventures in consortium with Brookfield to buy 100% of AGL and block its demerger plans. According to Cannon-Brookes, the demerger would see the transition away from coal take too long for Australia's largest emissions contributor. While the takeover bid was rejected, Cannon-Brookes has managed to exert his influence through Grok acquiring an 11.3% stake and one board seat.

Innovation in utilities

- Utilities are using flexible demand i.e., innovative ways to curtail solar exports, as a solution to maintain system reliability and security. The Australian government is making investments via government vehicles, such as the Australian Renewable Energy Agency (ARENA), helping network operators stand up projects that assist the market operator with system stability.
  - The Evolve project (with Ergon Energy, Energex, Essential Energy, Endeavour Energy, Ausgrid) and the Symphony project (with Western Power, WA Energy Retailer Synergy and the Australian Energy Market Operator) are two such ARENA funded projects aiming to manage energy distribution, market operation and market aggregation in a highly distributed renewable energy environment. These projects will allow simulation of the effective monitoring and coordination of a high volume of mostly customer DER assets in a controlled environment.
  - Ausgrid's project Edith, previously mentioned in the 23rd edition of this publication aims to showcase how the grid can facilitate technology and green energy solutions (like Virtual Power Plants (VPPs)) to participate in energy markets while staying within distribution network capacity limits also known as "Dynamic Operating Envelopes".
  - Utilities are investing in community battery initiatives which are quickly becoming a cost-effective alternative to traditional infrastructure investment. These have the ability to address local electricity network constraints, as well as provide a range of broader system level services and benefits, such as wholesale market arbitrage and Frequency Control Ancillary Services (FCAS).
  - For example, Ausgrid's community battery project offers a shared battery solution in a local neighbourhood and allows customers and the wider community to access the multiple benefits that batteries can provide. Ausgrid currently has three community batteries for its two-year community battery trial. These are located in Cameron Park, Beacon Hill and Bankstown. Results of the trial will inform a potential wider scale roll out in the future.
  - For example, Ausgrid's Jolt EV partnership aims to step change accessibility of electric vehicle charging by providing customers access to free, fast charging across Sydney, with 17 sites live at the time of writing. Jolt is hoping to adapt about 500 Ausgrid power distribution boxes into charging stations, most of them in Sydney by 2026.
- There has also been progress made on key market reforms such as the Independent System Plan (ISP) released by AEMO and the role of the distribution system operator (DSO) in the market. provides a comprehensive roadmap for the National Electricity Market. The ISP draws on extensive stakeholder engagement and power system expertise to develop a roadmap that optimises consumer benefits through a transition period of great complexity and uncertainty.

9 https://www.afr.com/street-talk/ausnet-knocks-out-1-45b-debt-deal-post-takeover-20220703-p5aynw

Digital twins: Spotlight

- Australia has seen the rise of digital twins in the utilities industry, specifically in the linear asset management space. Up-and-coming Australia based start-up Neara offers a digital twin platform that delivers a true digital twin for linear assets — a physics-enabled, engineering-grade, 3-D, interactive digital model of critical infrastructure such as poles, overhead and underground conductors as well as equipment that hangs off most linear assets
- Essential Energy is now using digital twin modelling to assess scenarios across the network to determine the resilience of network assets under various environmental conditions and stresses. This allows Essential Energy to forecast network reliability and balance their customer's expectations of performance with the required investment to achieve network resilience[1]
- Digital twin platforms have recently solved complex problems in the industry such as risk of damage to critical assets due to floods and bushfire mitigation in a very short time span.
- As an example, Endeavour Energy, in recent flooding from heavy storms, has successfully used the digital twin model to not only accelerate its design process and ratings studies, but also to simulate likely floodwater patterns. The simulator was implemented using open-source government data to model the impact of rising floodwater and keep customers and workers safe. Endeavour Energy was able to accurately isolate electricity supply ahead of areas being inundated where floodwaters brought people close to live power lines[2].

In a changing climate where we're already seeing the effects of unprecedented natural disasters impacting our customers, our team can now use digital twin modeling to assess scenarios across the network and determine how resilient our network assets are under various environmental conditions and stresses,"

"This allows us to forecast network reliability and balance our customer's expectations of performance with the required investment to achieve network resilience.

Luke Jenner
COO, Essential Energy

1 https://www.businesswire.com/news/home/20220524005081/en/Neara-Secures-USD14M-Series-B-Funding-Expanding-Global-Focus

2 https://www.tdworld.com/disaster-response/article/21243732/mitigate-flood-risk-with-digital-twin-technology

We cannot finish this editorial without mentioning the disruption (supply chain, price fluctuation and energy stability) Covid-19 has caused in the Australian energy market. There are also international factors such as the war in Ukraine, which are heavily impacting global gas supply and prices. As we are writing this editorial, the energy crisis in Australia is not over and the extent of the impact on the energy sector is still unfolding.

Over the remainder of 2022 and as we enter 2023, we will be monitoring with interest, growth of DER connections in the NEM and the progress of Renewable Energy Zone (REZ) investments in NSW, real-world implementations of digital twin technology in the utilities industry, and the impact of wholesale prices in the electricity market.

SOUTH EAST ASIA ENERGY ID CARD

ISHANDEEP
NUPUR SINHA

Country Description

Country profile

- **Region:** Southeast Asia (SEA) (Hong Kong, Singapore, Malaysia, Philippines, Vietnam, and Taiwan)
- **Population:** 0.28 billion (2021)[1]
- **GDP:** $3 trillion (2021)*

Electricity

- **Total electricity generation (2021):** 914.1 TWh
  – Hong Kong: 37.1 TWh; Malaysia: 177.2 TWh; Philippines: 108.3 TWh; Singapore: 55.8 TWH; Taiwan: 290.9 TWh; and Vietnam: 244.8 TWh

1 Taiwan data considered for 2020

- Access to electricity (average % of population): **99.5% (2020)**

Renewable Energy

- Renewable energy consumption (Average): **169 TWh**

Energy-related CO_2 emissions (2021):

1,207.6 million tons CO_2

- **Hong Kong:** 64.6 million tons CO_2
- **Malaysia:** 238.6 million tons CO_2
- **Philippines:** 136.8 million tons CO_2
- **Singapore:** 215.7 million tons CO_2
- **Taiwan:** 279.2 million tons CO_2
- **Vietnam:** 272.7 million tons CO_2

EV Charging

- Hong Kong: **5,046 chargers** (June 2022)
- Singapore: **1,600 charging points** (July 2022)
- Malaysia: **600 charging stations** (July 2022)
- Taiwan: **3,652 chargers** (including 552 rapid chargers and over 3,100 public by end of 2021)
- Vietnam: **455 stations with nearly 11,000 charging ports** (June 2021)

Energy Players

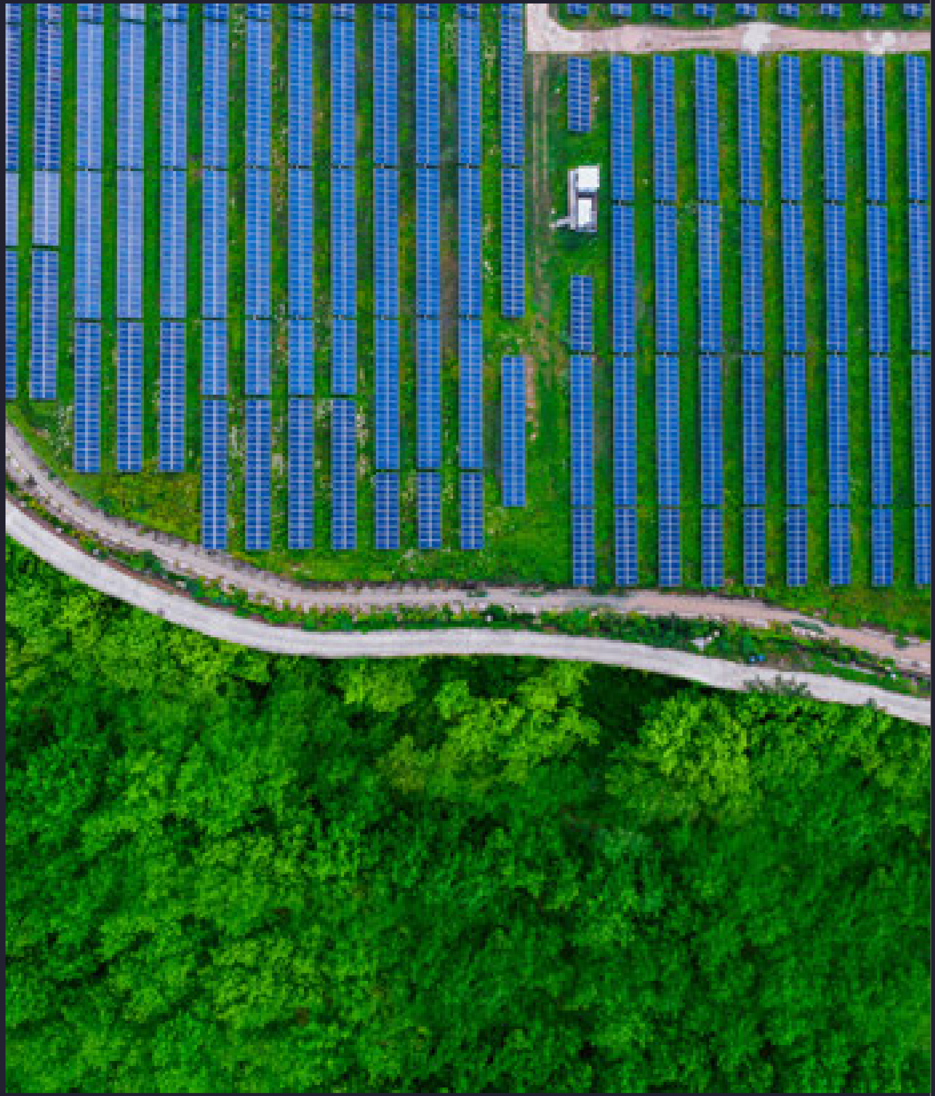
- **Hong Kong:** CLP Group and Hong Kong Electric Company
- **Singapore:** Singapore Power Ltd.
- **Malaysia:** Tenaga Nasional Berhad and Sarawak Energy
- **Philippines:** Manila Electric Company (Meralco)
- **Taiwan:** TaiPower
- **Vietnam:** Vietnam Electricity (EVN)

Recent Developments

- **Hong Kong:** HK Electric unveiled 150MW offshore wind plan in May 2022.
- **Malaysia:** Government is approving the allocation and redistribution of a renewable energy quota of 1,200MW for solar resources to boost the country's commitment in the energy transition.
- **Philippines:** Department of Energy (DOE) released Offshore Wind Roadmap; the World Bank Group (WBG) shows that the Philippines has potential to install 21GW of offshore wind power.
- **Singapore:** Commenced first renewable energy electricity import via regional multilateral power trade in June 2022.
- **Taiwan:** Reached a cumulative installed solar capacity of around 7.7 GW at the end of 2021.
- **Vietnam:** Country's power development plan draft incorporates renewables and reduces coal.

04

CLIMATE CHANGE & ENERGY TRANSITION



CLIMATE CHANGE GLOBAL PERSPECTIVE (EMISSIONS, CONSUMPTION, RENEWABLES)

DAVID PEREZ LOPEZ

The time is now or never, there is no alternative

Without immediate action, the world could become uninhabitable.

“*We are on a fast track to climate disaster: Major cities under water. Unprecedented heatwaves. Terrifying storms. Widespread water shortages. The extinction of a million species of plants and animals. It is what science tells us will result from our current energy policies.*

We are on a pathway to global warming of more than double the 1.5-degree limit agreed in Paris. Some government and business leaders are saying one thing – but doing another. And the results will be catastrophic. This is a climate emergency.

This is not fiction or exaggeration. It is what science tells us will result from our current energy policies. We are on a pathway to global warming of more than double the 1.5° limit that was agreed in Paris in 2015. The science is clear. To keep the 1.5° limit, we need to cut global emissions by 45% this decade. But current climate pledges would mean a 14% increase in emissions.

Climate promises and plans must be turned into reality and action now. It is time to stop burning our planet and start investing in the abundant renewable energy all around us.[1]”

António Guterres
United Nations’ Secretary-General, April 2022

1 António Guterres, United Nations’ Secretary-General, 04 April 2022

The science is unequivocal and the action windows is rapidly closing, to delay action will trigger impacts of climate change so catastrophic and our world will become unrecognizable. Next few years offer a narrow window to realize a sustainable world for all. There is no alternative.

Compounding crises underscore the pressing need to accelerate the global energy transition. Events of recent years have accentuated the speed and the costs to the global economy of a centralized energy system highly dependent on fossil fuels. Oil and gas prices are soaring to new highs and the crisis in Ukraine brings new levels of concern and uncertainty. Additionally, the Covid-19 pandemic continues to hamper recovery effort and citizens worldwide worry about the affordability of their energy bills. The need for energy transition is urgent. The time is now or never.

At the same time, the impacts of human-caused climate change are increasingly evident around the globe[2]; between 3.3 and 3.6 billion people already live in settings highly vulnerable to climate change[3]. Therefore, short-term interventions to ameliorate challenges must be accompanied by a steadfast focus on a successful energy transition in the medium and long term.

Despite the urgency for change and after the Covid-19-induced dip in 2020, carbon emissions have risen every year since 2015, the year of the Paris Conference of the Parties (COP).

2 IRENA World Energy Transitions Outlook 2022 report
3 Intergovernmental Panel on Climate Change (IPCC)

The carbon budget is finite, and it is running out. Further delays in reducing emissions could greatly increase the economic and social costs associated with trying to remain within the emissions budget[4].

The stimulus and recovery efforts associated with the pandemic have also proved a missed opportunity, with only 6% of the G20's $15 trillion in recovery funding in 2020 and 2021 being channeled towards clean energy.

Current path the global warming will exceed 2°C

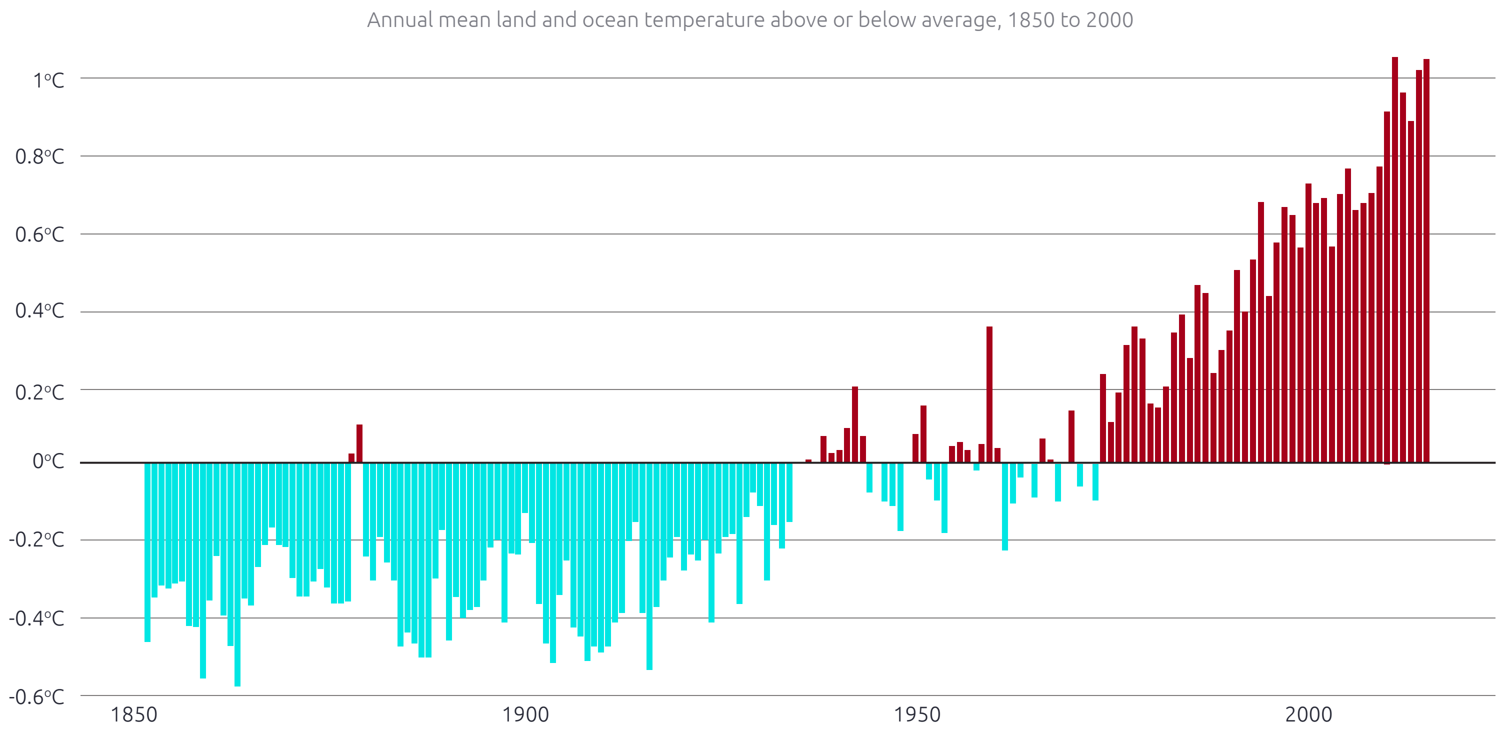
Given the inadequate pace and scope of the transition, any action short of radical and immediate will diminish the chance of staying on the 1.5°C or even 2°C path.

National climate pledges combined with other mitigation measures put the world on track for a 2.7°C temperature rise by the end of the century, above the threshold of 1.5°C. This could lead to catastrophic changes in the earth's climate. To keep global warming below 1.5°C this century, annual greenhouse gas (GHG) emissions will need to be halved in the next eight years[5]. The net zero emissions pledges could limit warming to 2.2°C, closer to the goal of the Paris Agreement. However, many national climate plans delay action until after 2030.

4 BP Energy Outlook 2022 report
5 UNEP and UNEP CCC (Copenhagen Climate Centre) Emissions Gap report 2021

FIGURE 1

World is getting warmer



Note: Average calculated from 1951 to 1980 data

Source: University of California Berkeley

Every tenth of a degree of additional warming will escalate threats to people, species and ecosystems, even limiting global warming to 1.5°C is not safe for all where for instance many glaciers around the world will either disappear completely or lose most of their mass; an additional 350 million people will experience water scarcity by 2030; and as much as 14% of terrestrial species will face high risks of extinction.

Nowadays between 3.3 billion-3.6 billion people live in countries highly vulnerable to climate impacts. For instance, in highly vulnerable nations, for example, mortality from droughts, storms and floods in 2010-2020 was 15 times greater than in countries with lower vulnerability[6].

Acceleration of the energy transition is also essential for long-term energy security, price stability, and national resilience. Some 80% of the global population lives in countries that are net energy importers. With the abundance of renewable potential yet to be harnessed, this percentage can be dramatically reduced[7].

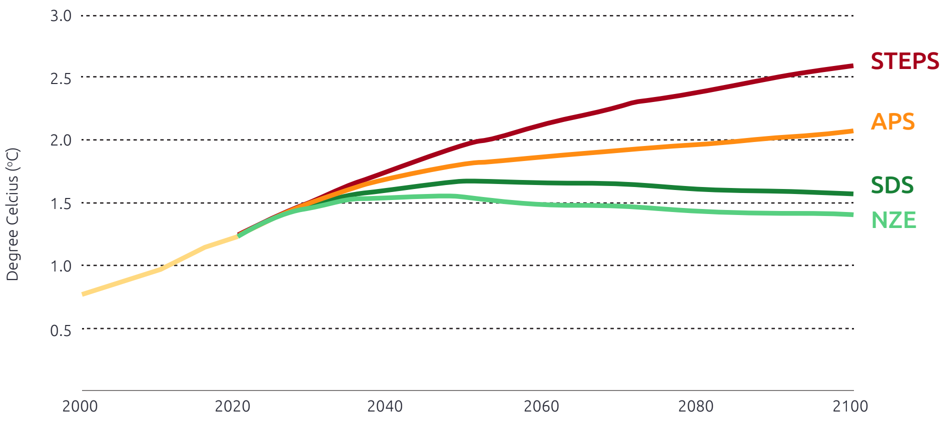
6 Intergovernmental Panel on Climate Change (IPCC) Climate Change 2022 – Impacts, Adoption and Vulnerability report
7 IRENA World Energy Transitions Outlook 2022 report

Global median surface temperatures rise over time under four scenarios, according to the World Energy Outlook 2021[8]:

- Net Zero Emissions by 2050 Scenario (NZE) is designed to achieve an emissions trajectory that limits the global temperature rise to 1.5°C without a temperature overshoot (with a 50% probability).
- Announced Pledges Scenario (APS) assumes that all climate commitments made by governments worldwide, including Nationally Determined Contributions (NDCs) and longer-term net zero targets, will be met in full and on time.
- Stated Policies Scenario (STEPS) reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place, as well as those that governments around the world have announced.
- Sustainable Development Scenario (SDS) pathway is consistent with the well below 2°C goal of the Paris Agreement.

FIGURE 2

Global median surface temperature rise over time



The temperature rise is 2.6°C in the STEPS and 2.1°C in the APS in 2100 and continues to increase.
It peaks at 1.7°C in the SDS and 1.5°C in the NZE around 2050 and then declines.

Source: IEA

8 IEA World Energy Outlook 2021 report

If the world stays on its current track temperatures, we are on average on a 2.7°C trajectory[9]. The difference between a warming of 2°C in spite of 1.5°C, only a difference of 0.5°C, the climate change consequences will be dramatic and catastrophic causing irreversible effects.

Many impacts of climate change have been observed worldwide, including: terrestrial effects; oceans and freshwater ecosystems; species shift and phenology; human systems (water scarcity and agriculture production); animal and livestock health and production; fisheries yield and aquaculture production; infectious diseases; malnutrition; displacement; floods; and storms causing damages[10].

Even under the ambitious 1.5°C scenario, which will stave off much greater losses to nature and humans[11], the world will still face significant harm from climate change: coral reefs could decline as much as 90%; up to 14% of terrestrial species could face a very high risk of extinction; and 40% of megacities globally could record a heat index higher than 40.5°C (105°F).

Under the well below 2°C goal would put 10 million more people at risk from sea level rise and direct flood damage could be twice as high. At 3°C of warming, disruption to ports and coastal infrastructure could impact entire financial systems, and risks to agricultural yields are three times higher than at 2°C[12].

9 IPPC
10 Intergovernmental Panel on Climate Change (IPCC) Climate Change 2022 – Impacts, Adoption and Vulnerability report
11 Intergovernmental Panel on Climate Change (IPCC) Climate Change 2022 – Impacts, Adoption and Vulnerability report
12 Intergovernmental Panel on Climate Change (IPCC) Climate Change 2022 – Impacts, Adoption and Vulnerability report

FIGURE 3

Half a degree of warming makes a big difference: Explaining IPCC's 1.5°C special report

	1.5°C	2°C	2°C Impacts
Extreme heat Global population exposed to severe heat at least once every five years	14%	37%	2.6X Worse
Sea-ice-free Arctic Number of ice-free summers	At least 1 every 10 years	At least 1 every 10 years	10X Worse
Sea level rise Amount of sea level rise by 2020	0.40 meters	0.46 meters	.06M More
Species loss: Vertebrates Vertebrates that lose at least half of their range	4%	8%	2X Worse
Species loss: Plants Plants that lose at least half of their range	8%	16%	2X Worse

	1.5°C	2°C	2°C Impacts
Species loss: Insects Insects that lose at least half of their range	6%	18%	3X Worse
Ecosystems Amount of earth's land area where ecosystems will shift to a new biome	7%	13%	1.86X Worse
Permafrost Amount of Arctic permafrost that will thaw	4.8 Million KM²	6.6 Million KM²	38% Worse
Crop yields Reduction in maize harvests in tropic	3%	7%	2.3X Worse
Coral Reefs Further decline in coral reefs	70-90%	99%	Up to 29% Worse
Fisheries Decline in marine fisheries	1.5 million tonnes	3 million tonnes	2X Worse

Source: IPCC 2022 report

FIGURE 4

Comparing risks from rising temperatures: Explaining IPCC's working group II report (AR6)

	1.5°C	2°C	3°C	1.5°C vs 2°C	1.5°C vs 3°C
Biodiversity loss: Maximum percentage of species at high risk of extinction across forests and lands	14%	18%	29%	1.3X Worse	2.1X Worse
Drought: Dryland population exposed to water stress, heat stress and desertification	0.95 B people	1.15 B people	1.29 B people	200M more people	340M more people
Food Security: Costs for adaptation and residual damage to major crops	$ 63 billion US	$ 80 billion US	$ 128 billion US	$17B more	$65B more
Fires: Increase in burnt areas across Mediterranean Europe	40-54%	62-87%	96-187%	1.6X Worse	3X Worse
Extreme heat: Increase in number of days per year with a maximum temperature above 35°C (95°F)	45-58%	52-68%	66-87%	1.2X Worse	1.5X Worse

	1.5°C	2°C	3°C	1.5°C vs 2°C	1.5°C vs 3°C
Extreme heat: Increase in annual number of heat waves in Southern Africa	2-4 times	4-8 times	8-12 times	2X Worse	3.3X Worse
Sea level rise: Global mean sea level rise by 2100	0.28 - 0.55 M	0.33 - 0.61 M	0.44 - 0.76 M	1.1X Worse	1.4X Worse
Floods: Increase in global population exposed to flooding	30%	24%	No data available	1.3X Worse	No data available
Coral reefs: Further decline in coral reefs	70-90%	99%	No data available	1.2X Worse	No data available

Note: For climate risks with projected ranges, we used the midpoint of the ranges to compare risks at different temperature thresholds. Sea level rise projections correspond to SSP1-1.9, SSP1-2.6, SSP2-4.5, which are approximate to global warming of 1.5°C, 2°C and 3°C respectively.

Source: IPCC 2022 report

Insects, vital for pollinating crops and plants, are likely to lose half their habitat at 1.5°C. This becomes twice as likely at 2°C. The frequency and intensity of droughts, storms, and extreme weather events will rise with every increment in temperature – as we are already seeing with a global temperature increase over pre-industrial levels of around 1.1°C.

Extreme climate records were smashed in 2021 even worse than expected

From 1999 to 2018, there have been nearly 500,000 fatalities and close to $3.5 trillion of economic costs due to climate impacts worldwide, with China, India, Japan, Germany, and the U.S. being hit particularly hard in 2018.

Climate impacts are already more widespread and severe than expected causing widespread disruption in every region in the world with just 1.1ºC of warming as currently is today.

We are locked into even worse impacts from climate change in the near-term. For 2021, several climate change records were registered with extreme weather events[13]:

- A high temperature of 18.3°C was set in the Antarctic four times faster than the rest of the planet. Death Valley in California recorded the world's highest-ever temperature of 54.4°C. Italy set a new provisional European record in Syracuse (Sicily) with a temperature of 48.8°C. Kairouan (Tunisia) reached a record 50.3°C. Spain and Turkey also broke new national records, with temperatures of 47.4°C and 49.1°C, respectively.
- Sea levels rose 4.5 mm a year on average between 2013 and 2021. In the southwest Pacific, the southwest Indian Ocean and the south Atlantic, the sea level is rising substantially faster than the global average.
- The Antarctic ozone hole was larger and deeper than 70% of the ozone holes measured since 1979.
- Rain was recorded for the first time at Greenland's highest point, which is more than 3,200 meters above sea level. The area received several hours of rain and experienced air temperatures above freezing for about nine hours.
- Hurricane Ida wind speeds of 240 km per hour matched the strongest landfall on record for Louisiana in the United States, causing significant wind damage and flooding from storm surges with an estimated $75 billion in economic loss and 115 deaths. There were 21 named storms in 2021, well above the average of 14 per year between 1981 and 2010.
- The worst flooding ever was recorded in Western Europe. Hagen in western Germany reported 241 mm of rainfall in 22 hours. Germany reported 183 deaths and Belgium, 36.
- In July, the water levels in Lake Mead (a reservoir on the Colorado River in the southwestern U.S.) fell to 47 m below its full capacity, its lowest level on record. Drought also affected other parts of the world, including Canada, Iran, Pakistan, Afghanistan, Turkey, and Turkmenistan.

13 World Meteorological Organization (WMO), State of the Global Climate 2021 report

In the summer of 2022, Europe was hit by a climate-driven drought crisis with water shortages across the continent – possibly the worst in 500 years[14]:

In mid-August, the European Union (EU) registered a historical record of almost 660,000 hectares of land burned, especially affecting Spain, Romania, Portugal, and France, as well as in latitudes further north not usually affected, such as Slovenia, where the worst fires in generations were recorded[15].

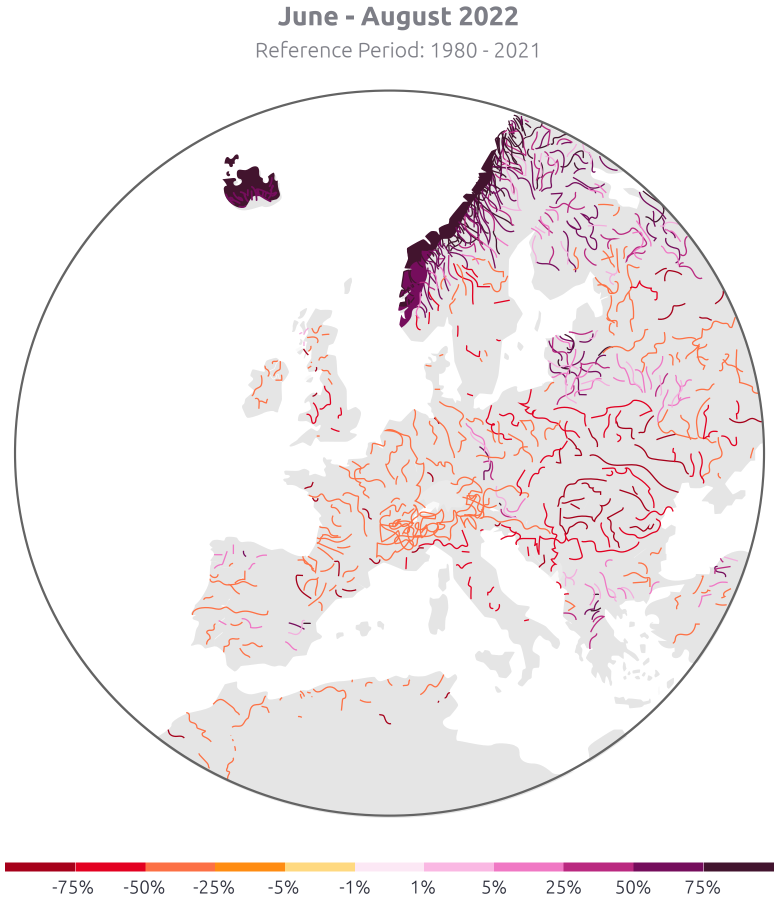
The English government officially declared a drought across southern and central England amid one of the hottest summers on record. The last eight months were the driest since 1976, which constrained water supply in the east of England; last July was the driest since 1935[16].

The Rhine, Germany's biggest waterway, could reach critically low levels around 35 centimeters. The Danube River authorities in Serbia have started dredging to keep vessels moving. The Po River, Italy's longest, is so low that barges and boats that sank decades ago are resurfacing. In Hungary, wide parts of Lake Velence near Budapest have turned into patches of dried mud.

A map of European rivers' discharge based on data from June to August 12, 2022, shows an average negative anomaly of -29% and reaching less than -62% at some points[17]:

FIGURE 5

River Discharge Anomaly



Source: Dr. Dominic Royé

Death Valley (California), America's driest place, recorded torrential rains with 75% of the average annual falling in just three hours in an extremely rare event – once per 1000 years. Future extreme storms and megafloods in California will occur with 200% to 400% greater probability than historical averages[18].

Drought crisis conditions were also reported in east Africa, the western United States, and northern Mexico.

After some of the highest recorded temperatures across South Asia, flooding in Pakistan, from the highest rainfall in more than three decades, killed more than 1,000 people and caused more than $10 billion in damage.

14 European Commission's Joint Research Center
15 EFFIS (European Forest Fire Information System)
16 UK Met Office weather agency
17 Data: GLOFAS Copemicus

18 https://www.science.org/doi/10.1126/sciadv.abq0995

A new global climate pact was reached at the COP26 summit

The 26th Conference of the Parties (COP26) of the United Nations took place in Glasgow from October 31 to November 12, 2021. The main topics discussed were nationally determined contributions and their accounting (article six of the Paris Agreement), adaptation plans, financing commitments, follow-up and analysis of the inadequacy of the resources and actions committed to date, and the need to increase climate action and ambition without pause, reinforcing the three main principles:

- Strengthen the credibility of advertisements – strengthen transparency mechanisms of compliance by all countries and the credibility of companies.
- Reinforce Solidarity – at the summit, this principle was made clearer than ever.
- Sense of urgency – in the middle of an emergency, the temperature increase should not exceed 1.5°C, and there is a large difference between 1.5°C and 2°C.

The main advances in the Glasgow Pact were[19]:

- To raise ambition at the national level, but more importantly, to spur immediate action and get started on reducing emissions. Establishment of a 2-year work program to define and achieve the Global Adaptation Goal of the Paris Agreement.
- To reaffirm the commitment to mobilize $100 billion-a-year. Define the goal for 2025 to finance the climate transition of developing countries and stimulate the large-scale private finance needed to reach the Paris Agreement.
- To encourage solutions that can reduce GHG emissions while also adapting to climate impacts like extreme weather events. Proposal for measures to reduce the gap between commitments and scientific evidence. The need to reduce emissions by 45% by 2030, compared to 2010, is specified to achieve compliance with the objective of not increasing the temperature by more than 1.5°C.
- Importance of the need to deal with the catastrophic impacts of climate change in vulnerable countries.
- Approval of the Paris Agreement rulebook, the market and cooperation mechanisms, the transparency framework, and the common deadlines for country contributions.
- Carbon dioxide emissions: To pledge further cuts to CO_2 emissions in 2022, keeping the goal of temperature rises within 1.5°C. Current pledges, if met, will only limit global warming to about 2.4°C.
- Methane emissions: Cut 30% of methane emissions by 2030, currently responsible for a third of human-generated warming. The biggest methane emitters China, Russia and India didn't joined.
- Coal: For the first time at COP, there was an explicit plan to reduce the use of coal, which is responsible for 40% of annual CO_2 emissions, but in a weaker commitment to "phase down" rather than "phase out."
- Fossil fuel subsidies: To phase-out subsidies that artificially lower the price of coal, oil, or natural gas.
- Forests: more than 100 countries with about 85% of the world's forests agreed to stop deforestation by 2030, which is vital to absorbing vast amounts of CO_2.

19 www.unep.org

Carbon emissions have rebounded quickly after the Covid-19 dip

In 2020, the Covid-19 pandemic lockdowns led to a 5.4% global drop in CO_2. In 2021, levels were similar to the record high of 2019. Emissions increased by 4.9%[20], pushing the CO_2 levels to the highest in the last two million years, closing the carbon budget threshold to limit the temperature increase to the critical figure of 1.5°C.

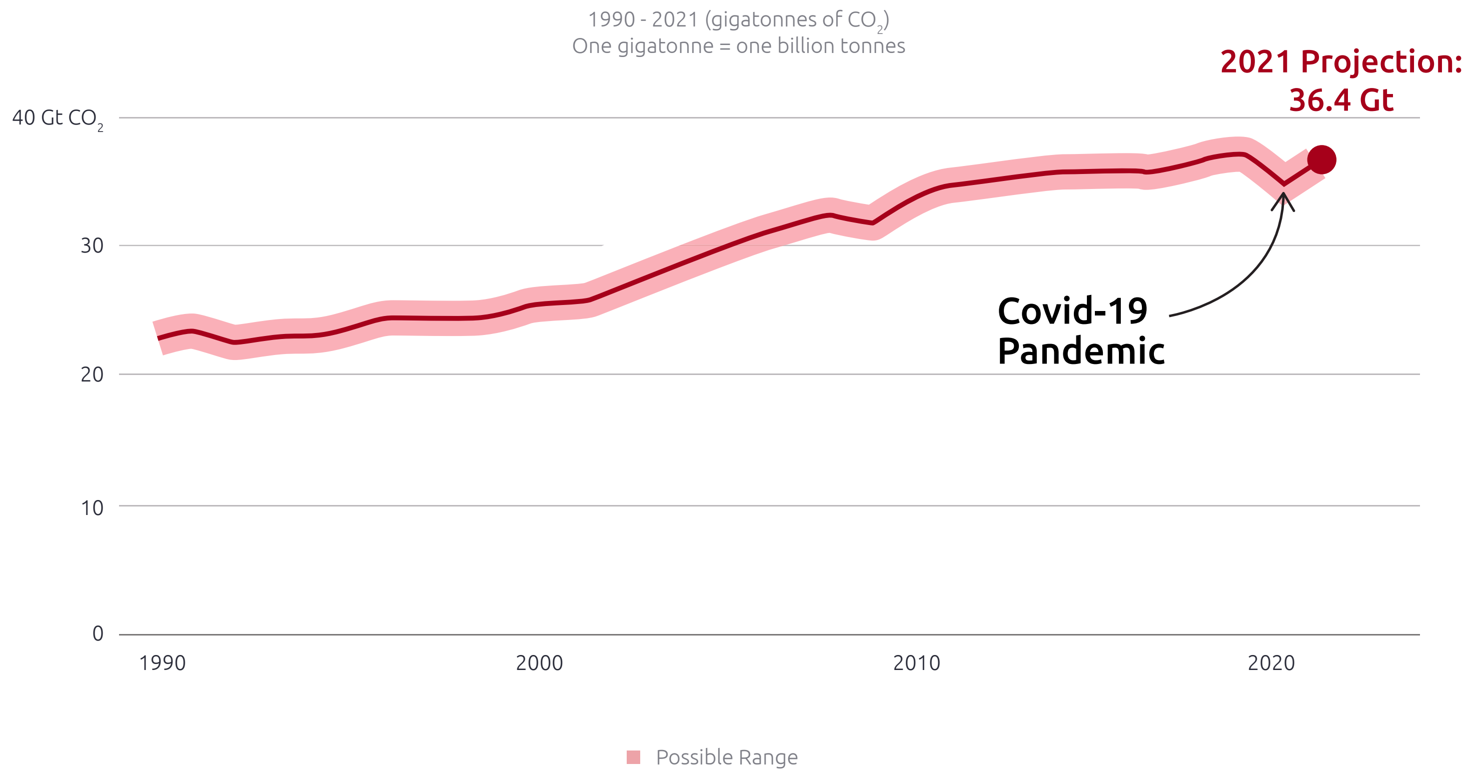
Important pledges were struck at the COP26 on limiting emissions of CO_2 and methane and on curbing deforestation, but the rapid rebound in emissions is at odds with the ambitious CO_2 cuts required to limit global temperature rise to 1.5°C. If we continue along as we are and don't cut emissions, there's a 50% likelihood of reaching the 1.5°C of warming in about 11 years[21] by the early 2030s[22].

To limit climate change to 1.5°C, we will need to cut global emissions by 1.4 billion tonnes of CO_2 yearly. The level in the fall of 2020 was 1.9 billion tonnes during the lockdown[23]. So, reducing emissions by roughly the equivalent in the post-lockdown period presents a huge challenge.

Only 17-19% of pandemic economic recovery ($438 billion out of $2.28 trillion) is being used for green recovery and reducing GHG emissions. Of the green recovery, 90% comes from seven countries, which needs to be expanded[24].

FIGURE 6

Global Carbon Emissions returning to pre-Covid levels



Source: Global Carbon Budget 2021

20 Climate Action Tracker, Global Carbon Project.
21 16th annual Global Carbon Budget report
22 IPCC
23 16th annual Global Carbon Budget report
24 UNEP (United Nations Environment Programme) Emisions gas report 2021.

The 1.5°C scenario by 2030 will require investments of $5.7 trillion per year until 2030. Investment decisions are long-lived, and the risks of stranded assets are high, so decisions

should be guided by long-term ratioale. $0.7 trillion in annual investments in fossil fuels should be redirected towards energy transition technologies, which could create close to 85 million additional energy transition-related jobs and boost global GDP (gross domestic product).[25]

There is a huge gap between where GHG emissions are predicted to be in 2030 based on current government commitments and where we need to be to meet the targets of the Paris Agreement. Current commitments put the world on track for a global temperature rise of 2.7°C by the end of the century.

Current commitments will only take 7.5% off predicted 2030 emissions, while a 55% reduction is needed to meet the 1.5°C targets. Any temperature increase approaching 2.7°C will be a disaster for humanity and many of the planet's species. Even an increase of 2°C would have a major impact on food, security, and human health[26].

To stand a chance of limiting global warming to 1.5°C, the next eight years will be crucial. GHGs need to be halved. On top of the current commitments, a further 28 gigatonnes of CO_2 equivalent ($GtCO_2e$) of annual emissions must be reduced.

Methane is crucial for short-term climate action. This gas has a global warming potential of more than 80 times that of carbon dioxide over 20 years, making it a powerful heat trapper. However, it only stays in the atmosphere for 12 years, far less than carbon dioxide, so reducing methane emissions can have a faster impact on reducing global warming in the short term.

Carbon markets will also help slash emissions with clearly defined rules and target actual reductions while being supported by arrangements to track progress and transparency[27].

25 IRENA World Energy Transitions Outlook 2022 report
26 Intergovernmental Panel on Climate Change (IPCC)

27 UNEP and UNEP CCC (Copenhagen Climate Centre) Emissions Gap report 2021

GHG emissions caused by humans are still increasing and will peak in 2025

Greenhouse gas emissions caused by humans are still increasing. The emissions reductions from actions have been lower than the emissions increase that comes from rising global activity. However, the growth rate of emissions was slower between 2010 and 2019 than between 2000 and 2009. To limit global warming to 1.5°C, GHG emissions would have to peak before 2025, be reduced by 43% by 2030 in the pathway to achieve net zero carbon dioxide emissions globally in 2050[1]. A 43% decrease in five years seems too much challenging or almost impossible to meet.

The 1.5°C pathway requires a massive change in how societies produce and consume energy and would result in a cut of nearly 37 gigatonnes of annual CO_2 emissions by 2050[2].

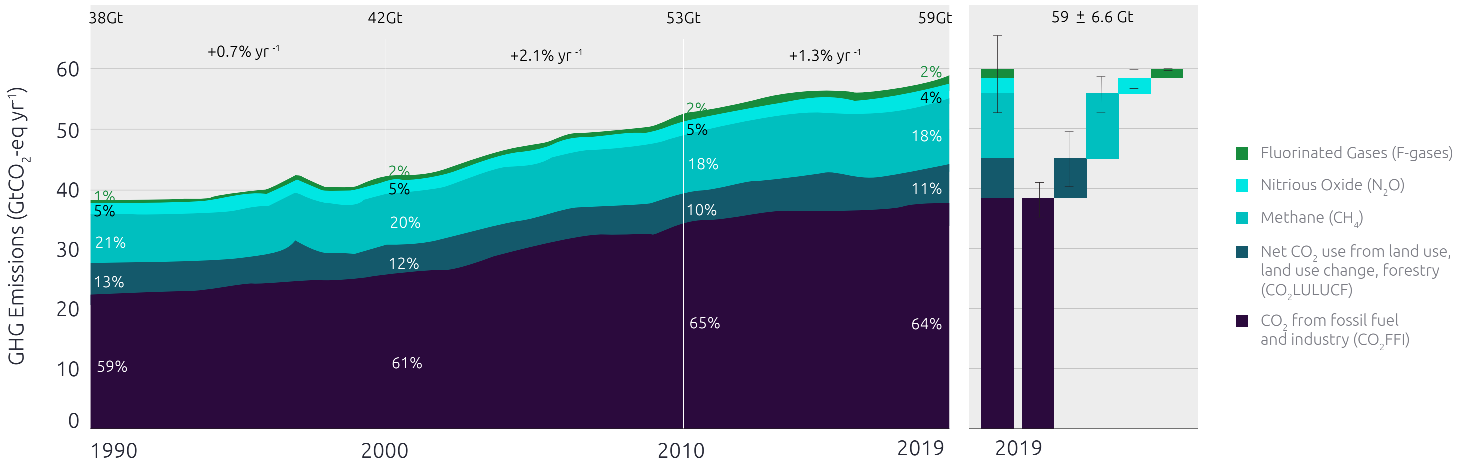
Fossil fuels accounted for 82% of primary energy use in 2021, up from 83% in 2019 and 85% five years ago; CO_2 emissions from energy use, industrial processes, flaring, and methane emissions increased 5.7% in 2021 to 39.0 $GtCO_2e$, and carbon dioxide emissions from energy increased 5.9% to 33.9 $GtCO_2$, close to 2019 levels[3].

GHG emissions have overwhelmingly come from more developed countries and wealthier individuals[4] being climate change the result of more than a century of unsustainable energy and land use, lifestyles, and patterns of consumption and production.

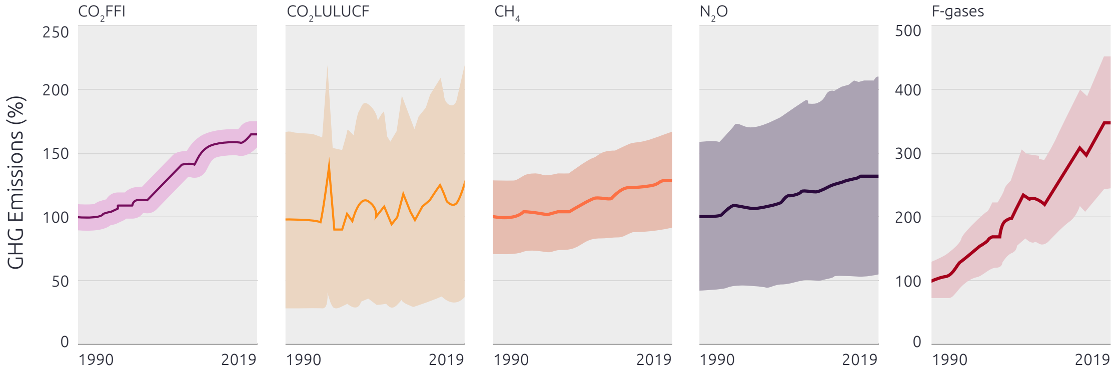
FIGURE 7 & 8

Global net anthropogenic GHG emissions have continued to rise across all major groups of greenhouse gases

7. Global net anthropogenic GHG emissions, 1990-2019



8. Global anthropogenic GHG emissions and uncertainties by gas – relative to 1990



	2019 Emissions ($GtCo_2$-eq)	1990 - 2019 Emissions (Gt-Co_2-eq)	Emissions in 2019, relative to 1990 (%)
CO_2FFI	38 ± 3	15	167
$CO_2LULUCF$	6.6 ± 4.6	1.6	133
CH_4	11 ± 3.2	2.4	129
N_2O	2.7 ± 1.6	0.65	133
F-gases	1.4 ± 0.41	0.97	354
Total	59 ± 6.6	21	154

The solid line indicates central estimate of emissions trends. The shaded area indicates the uncertainity range.

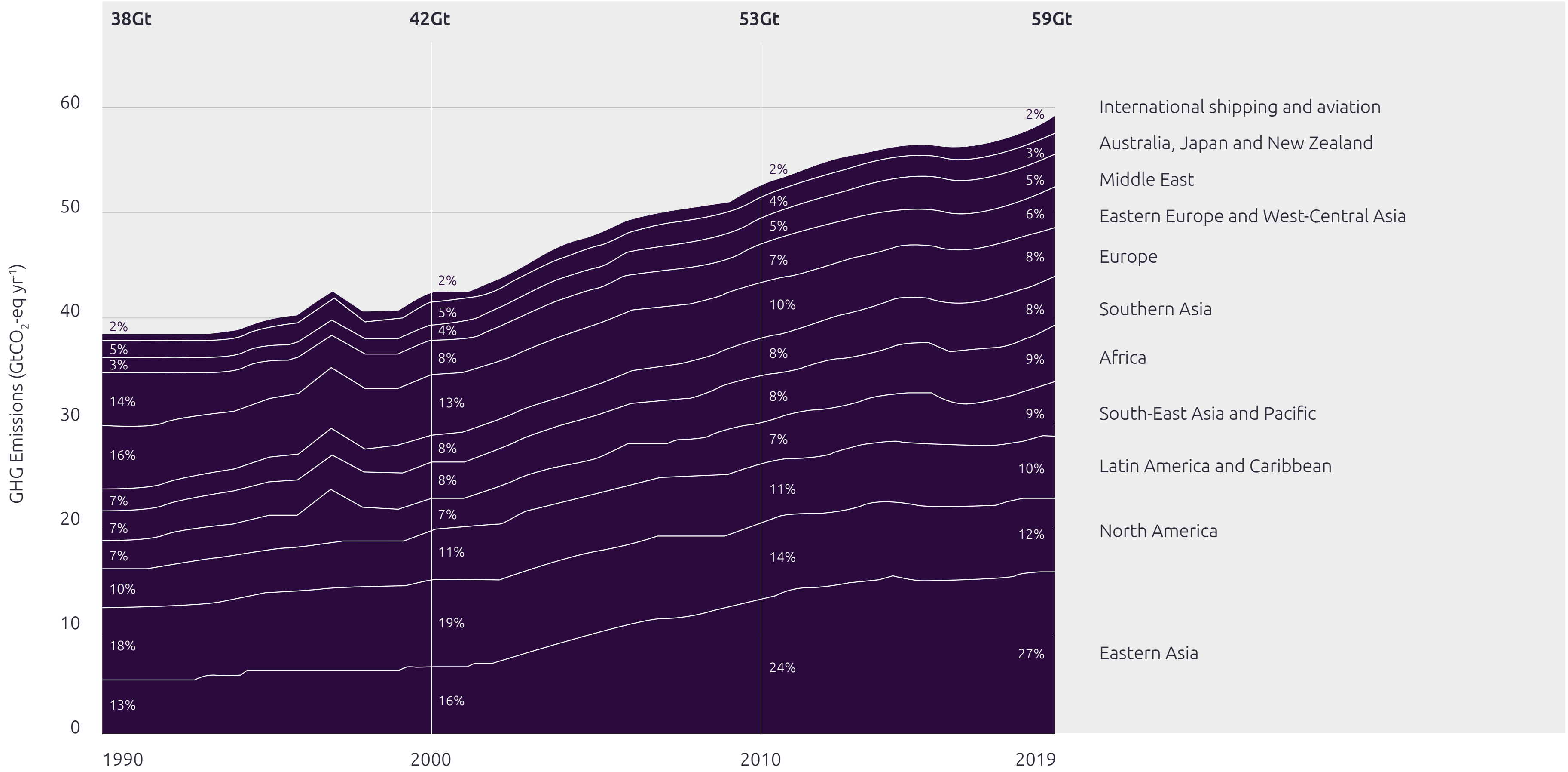
Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

1 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report.
2 IRENA World Energy Transitions Outlook 2022 report
3 BP Energy Outlook 2022 report
4 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report.

FIGURE 9a

Emissions have grown in most regions but are distributed unevenly, both in present day and cumulatively since 1850.

Global net anthropogenic GHG emissions by region, 1990-2019



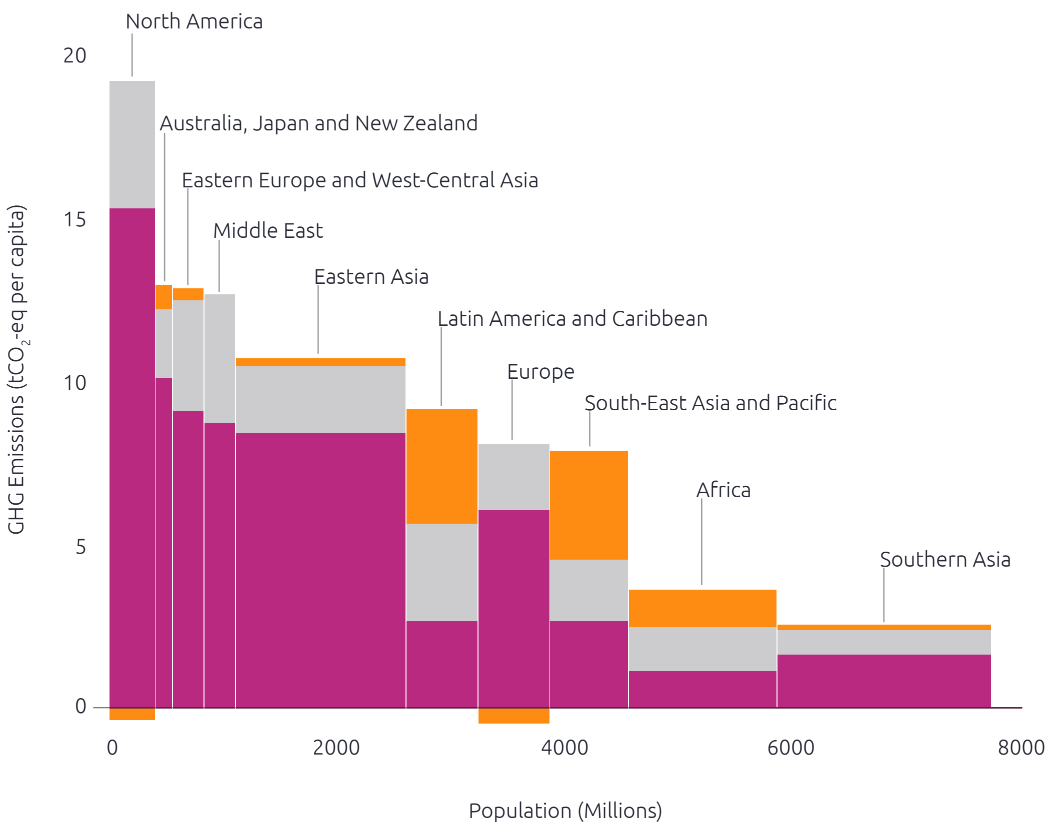
Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

FIGURE 9b

Historical cumulative net anthropogenic CO2 emissions per region, 1850-2019

FIGURE 9c

Net anthropogenic GHG emissions per capita and for total population, per region (2019)



Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

FIGURE 9d

Regional indicators (2019) and Regional production vs consumption accounting (2018)

	Africa	Australia, Japan, New Zealand	Eastern Asia	Eastern Europe, West-Central Asia	Europe	Latin America and Caribbean	Middle East	North America	South-East Asia and Pacific	Southern Asia
Population (million persons, 2019)	1292	157	1471	291	620	646	252	366	674	1836
GDP per capita (USD1000$_{ppp}$2017 per person)[1]	5.0	43	17	20	43	15	20	61	12	6.2
Net GHG 2019[2] (production basis)										
% GHG contributions	9%	3%	27%	6%	8%	10%	5%	12%	9%	8%
GHG emissions intensity (tCO_2-eq / USD1000$_{ppp}$2017)	0.78	0.30	0.62	0.64	0.18	0.61	0.64	0.31	0.65	0.42
GHG per capita (tCO_2-eq per person)	3.9	13	11	13	7.8	9.2	13	19	7.9	2.6
CO_2FFI, 2018, per person										
Production-based emissions (tCO_2FFI per person, based on 2018 data	1.2	10	8.4	9.2	6.5	2.8	8.7	16	2.6	1.6
Consumption-based emissions (tCO_2FFI per person, based on 2018 data	0.84	11	6.7	6.2	7.8	2.8	7.6	17	2.5	1.5

[1] GDP per capita in 2019 in USD2017 currency purchasing power basis
[2] GIncludes CO_2FFI, CO_2LULUCF and Other GHGs, excluding international aviation and shipping

Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

Renewables, energy efficiency, and electrification will dominate the energy transition

Renewables technologies, energy efficiency, and electrification will dominate energy transition. In 2050, 90% of all decarbonization will involve renewable energy through a direct supply of low-cost power, efficiency, electrification, bioenergy with carbon capture and storage (CCS), and green hydrogen[5].

A radical shift in energy demand should be accelerated to reach the Paris Agreement's declining role for fossil fuel sources and an accelerated and rapid expansion in renewables and electrification to substitute fossil fuels, in this context the use of low carbon technologies like nuclear will play a crucial role also.

5 IRENA World Energy Transitions Outlook 2022 report

Renewables must accelerate and triple their installation pace

Renewables-based electricity is now the cheapest power option in most regions. The global weighted-average levelized cost of electricity from newly commissioned utility-scale solar photovoltaic (PV) projects fell by 85% between 2010 and 2020. The corresponding cost reductions for concentrated solar power (CSP) were 68%, onshore wind was 56%, and offshore wind was 48%[6], but the speed of the shift to renewable energy must triple[7].

Renewables accounted for more than two-thirds of investment in new power capacity in 2021[8], yet a sizeable gain in coal and oil use have caused the second largest annual increase in climate change-causing CO_2 emissions[9].

Nowadays the situation has become specially complex due to current geopolitical energy crisis, high electricity, oil and gas prices, extremely high level of inflation, cost of capital increasing, constraints and price increasing in raw materials supply, accelerated increase in the demand side, high dependency on Chinese critical minerals, manufacturing and logistics, and finally more ambitious and accelerated renewables goals. This is causing a crossroads and a perfect storm situation in the renewables industry. Yet, definitely renewables remain the major option today to decarbonize the largest part of the economy.

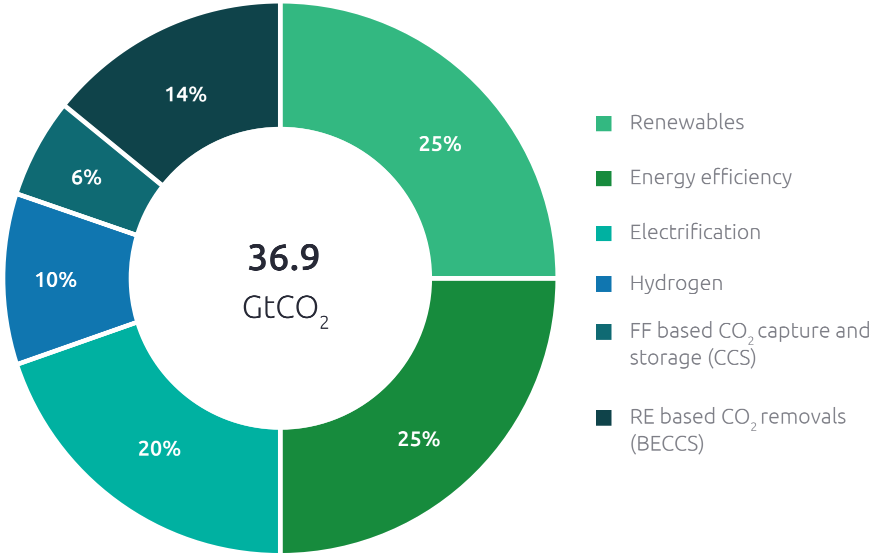
6 IRENA World Energy Transitions Outlook 2022 report
7 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report, IEA
8 IEA (International Energy Agency)
9 IEA (International Energy Agency)

Green electricity is a quick and cheap option to clean the electricity sector and electrify the whole economy as much as possible, being a radical acceleration needed to change the current trajectory. The energy transition is far from being on track to 1.5°C. Achieving the net zero target in 2050 will depend on sufficient action for this decade[10].

10 IRENA World Energy Transitions Outlook 2022 report

FIGURE 10

Reducing emissions by 2050 through six technological avenues



Source: IRENA World Energy Transitions Outlook 2022

FIGURE 11

Tracking progress of key energy system components

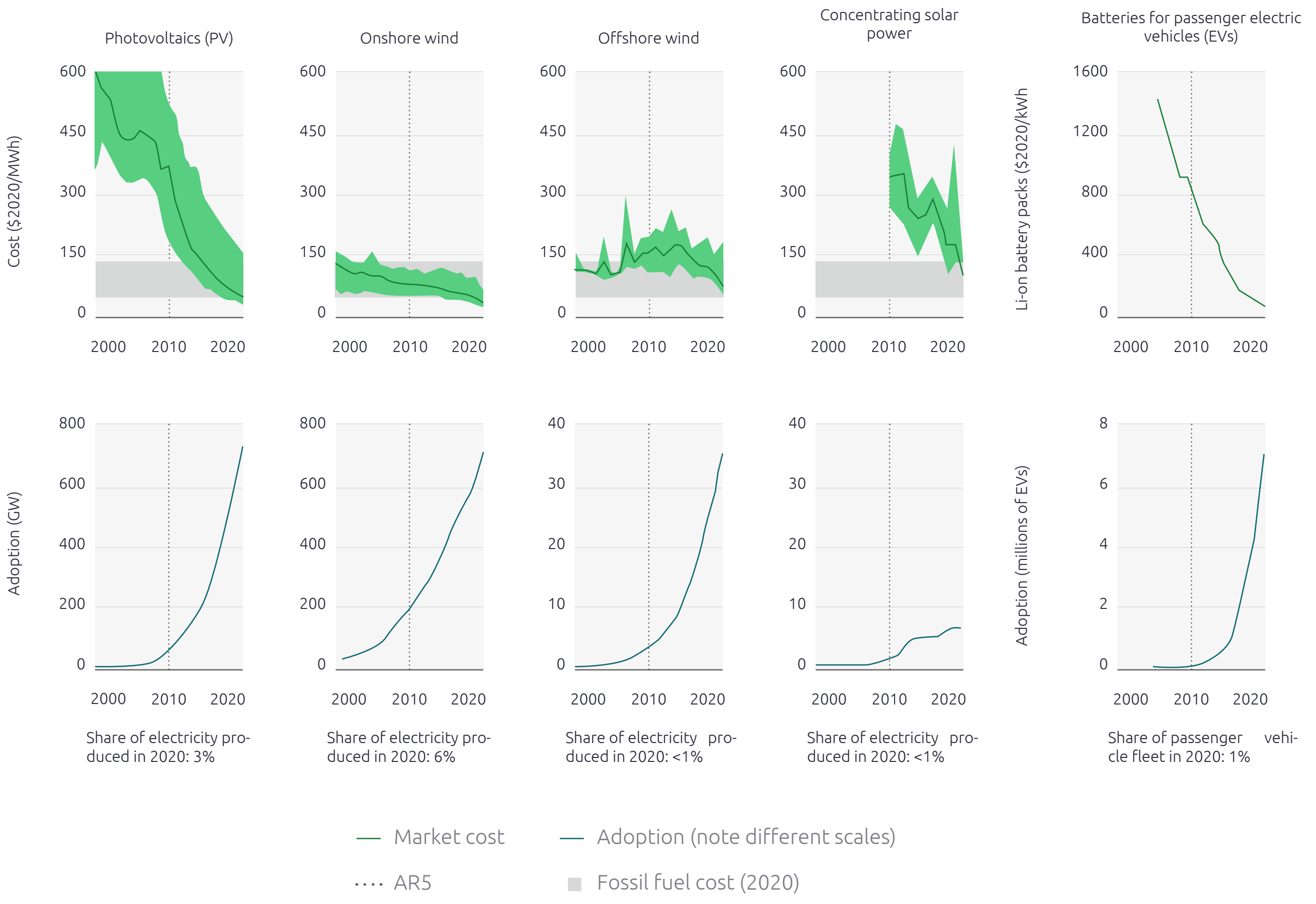
	Indicators	Recent Years	2050	Off/On track
RENEWABLES	Share of renewables in electricity generation	26%	90%	
	Modern bioenergy consumption	18 EJ	58 EJ	
ENERGY EFFICIENCY	Investment needs for energy efficiency	0.3 USD trillion/yr	1.5 USD trillion/yr	
ELECTRIFICATION	Passenger electric cars on the road	7 million/yr	147 million/yr	
HYDROGEN	Clean hydrogen production	0.8 Mt H_2	614 Mt H_2	
CCS AND BECCS	CCS and BECCS to abate emissions in industry	0.04 $GtCO_2$ captured/yr	8.4 $GtCO_2$ captured/yr	

Source: IRENA World Energy Transitions Outlook 2022

Energy transition will be underpinned by a range of low-carbon energy sources (nuclear, biofuels and biogases) also and technologies for transition pathways, especially for transport (aviation, maritime, heavy road) and industrial thermal processes, until green hydrogen can be deployed massively and widely used for the next decades.

FIGURE 12

Unit costs of some forms of Renewable energy and batteries for passenger EVs have fallen, and their use continues to rise



Source: UBS Asset Management, MSCI. Index Holdings as of 28 February 2022, ESG data as of 02 March 2022

China, the U.S., the European Union, India, and Russia are responsible for most of the world's CO_2 emissions

The G20 group is responsible for around 75% of global emissions[11], being China, the U.S., the European Union, India, and Russia responsible for most of the world's emissions of CO2 and GHG responsible for global warming.

China is the world's biggest emitter, responsible for nearly 30% of the global carbon emissions[12]; its emissions are still rising largely because of a reliance on coal. China's emissions increased 5.5% in 2021 and carbon emissions will peak before 2030. The country is aiming for 25% of energy from non-fossil fuels by 2030 and expecting to be carbon neutral before 2060, considering measures to absorb it from the atmosphere.

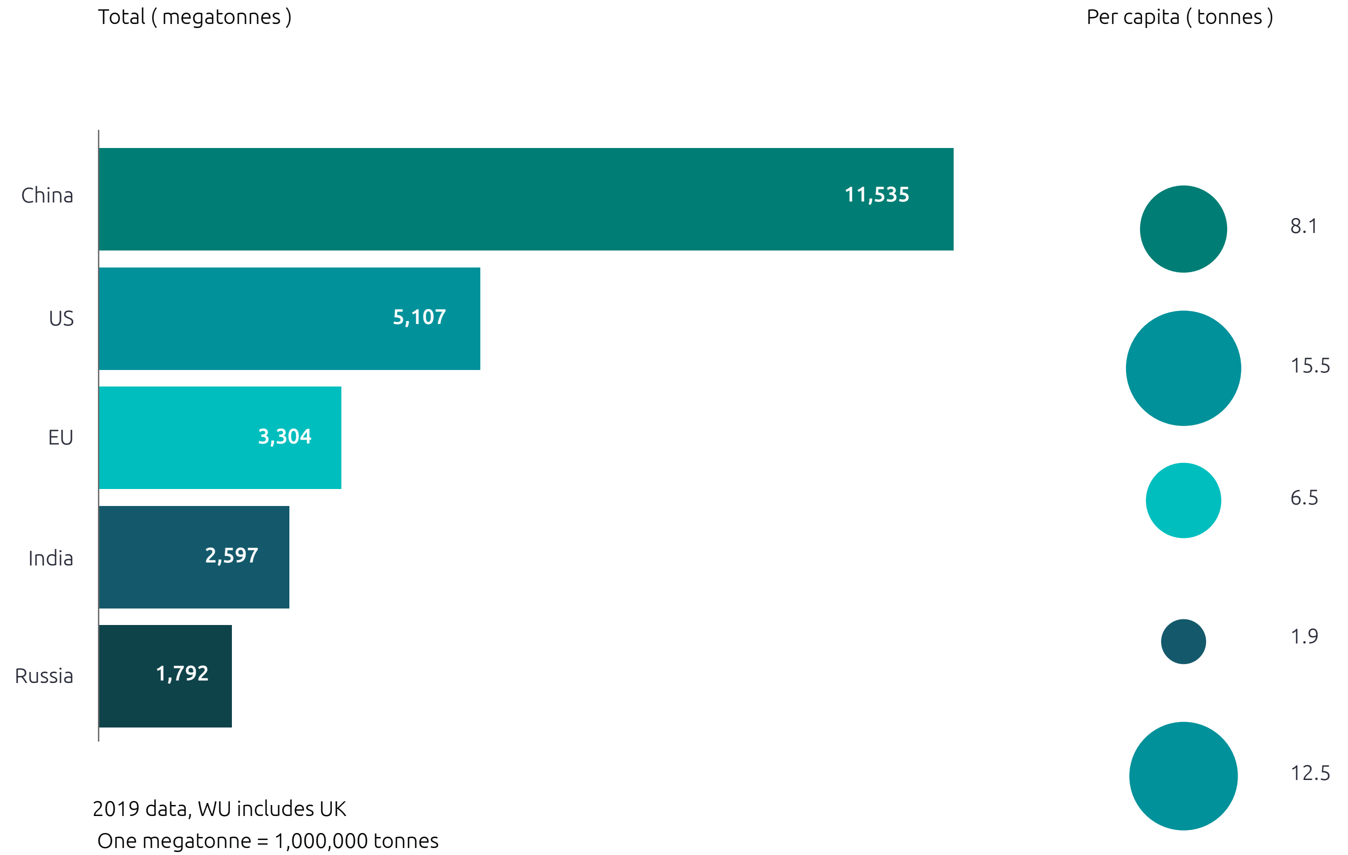
CO2 increased by 4% across the G20 group in 2021, after dropping 6% in 2020 due to the pandemic[13]. China and India exceeded their 2019 emissions levels, China being responsible for around 60% of the rise[14], mostly due to coal use.

Coal consumption rose by almost 5% for 2021, reaching its record that year. China accounted for 61% of the growth, the U.S. for 18%, and India for 17%[15].

11 Climate Transparency report
12 Global atmospheric research
13 Climate Transparency report
14 Climate Transparency report
15 Climate Transparency report

FIGURE 13

Countries which emit the most CO_2



2019 data, WU includes UK
One megatonne = 1,000,000 tonnes

Source: EC, Emissions database for Global atmospheric research

FIGURE 14

CO_2 emissions per person in 2017 (in tons per capita):

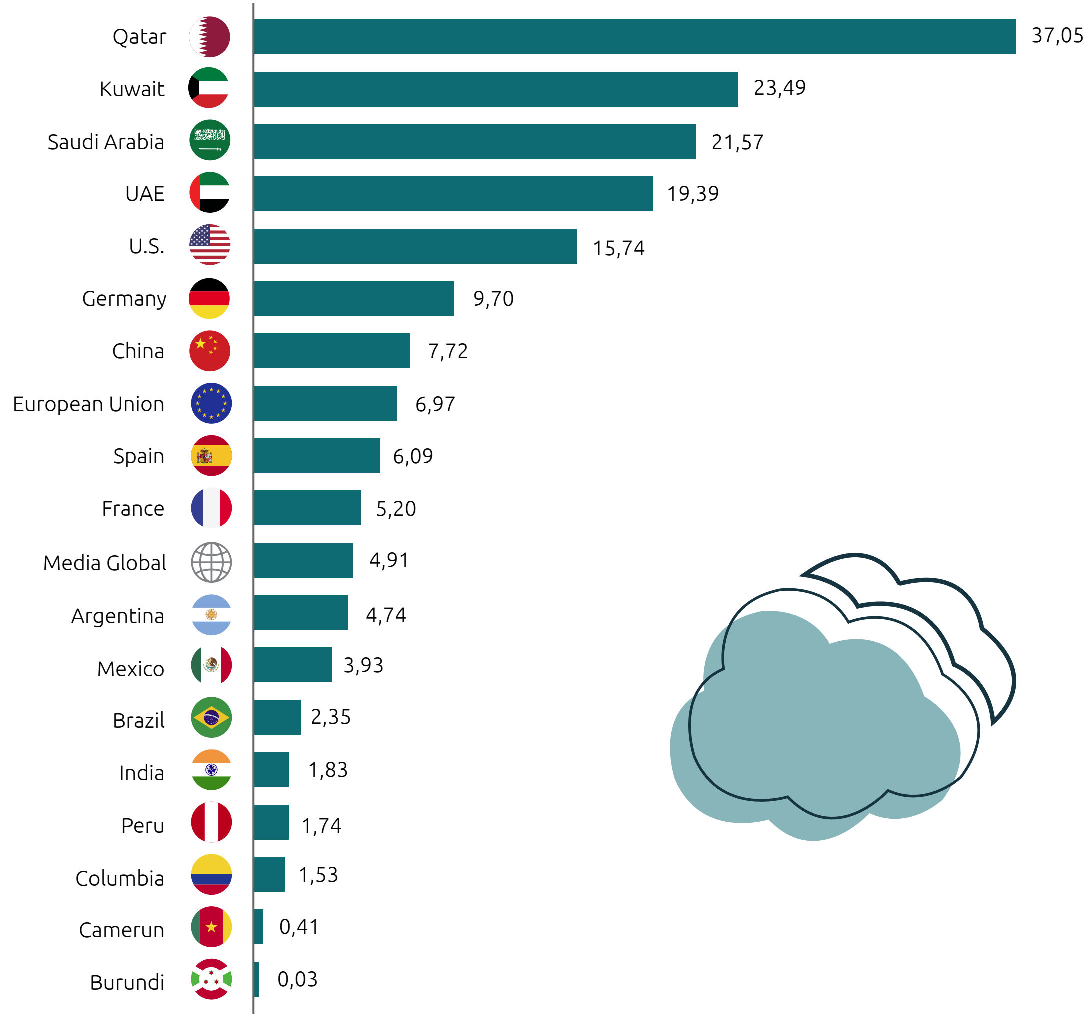
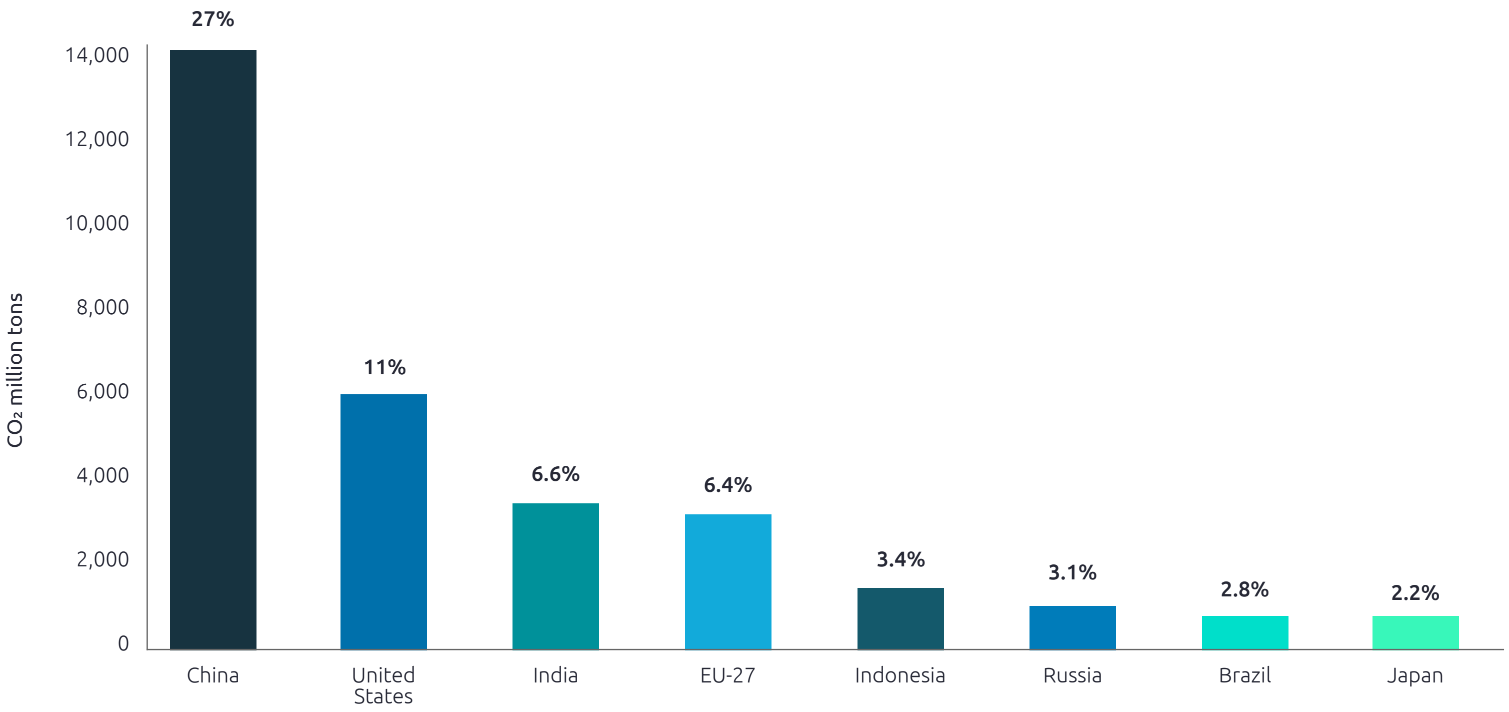


FIGURE 15

Ranking of the most GHG emissions producing countries

GHG emission %



Source: Rhodium Group

China is the largest producer of CO_2 and its carbon emissions. Recently, China announced it would stop funding new coal-fired projects overseas, but at home coal mines have been ordered to ramp up production to meet surging energy demand. China expects to cut back on coal use from 2026. China has not joined the pledge made at the climate summit by more than 100 countries to reduce emissions of other GHG, mainly methane, by 30% by 2030.

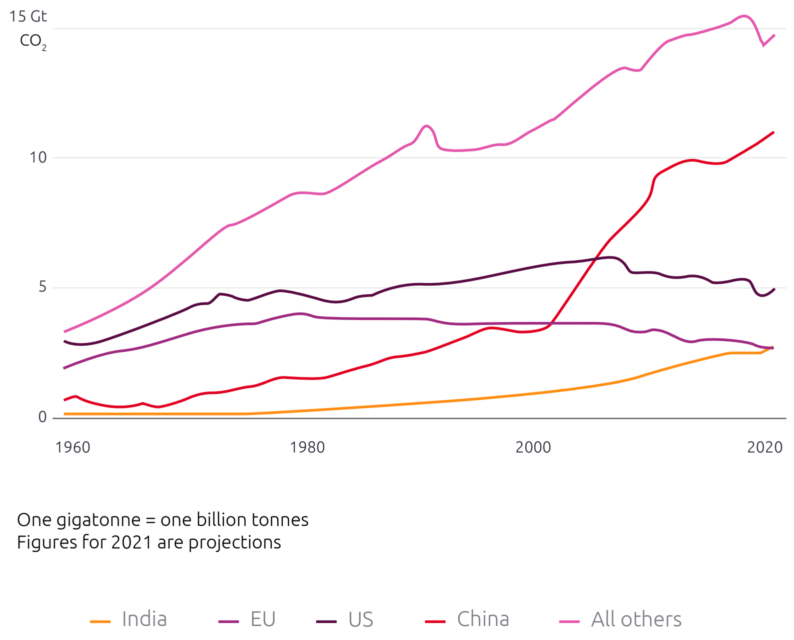
On the other side China accounts for more than one-third of all global solar power and is the world's biggest producer of wind energy by far; it has switched to low-carbon energy sources faster than many other countries. At the same time, China is deploying electric buses and electric vehicles, but industrial sectors such as construction, steel, and cement still require a high intensity of coal. China needs to cut demand for coal by more than 80% by 2060 to meet its climate goals[16].

16 International Energy Agency

FIGURE 16

China's emissions are still rising

Annual CO_2 emissions in the gigatonnes

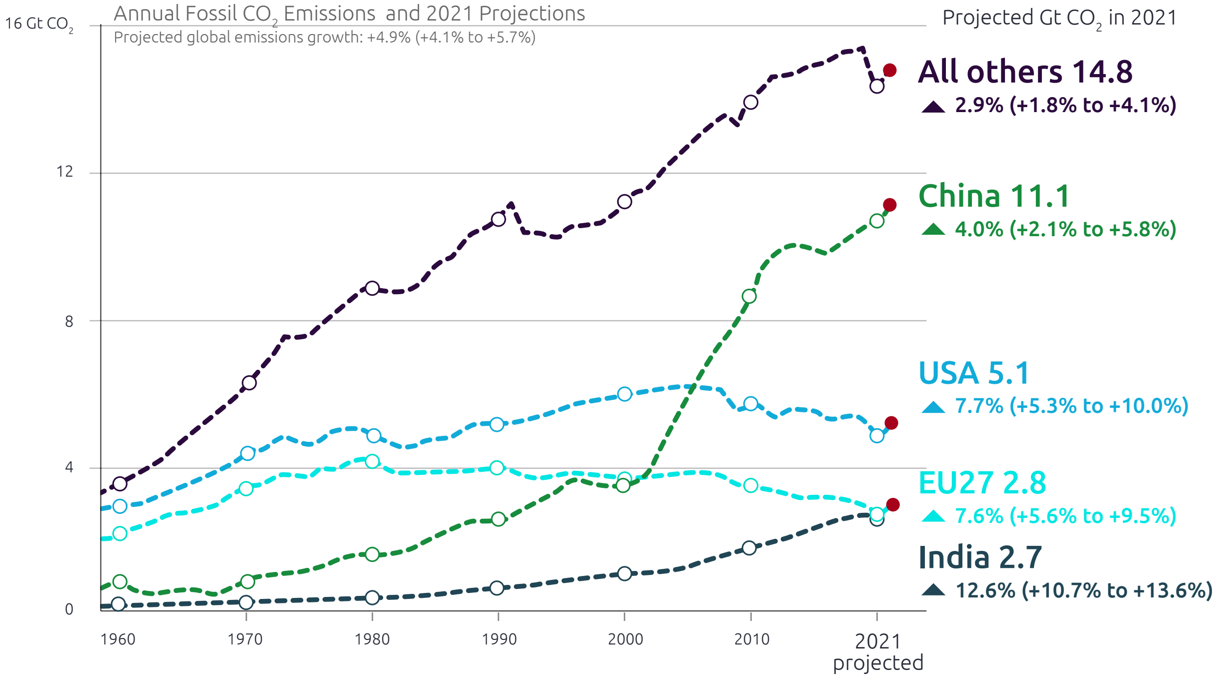


One gigatonne = one billion tonnes
Figures for 2021 are projections

Source: Global Carbon Budget 2021

FIGURE 17

Global fossil CO_2 emissions are projected to increase by 4.9% (4.1%-5.7%) in 2021



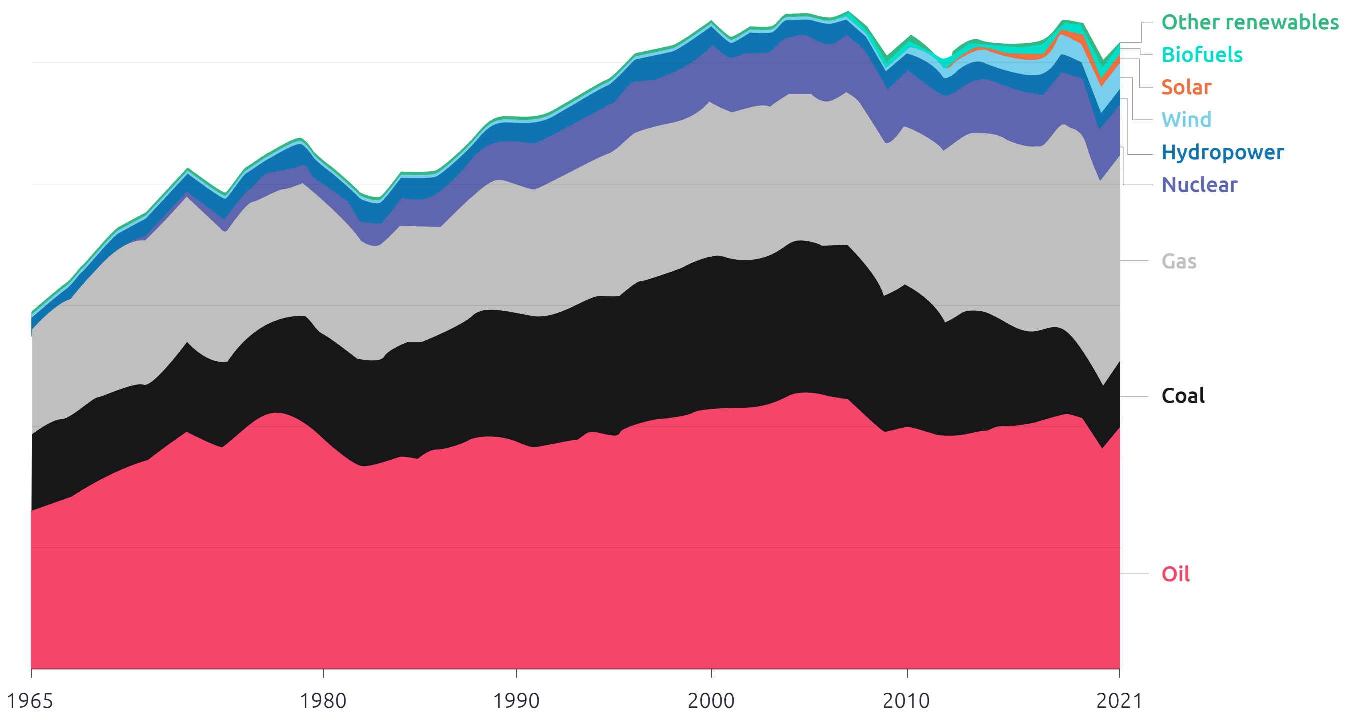
The 2021 projections are based on preliminary data and modelling.

Source: Global Carbon Project: Global Carbon Budget 2021 report

FIGURE 18

Energy consumption by source, United States

Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the substitution method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption



Note: "Other renewables" includes geothermal, biomass and waste energy.

Source: https://ourworldindata.org/energy-mix https://

Emissions in India were 4.4% higher in 2021 than in the 2019 pre-pandemic level. Nevertheless, and fortunately, 2021 emissions in the U.S., European Union, and the rest of the world remained 3.7%, 4.2%, and 4.2%, respectively, below their 2019 levels due to policies designed to reduce emissions from fossil fuels.

The U.S. has the most emissions per person at 4.9 tCO_2/capita (followed by Australia at 4.1 tCO_2/capita with the G20 average of 1.4 tCO_2/capita)[1] and will cut CO_2 by at least 50% of the 2005 level by 2030. The US currently is getting more than 80% of energy supply from fossil fuels although renewable energy sources is increasing significantly yearly. The U.S. expects half of new vehicles to be electric by 2030 and carbon-neutral by 2050 because of a clean-electricity program to reward utility companies for switching from fossil fuels. CO_2 emissions have been dropping over the past decade, but it's not sufficient and substantial improvement is needed to reach the Paris Agreement[2].

1 Climate Transparency report
2 Climate Action Tracker

In a joint statement at the COP26 summit, the U.S. and China pledged 100% carbon pollution-free electricity by 2035. However, the pledge was subsequently broken in response to Taiwan support.

The European Union expects a 55% emissions cut from the 1990 level by 2030, 40% of energy from renewables by 2030, and to be carbon neutral by 2050. The top CO2 emitters are Germany, Italy, and Poland due to the high dependency on fossil fuels, especially coal. It is currently even more complex a situation due to the Ukraine war and dependency on Russian gas.

The European Union negotiates as a single entity at COP26, but all members need to agree on how to reach the targets as a whole. Its policies and actions are almost sufficient to keep the global temperature rise to less than 2°C[17].

India is highly reliant on coal and is aiming for a 45% reduction in emissions intensity by 2030, expecting 50% of electricity capacity from non-fossil fuels by 2030, and reaching net zero by 2070. CO2 annual emissions have risen steadily in the past decades, but India produces the lowest emissions per person among the largest emitters, with a target for cutting CO2 emissions intensity per unit of economic growth.

India is significantly increasing its clean energy production from wind, solar and hydropower, reaching 23% by 2019. However, about 70% of the electricity grid is powered by coal, and being a major methane emitter, it has not joined the methane emissions reduction initiative at COP26. India needs to phase out coal power generation before 2040 and boost its target for clean energy sources[18].

17 Climate Action Tracker
18 Climate Action Tracker

FIGURE 19

Per capita energy from fossil fuels, nuclear and renewables, 2021

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

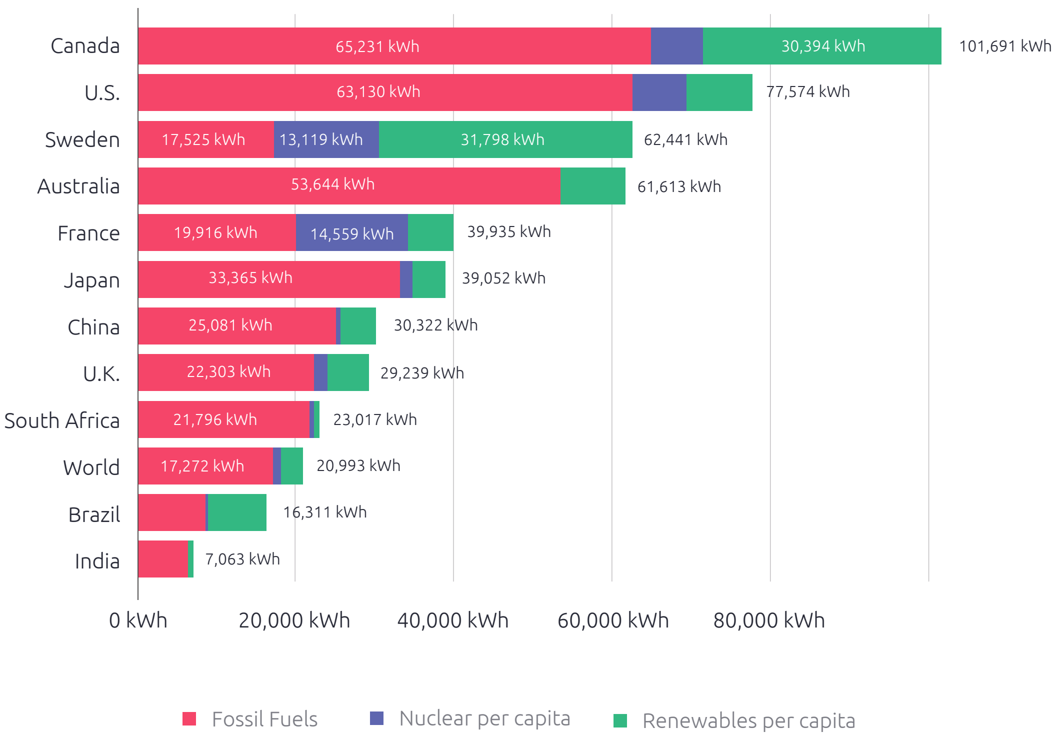
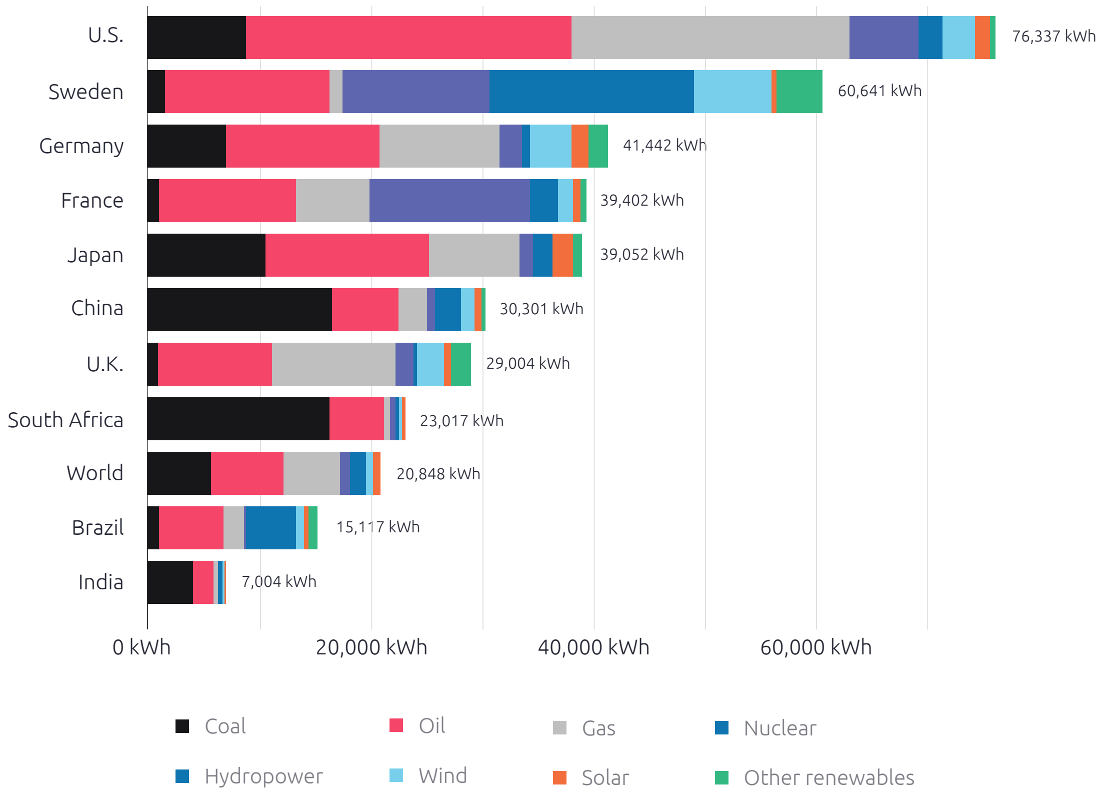


FIGURE 20

Per capita primary energy consumption by source, 2021

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



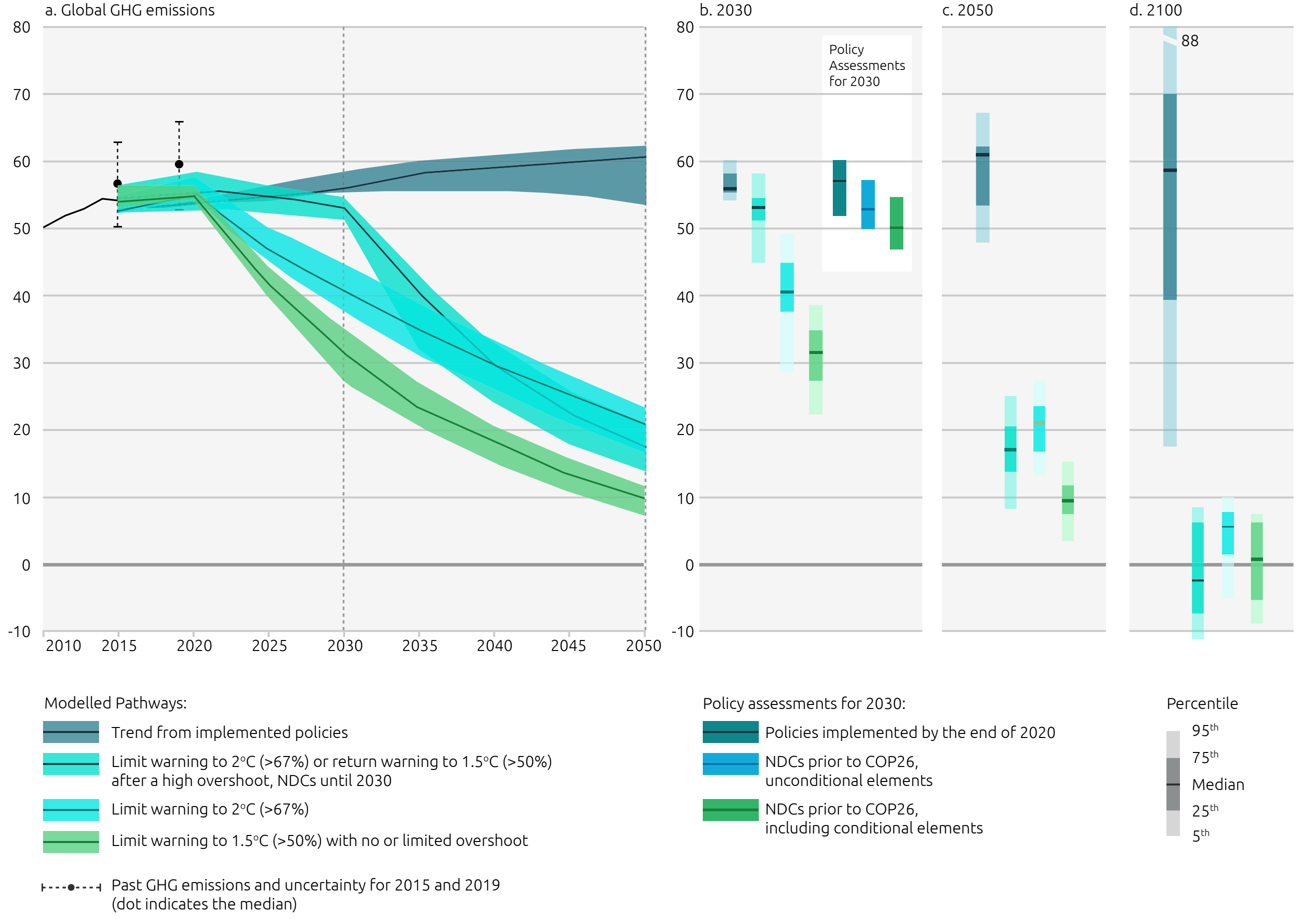
Source: https://ourworldindata.org/energy-mix

Drastic changes are required to reach the 1.5°C limit of the Paris Agreement

The current global response to climate change is insufficient to limit global warming to 1.5°C following the current trend of policies (as seen in dark blue in the chart). GHG emissions reduction must be accelerated to limit global warming to 1.5°C (green) and 2°C (light blue)[1].

FIGURE 21

Projected global GHG emissions from NDCs announced prior to COP26 would make it likely that warming will exceed 1.5°C and would also make it harder after 2023 to limit warming to below 2°C.

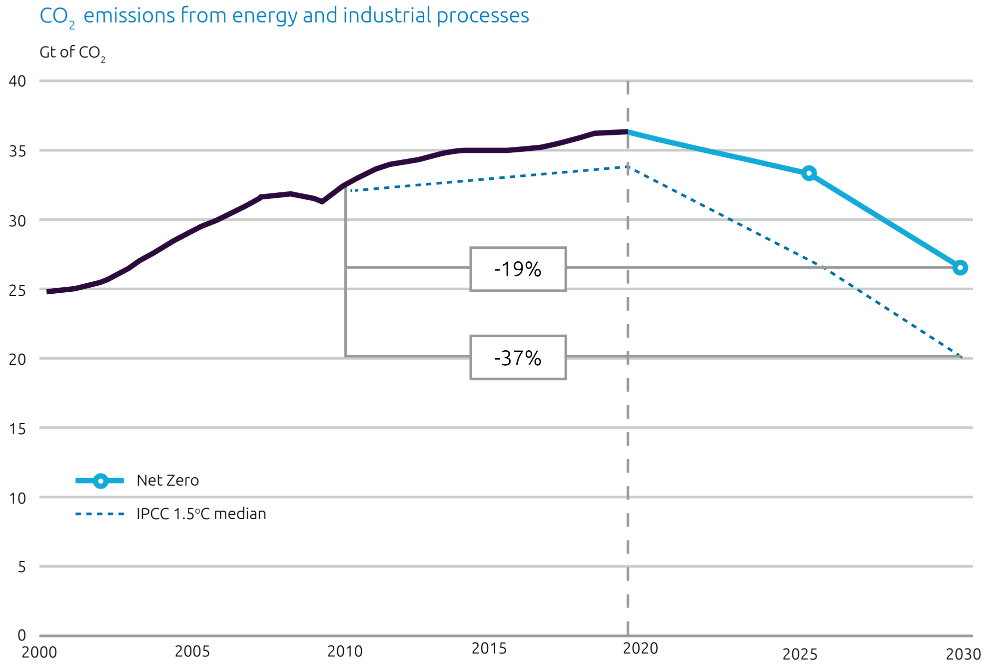


Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

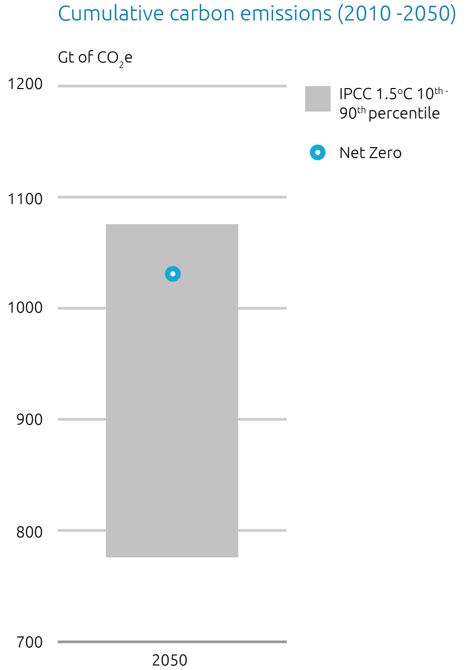
1 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report.

FIGURE 22

Increased focus on speed of global decarbonization to 2030



The IPCC 1.5°C median is based on scenarios with limited or no overshoot



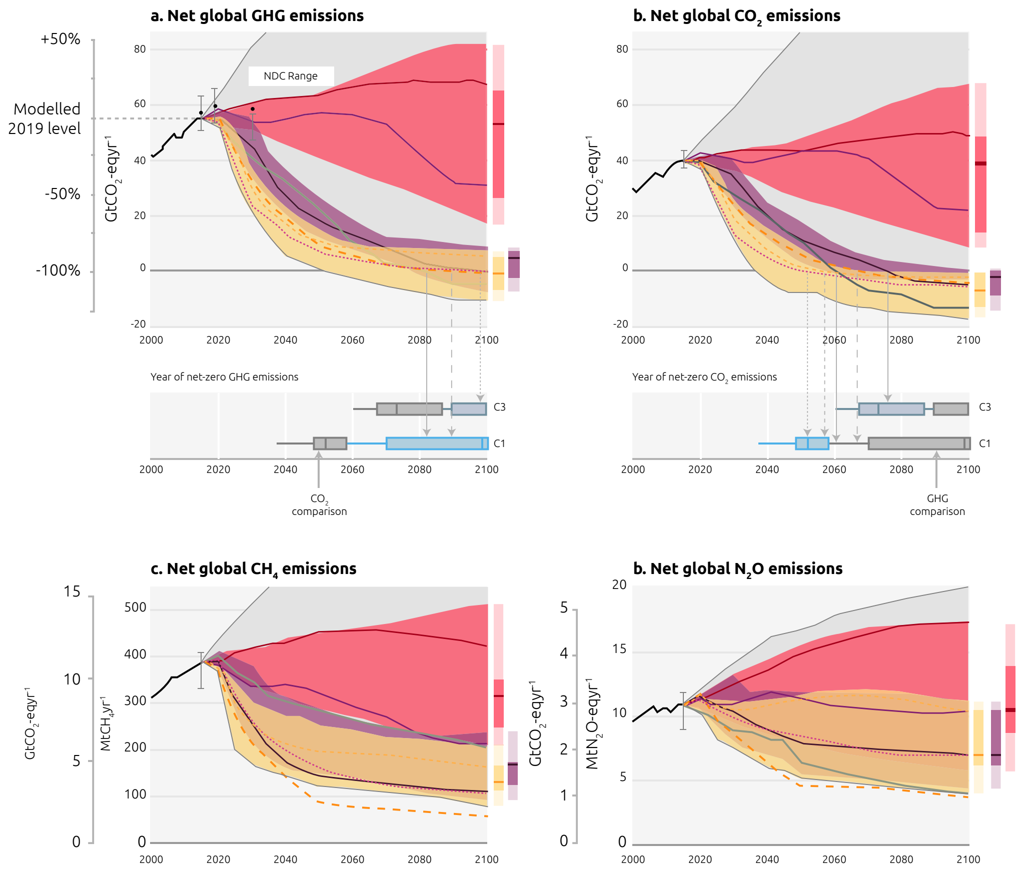
Source: EUROSTAT

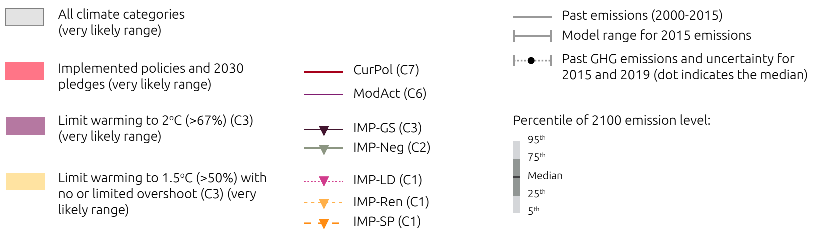
To reach the 1.5°C climate goal the global net anthropogenic CO_2 emissions would need to decline by about 45% by 2030 (relative to 2010 levels). Considering that CO_2 emissions from fossil fuels and industry decrease by around 37% and 19% under a 2050 Net Zero scenario[2] (relative to 2010), is a must accelerate emissions reductions before 2030.

2 BP Energy Outlook 2022 report

FIGURE 23

Modelled mitigation pathways that limit warming to 1.5°C, and 2°C, involve deep, rapid and sustained emission reductions





Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

Pathways that limit global warming to 1.5°C or 2°C require immediate action and deep GHG emissions reductions, CO_2, methane (CH_4) and nitrous oxide (N_2O) across all sectors. Emissions pathways with more aggressive policies that limit global warming to 1.5°C must be implemented (orange) despite the current policy's projected emissions pathways (purple)[3].

3 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report.

Fossil fuels (coal, natural gas, and oil) made up nearly 77% of the world's energy supply in 2021 while low carbon technologies were just 23%[4] and 12%[5] considering renewables sources.

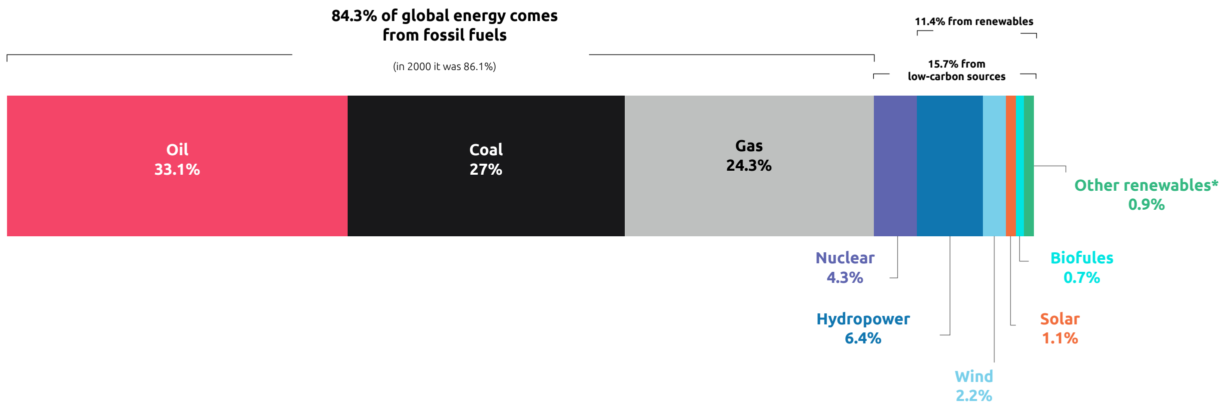
For the first time, the IEA foresees a peak in oil demand in all its scenarios in the mid-2030s. The SPS forecast shows a very gradual decline. And in the NZE forecast, it plateaus within a decade and drops further by nearly three-quarters by 2050[6].

To limit the rise to 1.5°C, the IEA's Net Zero Emissions by 2050 prediction envisions those fossil fuels shrinking to just under a quarter of the mid-century supply mix with renewables skyrocketing to just over two-thirds[7].

FIGURE 24

Global primary energy consumption by source

The breakdown of primary energy is shown based on the 'substitution' method which takes account of the inefficiencies in energy production from fossil fuels. This is based on global energy for 2019.



*'Other renewables' includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.
OurWorldInData.org - Research and data to make progress against the world's largest problems.

Source: BP's Statistical Review of World Energy.

4 BP Statistical Review of World Energy (including solar, wind, hydropower, other renewables, nuclear, biofuels and biomass energy)
5 BP Statistical Review of World Energy (including solar, wind, hydropower, and other renewables)

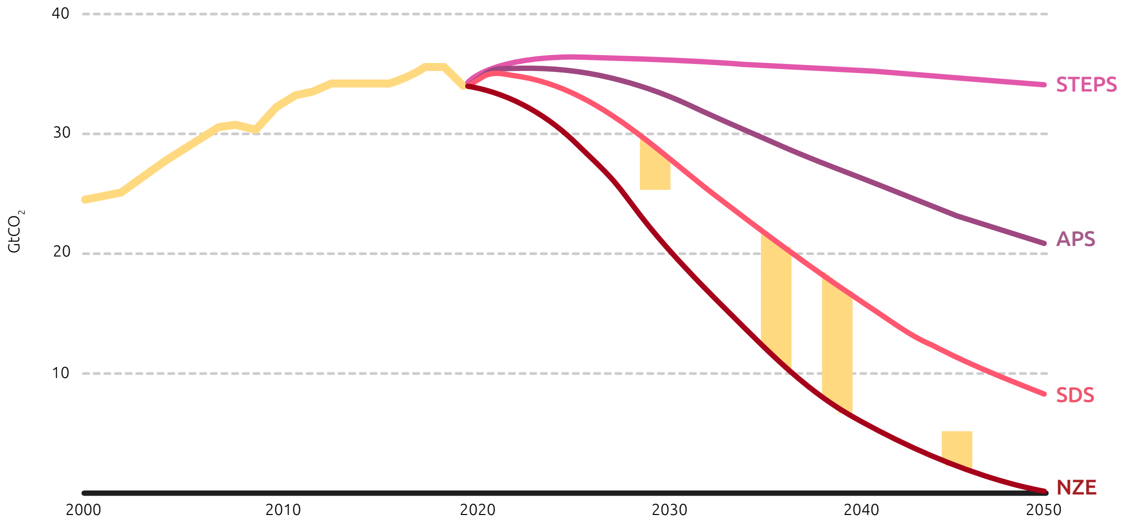
6 IEA World Energy Outlook 2021 report

7 IEA World Energy Outlook 2021 report

Following chart shows carbon dioxide emissions in the World Energy Outlook 2021 under 4 different scenarios over time[8]: Announced Pledges Scenario (APS)[9], Net Zero Emissions by 2050 Scenario (NZE)[10], Stated Policies Scenario (STEPS)[11] and Sustainable Development Scenario (SDS)[12].

FIGURE 25

Carbon dioxide emissions in World Energy Outlook 2021 scenarios over time



The APS pushes the emissions down, but not until after 2030; the SDS goes further and faster to be aligned with the Paris Agreement; the NZE delivers net zero emissions by 2050.

Source: IEA World Energy Outlook 2021 report

8 IEA World Energy Outlook 2021 report

9 Net Zero Emissions by 2050 Scenario: scenario which sets out a narrow but achievable pathway for the global energy sector to achieve net zero CO_2 emissions by 2050. It doesn't rely on emissions reductions from outside the energy sector to achieve its goals. To show what is needed across the main sectors by various actors, and by when, for the world to achieve net zero energy related and industrial process CO_2 emissions by 2050 while meeting other energy-related sustainable development goals.

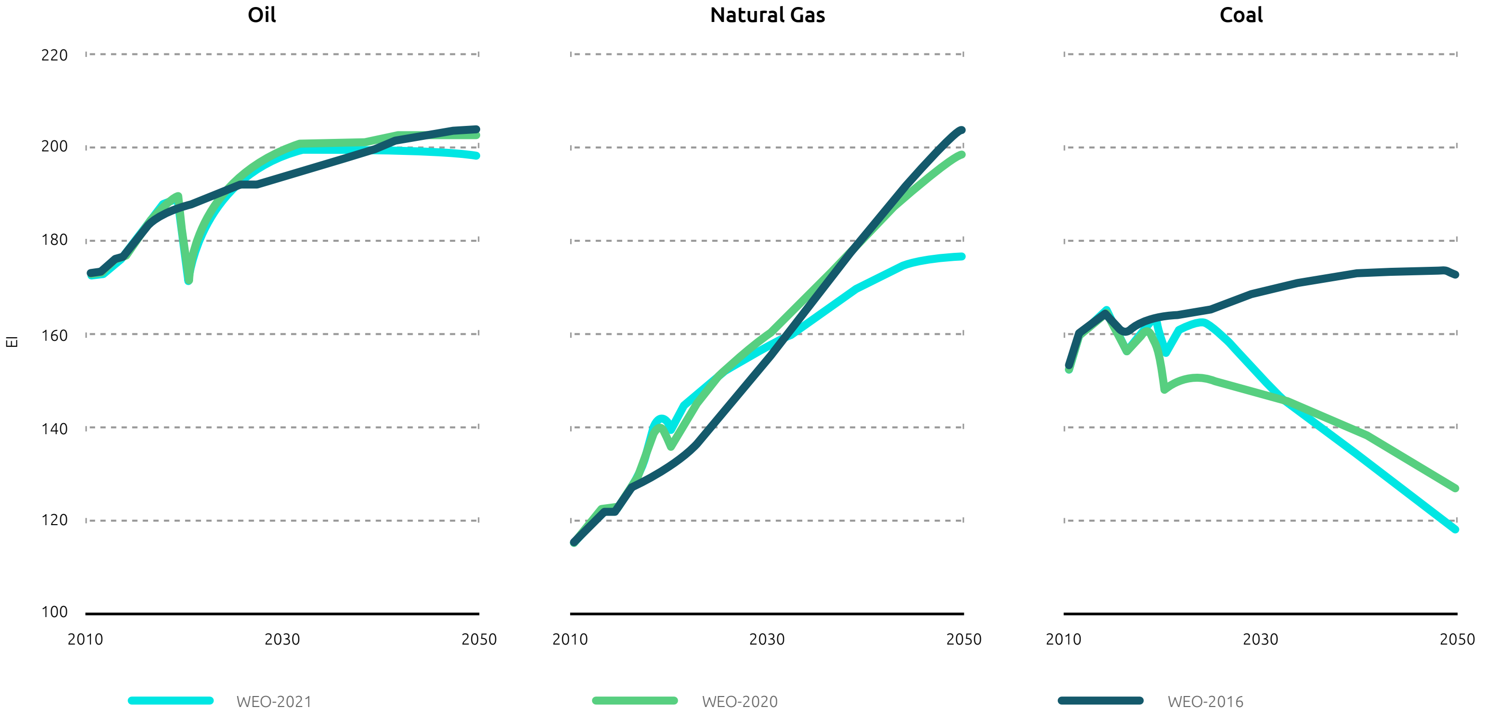
10 Announced Policies Scenario: scenario which assumes that all climate commitments made by governments around the world, including Nationally Determined Contributions (NDCs) and longer-term net zero targets, will be met in full and on time. To show how close do current pledges get the world towards the target of limiting global warming to 1.5 °C, it highlights the "ambition gap" that needs to be closed to achieve the goals agreed at Paris in 2015.

11 Stated Policies Scenario: scenario which reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place, as well as those that have been announced by governments around the world. To provide a benchmark to assess the potential achievements (and limitations) of recent developments in energy and climate policy.

12 Sustainable Development Scenario: integrated scenario specifying a pathway aiming at ensuring universal access to affordable, reliable, sustainable and modern energy services by 2030; substantially reducing air pollution; and taking effective action to combat climate change. To demonstrate a plausible path to concurrently achieve universal energy access, as well as set a path towards meeting the objectives of the Paris Agreement on climate change and significantly reduce air pollution.

FIGURE 26

Comparison of oil, natural gas and coal demand in Stated Polices Scenario in World Energy Outlooks 2016, 2020 and 2021 over time



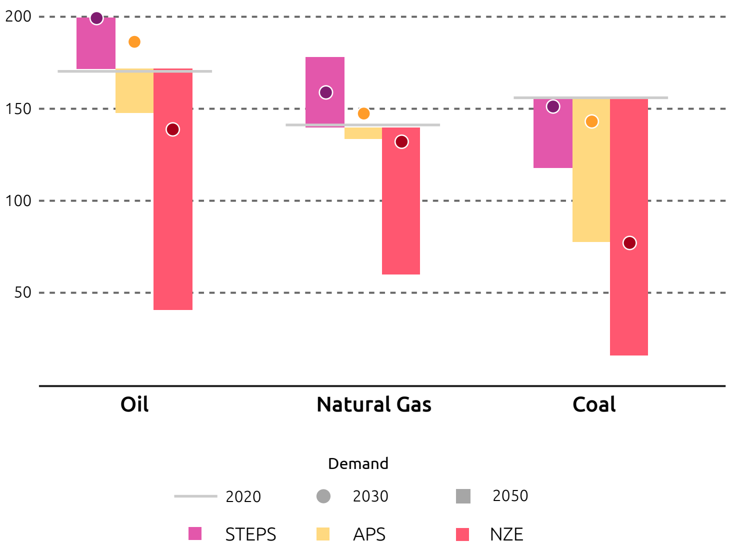
Oil demand peaks for the first time in the WEO-2021 steps; natural gas has been revised down from the WEO-2020; coal use is a lot lower than projected five years ago.

Source: IEA World Energy Outlook 2021 report

New oil fields are required in the two most conservative scenarios, and they would mitigate their climate impact by reducing methane flaring. Therefore, today's energy system cannot meet low emissions challenges[13]. Next chart shows fossil fuel use by STEPS, APS, and NZE scenarios by 2030 and 2050.

FIGURE 27

Fossil fuel use by STEPS (Stated Policies), APS (Announced Pledges) and NZE (Net Zero) scenarios by 2030 and 2050



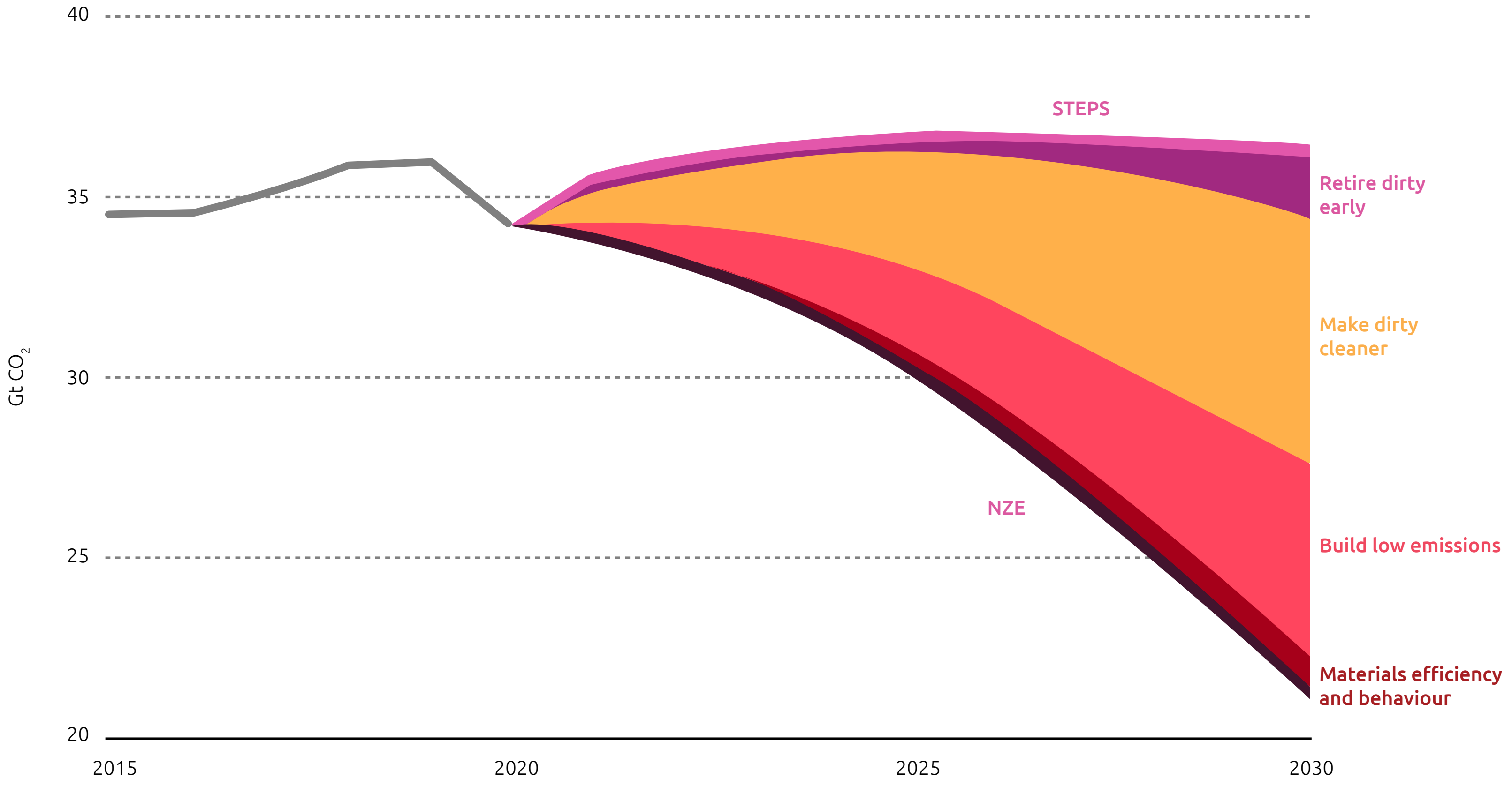
Oil demand peaks in each scenario, but the level and timing vary; natural gas increases to 2025 with sharp divergences thereafter; coal falls in all scenarios

Source: IEA World Energy Outlook 2021 report

13 IEA

FIGURE 28

Emissions reductions by 2050 in the NZE (Net Zero) and STEPS (Stated Policies) scenarios



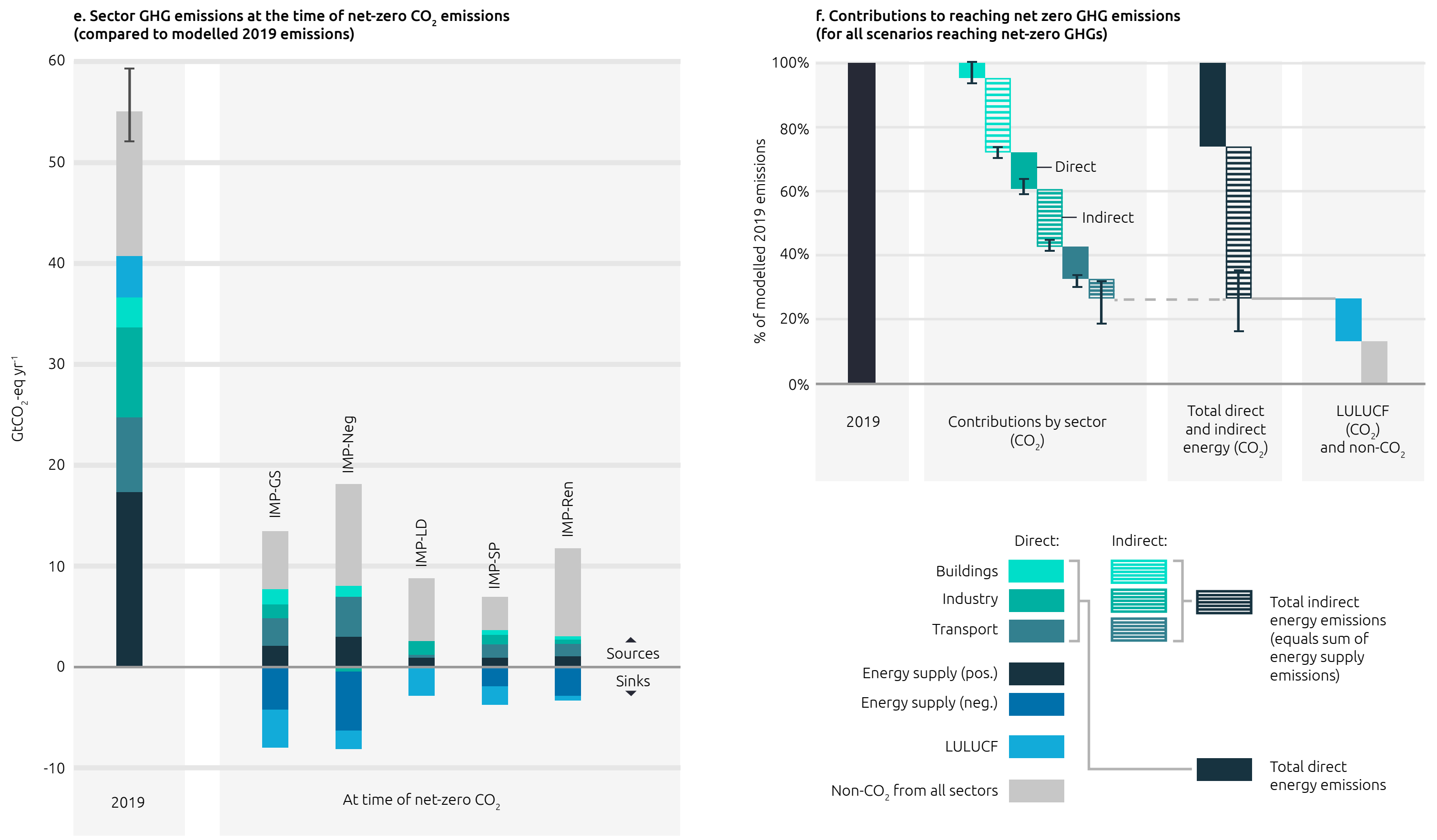
Delivering net zero requires more than retiring dirty and building low emissions projects; there is a large middle ground that defines the speed and scope of change

Source: IEA World Energy Outlook 2021

FIGURE 29

Carbon dioxide emissions come by 3 main sectors mostly: energy supply, transport and industry

Net zero CO_2 and GHG emissions are possible through different modelled mitigation pathways



Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

Today, in all sectors, many options are available to significantly decrease emissions by 2030, with several mitigation strategies. However, not all climate change solutions will have the same impact or cost[14].

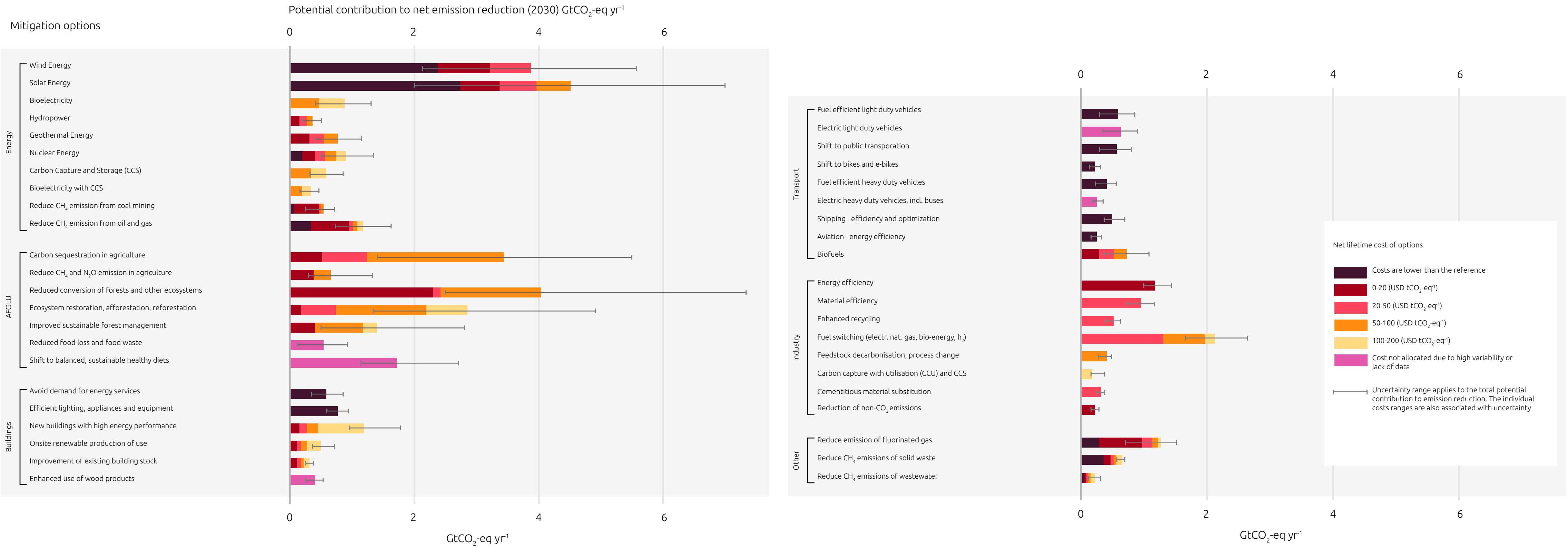
Climate change is not caused by one reason and won't be solved by one solution. It is caused by a group of issues and needs to be resolved by a group of mitigation actions. The mix of factors and solutions are all incremental, but the consequences of inaction are urgent and clear.

14 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report.

FIGURE 30

Mitigation options for net emission reduction by 2030

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.



Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

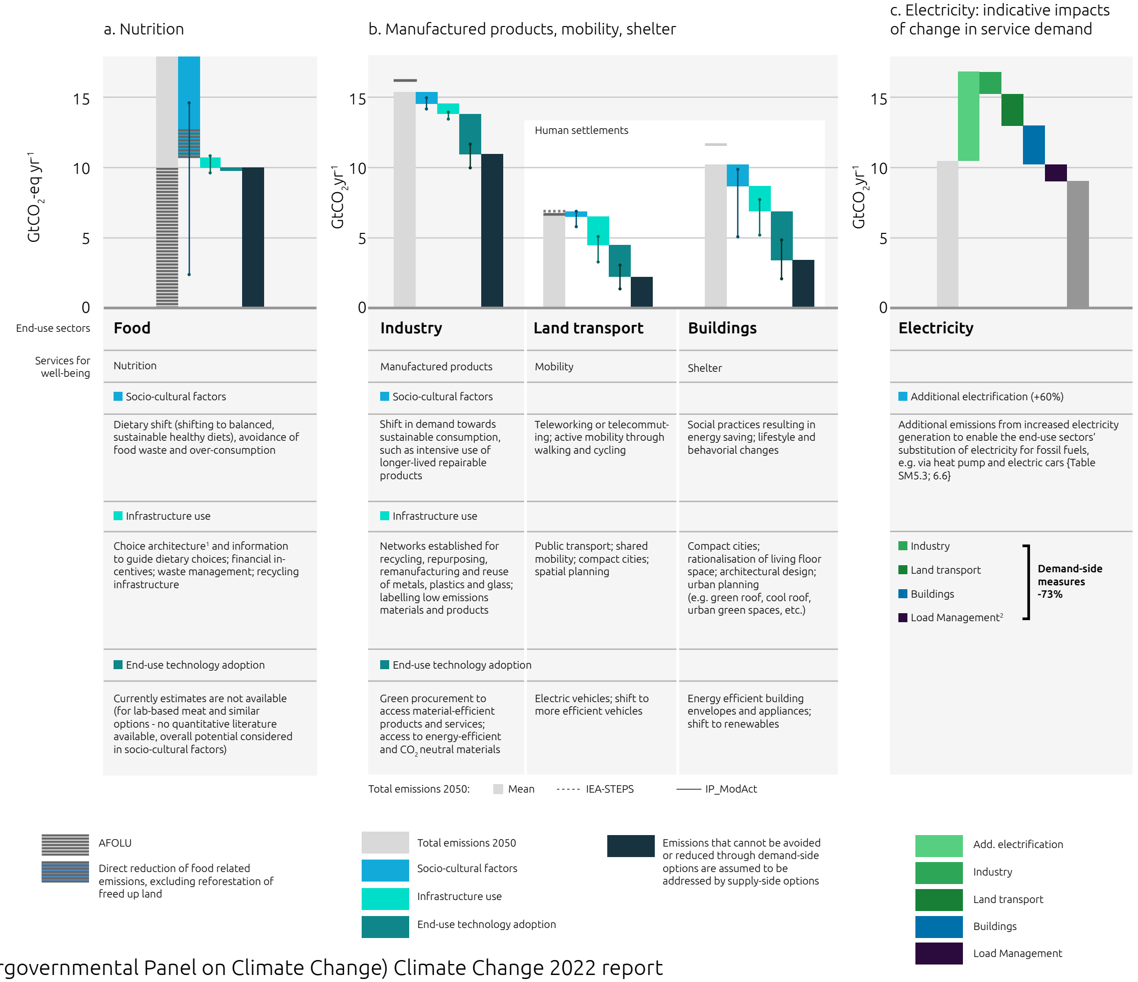
Efficiency savings and consumer behavior changes can lower demand. Climate change mitigation is affected by changing the demand for food, electricity, and manufactured products through infrastructure and behavioral adaptations. There are three ways to impart change: through socio-cultural factors (behavioral choices individuals make); through infrastructure use (changes in the design of the infrastructure that make it possible for individuals to make different choices); and through end-use technology adoption (changes in the uptake of technologies by end users)[15].

Countries and economic stakeholders must decide on and implement national and local causes for consumption reduction and energy efficiency. Traveling less and eating less meat are among a long list of possible actions. Of course, public administration should show the way (like some companies are doing or have started to do) with transportation electrification, building refurbishment for energy efficiency, and many other actions. This also means subsidizing the development and appropriation of low-carbon technologies and growing infrastructures (EV charging networks, smart grids, and H_2 networks, notably).

Having the right infrastructure and technology policies will enable lifestyle and behavior changes and result in a 40-70% reduction in GHG emissions by 2050. This offers significant untapped potential in improving health and well-being.

FIGURE 31

Demand-side mitigation can be achieved through changes in socio-cultural factors, infrastructure design and use, and end-use technology adoption by 2050



Source: IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report

15 IPCC (Intergovernmental Panel on Climate Change) Climate Change 2022 report.

The most urgent priorities should strive to put energy transition on track to the 1.5°C goal[16]:

- Resolutely replacing coal power with clean alternatives, i.e., renewable sources. Replacing coal in industry must also be tackled, as almost 30% of all coal is used in iron, steel, cement, and other industries. In the power sector, renewables are three times faster and cheaper than the current deployment rate.
- Ramping up renewables with an aggressive energy efficiency strategy is the most realistic path toward halving emissions by 2030.
- Phasing out fossil fuel assets should be done in tandem with measures to eliminate market distortions and incentivize energy transition solutions supported with storage options and or another low carbon sources guarantying the supply. This will ensure the full cost (environmental, health, and social) of burning fossil fuels is reflected in their prices, eliminating existing market distortions.
- Securing nuclear power development with present technologies (long cycle projects) and promising ones (small modular reactors (SMR) and fusion) is required for net zero targets but will be more for the 2030s-2050s.

16 IRENA World Energy Transitions Outlook 2022 report

Recommendations and Actions

The world has a huge challenge to move a net zero economy by 2050 from a narrow possibility to urgent actions comes to a reality, now doubly urgent and complex due to the emissions rebounding sharply after pandemic and geopolitical situation, time is over and act urgently to accelerate the clean energy transformation must be our highest priority as human beings.

Despite some progress, the energy transition is far from being on track, and radical actions is needed to change current trajectory, and to achieve the 2050 net zero target depends on today actions where coming years will be critical for accelerating the energy transition up to 2030 reaching a crucial moment for international efforts to tackle the climate crisis.

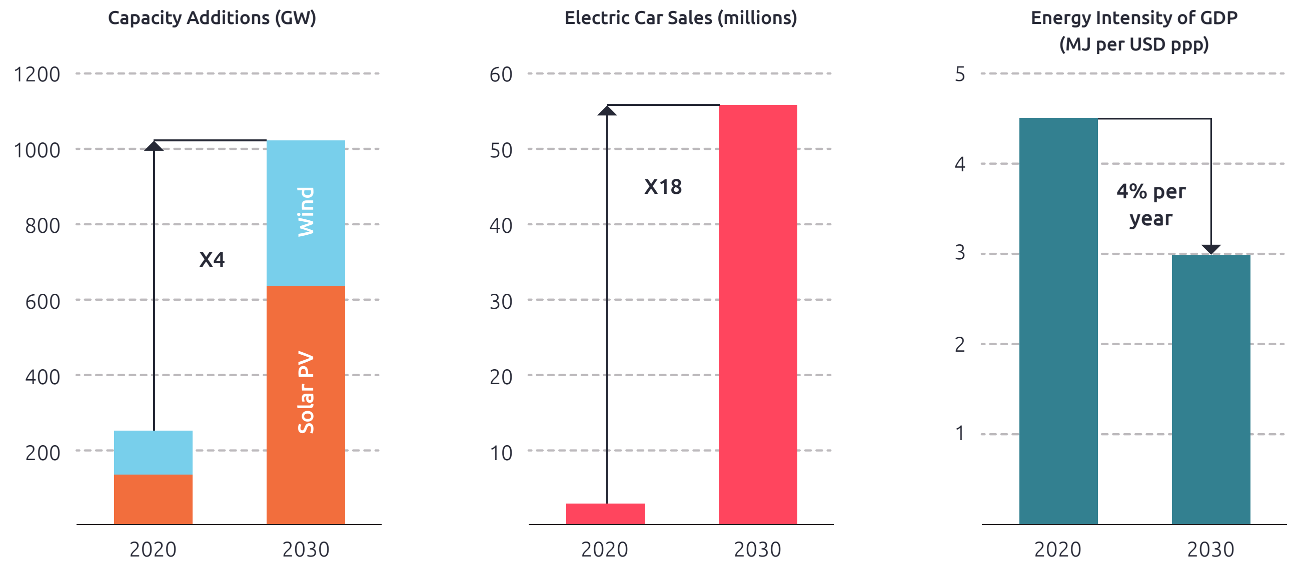
The number of countries that have pledged to reach net zero emissions by 2050-or soon after is growing, but the gap between rhetoric pledges and actions need to close if we want to limit the global warming to 1.5 °C requiring from now on a total transformation of the energy systems and our economies.

Energy transition actions and the way to reach net zero emissions economies have to be guided by several principles[1]:

- secure and affordable energy supplies to foster economic growth with a huge opportunity for boost economic growth, creating millions of new jobs.
- transparent, fair and inclusive, leaving nobody behind. Developing economies need to receive the financing and technological know how needed for those expanding populations and economies in a sustainable way.
- is about people and centered in people along the entire process changing habits in final consumers, specially from power, industry, and transport, including lifestyle and consumption shifts.
- each country will need to review and improve actual actions, accelerating its own pathway according to its own specific circumstances. There is no one single magic action for all.

FIGURE 32

Key clean technologies ramp up by 2030 in the net zero pathway



Note: MJ = megajoules; GDP = Gross Domestic Product in purchasing power parity.

Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

1 IEA Net Zero by 2050-Roadmap

Urgent recommendations and actions today, not tomorrow

Massive clean energy expansion and an unparalleled clean energy investment boom from today accelerating the current paths increasing ambition by 2030. World is in a 2.7°C warming track far from the limit to 1.5°C leaded by bigger economies, and all technologies needed already exist.

World leaders, countries, businesses and people must shift the gear and accelerate in the right direction.

A transition of the scale and speed to reach a net zero pathway cannot be achieved without sustained support and participation from citizens affecting of people's lives in demand for energy services from transport, heating and cooking to urban planning and jobs. Behavioral changes, particularly in advanced economies such as replacing car trips with walking, cycling or public transport, or foregoing a long-haul flight.

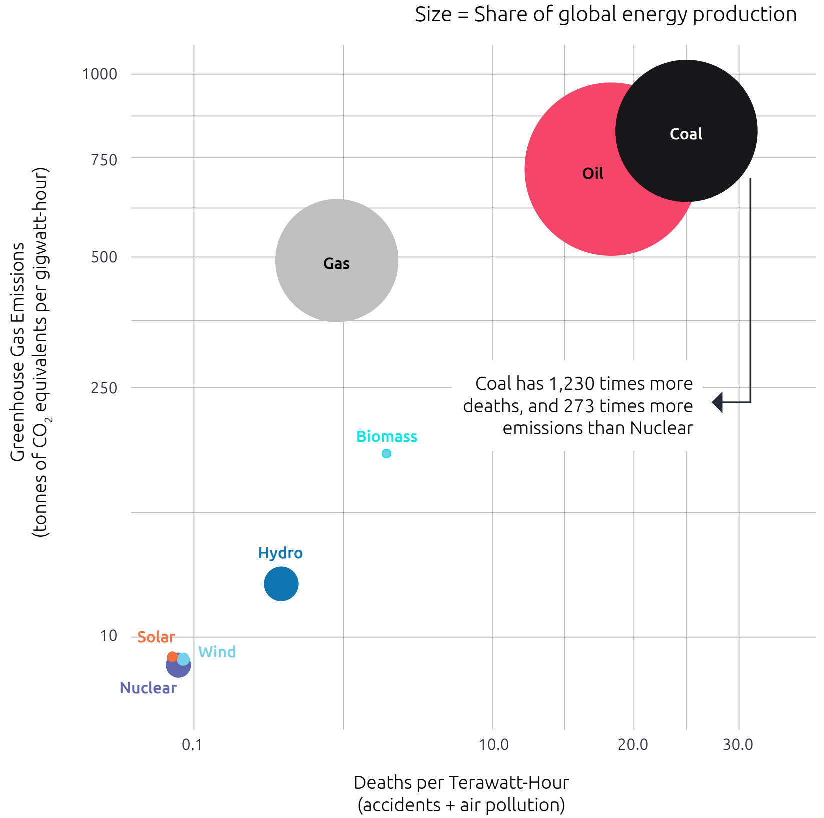
The rapid electrification of all sectors makes electricity even more central to energy security around the world than it is today. Electricity from renewables sources (solar, wind, and hydro mostly) together nuclear power plants as main low-carbon technologies becomes the primary energy carrier in future energy systems[2]:

- Global electricity demand in end-use sectors will rise 1.3 times the 2019 levels to reach Ca.31,000 TWh by 2030.
- The share of electrification in end-use sectors like industry, buildings, and transport would reach 28%, 56%, and 9% in 2030, respectively.

Today's technologies with lower GHG emissions and lower death rates from accidents and air pollution are solar, wind, nuclear and hydropower:

FIGURE 33

US EV Sales and Sales Share Forecast 2021-2030

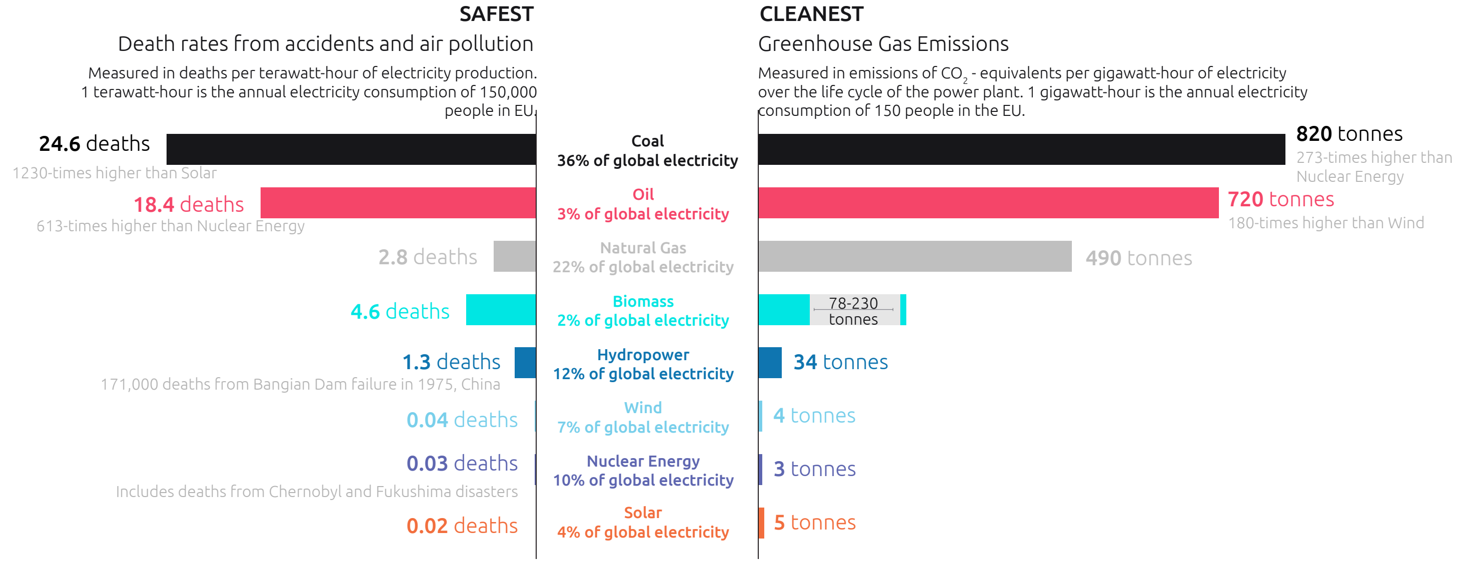


Source: Our World In Data, 2020. Square root scales for x and y axes. Graph by: @rubenbmathisen (Twitter)

2 IRENA World Energy Transitions Outlook 2022 report

FIGURE 34

What are the safest and cleanest sources of energy?



Death rates from fossil fuels and biomass are based on state of the art plants with pollution control in Europe, and are based on older models of the impacts of air pollution on health. This means these death rates are likely to be very conservative. For further discussion, see our article: OurWorldinData.org/safest-sources-of-energy. Electricity shares are given for 2021.

Source: Markandya & Wilkinson (2007); UNSCEAR (2008; 2018); Sovacool et al. (2016); IPCC ARS (2014); Pehl et al. (2017); Ember Energy (2021).

Policies should be strengthened to speed up the deployment of clean and efficient energy technologies driving investments into the most efficient ones.

Infrastructure upgrades, modernization, and expansion are needed to increase system resilience and build flexibility for a diversified and interconnected system capable of accommodating high shares of variable renewable energy.

Governments must lead the planning and incentivizing of the massive infrastructure investments, especially in smart transmission and distribution grids expanding annual investment in T&D grids from USD 260 billion today to USD 820 billion in 2030, number of public charging points for EVs rises from around 1 million today to 40 million in 2030, battery production for EVs leaps from 160 GWh today to 6 600 GWh in 2030 equivalent of adding almost 20 giga factories.

The transition needs all major sources of flexibility options: batteries, demand response and a smarter and more digital electricity networks. The resilience of electricity systems to cyberattacks and other emerging threats needs to be enhanced. Transition will be green and digital, or won't be.

Green jobs will grow bringing substantial new economic opportunities for wealthiness and employment, with at least new 14 million jobs created by 2030.

Energy transition will require significant quantities of critical minerals, like copper, cobalt, manganese, lithium, and various rare earth metals creating new economic opportunities and no dependance of one or a very few countries. The quantities required will be multipled by a factor of 16 by 2050. Renewables technologies require a huge intensity of critical minerals per energy unit produced in comparison with low carbon technologies like nuclear, around 6 times more, and specially this difference many times higher considering the total critical minerals amount to reach the net zero goal.

Roll-out of hydrogen, CCUS, and even DAC technologies after 2030, currently all of them making remarkable progresses, means laying the groundwork now with annual investment in CO2 pipelines and hydrogen enabling infrastructure increases from USD 1 billion today to around USD 40 billion in 2030, and where hydrogen and CCUS.

No new investments in new fossil fuel power plants, no new coal mines or mine extensions, natural gas as bridge as minim as possible to guarantee security supply to be substituted by clean sources, and subsidy phase-outs.

Policymakers should identify priorities for electrification with a focus on hard-to-abate sectors and devise strategies for its deployment. and disincentive for the use of certain fuels and technologies, such as unabated coal-fired power stations, gas boilers and conventional internal combustion engine vehicles.

Oil and natural gas production will have far-reaching implications specially under current geopolitical circumstances and energy crisis. No new oil and natural gas fields are needed but current are necessary to bridge the transition, and structural reforms to carry out the transition and journey as quick as possible to technologies such as storage, hydrogen, CCUS, DAC, demand response and low-carbon flexible power plants.

Carbon pricing mechanisms and market reforms can ensure appropriate price signals to speed up the right and accelerated transition.

Set near-term milestones to get on track for long-term targets providing credible step-by-step plans to reach net zero goals, building confidence among investors, industry, citizens and other countries.

FIGURE 35

Net Zero Emissions situation by 2020

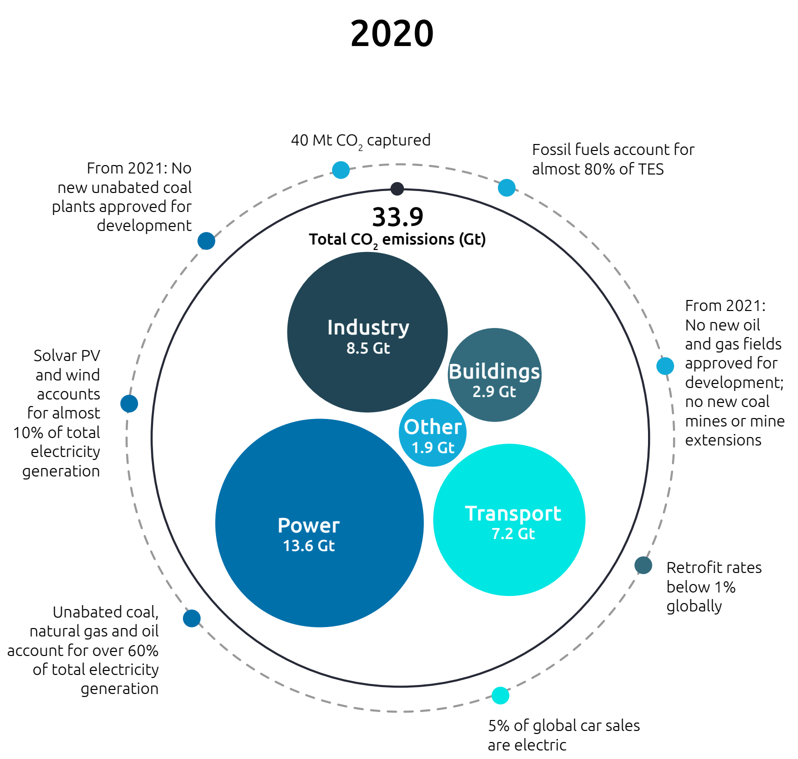
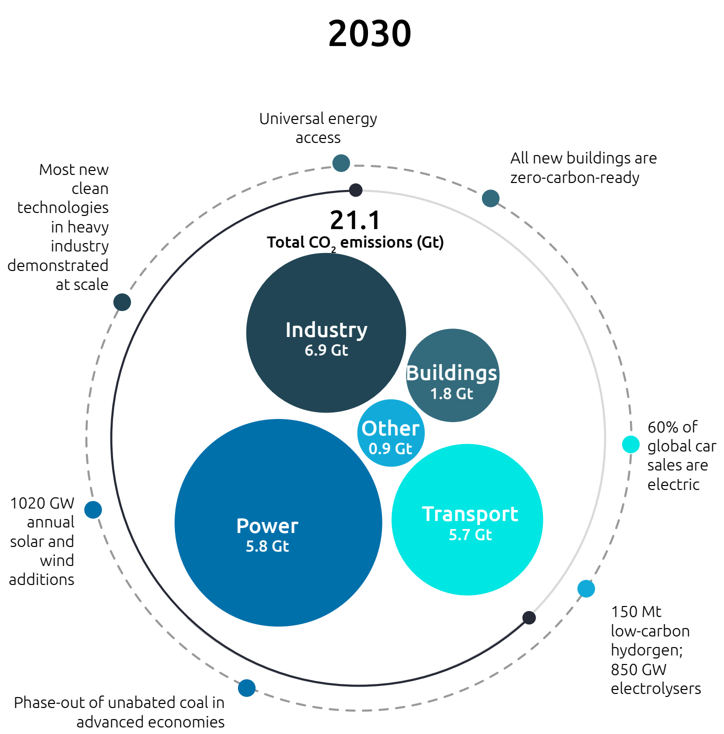


FIGURE 36

Net Zero Emissions situation by 2030



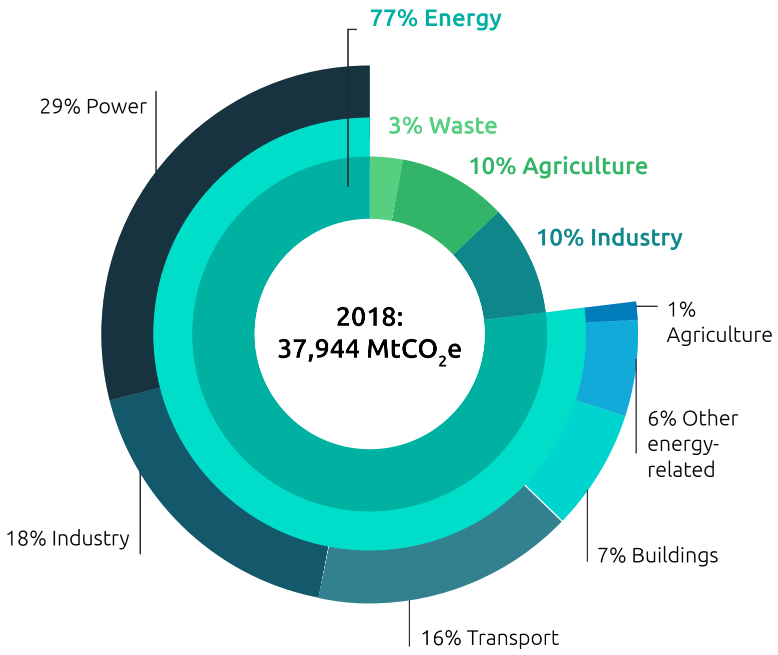
Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

Key milestones and actions for rapid emission reductions[3]:

- Ramping up renewables and an aggressive energy efficiency strategy is the most realistic path toward halving emissions by 2030. This also means adapting grids (smart grids).
- Scaling up solar and wind rapidly for this decade, reaching annual additions of 630 GW of solar PV and 390 GW of wind by 2030, four-times the record levels set in 2020. For solar PV, this is equivalent to installing the world's current largest solar park roughly every day.
- Hydropower and nuclear, the two largest sources of low-carbon electricity today, will be essential for transition.
- New buildings must be energy efficient, decarbonizing heating and cooling will require changes to building codes and energy performance standards using renewables-based heating and cooling technologies, solar water heaters, renewables-based heat pumps, and geothermal heating.
- Electric vehicles (EVs) go from around 5% of global car sales to more than 60% by 2030.
- Land use measures to curb the loss of forest areas and encourage replanting.
- Demand-side management would help alleviate multiple challenges in the short term while contributing to the long-term security of energy and materials supply.

FIGURE 37

G20 GHG emissions by sector (2018)



Source: The Climate Transparency Report 2021

Accelerated deployment of green hydrogen and sustainable biomass are key solutions to decarbonize hard-to-abate sectors while also contributing to energy security[4]:

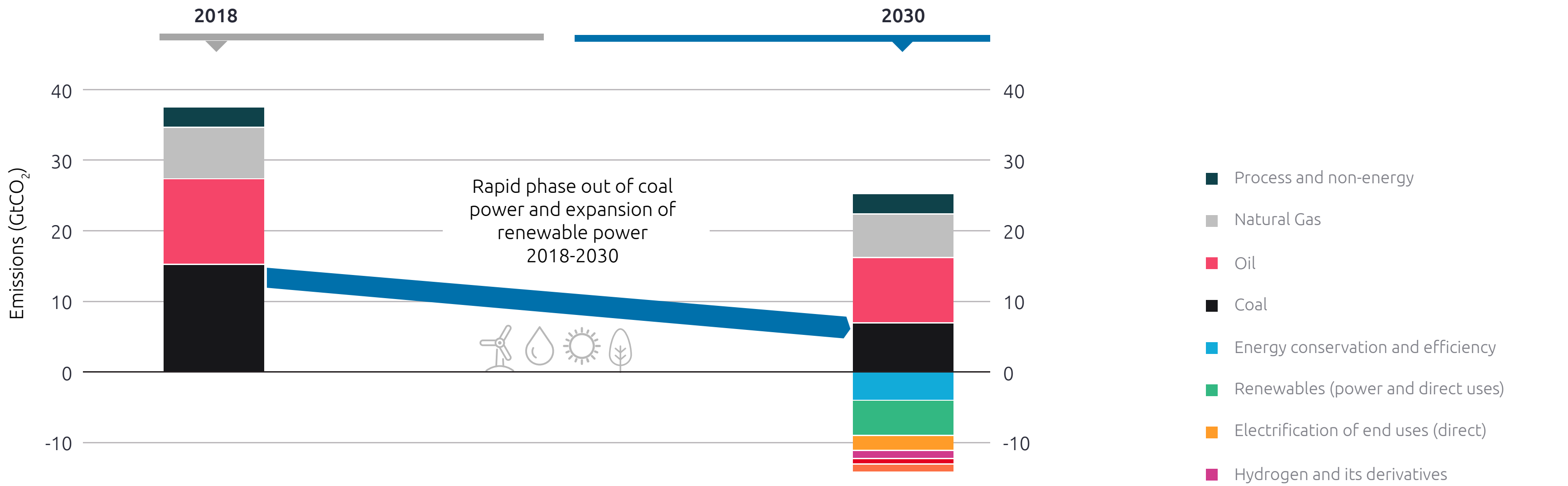
- Green hydrogen should move from niche to mainstream by 2030. In 2021, only 0.5 GW of electrolyzers were installed; cumulative installed capacity would need to grow to 350 GW by 2030 what looks like a great challenge considering current status and lack of infrastructures. Coming years should bring relevant actions to develop the global market and reduce costs with specific support schemes and policies by Governments to reach long term goals.
- Modern bioenergy's contribution to meet energy demand, including demand for feedstock, will have to triple by 2030. At the same time, the traditional use of biomass (such as firewood) needs to be replaced by clean cooking solutions.

3 IRENA World Energy Transitions Outlook 2022 report

4 IRENA World Energy Transitions Outlook 2022 report

FIGURE 38

Emissions reductions 2018-2030



Renewable energy share in electricity generation must increase to 65% by 2030.

- And additional 8000 GW of renewable capacity in this decade.
- Installed capacity of onshore wind of 3000 GW, four times that of 2020.
- Offshore wind to scale up to 380 GW, 11 times more than in 2020.
- Installed capacity of solar PV to reach 5200 GW, 30% more than in 2020.
- Other renewable technologies to reach 750 GW, up six-fold from 2020.

The share of direct electricity in total final energy consumption (TFEC) must rise from 21% to 30%; deployment of energy efficiency measures must increase 2.5 times.

- A drop in TFEC from ca. 390 EJ today to 370 EJ.
- Expanded electrification of energy services, especially in transport sector.
- Improved energy efficiency standards and retrofitting of existing buildings.
- Process changes in industry, relocation of industries, and circular economy practices.

Direct renewables in end use sectors must grow from 12% in 2019 to 19% by 2030.

- Hydrogen consumption to reach a minimum of 19 EJ by 2030.
- Total consumption of bioenergy and feedstock in industry to increase to 25 EJ. 2.5 times more than in 2019.
- Solar thermal, geothermal and district heating solutions to be scaled up to 60 EJ, 1.3 times the 2019 levels.
- Biofuel's share for energy consumption in transport to increase from 3% in 2019 to 13%.
- Increase ambition on biojet to reach 20% of total fuel consumption by 2030.

Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

Net zero pathway by 2050

Electrification and efficiency are key drivers of the energy transition, enabled by renewables, hydrogen, and sustainable technologies, and a massive change in how produce and consume energy, would result in a cut of nearly 37 gigatonnes of annual CO2 emissions by 2050. These reductions can be achieved through:

- scale up generation and direct uses based on renewables-electricity sou rces.
- significant increase in energy efficiency measures.
- electrification of end-use (EV, heat pumps, etc.).
- green hydrogen and its derivatives.
- nuclear renaissance in some countries, acceleration in others.
- bioenergy coupled with CCS.
- last-mile use of carbon capture and storage.
- storage, smart grids and flexibility.

Energy sector shall be based largely on renewable energy sources with two-thirds of total energy supply in 2050 from wind, solar, bioenergy, geothermal and hydro energy, and being solar the largest source accounting for one-fifth of supplies. Solar PV capacity will have to increase 20-fold from now to 2050, and wind power 11-fold.

Net zero means a huge decline in the use of fossil fuels that shall remain in 2050 used in goods where the carbon is embodied in the product such as plastics, in facilities fitted with CCUS, and in sectors where low-emissions technology options are scarce.

Electricity accounts for almost 50% of total energy consumption in 2050. It plays a key role across all sectors from transport and buildings to industry, and is essential to produce low emissions fuels such as hydrogen. To achieve this, total electricity generation increases over two-and-a-half-times from today to 2050. By 2050, almost 90% of electricity generation shall come from renewable sources, with wind and solar PV together accounting for nearly 70% and most of the remainder will come from nuclear.

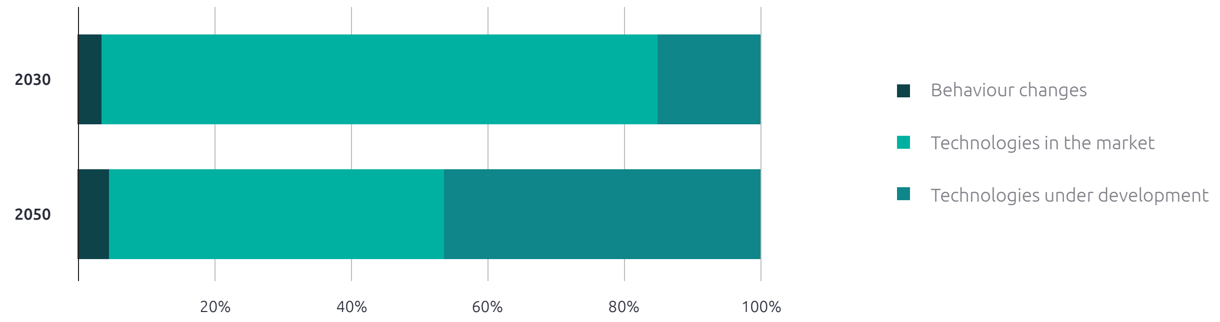
Emissions from industry, transport and buildings take longer to reduce. Cutting industry emissions by 95% by 2050 involves major efforts to build new infrastructure through R&D and initial deployment between now and 2030 to bring new clean technologies to market, such as CCUS, new hydrogen-based industrial plants, end of sales of new internal combustion engine cars by 2035 and boost electrification underpin the massive reduction in transport emissions. In 2050, cars on the road worldwide run-on electricity or fuel cells. Low-emissions fuels are essential where energy needs cannot easily or economically be met by electricity.

Reaching net zero by 2050 will require new technologies that are not available on the market yet. Major innovation efforts must occur over this decade in order to bring these new technologies to right time. Most of the global reductions in emissions in 2030 will come from technologies available today, but in 2050 almost half the reductions will come from technologies that are currently under development specially in the field of storage, batteries, hydrogen electrolysers, and direct air capture and storage

Set clear and key milestones to short, medium and long-term providing credible step-by-step plans to reach net zero target, will create confidence with all stakeholders describing ambition and fairness, with precise description of the targets, making a link to Paris Agreement goals, sharing the planning process and implementation plans.

FIGURE 39

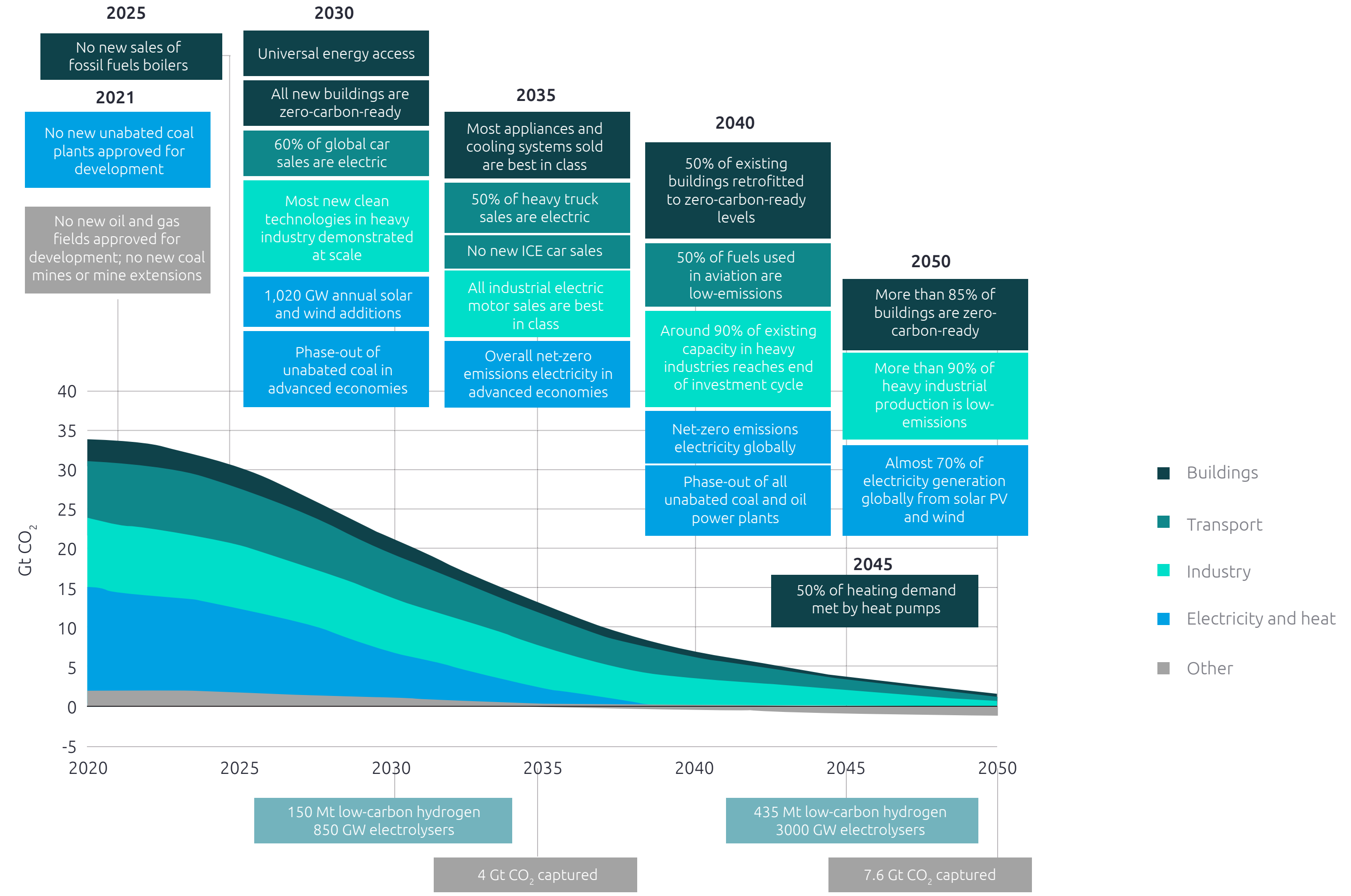
Annual CO_2 emissions savings in the net zero pathway, relative to 2020



Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

FIGURE 40

Key milestones in the pathway to net zero



Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

Governments, politicians, investors, business and industry players, and citizens must address these challenges everywhere.

Address emerging energy security risks from now will ensure reliable supplies of energy and critical related commodities at affordable prices rising in importance on the way to net zero, creating adequate terms for new investments required, digital enablers, grids, flexibility solutions, ….

Unprecedented international efforts and cooperation is pivotal for achieving net-zero emissions by 2050 worldwide. Net zero challenge is huge and global, the cooperation between countries will provide comfort scenarios to all stakeholders. Including comprehensive policy decisions and fiscal and tax regimes where in the net zero tax revenues from oil and gas sales will decline close to zero in long-term. Developed countries need to ramp up climate finance contributions to support developing countries.

FIGURE 41

Net Zero Emissions roadmap by 2035

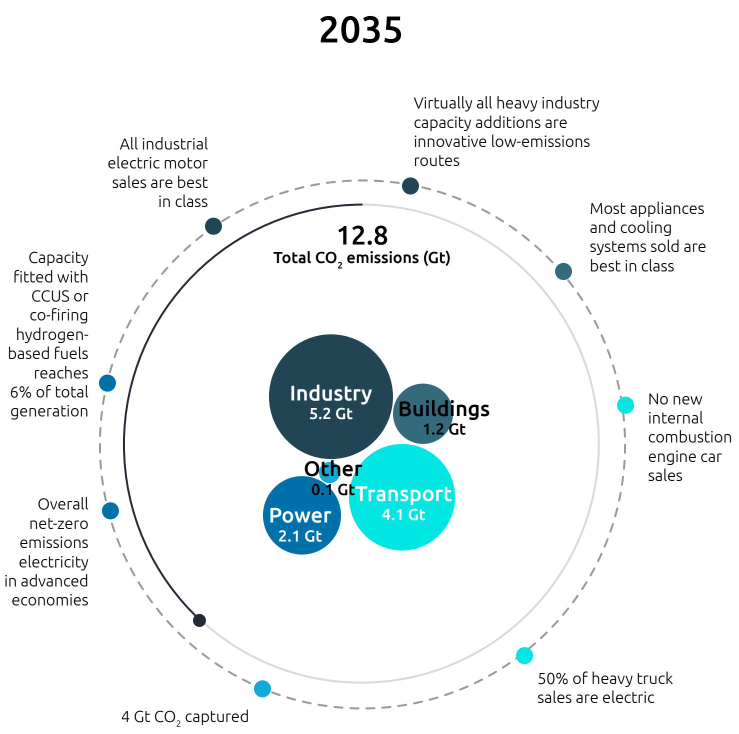


FIGURE 42

Net Zero Emissions roadmap by 2040

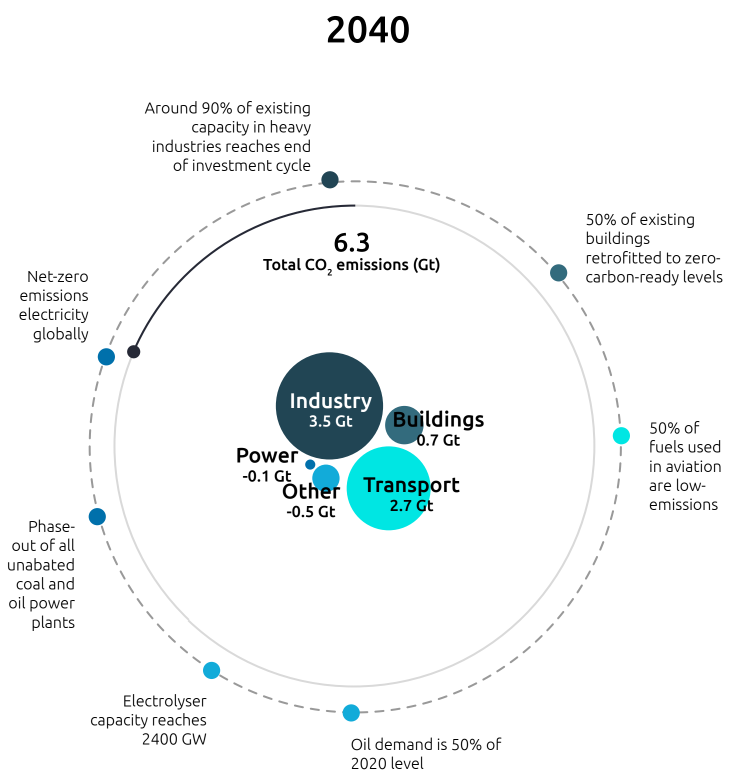
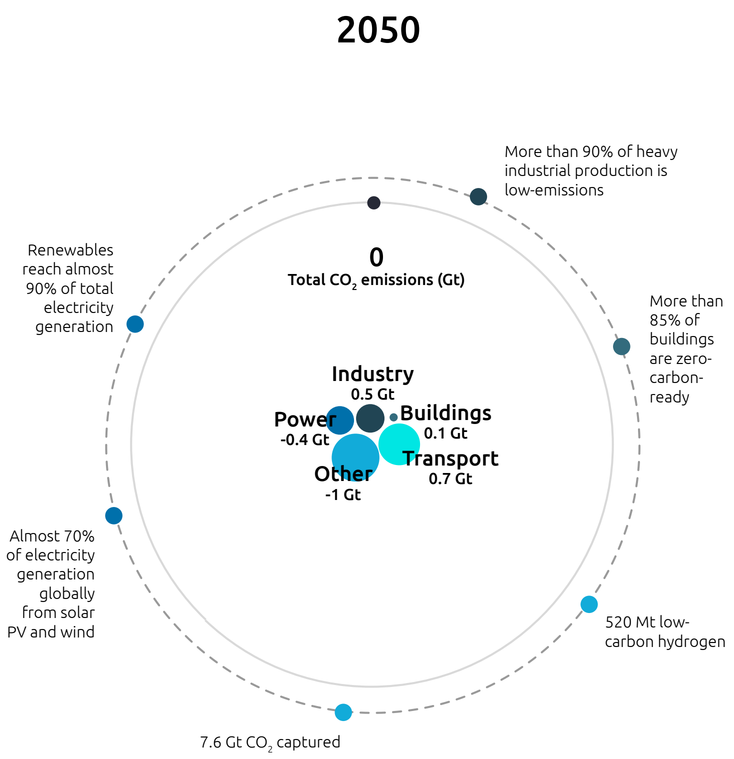


FIGURE 43

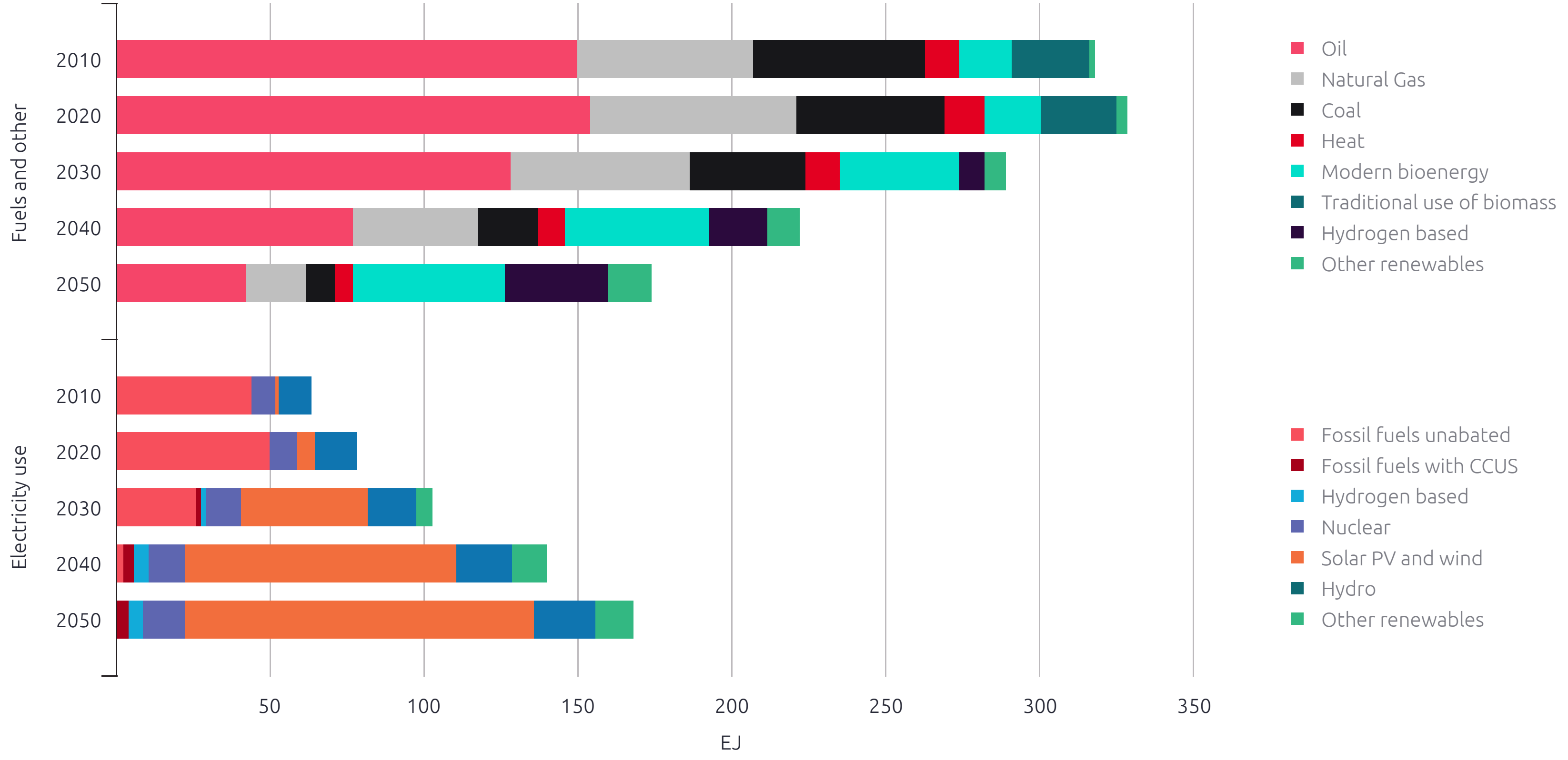
Net Zero Emissions roadmap by 2050



Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

FIGURE 44

Global total final consumption by fuel in the NZE



The share of electricity in final energy use jumps from 20% in 2020 to 50% in 2050
Note: Hydrogen-based includes hydrogen, ammonia and synthetic fuels.

Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

FIGURE 45

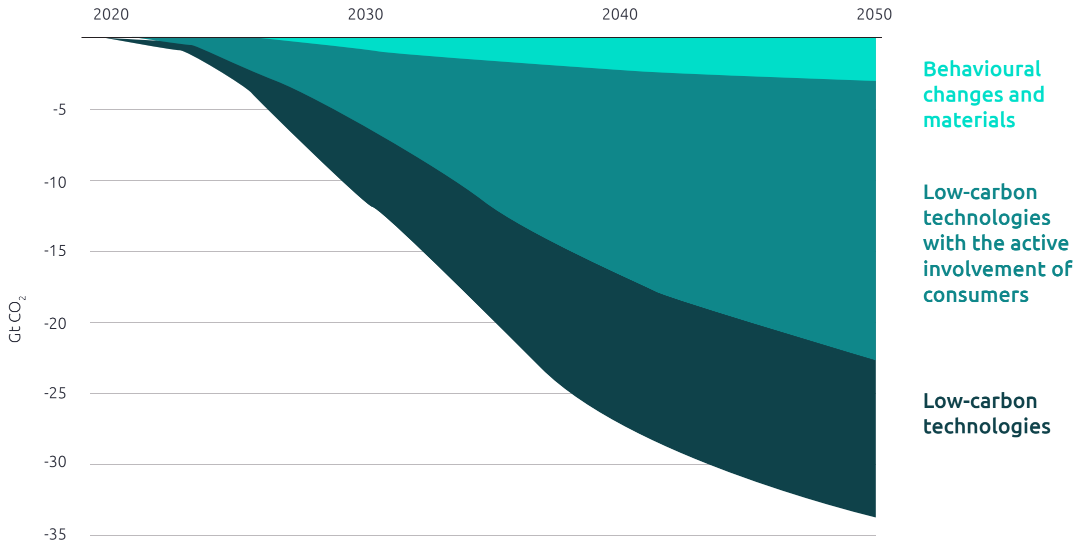
Emissions reductions by mitigation measures in the NZE 2020-2050

Solar, wind and energy efficiency deliver around half of emissions reductions to 2030 in the NZE, while electrification, CCUS and hydrogen ramp up thereafter.

Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

FIGURE 46

Role of technology and behavioural change in emissions reductions in the NZE



Source: IEA Net Zero by 2050 A Roadmap for the Global Energy Sector

BUSINESS CASE - ENERGY TRANSITION

MARNE SHAFER
DEBARGHYA MUKHERJEE
PETER KING
ALAIN CHARDON

Climate change indicators like greenhouse gas concentrations, sea level rise, ocean heat, and acidification are setting records

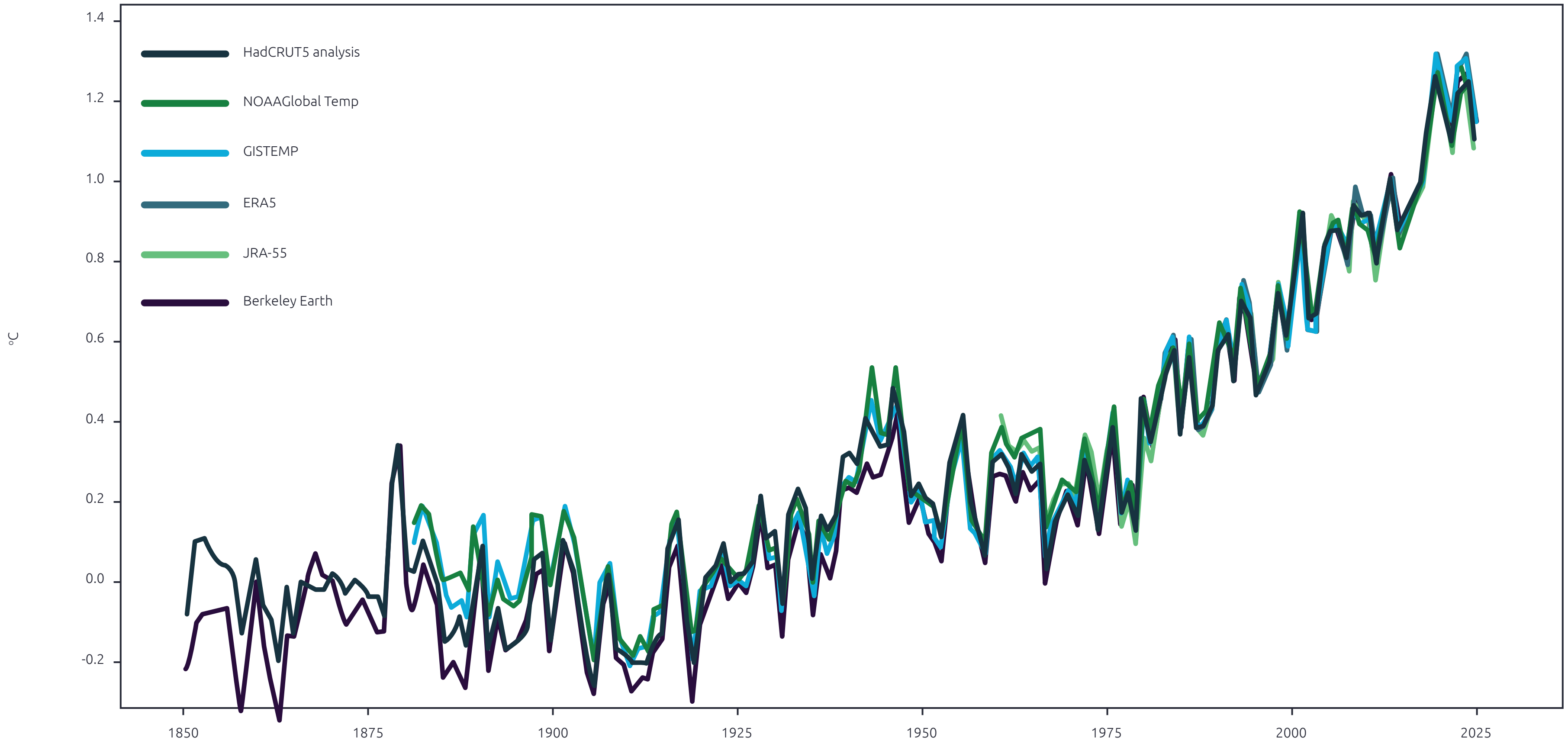
Human activities are causing planetary scale changes on land, in the ocean, and in the atmosphere, with harmful and long-lasting consequences for sustainable development and ecosystems. Increasing frequency and financial impact of unprecedented weather events has led to billions of dollars in economic losses, created a heavy toll on human lives and well-being, and triggered shocks for food and water security and displacement.

- Greenhouse gas concentrations are increasing year after year, while atmospheric concentration of CO_2 is increasing at an average rate of approximately 2.4 parts per million (ppm)/year (0.6%/year).
- Largest value of XCO_2 recorded until the end of 2021 was in April 2021, at approximately 416 ppm; the annual average for 2021 was approximately 414 ppm.
- In 2021, the global average temperature was 1.1 °C above the 1850-1900 pre-industrial average.
- Ocean heat reached a record high. The upper 2000-meter depth of the ocean continued to warm in 2021 and it is expected to continue to warm in the future – a change which is irreversible on centennial to millennial time scales. All data sets agree that ocean warming rates show a particularly strong increase in the past two decades.
- Exceptional heatwaves broke records across western North America and the Mediterranean.
- Flooding induced economic losses of $17.7 billion in the Henan province of China; Western Europe experienced some of its most severe flooding on record in mid-July with economic losses in Germany exceeding $20 billion.
- Drought affected many parts of the world, including Africa, Canada, the western United States, Latin America, Iran, Afghanistan, Pakistan and Turkey.
- Hurricane Ida was the most significant storm of the North Atlantic season, with economic losses in the United States estimated at $75 billion.

HOME

FIGURE 1

Global annual mean temperature difference from pre-industrial conditions (1850–1900) for six global temperature data sets (1850–2021)



Source: MET Office UK, WMO

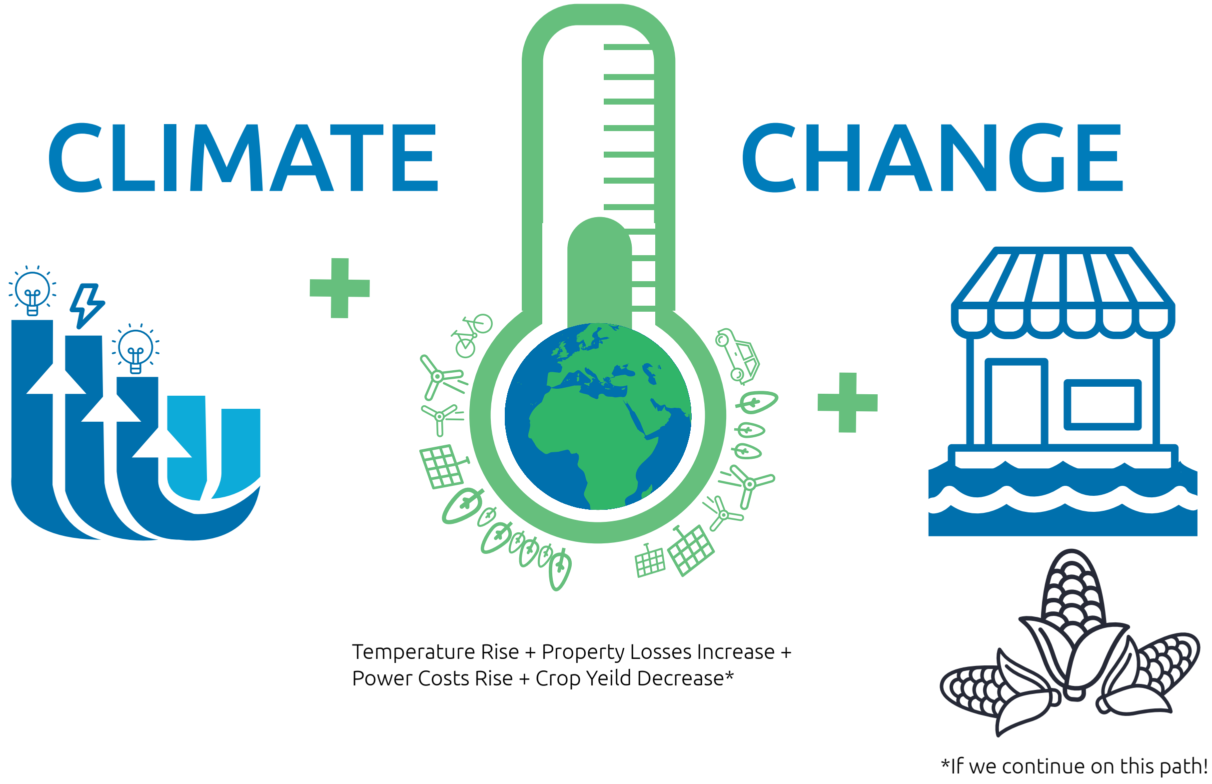
The rising costs of climate change: Impact of volatile temperatures and extreme weather on government, industrial facilities, and the insurance sector

The escalating frequency and severity of extreme weather-related events – from wildfires to record heat waves and floods – have shone a brighter regulatory spotlight on insurance risk and climate change.

- A Stanford study finds that global warming increased U.S. crop insurance losses by $27 billion in the past 27 years.
- Without adapting to the changing climate, some midwestern and southern counties in the U.S. could see a decline in crop yields of more than 10% over the next five to 25 years.
- By 2050, up to $106 billion worth of coastal property will likely be below sea level (if we continue the current path).
- According to NOAA's Office for Coastal Management, over the next five to 25 years, greenhouse gas-driven temperature rises will likely necessitate the construction of new power generation that would cost ratepayers up to $12 billion per year in the U.S.
- Climate change is causing an insurance crisis in Australia; The Australian Climate Council has released a study which estimates that one in 25 of all homes and commercial buildings in the country will become effectively uninsurable by 2030.
- According to the CDP Global Supply Chain Report released in 2021, a total of $1.3 trillion in revenue losses is anticipated for suppliers globally across all major industries within the next five years due to climate change, deforestation, and water insecurity.
- Higher temperatures and intensified weather events will also result in huge costs for the EU's economy and hamper crop yields; (corn, sunflower and soyabean yields are forecast by the EU to drop by about 10%-15%).

FIGURE 2

Impact of climate change on property, power and crops

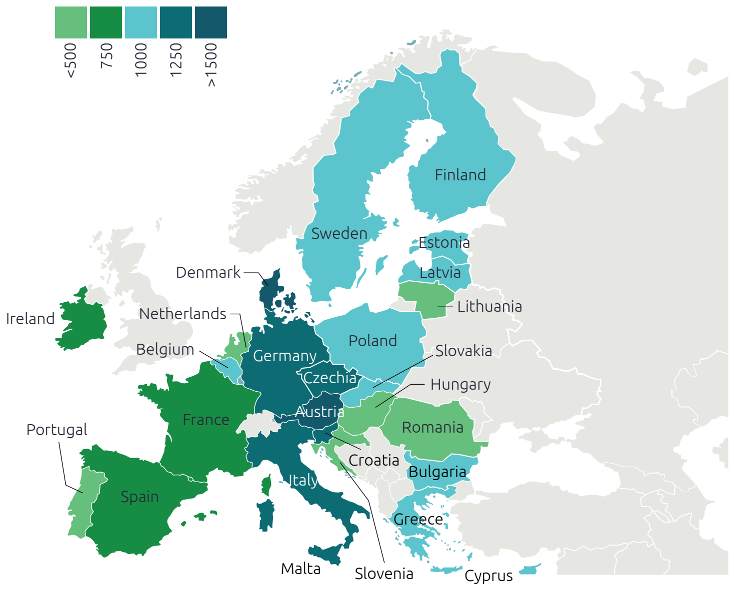


Source: NOAA's Office for Coastal Management

FIGURE 3

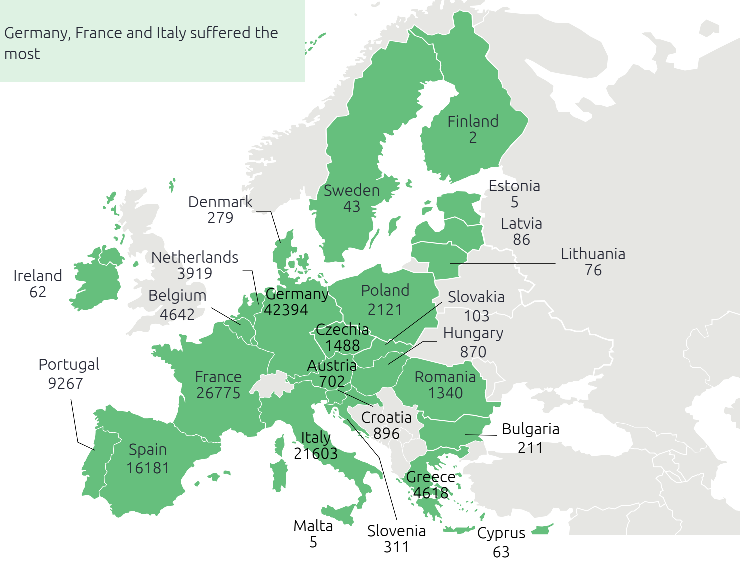
Climate change costs lives and money in Europe

Impact of extreme weather and climate-related events between 1980 and 2020



Between 1980 and 2020,
over 138,000 people
in the EU lost their lives due to extreme weather and climate - related events.

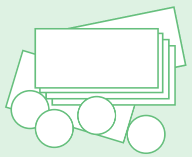
Germany, France and Italy suffered the most



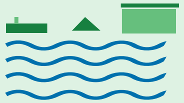
The financial losses caused by extreme weather and climate-related events exceeded
€487 billion
in the EU27 over the last 40 years.

This is significantly more than what the EU spends over **two years on all its policies and programs.**

The overall cost was the highest for Germany, Italy, and France.



over €5 billion
Economic cost of river flooding in Europe on average every year



€2 billion
Economic damage caused by forest fires every year

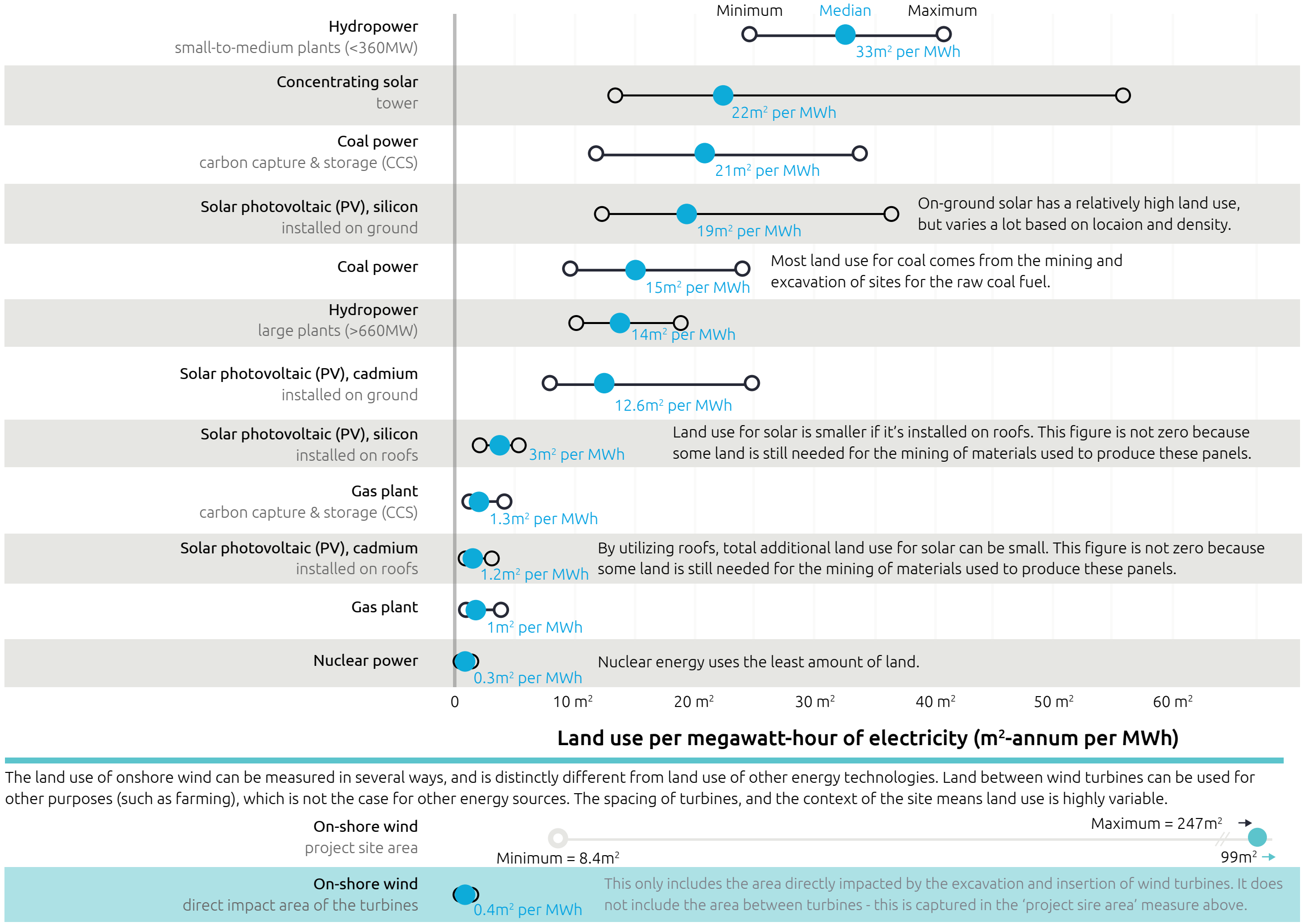
Source: consilium.europa.eu

Energy sources need to balance in-depth challenges around energy density, land use requirements, hidden supply chain complexities, and economic viability

- Whether it is coal, gas, nuclear, or renewables, every energy source takes up land, uses water, and needs some natural resources for fuel or manufacturing.
- Land occupation is found to be highest for concentrated solar power plants, followed by coal power and ground-mounted photovoltaics.
- Lifecycle land occupation is minimal for fossil gas, and nuclear
- Nuclear energy is the most land-efficient source: per unit of electricity, it needs 50-times less land compared to coal and 18 to 27-times less than on-ground solar PV.
- Costs of land use can vary significantly depending on where energy sources are built, and what the alternative uses of that land are; An energy source expanding into natural habitats or forests is not the same as building a solar farm in an unproductive desert.
- Land use required to generate the equivalent electricity output for Solar and Wind like a 1GW Nuclear power plant:
  - Nuclear – 3.4 km²
  - Solar – 100-200 km²
  - Wind – 670–930 km²

FIGURE 4

Land use of energy sources per unit of electricity



Source: UNECE (2021)

Major challenges and opportunities, by energy source

Wind energy

- Adverse environmental impacts, including the potential to reduce, fragment, or degrade habitat for wildlife, fish, and plants.
- Furthermore, spinning turbine blades can pose a threat to flying wildlife like bird species; ESI Energy (a subsidiary of NextEra Energy Inc.) was sentenced to probation and ordered to pay more than $8 million in fines and restitution after at least 150 eagles were killed over the past decade at its wind farms in eight states.
- Land use and area requirement. For example, a Siemens windmill that generates 6MW of power has a diameter is 154 meters, with a sweep area of 18,600 square meters.

Solar/PV

- Primary challenges include the need for land, as well as land-ceiling laws and attaining environmental and local clearances, etc.
- Negative impact to land use, but a viable option on top of existing alternative land use, such as rooftops, etc.

Nuclear

- Previous issues with time and cost need to be overcome.
- The highest density energy solution available resides in nuclear energy. The future potential of nuclear small modular reactors should be tested and scaled to commercial levels as a near-term solution to the complexities behind other energy sources.
- Small nuclear reactors (SMR) that can be produced in a centralized facility and then stored underground with a small footprint near where the energy is needed is a viable option that is not commercially scaled to date.

Hydrogen

- Hydrogen blending in gas grid would lead to limited CO_2 benefits and a large increase in energy costs; 20% blend with natural gas using existing pipeline only reduces GHG emissions by 6%-7%, but it will result in costs increase to rate payers 2-4 times above natural gas prices

Ammonia

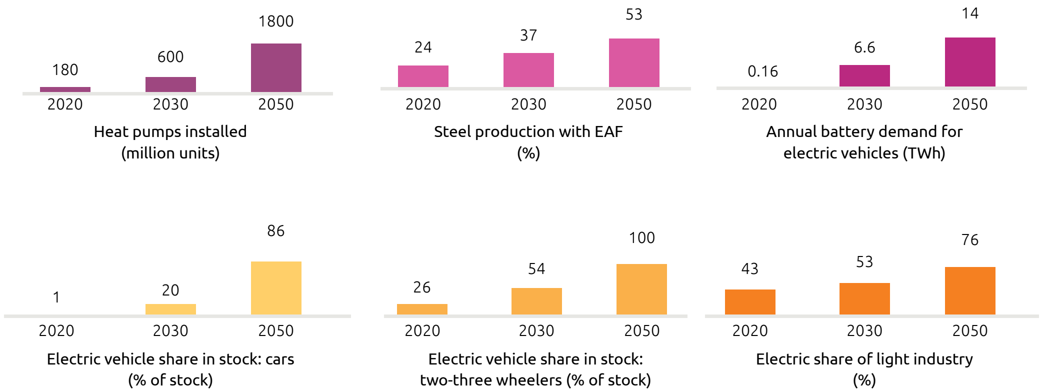
- Strong option for marine shipping fuel replacement; challenge is ships built on this technology are still in the conceptual design phase.
- Japan's Mitsubishi Shipbuilding and South Korea's Samsung Heavy Industries each reported approval for additional ships designed to employ ammonia as their primary fuel. Samsung aims to deliver an Aframax crude oil tanker fueled by ammonia by 2024.

Role of electrification in energy transition

- Electrification of areas previously dominated by fossil fuels emerges as a crucial economy-wide tool for reducing emissions.
- This takes place through technologies like electric cars, buses, and trucks on the roads, heat pumps in buildings, and electric furnaces for steel production.
- Net zero by 2050 hinges on an unprecedented clean technology push through 2030.
- Electric vehicles (EVs) go from around 5% of global car sales to more than 60% by 2030.
- Renewables and electrification make the largest contribution to emissions reductions, but a wide range of measures and technologies are needed to achieve net zero emissions.

FIGURE 5

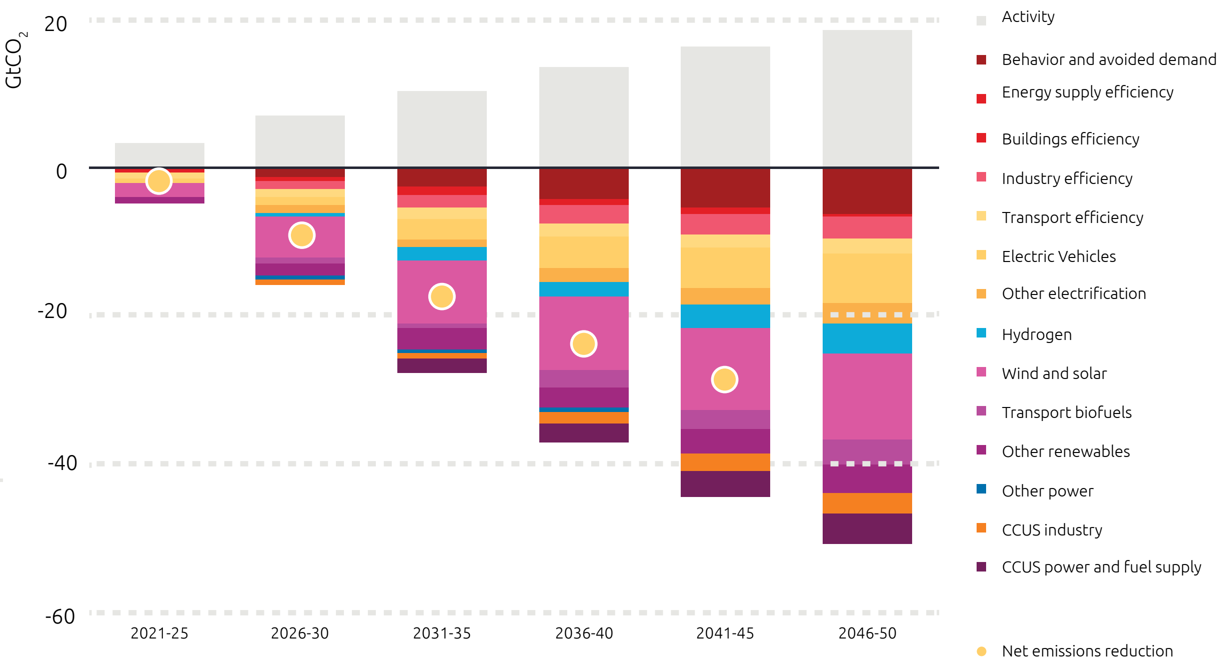
Role of Electrification



Source: IEA

FIGURE 6

Average annual CO_2 reductions from 2020 to 2050 in net zero emissions scenario



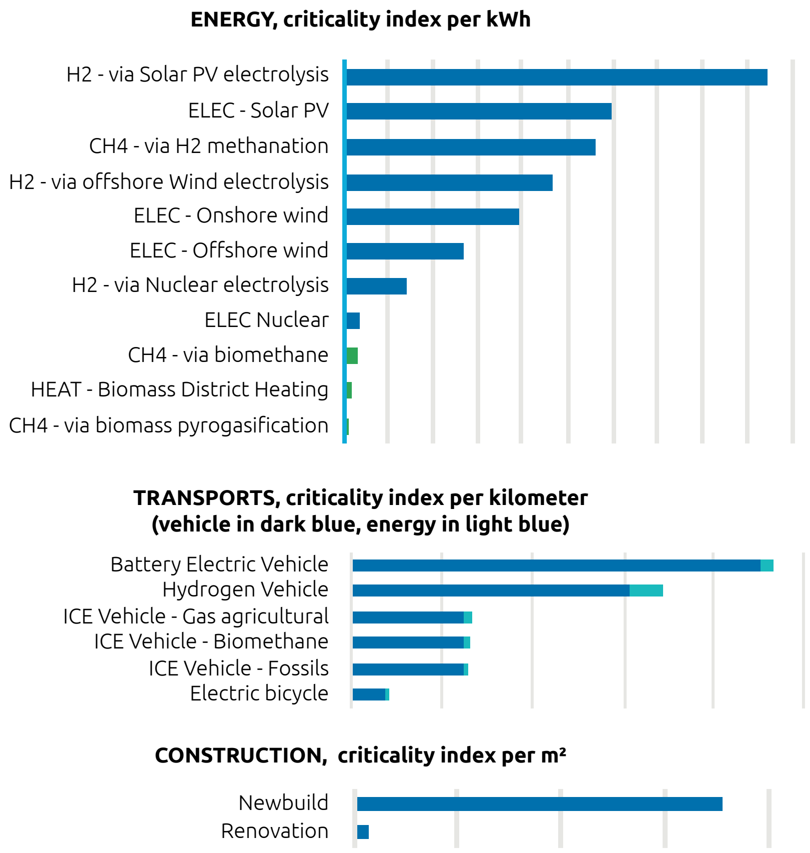
Source: IEA

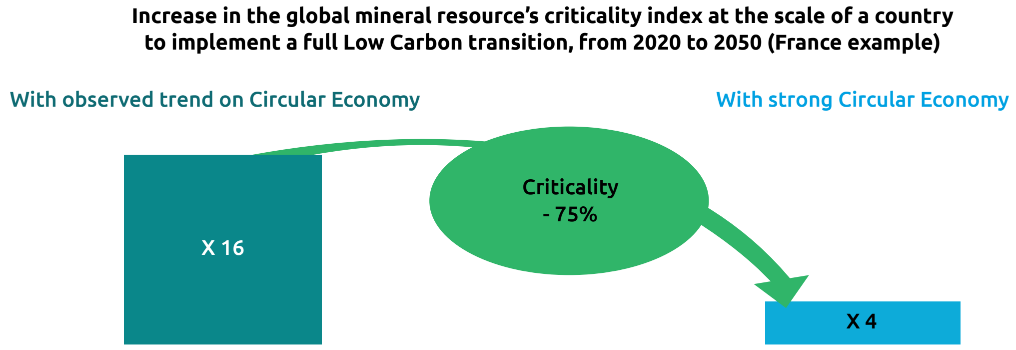
Low-carbon technologies shift criticality from fossils to mineral resources, questioning 100% electrification strategies and making circular economy an absolute must-have

- Low-carbon technologies will require massive amounts of critical resources such as cobalt, lithium, platinoids, rare earths, graphite, silicon, nickel, copper, aluminum, steel, concrete, sand, etc.
- Per kWh of energy, synthetic fuels, hydrogen, solar, and onshore wind generate more resources' criticality than offshore wind, nuclear, biomethane, district heating, and biomass.
- Per kilometer, battery electric vehicles generate more criticality than hydrogen vehicles, and, more importantly, internal combustion engines (ICE) vehicles fueled with biogas. This questions the European decision to shift 100% of the 300 million vehicles fleet to electric mobility.
- Per square-meter of buildings, new build generates 40-times more criticality than renovation.
- At the scale of the low-carbon transition for a country such as France, the resource criticality will be multiplied by a factor of 16 between today and 2050. This wall of criticality makes net zero transition uncertain.
- Capgemini has built a new and unique resource criticality index, which is based on a mix of factors including: price; resource availability (geological reserves, extraction and first transformation oligopolies, competition with other strategic uses); resource replaceability and recyclability; and social and environmental impacts.
- Circular economy applied to low carbon is an absolute must-have: The shift from a linear economy and extractive resources to shared economy, regenerative bioresources, reduce, reuse and recycle models.

FIGURE 7

Increase in the global mineral resource's criticality index





Source: INEC Capgemini report, SNBC sous contrainte de ressources, 2022

Transitions in the developing world must be built on access and affordability

- The world's energy and climate future increasingly hinges on decisions made in emerging and developing economies – a very diverse group that spans Africa, Asia, Europe, Latin America, and the Middle East. This group includes the world's least developed countries as well as many middle-income economies.
- Developing and emerging economies account for two-thirds of the world's population but only one-fifth of investment in clean energy – and just one-tenth of global financial wealth.
- Expanding economies and rising incomes create vast potential for future growth. The challenge is to find development models that meet the aspirations of their citizens while avoiding the high-carbon choices that other economies have pursued in the past.
- The falling cost of key clean energy technologies offer a tremendous opportunity to chart a new, lower-emissions pathway for growth and prosperity. If this opportunity is not taken, and clean energy transitions falter in these countries, this will become the major fault line in global efforts to address climate change and reach sustainable development goals.
- **Affordability is a key concern for consumers.** There are almost 800 million people who do not have access to electricity today and 2.6 billion people who do not have access to clean cooking options.
- Most of these people are in emerging and developing economies, and the pandemic has set back financing of projects to expand access. Efficiency is key to least-cost and sustainable outcomes.
- **Many emerging and developing economies do not yet have a clear vision or the supportive policy and regulatory environment that can drive rapid energy transitions.**
- Addressing transition challenges requires a focus on transparent public dialogue, developing programs to boost skills in all aspects of clean energy transitions, and supporting the growth of new job opportunities in more sustainable economic activities.
- International engagement and support is needed to boost clean energy investment in emerging and developing economies. Actions by policy makers within their countries to address the challenges and seize the opportunities will not, on their own, generate sufficient momentum. Supportive international actions will be essential to catalyze the necessary investments in critical areas and to support longer-term reform processes.
- **Annual clean energy investment in emerging and developing economies needs to increase by more than seven times – from less than $150 billion in 2020 to over $1 trillion by 2030 to put the world on track to reach net zero emissions by 2050, according to IEA.**

Business case for action

Key Issues/problems	Costs	Energy transition, investment benefits	Recommendations
• Impact of adverse climate change, rising temperature, deforestation, and GHG emissions leading to billions of dollars in economic losses, affecting human lives and well-being. • Fossil fuels are causing the most damage to the environment; Phasing out unabated fossil fuels is critical to keep on a pathway of 1.5-2°C. • Negative environmental impacts on ecosystem, wildlife, trees. • In many emerging and developing economies, emissions are heading upwards while clean energy investments are faltering. • Debt burdens are on the rise in many economies. • Access and affordability are key concerns for many emerging and developing economies lacking vision or supportive policy and regulatory environment. • Low socioeconomic communities suffer heavy losses in adverse climate change events and have less resources to recover.	• Unprecedented weather events (hurricane, flood, drought) induced economic losses • Financial and economic costs • Land area requirement high for wind, solar, coal • Insurance loss (property, crop) • CAPEX and OPEX, Investments in clean energy, electrification	• Emission reduction • Reducing dependency on fossil fuel • Controlling the global climate change • Avoided energy and capacity costs • Low land requirement for nuclear and gas compared to coal, solar, and wind • Creating economic development and jobs	• Need to balance challenges around energy density, land use requirements, supply chain complexities, and economic viability • Policy parity across all low- and zero-carbon technologies • Governments need to ensure that clean energy transitions are people-centered and inclusive, helping communities navigate the new • Disruptive technologies and market available to support grid defection will threaten their business and challenge leadership to innovate, improve quality of operations, and deliver value to customers • Mandate for utilities will be to establish a reliable grid that decarbonizes their clients' footprints as their investors further demand SEC auditable carbon emissions reduction tracking • Energy transition will require mass electrification to accommodate the demand for households in heating and the charging of electric vehicles • Speeding up renewables and electrification technologies implementation – solar PV, wind, electric vehicles, heat pumps, and electric furnaces for steel production • Circular economy applied to low carbon is an absolute must-have

FORECASTED INVESTMENTS: RENEWABLES & NETWORKS

PHILIPPE VIÉ
COLETTE TALBOT
ABHISHEK GOKHALE
ANIKET MAHATO

Accelerating to net zero is required. The main effort is focusing on reducing emissions out of energy use (scope 3 emissions).

What are the main players doing?

The **intensity** and **pace of transformation** within the Energy & Utilities (E&U) sector have never been so important, with multiple triggers:

- Climate change (the energy transition imperative)
- Deep and digital technologies' fast development
- Resource scarcity
- Value chain deconstruction and innovative business models
- Energy sovereignty, independency, and affordability

Energy transition is imperative for the planet and a clear mandate for sector players. 73% of greenhouse gas (GHG) emissions come from energy use—

Industry first, then transportation, buildings, agriculture, and energy production.

In less than five years, energy transition has become the mission statement for most E&U players, notably in Europe (the most climate-friendly region). The two segments, Energy and Utilities, are blurred, as large International Oil Companies (IOCs) become utilities on their route to net zero. But it's a long, bumpy road, with many obstacles to overcome.

And we are totally convinced that today's energy transition leaders will become the energy leaders of tomorrow.

That's why we conducted a benchmark to assess the choices and investment levels of more than 60 E&U players in various locations. What are their priorities and commitments? How can they afford the requested level of investments to lead a domain? Which technologies are they considering (deep low carbon and digital technologies)? The present article highlights our findings.

Our benchmark data mainly comes from players' communications (annual reports, environmental, social, and governance strategies (ESG), etc). About 60 utilities' and IOCs' energy transition strategies were examined – examples to follow.

Same objective for utilities and IOCs, but totally different routes and challenges

Utilities need to accelerate and scale energy transition offers

Even if utilities have started to provide energy transition solutions and services, acceleration and scale up are urgently needed.

- **Leveraging low carbon technologies**
- **A wall of investments**
- **Providing innovative solutions**
- **Securing leadership positions on chosen domains**

Ability to make choices consistent with actual and desired balance sheet?

Distributed and intermittent renewables growth

Storage competitiveness, batteries today, hydrogen tomorrow

Massive electrification, transportation, heating

Endless regulation changes, business models under pressure

Various common challenges

← Risks and challenges preventing players from being successful during the journey →

Oil & Gas (O&G) majors must commit to carbon neutrality

These large companies need a complete shift and reinvention to face oil peak and operate in volatile markets

- **Moving away from fossil fuels, portfolio of energy sources shift**
- **Evolving business models**
- **Growing low-carbon technologies and becoming utilities**
- **Spending billions and billions**

Ambitious, realistic, funded and measured action plan for the business reinvention?

A successful route to net zero is helping companies to become market leaders

Mission statements and commitments

The current commitments and targets set by the countries responsible for 70% of global emissions, including scope 3 emissions, are **not on track to achieve the 1.5°C target** of the Paris Agreement. Since the Paris Agreement in 2015, the GHG theoretical scenarios based on the commitments and pledges made by businesses, countries, and governments are improving; however, they are not reaching 1.5°C. The global temperature is currently about 1.1°C above pre-industrial levels.

The current policies are **expected to raise the global temperature to 2.7°C.** More than 140 countries responsible for 90% of global CO2 emissions are committed to a net zero emissions target. Considering the current commitments, we can expect **the rise in global temperatures could be halted at 1.8°C.**

The **optimistic scenario of 1.8°C includes** 127 countries and the European Union, which has submitted strong nationally determined contribution (NDC) targets. Nevertheless, there is **still room to increase target ambitions and NDC.**

Emissions

Utilities and IOCs have already defined their goals with a roadmap for scope 1 and 2 emissions reductions, with limited coverage of scope 3 emissions reduction targets.

A majority of **Europe's** utilities have set or updated their position to strengthen net zero emission reduction targets covering scope 1 and 2 emissions. Utilities such as Iberdrola SA, Ørsted A/S, E.ON SE, Fortrum Oyj, SSE Plc, Centrica PlC, Vattenfall AB, and Electricité de France have all included scope 3 emissions in their CO2 emission targets.

Utilities from the **U.S.**, such as CMS Energy, Dominion Energy Inc., Duke Energy Corporation, and Edison International, have stepped up to update climate targets, which include scope 3 emissions and all other emissions linked to natural gas.

In 2021, **China,** the world's largest energy consumer, experienced acute power shortages. It officially submitted its NDC to peak CO2 emissions before 2030 and reach carbon neutrality by 2060. In addition, the Chinese national oil companies (NOCs) have made net zero commitments focused only on its scope 1 and 2 emissions.

Commitments

According to NetZero tracker (as of June 24, 2022), 198 countries have made pledges that include net zero emissions and emission-reduction targets (covering scope 1, 2, and 3). Additionally, 137 countries have committed to net zero transition, 43 countries to achieving carbon neutrality, and 18 countries have set emission-reduction targets to minimize their carbon footprint.

FIGURE 1

Commitments comparison for IOCs (a few examples)

Companies	Scope 1 and 2	Scope 3	Targets
TotalEnergies	✓	✓	Scope 1+2 → 40% (2030) Scope 3 → 30% (2030) Net Zero → 2050
BP	✓	✓	Scope 1+2 → 20% (2025), 50% (2030), Net Zero (2050) Scope 3 → 20% (2025), 35-40% (2030)
Shell	✓	✓	Scope 1+2 → 50% (2030) Scope 3 → 20% (2030) Net Zero → 2050
ExxonMobil	✓		Scope 1+2 → 30% upstream (2025), 40-50% methane (2025), Net Zero (2050)
Chevron	✓	✓	Scope 1+2 → 35%(2028), Net Zero(2050) Scope 3 → 5%(2028)
Repsol	✓	✓	Scope 1+2 → 30%(2030) Scope 3 → 30%(2030) Net Zero → 2050
Equinor	✓	✓	Scope 1+2 → 25%(2025), 50%(2030), 100% (2050) Net Zero → 2050

Source: Players' announcements, Capgemini analysis

FIGURE 2 A successful route to net zero : Principal companies are becoming market leaders

The mission statements and commitments of large utilities are all energy transition focused

Companies	Mission Statements	Net-zero Targets
Enel	Accelerating future of energy generation through the process of decarbonizing our energy mix, the growth of renewables and the increasing electrification of consumption - all this is for a just, sustainable and inclusive transition	2040
EDF	To build a net zero energy future with electricity and innovative solutions and services, to help save the planet and drive wellbeing and economic development	2050
Engie	To act and accelerate the transition towards a carbon-neutral economy, through reduced energy consumption and more environmentally-friendly solutions	2045
E.On	Drive the energy transformation towards a connected and sustainable world, by transitioning to a low-carbon energy system that takes maximum advantage of renewable sources	2050
Iberdrola	To create value sustainably for society, citizens, customers, and shareholders, by providing a quality service using environmentally-friendly energy sources, through innovation and employee development and training	2030
Exelon Utilities	We believe that reliable, clean, and affordable energy is essential to a brighter, more sustainable future. That's why we're committed to providing innovation, best-in-class performance and thought leadership to help drive progress for our customers and communities	2050
RWE AG	We are investing massively in expanding renewables and are involved in innovative hydrogen projects. With our flexible fleet of power plants, we are supporting a secure energy supply and we are working on the storage technologies of the future. We are committed to climate-protection targets, engaged in creating high social standards and foster a diverse corporate culture	2040
EnBW AG	We want to expedite the energy turnaround and supply people and cities evermore with sustainable energy in the future, and we are transforming ourselves into a sustainable and innovative infrastructure partner	2050
ENEL	Open power for a brighter future: we empower sustainable progress	2050
Statkraft	Creating value by enabling a net-zero future by developing, acquiring, owning, and operating renewable assets, and providing our customers with the best energy solutions to reach a net-zero future	2050
Pacific Gas & Electric Co.	To remain focused on reducing our carbon footprint, helping our customers do the same and leading the transition to a low-carbon economy	2040
Oncor	Empowering our customers' modern lives through safe, reliable and efficient delivery of electricity	
Eneco	We are determined to bring people's energy requirements and energy consumption down to within the boundaries of a liveable planet. This is our One Planet concept	2035
Southern California Edison Co.	To build the cleanest, safest, most innovative energy company in America	2045
Duke Energy	We make people's lives better by providing gas and electric services in a sustainable way — affordable, reliable and clean. This requires us to constantly look for ways to improve, to grow and to reduce our impact on the environment	2050
NextEra Energy	To help decarbonize the U.S. economy is based upon that scalable platform and everything else that has made our company successful over at least the last 20 years	2045
AGL	To work responsively and responsibly to harness the power of these three forces – customers, community and technology – to support and enable the transition	2050
Singapore Power	To deliver reliable and efficient utilities services to enhance the economy and the quality of life of our consumers. This mission is rooted in our value system of commitment, integrity, passion and teamwork	2050

To reduce emissions, utilities and IOCs need to place energy efficiency and emissions reduction at the core of their business model and decision making across the process value chain

EU and the U.K.

Europe is on the cusp of a rapid energy transition. However, only a few power utilities have made explicit pledges toward the reduction of scope 3 emissions. It is expected that this will be primarily driven by increased renewable energy share by 2030, the most notable of which are Enel, ENGIE, EDF, Iberdrola, and RWE. The level of commitment by the utilities varies widely, and the coverage of scope 3 emissions is especially low. Some utilities have left scope 3 out of their climate pledges or have failed to disclose the full emissions profile for their operations. For instance, Iberdrola SA and ENGIE SA have set interim targets to reduce scope 3 emissions by 2030 and 2032. To meet the net zero objectives, Vattenfall AB and SSE Plc. are targeting the reduction of scope 3 emissions from use of products sold between 2018 and 2034.

European IOCs, including BP Plc., Shell Plc., Equinor ASA, and Total Energies SE, have all sworn to reach net zero with the inclusion of scope 3 emissions by 2050. They are expected to phase out the production of refined products by using cash flow from oil and gas operations to invest in renewable energy, mainly wind and solar.

U.S. and Canada

The majority of the U.S. electric power companies are working toward including scope 3 emissions to be net zero by 2050. To reduce emissions, utilities and IOCs need to place energy efficiency and emissions reduction at the core of their business models.

For example, Duke Energy plans to exit coal completely by 2035 and focus on renewables. It is also targeting its upstream methane, procurement of fossil fuels used for generation, curbing carbon emissions from purchased gas, and downstream carbon emissions from end-user consumption. Dominion Energy, for instance, is including downstream emissions and emissions related to upstream materials from suppliers to achieve its net zero goals. NextEra Energy is expected to reduce scope 3 emissions by working with its supply chain partners across the value chain.

On the contrary, U.S. IOCs such as ExxonMobil Corp., Chevron Corp., ConocoPhillips, TC Energy and others have set scope 2 emissions targets until 2050, but are less inclined to make commitments around scope 3 emissions. However, Canadian oil sands producer Suncor Energy Inc., Occidental Petroleum Corp., and Williams Cos. Inc. are committed to scope 3 emissions.

Asia-Pacific (APAC)

According to the International Energy Agency (IEA), the Asia-Pacific region still mostly relies on fossil fuels for power, accounting for 79% of global coal demand. Power utilities in Japan are aiming for net zero targets by 2050. Southeast Asian countries are closing the door on new coal projects with strict government intervention.

In China, coal still remains critical to alleviate peak demand power shortages, and there are no clear plans defined for coal plant decommissioning to reduce scope 1 and 2 emissions. However, in Japan, JERA is working toward making its thermal plants carbon neutral by shifting to alternative fuels such as ammonia and hydrogen. With limited access to wind and solar, YTL Power, and Senoko Energy Pte. Ltd are still reliant on gas and oil for power generation. In Australia, Origin Energy has committed to reducing scope 1, 2, and 3 emissions across the value chain by 2050. Malaysia's electric utility company Tenaga Nasional Berhad (TNB) is committed to fast-tracking the energy transition plan to achieve net zero emissions by 2050. With more and more countries in APAC committing to net zero targets, the inclusion of scope 3 emissions is not far away.

O&G major choices

With size and regional perspectives

FIGURE 3

Sum for all O&G companies (2020-2021 figures)

Segment (sum for all O&G companies / total worldwide capacity)	TotalEnergies	Galp	Eni	BP	Shell	ExxonMobil	Chevron	Equinor	Repsol
Offshore Wind (14 GW / 35 GW)	●	--	--	●	--	--	--	●	●
Onshore Wind (10 GW / 769 GW)	●	●	●	●	●	●	--	●	●
Solar PV (10 GW / 773 GW)	●	●	●	●	●	●	--	●	●
Hydro (1.1 GW / 1,331 GW)		--	--	●	--	--	--	--	●
Hydrogen Electrolyzer (5.8 GW / 180 GW)	●	--	--	●	●	●	--	--	--
Battery Storage (1 GW / 24 GW)	●	--	--	--	--	--	--	●	●
Biogas (... / 20 GW)	--	●	--	●	--	--	--	--	--
Sustainable Fules (inc. Biofuels) (... / x Mt)	●	●	--	●	●	●	--	--	--
EV charging points (... / 7.3 million)	●	●	●	●	●	--	--	--	●

Note: Sum for all O&G Companies are figures from 2020/2021
Source: Annual reports, Sustainability reports

- IOCs are increasing investments in renewables
  - At the end of Q2 2022, EBITDA from TotalEnergies' renewables and electricity business jumped 49% YOY. Gross installed renewable generation capacity grew by 900 MW to 11.6 GW over Q2 2022.
  - In 2022, BP is planning to spend $2.5 billion globally on renewable energy.
- **High energy prices have created windfall profits for O&G producers.** Net income is set to double this year to $4 trillion, according to the IEA. The windfall represents a once-in-a-generation opportunity for O&G companies to deliver on their net zero pledges with mergers and acquisitions (M&A) – providing enough cash to diversify their spending and fund investments in low-emission fuels such as low-carbon hydrogen.
- **IOCs are expanding clean energy portfolios incrementally.**
  - Shell plans to build Europe's largest green hydrogen plant.
  - BP is investing in a large renewables hub in Australia.
  - TotalEnergies joined an Indian conglomerate that will invest up to $50 billion in wind, solar, and hydrogen over the next 10 years.

- **Europe's majors have committed to pivoting away from their core business** into renewables, hydrogen, e-mobility, and low-carbon fuels.
  - Shell, TotalEnergies, and Equinor have evaluated the suitability of European utilities for takeovers.
- **However, the IEA's net zero emissions pathway also envisages existing oil and gas fields needing significant investment,** averaging $340 billion a year until 2030, to ensure supplies are maintained.
- On average, the world's IOCs invest about 5% of their profits in net zero projects. However, major European IOCs are far above, committing 10% to 15% and even up to 25% (TotalEnergies).

Utilities major choices

With size and regional perspectives

FIGURE 4

Sum for all utilities companies (2020-2021 figures)

Segment (sum for all Utility companies / total worldwide capacity)	Engie	EDF	EDP	Enel	Jera	Eneco	E.On	RWE	Vattenfall	NextEra Energy	Iberdrola
Offshore Wind (14 GW / 35 GW)	●	●	●	●	●	●	●	●	●	●	●
Onshore Wind (10 GW / 769 GW)	●	●	●	●	●	●	●	●	●	●	●
Solar PV (10 GW / 773 GW)	●	●	●	●	●	●	●	●	●	●	●
Hydro (1.1 GW / 1,331 GW)	●	●	●	●	–	–	●	●	●	●	●
Hydrogen Electrolyzer (5.8 GW / 180 GW)	–	●	–	–	–	–	●	–	–	–	●
Battery Storage (1 GW / 24 GW)	–	●	●	●	●	–	–	●	●	●	●
Smart grid	–	●	–	●	–	–	–	–	–	–	●
Biogas (... / 20 GW)	●	–	●	–	–	–	●	–	–	–	–
Sustainable Fules (inc. Biofuels)	–	–	–	–	●	●	●	–	–	–	●
EV charging points (... / 7.3 million)	–	●	●	●	–	●	●	–	●	–	–

Note: Sum for all Utilities Companies are figures from 2020/2021
Source: Annual reports, Sustainability reports

- According to the IEA, the fastest clean energy investment growth comes from the power sector – mainly in renewables and grids – and from energy efficiency.
  - NextEra Energy has committed to eliminating carbon emissions from its operations by 2045, leveraging low-cost renewables to drive energy affordability for customers. Reaching the goal will require significant investment by the company in transforming its generation fleet by eliminating all scope 1 and 2 emissions across its operations.
  - Enel Green Power has completed its first large-scale hybrid wind project, Azure Sky Wind + Storage, and the addition of battery storage facilities in Texas.
  - Iberdrola has built Europe's largest solar power plant to date, the 590 MW Francisco Pizarro PV plant in Spain.
  - NextEra Energy, ENEL, Iberdrola, and Danish ORSTED are considered today's renewables supermajors. ENGIE and others (Total, BP, Shell) intend to play in the same league.
  - ENGIE anticipates reaching 80 GW of renewables capacity by 2030, with projects including onshore and offshore wind and solar across Europe, North America, and Latin America. ENGIE is also planning to develop a green hydrogen capacity of 4 GW by 2030, with plans for 700 km dedicated to hydrogen networks and 1 TWh of storage capacity, along with more than 100 refueling stations.

IOCs' routes to net zero and major choices

With size and regional perspectives

FIGURE 5

Players' positioning towards energy transition

Portfolio energy sources diversification

ExxonMobil

ADNOC

Offshore Oil Engineering Co., Ltd

ConocoPhillips

Petrobras

Scope 1 & 2

- Electrification
- Energy Efficiency
- Methane leakages

Evolve their business model

Equinor

Chevron

TotalEnergies

BP

Petronas

Shell

Galp

ENI

Repsol

+ Scope 3

- Electricity
- Renewables
- Hydrogen
- Storage

Full transition

Dong Energy → Orsted

GDF SVEZ → Engie

- New portfolio

- Carbon Offsetting

Source: Players' announcements, Capgemini analysis

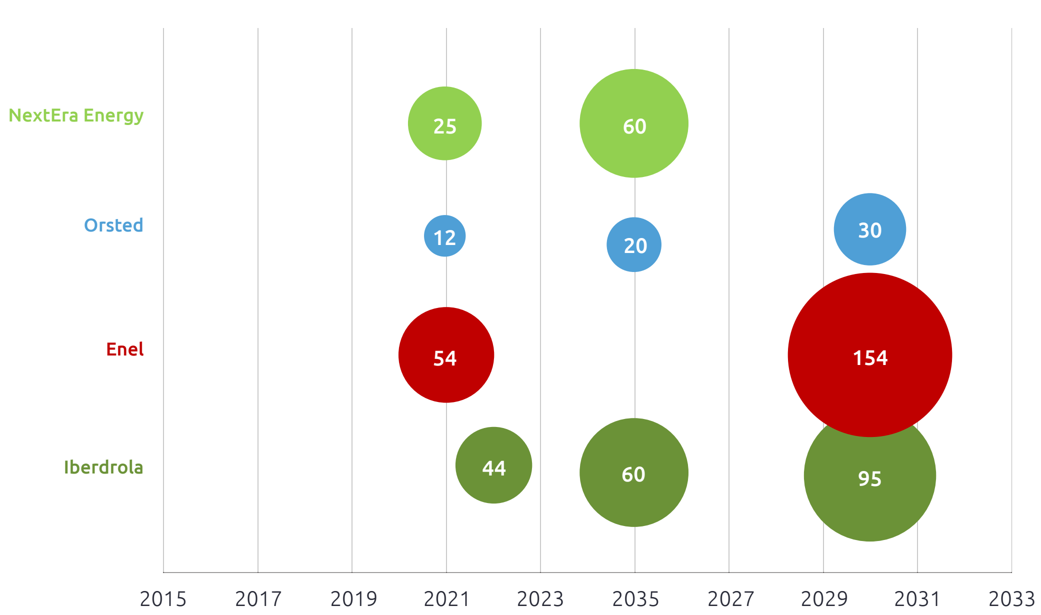
- Rising energy prices have seen the world's five biggest oil companies (BP, Chevron, TotalEnergies, Shell and ExxonMobil) share bumper profits of $98 billion in H1 2022.
- There is strong stakeholder pressure to invest these profits in carbon neutrality. However, there will also be further investment in oil fields and platforms.
- Most O&G operators have announced a net zero target by 2050.
- O&G players have different levels of positioning vis-a-vis the energy transition.

How can you join the renewables supermajor league?

- The renewables supermajors have all strongly highlighted their strategy to move away from fossil fuel-based generation and have made clear bets on renewables.
- They have publicly outlined their renewable capacity goals for the next decade and announced their strategic choices (like offshore wind, solar, etc.) as well as some of their upcoming projects
- Being first movers, they have leveraged public support (subsidies, etc.)

FIGURE 6

Renewables supermajors track record and commitments



Source: Players' announcements, Capgemini analysis

FIGURE 7

Players Commitments comparison

Company	Net-zero Targets	Comments
NextEra Energy	2045	Aiming for 70% reduction in CO_2 by 2025 & 82% reduction by 2030
Orsted	2040	Carbon neutral operations and energy generation by 2025. Aim to reduce emissions from energy trading and in the supply chain by 50% by 2032
Enel	2040	Aim to reduce direct GHG emissions to 140gCO2eq/kWh in 2024 & achieve the target of an 80% reduction in direct GHG emissions by 2030
Iberdrola	2050	Aim to be carbon neutral company by 2030 in Europe and reduce its global CO2 emissions to 50g/kWh by 2030

Source: Players' announcements, Capgemini analysis

Hydrogen and storage comparison

Investments in hydrogen

With the increasing impetus toward energy transition, leading IOCs are turning towards low-carbon hydrogen in order to transform into integrated energy providers. As of March 2022, over 2.9 million tonnes per annum of low carbon hydrogen projects have been announced. Another interesting finding is that 87% of the pipeline consists of green hydrogen projects and a majority of the remaining 13% comprise blue hydrogen projects.

IOCs are also investing in electrolyzers, fuel cell technologies, refueling networks, and hydrogen storage to help create alternative revenue streams in the energy sector, as well as aid them in the decarbonization efforts of their operations.

BP is leading the $36 billion Renewable Energy Hub project in western Australia's Pilbara region to install 26 GW of solar and wind farms. At full capacity, it will produce around 1.6 million tonnes of hydrogen or 9 million tonnes of green ammonia per year.

A joint venture between **TotalEnergies SE and Adani Enterprises Ltd.** will invest $50 billion over the next 10 years in green hydrogen. $5 billion will be invested initially to develop 4 GW of wind and solar capacity, with plans to produce 30 GW of clean power by 2030, enough to power one million tons of annual green hydrogen production.

Energy storage market

IEA predicts nearly 600 GW of battery storage capacity installed globally by 2030, boosted by new policies and projects in key markets to align with the Net Zero Emissions by 2050 scenario.

According to Wood Mackenzie, the global energy storage market will deliver over 460 GW/1292 GWh of new deployments over the next 10 years. China and the U.S. will represent 75% of total demand.

Precedence Research predicts that the global energy storage systems market will surpass around $435.32 billion by 2030, growing at a compound annual growth rate (CAGR) of 8.4% from 2022 to 2030. They also predict the energy storage as a service market size to cross $128.84 billion by 2030.

TotalEnergies launched a 25 MWh storage capacity battery energy storage site at its Carling platform. This is after the start-up of a 61 MWh storage capacity in Dunkirk, the largest storage site in France. The next installation of 43 MWh is scheduled to be commissioned at Granpuits, northern-central France, by the end of 2022.

Equinor is set to acquire a 100% stake in U.S.-based battery storage developer East Point Energy, which has a 4.1 GW pipeline of "early to mid-stage battery storage projects focused on the U.S. east coast."

EDF U.K. has secured £2 million in funding from the Department for Business, Energy & Industrial Strategy (BEIS). This is to support four innovative methods of storing electricity for long periods of time, with R&D U.K. Centre playing a major role in three of the projects.

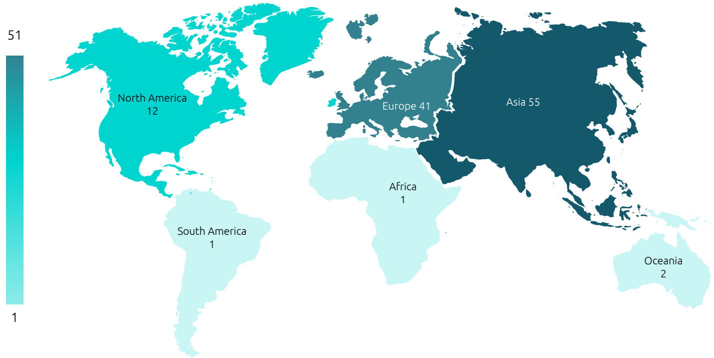
Enel Green Power has more than 52 GW of Battery Energy Storage System (BESS) projects in development worldwide, with more than 2.7 GW already under construction or in operation.

Gigafactories comparison

Currently, there are **112 gigafactories** (both operational and ongoing projects) around the world, with around 35% (40 gigafactories) coming from **China. Germany** and the **U.S.** come next with 11 gigafactories each. Total capacity is expected to cross 2 TWh by 2025 and reach 3 TWh by 2030.

FIGURE 8

Gigafactories comparison



Source: Players' announcements, Capgemini analysis

In July 2022, Panasonic Energy, a Japanese conglomerate, announced an investment of $4 billion to set up an electric vehicle (EV) battery plant. The plant is expected to generate 4000 jobs.Panasonic has also collaborated with the city of Kansas to manufacture lithium-ion batteries; it is planning to build a factory, which is expected to be larger than its gigafactory with Tesla in Sparks, Nevada.

Ola will begin the mass production of lithium-ion cells at its upcoming gigafactory by 2023.The company has also invested in the Israeli battery technology company StoreDot, a forerunner in extreme fast charging (XFC) batteries.

Volkswagen has plans to open 6 new gigafactories by 2030. The company is planning to develop new cell technology that will be 95% recyclable.By 2023, a new Unified Premium Battery (UPP) cell will be developed, which will be used across all Volkswagen Group's brands including Bentley, Audi, Bugatti, Lamborghini, Seat, Skoda, and Porsche.

FIGURE 9

Expected Developments for Future Major Players in the sector

Company	Country	Planned capacity at the end of the decade (GW)	Summary
CATIL		53 258 311	Growth thanks to its current plant expansions and projects (including the one underway in Germany, which is expected to reach 100 GWh
Tesla		260 260*	Only the Giga Berlin Project (with a maximum capacity of 250 GWh) and the development of its Fermont plant make it a future major player
Svolt		4 176 180	Its growth is mainly based on the development of 5 new projects in China
LG Chem		81 98 179	It expects to increase its capacity thanks mainly to its joint venture with GM in the United States and scaling up of its first plant already operating in China
Northvolt		150 150	In addition to its macro projects in Sweden and Germany (together 64 GWh by 2024), it is working on new projects to reach 150 GWh by 2030
Farasis		10 136 146	It expects to start its ambitious project in Jiangxi this year (with a maximum capacity of up to 120 GWh in next few years) and to launch another in Germany in 2022
BYD		62 78 140	Growth through the development of two new plants in China and the expansion of existing plants in Qinghai and Chongqing (both in China)
SK Innovation		42 93 135	Its projects in the Hungarian regions of Ivancska and Komarom as well as in Georgia (USA) are expected to greatly increase its current capacity
Panasonic		58 49 107*	It plans a major capacity expansion at its Asian Plants
Samsung		30 58 88	It plans to expand its existing plants in Hungary and South Korea and has several projects that are still pending to determine their final capacity
A123 Systems		80 80	Wanxiang announced in 2018 its intention to invest in a plant with a capacity of 80 GWh in China's Hangzhou region
ITAVOLT		70 70	It expects to complete the first phase of the project in 2024, with an initial capacity of 24 GWh, which it expects to increase to 70 GWh in subsequent expansions
Saft		4 48 52	It is working on the launch of two new plants in France and Germany with an expected capacity of 24 GWh each
Verkor		50 50	Opening of its first Gigafactory in 2023, with an initial capacity of 16 GWh, to be increased to 50 GWh in the coming years
TATA		50 50	It expects to open a 10 GWh plant in the Indian region of Gujarat in 2021 that it wants to scale up to 50 GWh
Britishvolt		35 35	It is working on a 35 GWh plant in Northumberland (UK) by 2023
Freyr		32 32	It expects to have its 32 GWh plant in northern Norway operational by 2023

*Legend: Tesla's Gigafactory 1 capacity in Nevada is considered within Panasonic

Current capacity   Planned additional capacity

Players from different sectors are investing in gigafactories, like chemical, automotive, energy storage, high-tech, O&G, etc. The leading players have a partnership with automotive players; South Korea's LG Chem has collaborated with GM and Volkswagen, China's BYD is a regular partner of Toyota, and Japan's Panasonic is a partner for Tesla.

Source: Own production from public information based on capacity announcements made to date

Grid investments and related roadmaps

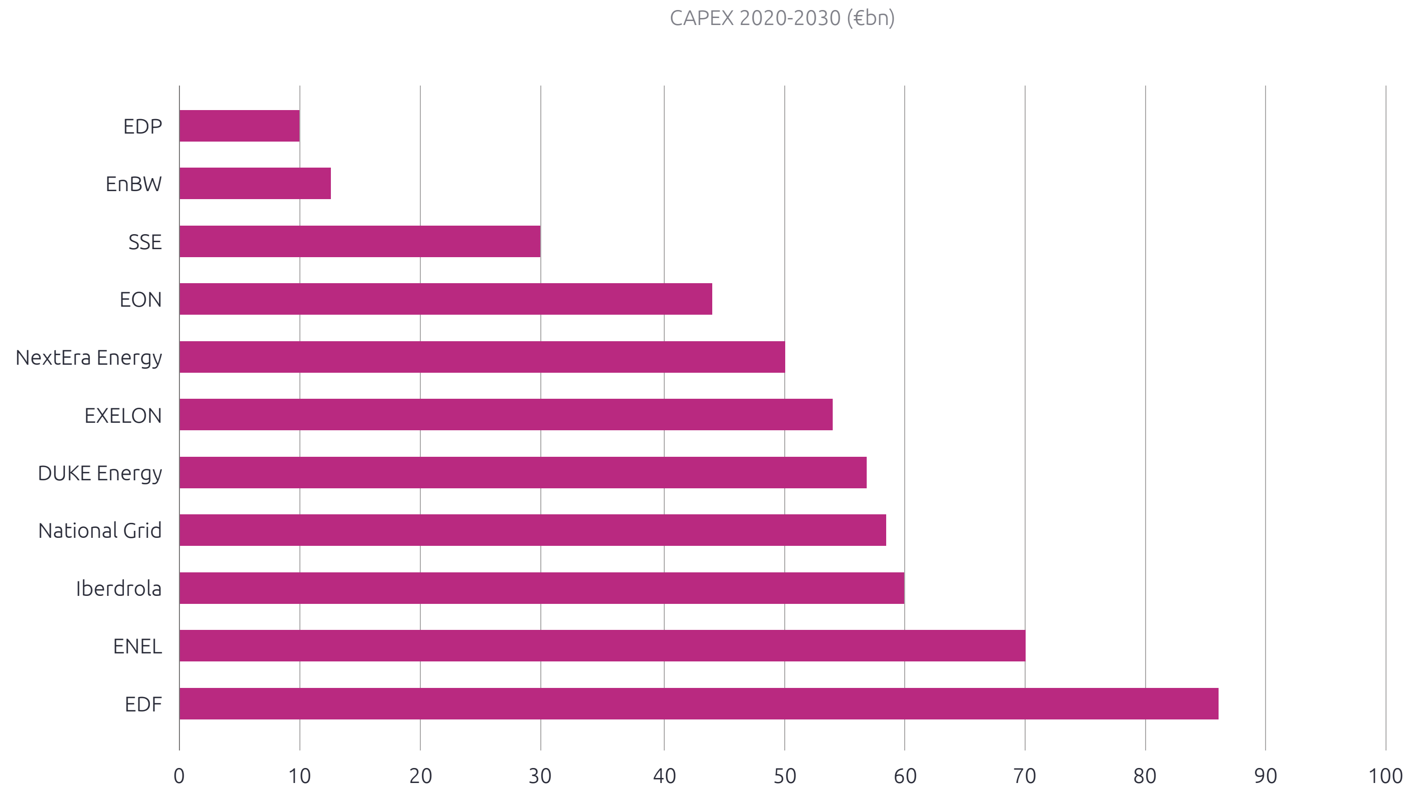
Investments in grid modernization

Players' communication could cover one year, three years, up to 15 years of program and related investments. We have made rough and cautious assumptions for the decade (2020-2030) to be able to compare the commitments. Direct comparisons are not so easy because requirements vary depending on the network's topology (number of delivery points, networks length, HV/MV/LV, substations numbers, energy transiting, network age, share of DER in the mix, weather conditions in the region, such as storms, floods, wildfires threats, etc.).

Data on the smart grid CAPEX – out of grid modernization figures aren't available. But if we rely on the IEA statements, Investvent on Smart Grid could, by 2025 and onwards, reach 15% for a transmission company (already smart and getting smarter) to 30%+ for distribution operators.

FIGURE 10

Investments in grid modernization



Source: Players' announcements, Capgemini analysis

Players have communicated this year or last year on their grid modernization investments

Key findings:

- About 30% of the Transmission & Distribution (T&D) players have increased their forecasted investments in 2021, and two or three have doubled the last decade's investments.
- Europeans lead the way, and are more engaged today in energy transition, massive distributed renewable growth, and electrification coverage (EV charging infrastructures, electric heating). They are more ambitious than their North American peers.
- We must also consider the regulation authority's investment approval. Sometimes complex regulators want to prevent massive tariff increases when energy prices are skyrocketing.
- EDF is leading the pack, with bold ambitions and 95%+ of French territory coverage, both for transmission and distribution. ENEDIS, the distribution sub of EDF, has been ranked #1 for the first time in the Greener and Smarter Singapore Index amongst more than 100 respondents.
- Some players, like NEXTERA Energy, have reported a specific budget to increase resiliency, improve quality indicators, and harden the network against weather events.
- Having a look at smart grid investments (source: Capgemini survey, no external data on the market):
  - About 50% allocated to smart metering (waves one or two), 30% for control room, 15% for asset management, and 5% for network instrumentation (this share should grow over time).
  - Specific split between hardware, software, and services. Dominant hardware share (and logistics/installation) is for smart metering. For other domains (network instrumentation, grid operation, and asset management) about 10% of the total CAPEX is for hardware, and 40%-50% for software and services.

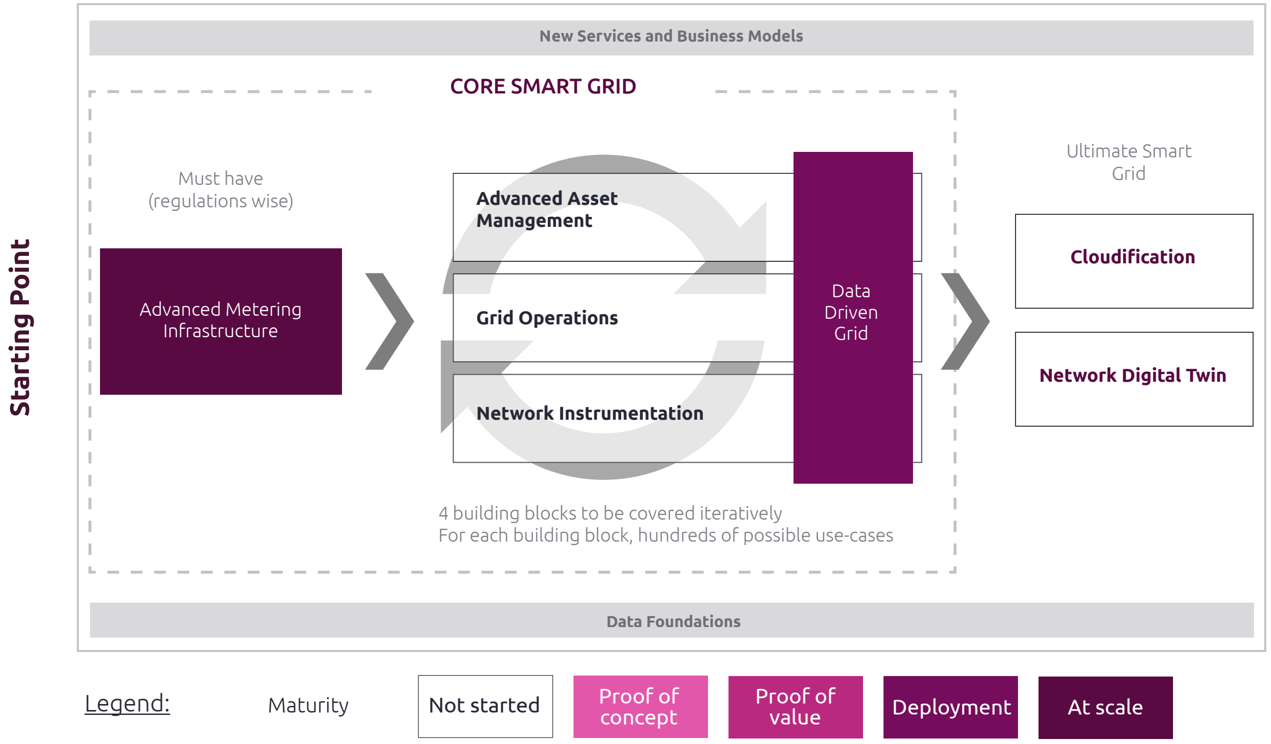
Investments in grid modernization, typical roadmaps

Not one size fits all!

The grid transformation roadmap must be built around each distribution system operator's (DSO's) business challenges, expected benefits, and digital maturity. Intermediate milestones of the transformation roadmap should enable the DSO to achieve regulatory approval, improve business processes, and track benefits via a return on investment (ROI) driven approach. Technology and digital solutions are enablers of grid transformation. Here we present an example of a transformation roadmap, which is designed to meet business objectives, synchronize new business processes, and develop workforce skills.

FIGURE 11

Digital grid journey example – Starting point

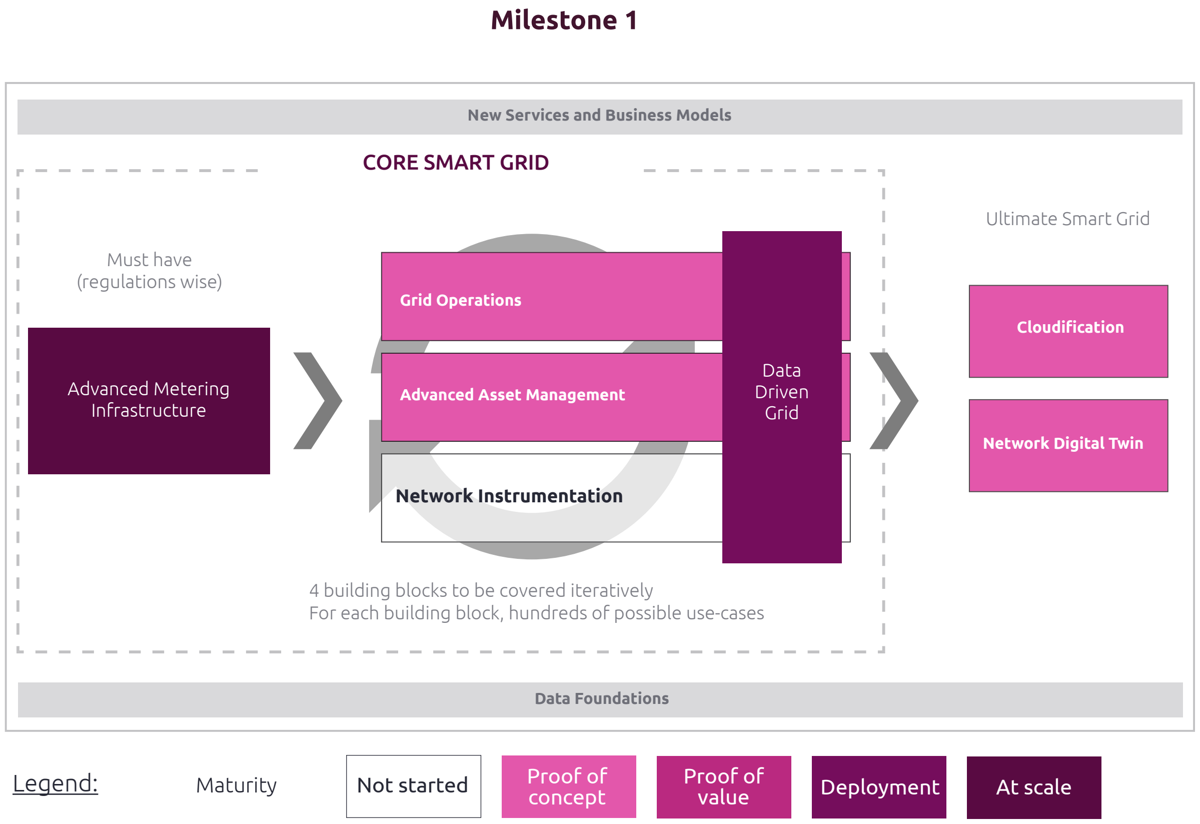


Milestone 1

- Improve the Advanced Distribution Management System (ADMS)
- Implement a Distributed Energy Resources Management System (DERMS)
- Deploy first data use case at scale (customer oriented, asset performance management)
- Launch a digital twin PoC
- Test cloudification

FIGURE 12

Digital grid journey example – Milestone 1

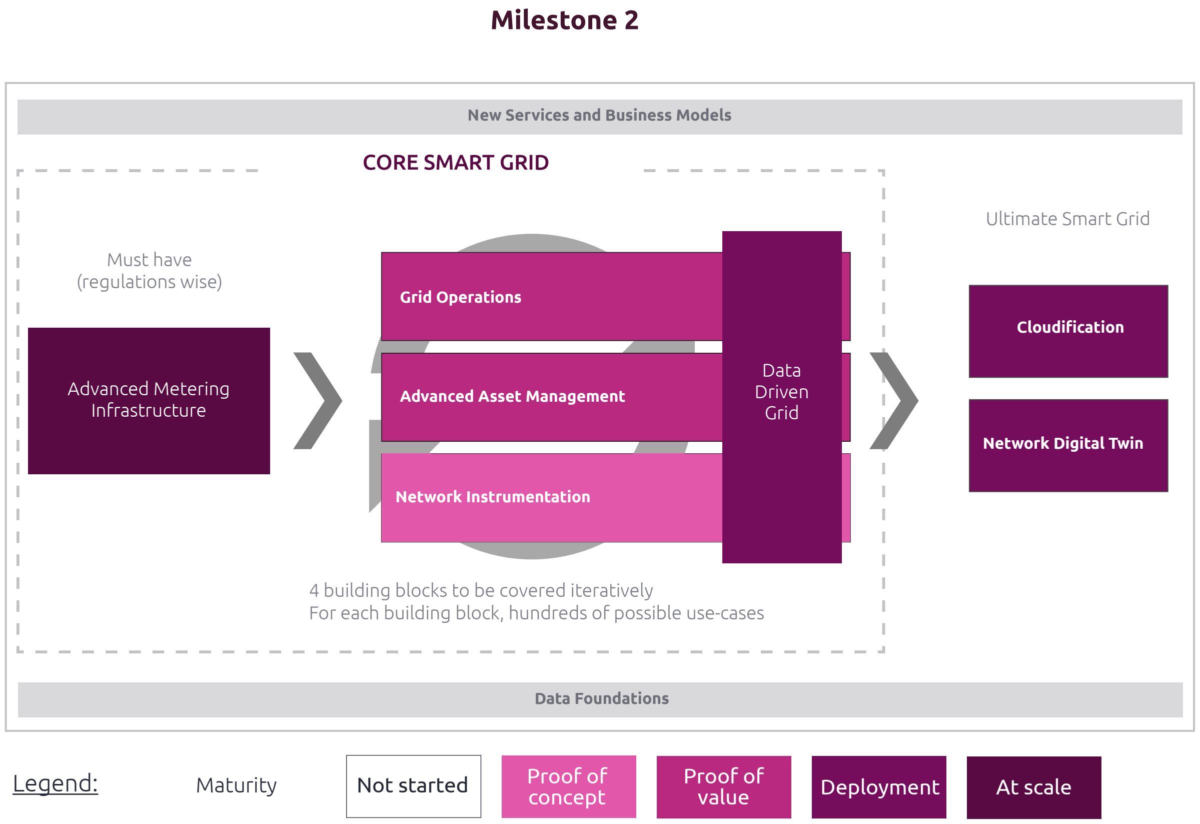


Milestone 2

- Launch network instrumentation proof of value
- Implement ADMS & DERMS at scale
- Implement first digital twin functions
- Test and deploy more data use cases at scale
- Start cloud implementation

FIGURE 13

Digital grid journey example – Milestone 2



Milestone 3

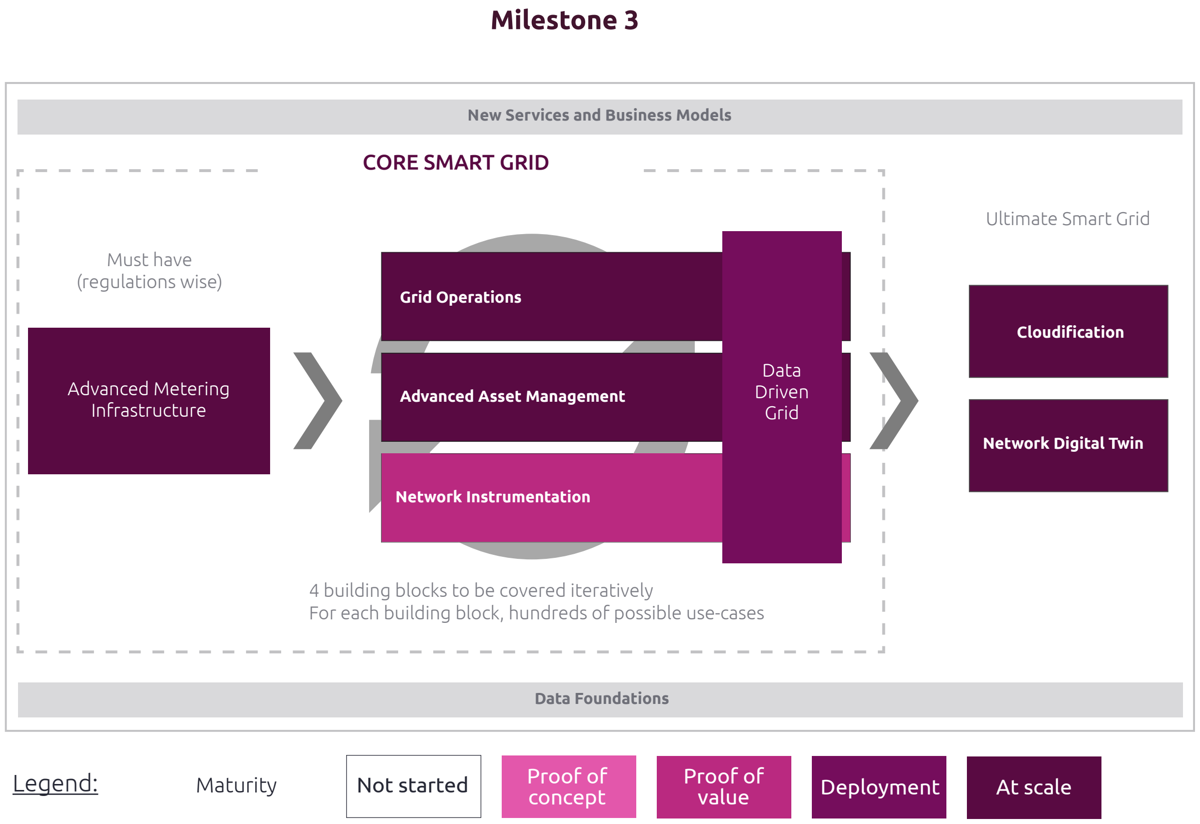
- Deploy network instrumentation at scale
- Implement wave 2 digital twin functions
- Test and deploy more data use cases at scale
- Deploy cloud at scale

An end-to-end approach to accelerate and de-risk the digital transformation journey of grid operators

Grid operators must adopt a holistic approach for their end-to-end transformation, to coherently develop people's skills, new business processes, and new technology capabilities while orchestrating a new industrial ecosystem.

FIGURE 14

Digital grid journey example – Milestone 3



EV adoption and its impact on original equipment manufacturer (OEM) profitability and charging infrastructure

EV adoption and charging infrastructure

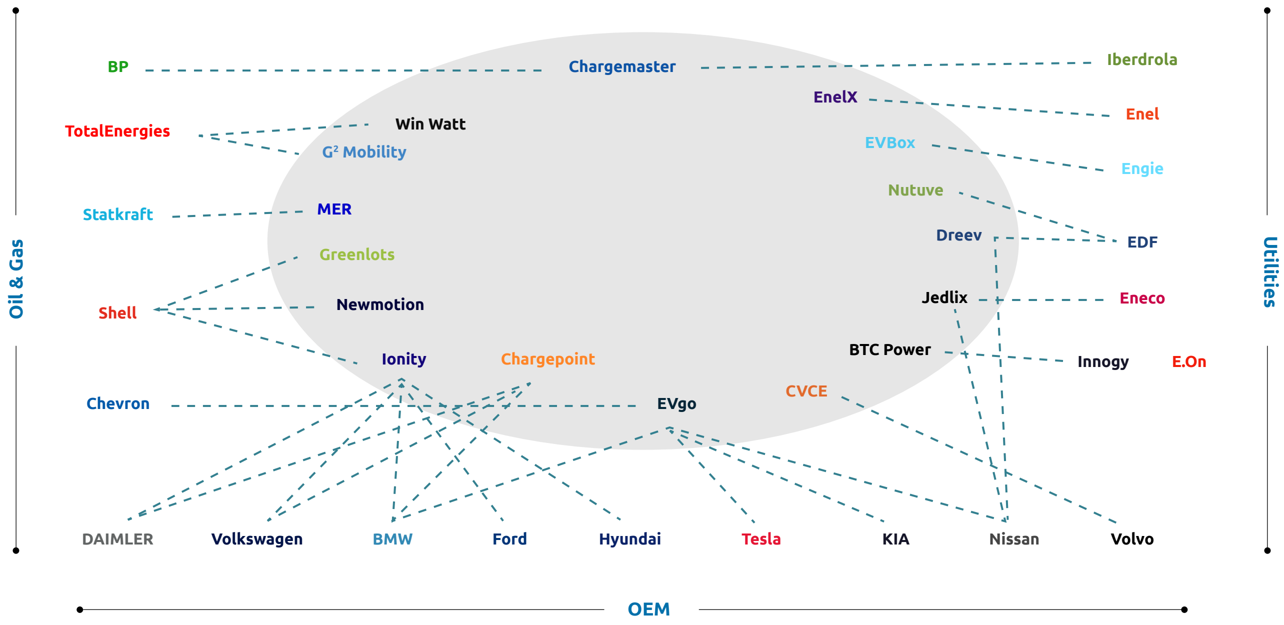
EV adoption is dependant on charging infrastructure, availability, electric mobility, connectivity, technology, and services offered by large EV OEM players (e.g., Tesla, NIO, BYD, Li Auto, Lucid Motors, Polestar, etc.), traditional OEMs (e.g., BMW, GM, Ford, Toyota, Volvo, VW, etc.), new start-ups and mobility as a service providers. While technologies, policies (e.g., Europe deciding to end internal combustion engines sales by 2035), and customer preferences are likely to shift based on the faster adoption. This will lead to a surge in demand, creating the need to upgrade the enhancements in the grid and the diversification of power sources which can support grid reliability.

According to Bloomberg, there were more than 20 million passenger electric vehicles, 280 million electric scooters, mopeds, and motorcycles, and 1.3 million commercial EVs, including buses and trucks in 2021. A report from the IEA highlights that there were 1.8 million public charging points in 2021 – one-third were fast-charging stations.

The uptake (faster today than expected one or two years ago give current oil prices) of EVs is expected to increase the demand for more charging stations and create new opportunities for retail businesses and utilities, as well as charging station operators from energy companies.

FIGURE 15

New business models emerging through mergers and acquisitions (M&A) and partnerships



Source: BNEF, SP Global, Volkswagen

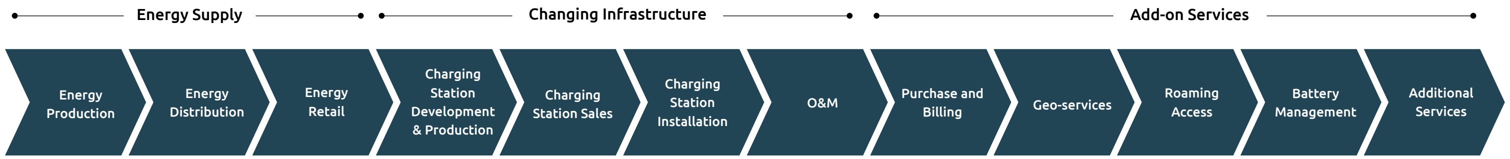
Evolving EV ecosystem: M&A activities and partnerships

OEM, utilities, and IOCs continue to reshape their investment strategies, transform their business models, and scale activities in the EV charging space. With energy companies trying to increase their foothold in the EV value chain and geographical coverage, the M&A activity in the charging infrastructure sector is expected to rise continuously based on the rapid growth in Europe and the U.S.

EV ecosystem and its impact on the charging value chain and new business models

FIGURE 16

EV charging value chain



The global supply chain issues and semiconductor shortage triggered by the Covid-19 pandemic and the Russia-Ukraine war have already seen car manufacturers adopting new business models to continue production amid a reduced supply of chips and parts needed to support the car manufacturing and charging infrastructure development.

EV profitability and scale-up challenges

Although the future looks very bright for EVs for most OEMs (traditional and EV specialists), market scale-up is essential as only a very few charging operators are profitable today. The current business model is not sustainable in the long run. It is directly influenced by the large stimulus for OEM EV investments, governmental subsidies, and tax exemptions, which are helping bridge the gap between OEM pricing, consumer expectations, and affordability as well as willingness to pay. OEMs are trying to find the right balance between vertical integration as a strategy to reduce and control costs and mitigate supply chain risks.

One of the important factors which is changing the dynamics of EV charging is the role played by utilities. In most E.U. countries, utilities have a significant share in charging infrastructure and large public networks as compared to the U.S., where charging stations are owned by private players. Utilities in the U.S. need to go through a long and cumbersome approval process for investing in EV infrastructure.

New business models and changing EV landscape

Charging operators, utilities, regulators, and policy makers are expected shift to an overarching business model - vehicle to everything (V2X), grid (V2G), Home (V2H), Building (V2B). This business model will be more attractive as it will drive renewable generation, storage, capacity, flexibility and, at the end, reduce emissions and accelerate investments from new partners in the eco-system.

It seems that before 2030, we will move from V2X technology demonstrations to real markets progressively at scale. This is expected to unlock a lot of potential value across the entire utility value chain.

Oil & Gas companies are eyeing the public charging infrastructure (replacing the gas station business with the expected end of fossil-fuels), but face headwinds from the private charging set-ups. Most charging operators are facing actual profitability concerns.

The future of the EV charging ecosystem is dependent on six primary triggers: **market size due to** unstoppable EV market growth (in many countries, we are beyond the tipping point, with more than 50% of cars sold today being electric (pure EV or plug-in hybrid electric vehicles – PHEV); **technology maturity; type of EV charging** (fast-slow, home, business or public); **regulatory environments; new business model attractiveness; and energy prices.**

Carbon

Internal Carbon Pricing is an instrument which helps companies put a value against per ton of carbon they emit. This tries to incentivize companies to reduce their GHG emissions and plays a key role for companies while deciding their future investments toward a more low carbon future. These prices are heavily influenced by policies and external events. Europe's carbon prices fell to €60 in March from a peak of €97 in February, but rebounded to peak levels in August. High carbon prices will give impetus to investments towards carbon capture, usage and storage (CCUS) and hydrogen technology.

- **EDF** partnered with and produced an International Emissions Trading Association (IETA) report, "Doubling Down on Carbon Pricing: Laying the Foundation for Greater Ambition." The report presents four scenarios for meeting both of the panel's targets, to increase carbon pricing coverage from the current level of 12% of global emissions to 25% in 2020. It also focuses on doubling to 50% coverage in the next decade.

FIGURE 17

Internal carbon prices examples

Company	EDF	National Grid PLC	Alliander	Gasunie	Tennet	Stedin	EWE AG
Carbon Accounting Tool	NA	Developed in-house	NA	NA	NA	NA	GHG Protocol SBTi
Internal Carbon Price	2020 : 47€/t CO_2 2040 : 150€/t CO_2	Operations are regulated by EU ETS, RGGI - ETS carbon pricing systems	50,- per tonne (will be increased in upcoming years	100,- per tonne	50,-per tonne	Total costs negative impact 125-175 mln EUR	NA

Source: Players' announcements, Capgemini analysis

- **National Grid Plc,** as a part of its commitment toward climate strategy, is putting a price on carbon to help inform its major investment decisions to ultimately achieve net zero goals. It has integrated carbon pricing into existing tools and processes – providing a comfort level with the current capabilities and helping to ease adoption. It also promotes internal collaboration – encouraging different functions to work closely together to ensure that complementary knowledge and skills are included in determining the right carbon data and pricing models to use.
- **Alliander** has made a good start on aligning its sustainable organization policy with its internal carbon policy and aims to improve in the upcoming years.

- The energy and utility companies are using various carbon accounting tools/software for dynamic reporting based on its emissions data, helping to track progress towards internal or industry wide emissions goals. No standard yet, but all are relying on undisputable carbon accounting methods.
- Fossil fuel companies around the globe emit the most greenhouse gases according to The Climate Accountability Institute.

FIGURE 18

Carbon accounting

Emissions (MT)	Total	BP	ExxonMobil	Shell
Scope 1	38	33.2	108	60
Scope 2	3	2.4	7	8
Scope 3	350	304	540	1299

Source: Players' announcements, Capgemini analysis (Figures from 2020 & 2021)

The major challenges associated with carbon accounting are:

- It is very difficult to measure scope 3 emissions. Hence, companies use industry-average data instead of specific emissions data from their actual suppliers and customers.
- Even though the scope is specified, getting data (and real-time data, specifically) around the emissions is challenging.
- Need for companies to use undisputable and auditable carbon accounting methods (Science Based Targets initiative (STBi) or others)
- Lack of a real leading tool in the market for carbon accounting, which is why companies are developing their own

E&U companies: Examples of carbon accounting tools

- **ENGIE** conducts its environmental reporting using a dedicated tool that allows data to be reported following a defined methodology
- **EARTH** is deployed in each regional hub and thus covers the entire ENGIE organization
- **RWE AG -** The SBTi officially confirmed to RWE that their climate protection targets are in compliance with the Paris Climate Agreement and the target used to limit the earth's warming to significantly less than 2°C
- **MVV AG** is adding CO2 capture facilities and storing or using CO2 on a long-term basis. Energy from waste plants can also achieve physical climate neutrality.
  - **The company's climate protection targets have been certified by the SBTi**

Carbon: Energy efficiency and energy sobriety – two important but difficult levers

Growing low-carbon technologies, moving away from fossil fuels, and reducing emissions are tough but achievable objectives with the appropriate policies, willingness, and resources. Being more energy efficient and sober has always been difficult.

Energy efficiency:

The use of less energy to perform the same task or produce the same result. Energy efficient homes and buildings use less energy to heat, cool, and run appliances and electronics. Energy efficient manufacturing facilities use less energy to produce goods.

Doing the same with less energy.

Energy efficiency objectives have always been difficult to meet. For example, in Europe in the 2008 3 x 20 package for 2020. Most of Europe's governments have asked energy players to meet energy efficiency objectives, fining those unable to help their clients. It comes through about 200 certified measures, like building renovation or boilers/heaters replacements. Targets were about 1.5% of energy efficiency per annum. And every year.

Utilities or IOCs supporting energy efficiency have invented and launched some related offers. On the next page you will find an overview of some recent value propositions.

Energy sobriety:

A variety of measures and daily uses that avoid **energy demand, preserve materials, soils and water, ensuring the well-being of everyone, and respecting planetary limits.**

Avoiding energy and resource consumption.

With the Ukraine/Russia war, resource (commodities) scarcity is expected for gas, oil, diesel, and perhaps coal in Europe, notably, for the next winters. That's why governments and utilities' CEOs have made a call for sobriety and are preparing several measures to strengthen that axis.

With prices increasing endlessly, the question of energy affordability/energy poverty also becomes prominent.

Changing behaviors and seeing the expected result (energy savings) is the combination of four main factors:

- Awareness: Ask for behavioral changes (e.g., limiting travel). Customer engagement programs (gamification, rewards, incitation, showing the way, educating olders). Getting actions from the young generation for the planet.
- Regulation (urgency law, rationing): For example, Hamburg residents were told to take shorter showers, avoid full baths, use water-saving shower heads, and install modern thermostats.
- Financial incentive to limit consumption (tariffs, limit time of use)
- Automating cuts or reductions (heating, lighting for retail shops or public lighting)

The combination of all factors is essential. Taking all four factors into consideration can end in significant savings overall. For example, saving 4-5% on each aspect will eventually reach 15%-20% energy savings.

It's interesting to learn from the Fukushima accident in 2011. The day after the accident, Japan was able to reduce electricity consumption by 30%. This was achieved by:

- Rotating industries;
- 26° in each public and tertiary buildings, allowing tertiary workers to remove neckties;
- Asking and getting savings from residential consumers. (There is a very disciplined mindset in Japan. Everyone contributed);
- Activating back-up supply; and
- Preparing rolling cuts.

Carbon: energy efficiency and energy sobriety – two important but difficult levers

Energy efficiency and energy sobriety examples:

Energy efficiency – Doing the same with less energy

ENGIE has launched CertiNergy & Solutions that helps companies and local authorities embrace energy transition and green their work by:

- Reducing energy bills to boost household purchasing power
- Delivering a competitive advantage

E.ON has launched a solution to help businesses monitor, optimize, and promote business energy efficiency amongst employees. The company also provides energy saving advice for businesses across a different range of industries.

Enel X is reducing CO_2 emissions in urban areas and making public buildings more energy efficient with the help of strategic solutions. They also utilize high-efficiency cogeneration and trigeneration systems to optimize energy consumption in smart cities.

EWE: Launched LiMBO, a web-based energy management tool for local authorities which generates electricity, gas, heat, and water consumption data. Cost and CO2 emission trends are also captured and displayed in the system, which helps to improve the energy efficiency of the property.

Energy sobriety – Avoiding consumption

Neighborhood energy saver program: Duke Energy is offering customers free walkthrough energy assessments to help them track home energy usage and lower monthly electric bills. They also provide qualified customers with up to 16 energy-saving products installed at no cost, such as:

- Energy-efficient light bulbs
- Water-saving shower heads and faucet aerators
- Air conditioning/heating system filters
- Water heater wraps

NextEra is assisting customers to lower their energy bills with the energy efficient **Power to Save** program. The program provides a free, comprehensive home energy survey, as well as installation of energy efficient measures to help customers save up to $500.

Below are the essential conclusions from the benchmark.

Energy use leads to 73% of CO2 /GHG emissions, all Energy & Utilities players are concerned with climate change/energy transition and must act accordingly.

It is nothing new for large utilities (notably European ones), engaged for decades in energy transition. However, they need to accelerate their routes to net zero and consider scope 3 emissions from energy use, not only scopes 1 and 2.

Measuring and managing scope 3 emissions is really difficult, notably for IOCs, explaining why they seem to be cautious in their commitments.

IOCs have started to move more recently on Energy Transition (5 years for the first movers). Energy transition should be considered a critical diversification, moving away from fossil fuels to become a new type of company in the energy sector.

All the players have announced their intention toward carbon neutrality or net zero. However, very few have sound plans for this transformation, notably on scope 3 reduction. Most, if not all, are in the no-regret races: Growing a renewable portfolio, betting on electric mobility, and considering hydrogen as a promising energy carrier.

Key learnings from the benchmark commented here and focusing on more than 50 prominent players, are:

- The importance of making clear choices and securing leading positions through investments, innovation, and ecosystem partnerships. Understanding that no company could be a leader in all energy transition market dimensions.
- European IOCs are the most advanced in energy transition and are becoming large utilities, with deeper pockets than existing utilities, thanks to the actual barrel level.
- U.S. IOCs, continuing to operate fossil fuel, are focusing on Carbon Capture and investing heavily in the related technology
- Carbon accounting matters. You can get only what you measure. This dimension remains foggy. Players are conscious of its importance but have not made enough steps to select appropriate accounting methods and external certified tools.

Considering the key learnings of the benchmark, we recommend the following actions:

- Pay particular attention to reducing the scope 3 dimension and decarbonizing the products or services you are selling
- Make clear choices
- Be innovative and leverage the power of the ecosystem
- Benchmark yourself every year or two with your peers and energy transition players

OIL & GAS CARBON NEUTRALITY IMPERATIVE AND BEST FOOT FORWARD

MARNE SHAFER
ALEXANDER RODRIGUEZ
DEBARGHYA MUKHERJEE

Industry leadership must find a balance between reliability, affordability, security, shareholder returns, and renewables

The Oil & Gas industry is in the crosshairs of people and investors who are passionate about climate change. All industries (in particular, Oil & Gas), must consider the environmental impact of their operations. As the world increasingly shifts towards clean energy, these companies are facing critical challenges. Fossil fuels drive companies' near-term returns. However, failure to address growing calls to reduce greenhouse gas (GHG) emissions could threaten their long-term social acceptability and viability.

FIGURE 1

Industry leadership must balance across reliability, affordability, security, shareholder returns and renewables

Source: IEA

The immediate challenge is providing energy needs that are affordable, reliable, and secure, while establishing profitable business models that deliver increasingly renewable energy sources. Corporate leadership must walk the line between those three elements, while also meeting the demands of shareholders and the world's environmental needs.

The Oil & Gas industry needs to clarify what clean energy transition means to it, and what role it plays in the energy transition. While some companies have identified measures and efforts to battle climate change, the industry as a whole is well-positioned to play a much more significant role.

The time is now: The increasing frequency of extreme weather events and GHG emissions require abrupt, short-term, and long-term change

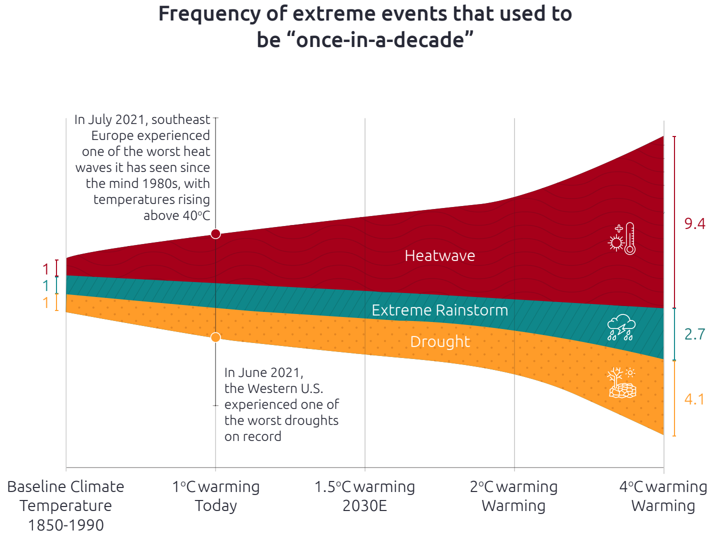
The global rising average temperature is associated with widespread changes in weather patterns. Scientific studies indicate that extreme weather events such as heatwaves and large storms are likely to become more frequent and more intense with human-induced climate change. Globally, 2016 was the warmest year on record, and 2020 was the second warmest. The warmest decade recorded since thermometer-based observations began was between 2012–2021. According to NASA, the last eight years have been the hottest years ever recorded, with 2021 coming in at sixth place.

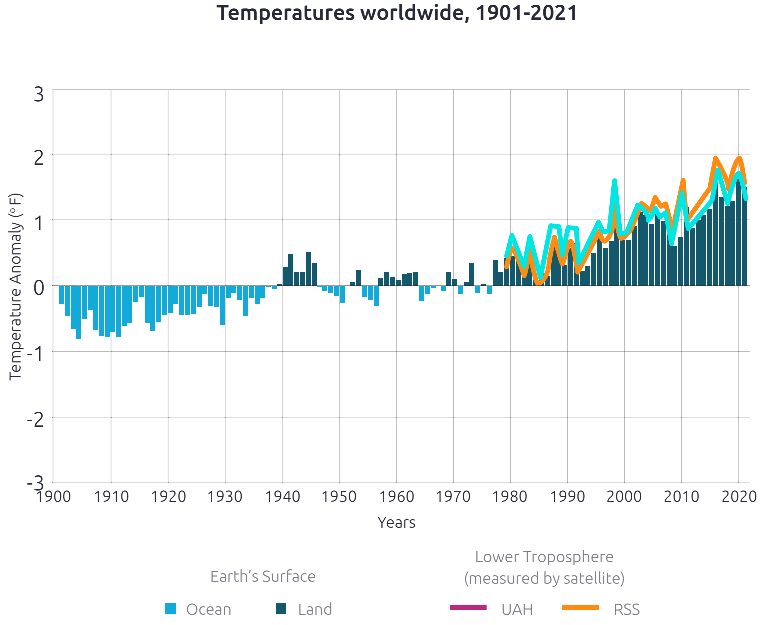
By 2030, the global surface temperature is expected to rise 1.5°C above the Earth's baseline temperature. This means that the frequency of heatwaves will increase by over 400%, droughts will double in frequency, and extreme rainstorms will be 1.5 times more frequent.

In 2021, emissions from energy rebounded strongly, back to the levels seen in 2019. This sharp rebound was primarily due to a surge in economic growth after 2020's Covid-19 restrictions. As economic activity recovered from lockdowns and other Covid-19 related measures, energy consumption increased rapidly.

FIGURE 2

Increasing frequency of extreme weather events

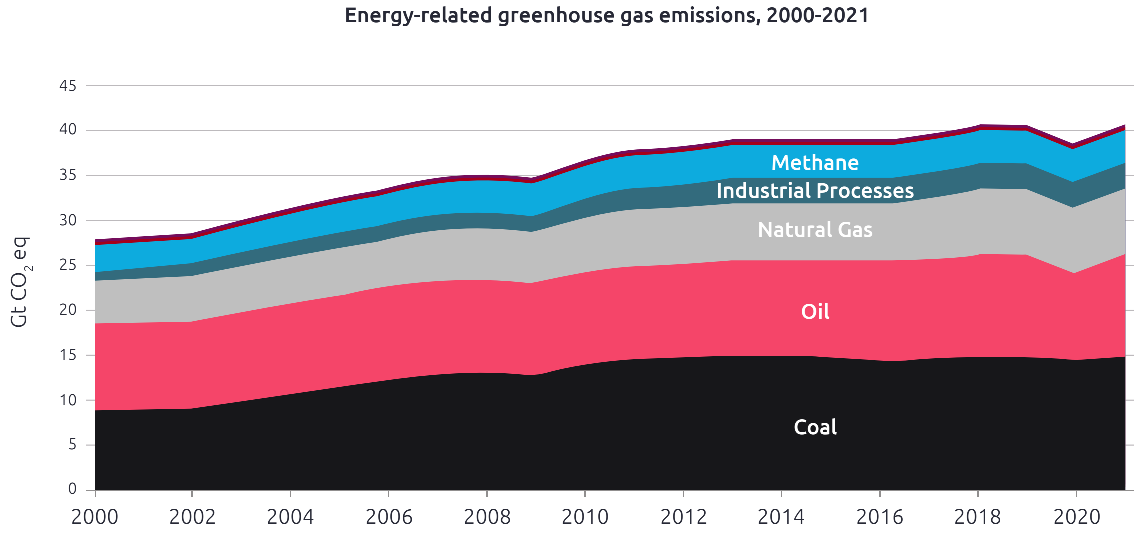


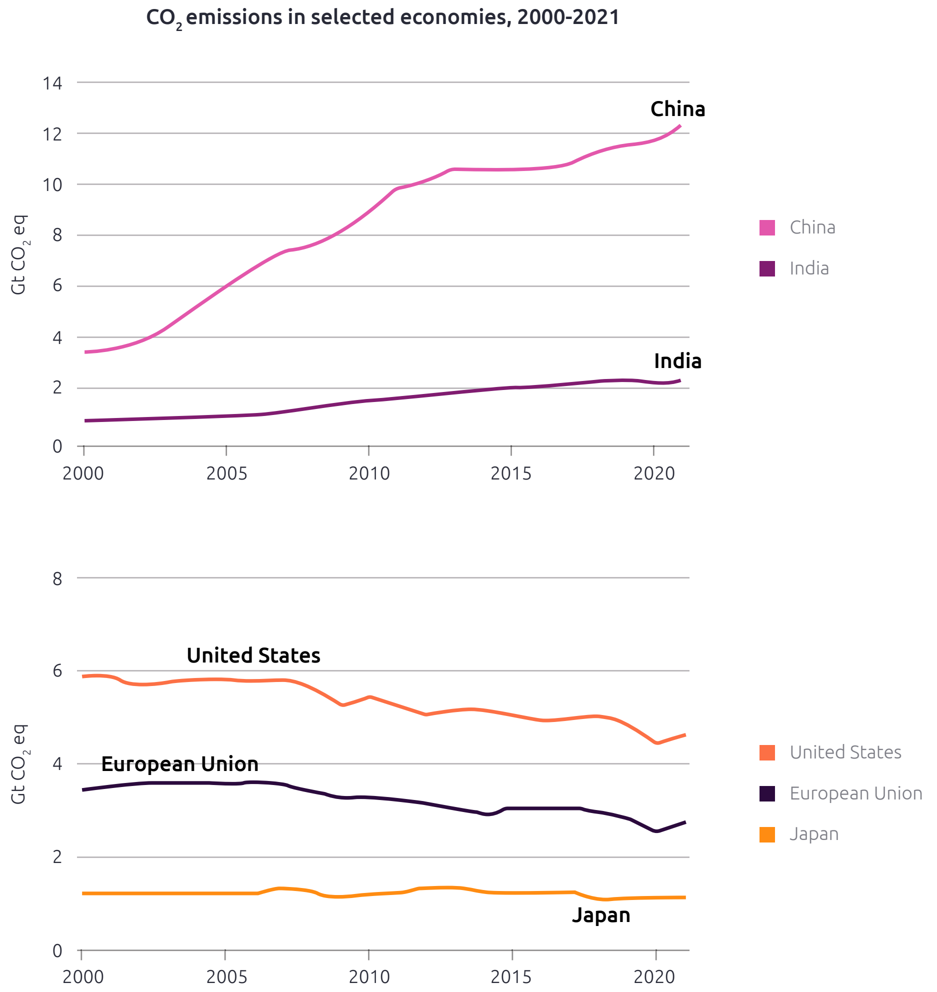


Source: EPA, IEA, IPCC

FIGURE 3

GHG and CO_2 emissions, 2000-2021





It is complex: Volatile commodity cycles with long, expensive capital investment make industry leaders slower to respond

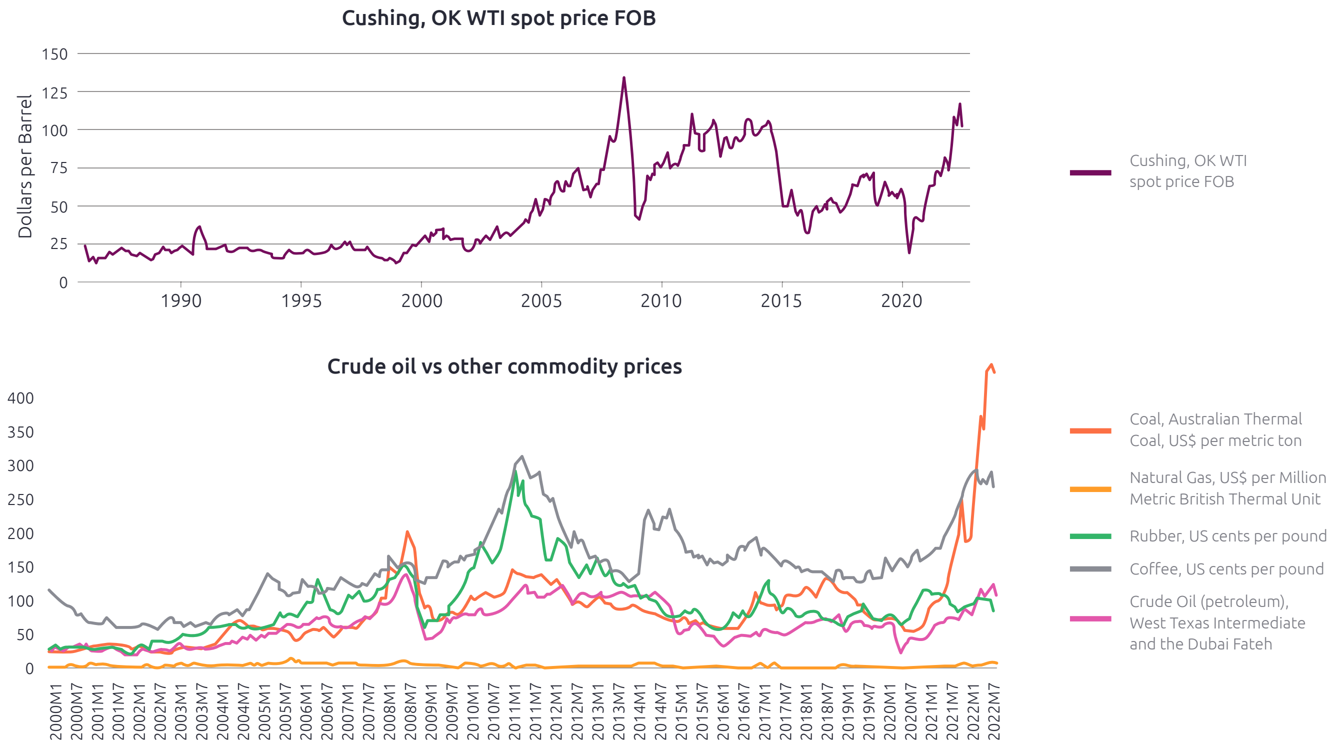
The Oil & Gas industry has always been considered highly cyclical, evident by the price tracking of Brent and WTI crude. It can take up to 30 years for companies in the industry to produce oil and gas, causing a slow response to short-term media and market indicators by the industry leadership. An example of this was the Chevron Gorgon gas project, discovered in 1980. Train 1 commissioning for that project did not occur until December 2015, and Train 3 production did not commence until March 2017. The value of LNG has grown in 2022, making Chevron and Australia well-positioned and well-timed LNG producers, with strong pricing fundamentals.

As Oil & Gas companies reposition themselves as energy companies, they must have the resources and technologies to improve the existing energy sources, while investing and researching renewables growth into viable new business models. U.S. government research groups have provided evidence for the current industry cooperation. This can be found within the technical accomplishments report, the U.S. DRIVE Alliance 2021. Alliance members include large corporations across the automotive, fuels, and the electric utilities industry, who are in partnership with the U.S. Department of Energy (DOE). Some promising highlights of technical accomplishments in 2021 include improvements in current technologies, as well as research into new technologies. One current example involves the application of machine learning to shorten the time it takes to design efficiency improvements in engine fluid dynamics by up to seven times. Accomplishments in longer-term energy transition include the NREL research facility in Golden, CO for high-flow hydrogen; it was created to understand how to utilize hydrogen for heavy duty vehicle options.

As renewables become an increasing percentage of the energy mix, governments will need to provide consistent, stable policies in cooperation with the industry – the same goes for all forms of disruptive innovation. Policy must also support innovations in making existing energy sources efficient.

FIGURE 4

Crude oil and other commodity prices



Source: EIA, IEA, IMF

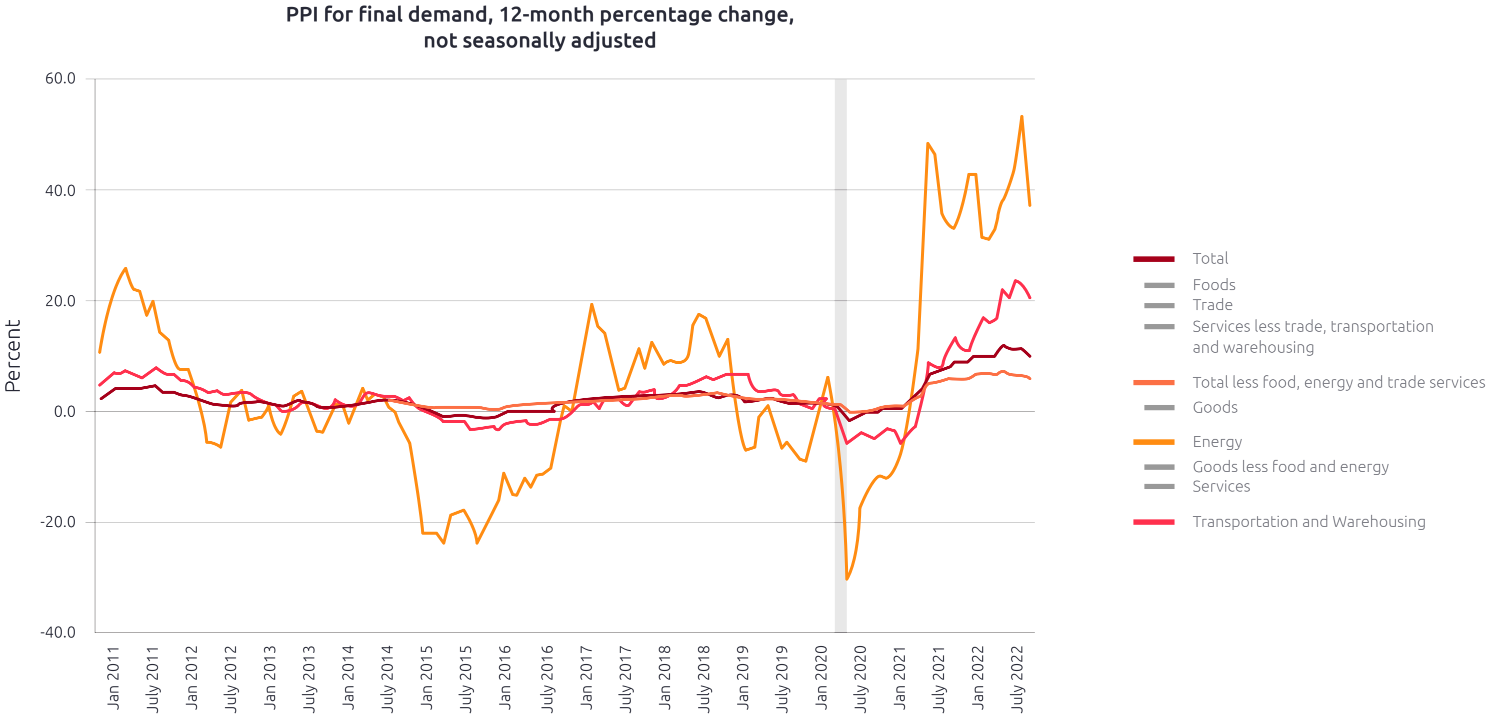
Affordability is critical: The impact of sustained high energy costs negatively impacts inflation and economic health

Oil prices impact virtually every aspect of people's lives, from the food we eat, to the products and services we consume. The price of oil significantly impacts the supply chain of products, and services that people do not typically associate with commodities. There are many unexpected examples of crossovers between the supply chain of products that are integral to our daily lives, and where oil and gas is consumed. These might include the diesel required to irrigate our crops or the asphalt roads, the polyester blend in our clothing, the energy required for metal smelting, and the diesel required for the trucks bringing products to our local grocery store. As the price of oil and gas commodities increase, the impact can be seen in two indices: PPI (Producer Price Index) and CPI (Consumer Price Index). However, research by the St. Louis Federal Reserve shows a positive correlation between energy costs and producers (at 0.71). Once the impact of energy costs are significant enough that producers can no longer bear the burden, those prices are passed along to consumers in the form of record inflation, which was felt across the globe in 2022.

The events so far in 2022 have been a strong reminder to everyone who disregarded the value of affordable energy. With record gasoline, diesel, and natural gas prices, the impact was felt across all products and services. Energy security and its impact on affordability was particularly highlighted with Russia's invasion of Ukraine, which drove up prices for energy and, subsequently, all related products.

FIGURE 5

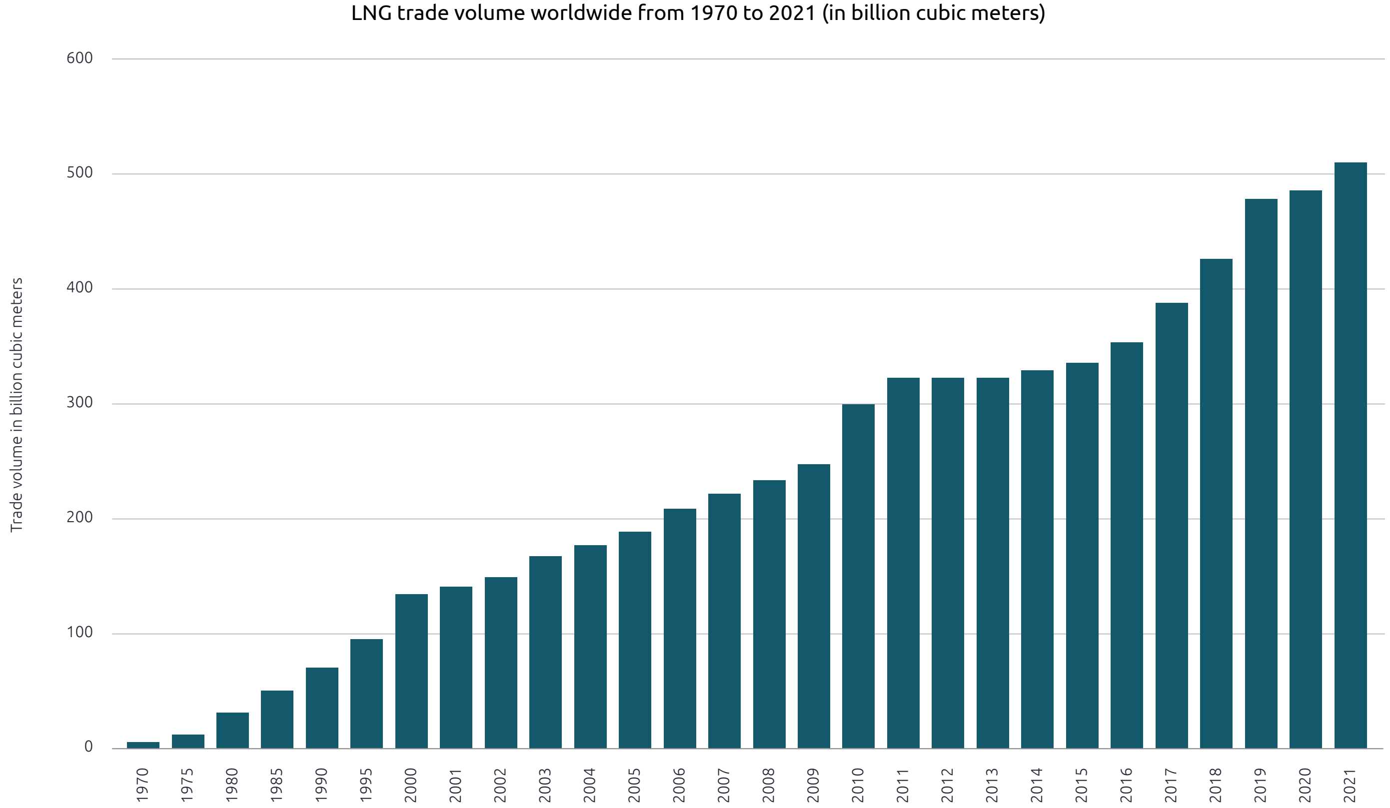
PPI for final demand



Source: EIA, IEA, IMF
U.S. Bureau of Labor Statistics
All data are subject to reivision 4 months after originally published

FIGURE 6

LNG trade volume worldwide from 1970 to 2021
(in billion cubic meters)



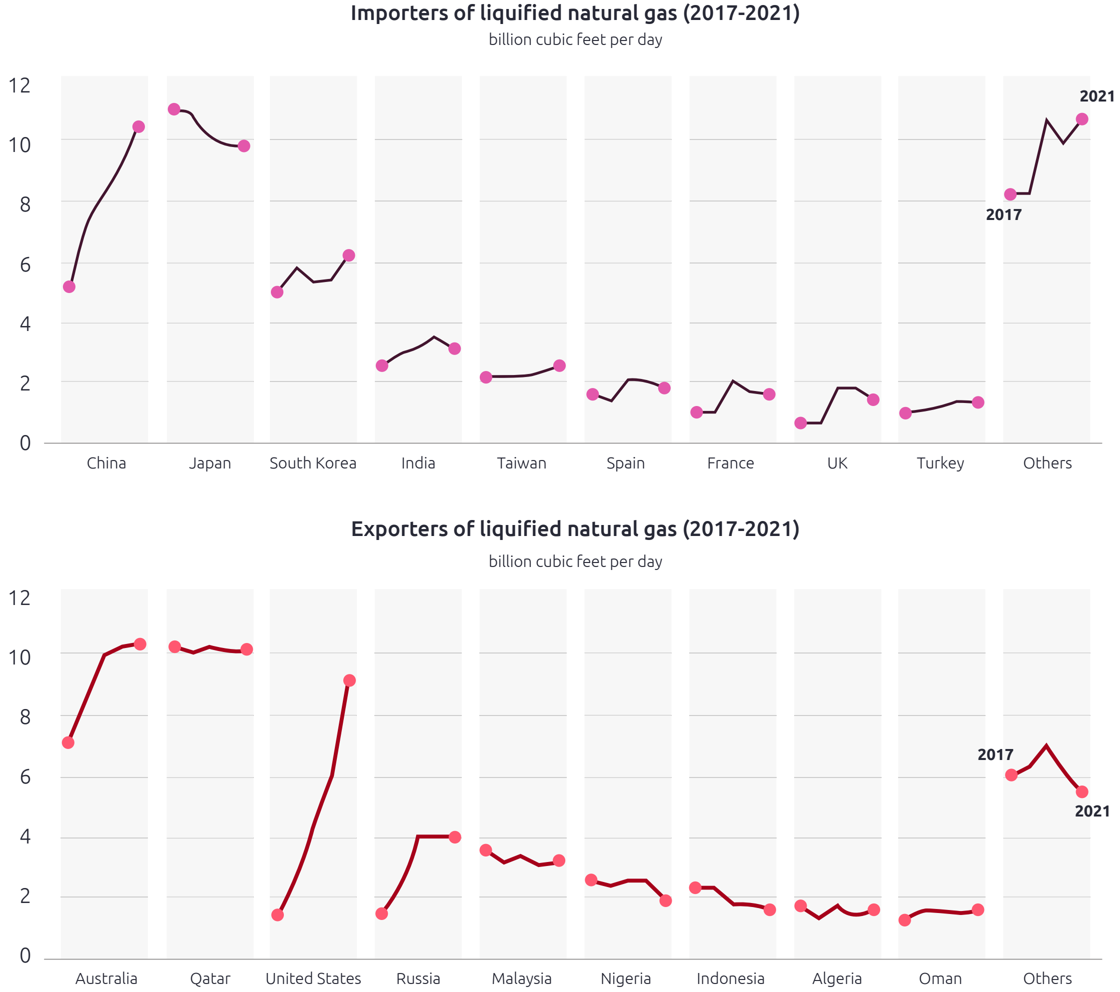
Source: GIIGNL, Statista

LNG is a transition fuel

- As Europe seeks to cut its energy dependence on Russia and other countries seek to reduce their carbon footprint related to coal baseload reliance, investments in liquefied natural gas (LNG) have grown.
- LNG projects in Europe have often faced opposition on environmental grounds. This gives support for more LNG financing, marking a political U-turn.
- Russia's invasion of Ukraine sent European prices soaring to record levels and forced nations to seek alternative suppliers. Due to this, governments are now backing some projects for fuel.
- More than 20 European LNG projects have been fast-tracked since March 2022, with the aim to replace about 80% of total imports from Russia.

FIGURE 7

Importers and Exporters of LNG, 2017-2021

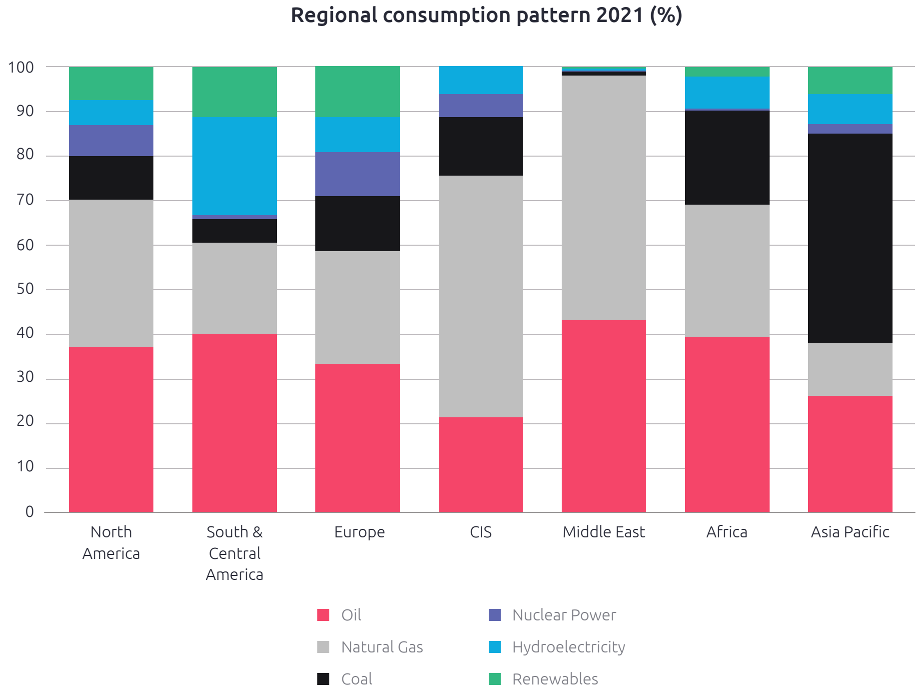


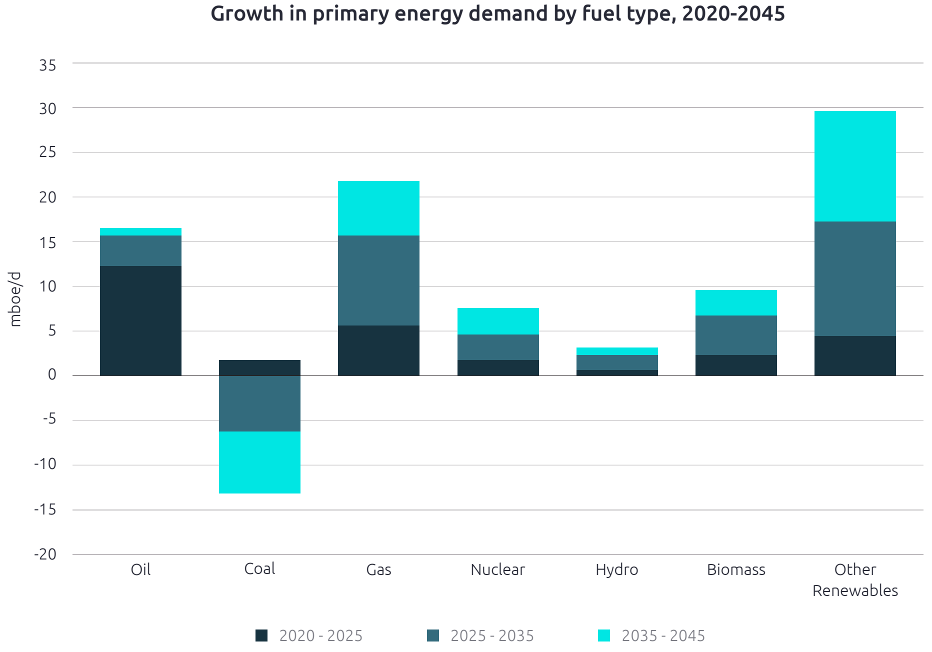
Progress in one part of the globe can be negated by regression in other countries

- Compared to Europe and North America, Asia remains heavily reliant on coal.
- The OPEC-forecasted energy demand mix shows continued growth in coal demand and is not offset by the growth in the mix of renewables.

FIGURE 8

Growth in Renewables





Source: Enerdata, BP, OPEC

Growth in renewables

During the decision-making process, corporate leaders must define what success will look like for all stakeholders involved. The world's success will be a journey of transformation, in which the energy supplies increase their mix of renewables over time.

However, the pace of change and the awareness of unintended consequences is critical. How fast can the world change their reliance, and how fast can both companies and energy infrastructures adapt? Furthermore, those that have the skills, technologies, and expertise to develop and scale the right future energy mix will have the added advantage.

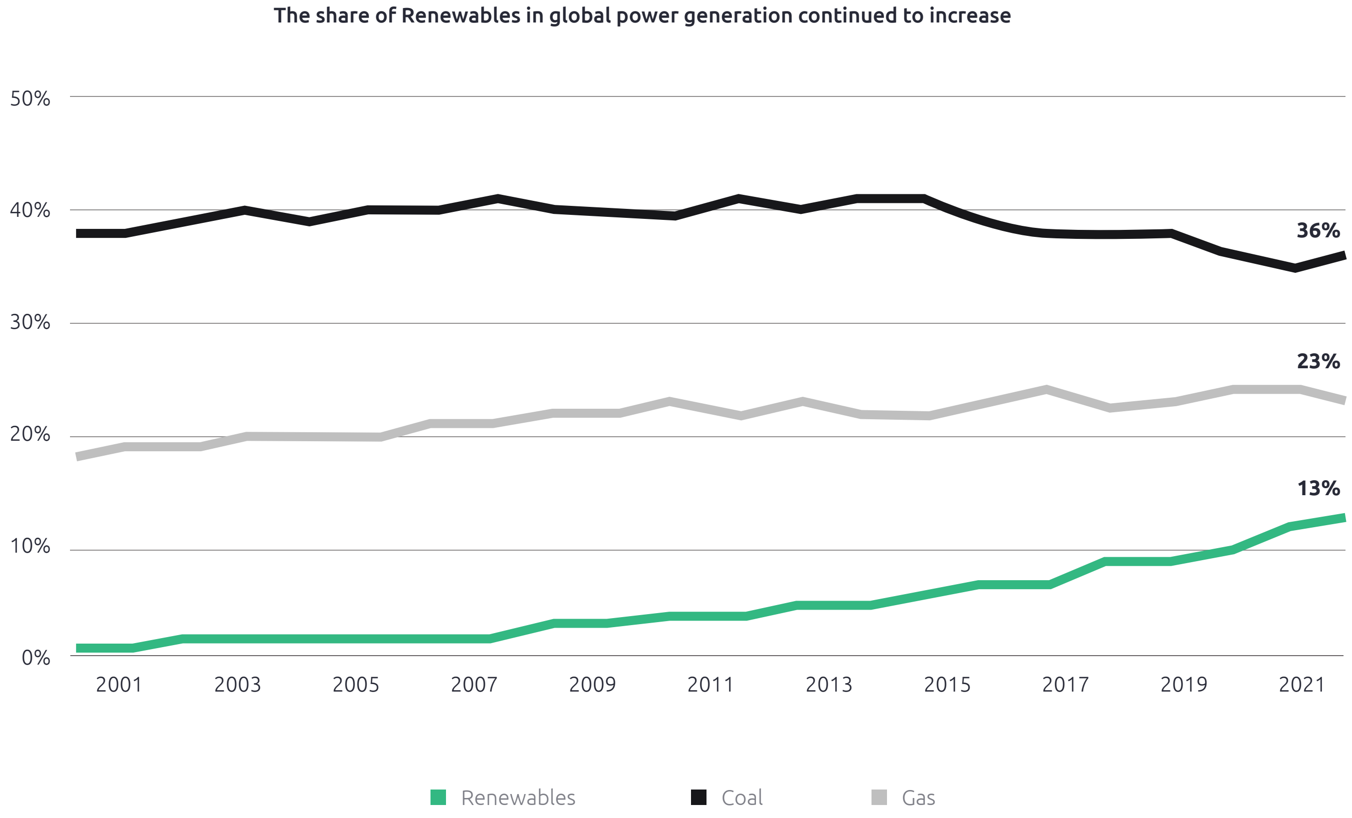
In the last two years, renewables have grown more than the growth of coal and natural gas supplies combined. The share of renewables (excluding hydro) in global power generation has continued its rising trend, driven by the strong expansion in solar and wind energy.

The share of renewables in power generation reached almost 13% in 2021, higher than the share of nuclear energy (9.8%).

In 2021, the share of coal in the power sector increased slightly, from 35% to 36%, but remained below its 2019 level. The share of gas generation in 2021 remained close to its 10-year average level.

FIGURE 9

Share of Renewables in Global power generation



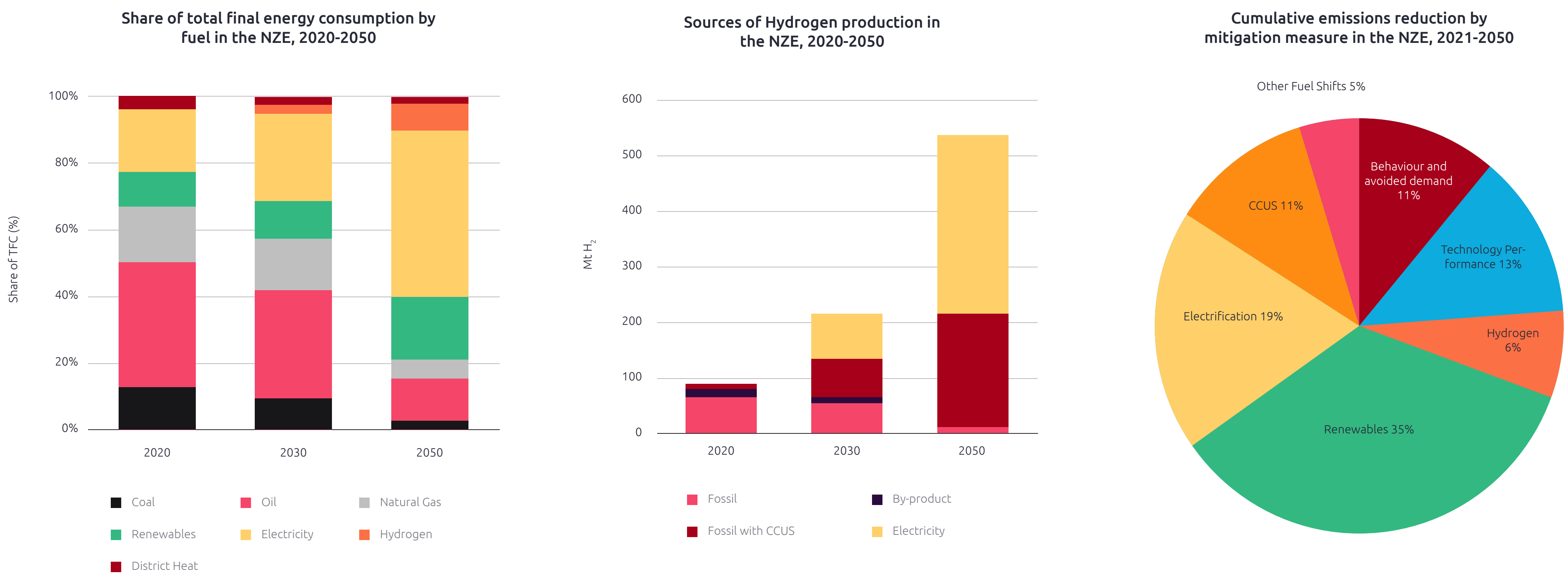
Source: IEA, BP

Hydrogen is an important growing component of the future renewable energy mix

- The Net Zero Emissions Scenario highlights the importance of hydrogen due to its increasing share in total final energy consumption (TFC). In 2020, hydrogen and hydrogen-based fuels accounted for less than 0.1%, but they are expected to meet 2% of TFC by 2030, and 10% by 2050.
- In addition to safety needs, the infrastructure investment cost indicates that the use of hydrogen in the future will not be for the end users. Rather, it will be utilized in commercial heavy-duty fleets, as well as being a logical solution for fuel switching, in order to reduce emissions in combustion in industrial facilities.
- Due to its large refining and chemical sectors, the U.S. is already one of the largest producers and consumers of hydrogen. With more than 11 Mt H2/yr. of consumption, the U.S. accounts for 13% of global demand; two-thirds is used in refining, and most of what remains goes into ammonia production.
- In 2020, The EU Hydrogen Strategy set the foundation. However, meeting net zero targets will require ambitious action over the next decade. In 2020, close to 7 Mt H2 of hydrogen was produced and used in the EU.
- With an annual consumption of more than 25 Mt, China is the world's largest hydrogen user. Hydrogen development focused on transport, but the carbon-neutrality pledge will offer opportunities for other applications, particularly in the industry.

FIGURE 10

Share of total final energy consumption by fuel, sources of Hydrogen production and cumulative emissions reduction in the NZE



Notes: NZE = Net Zero Emissions Scenario. TFC = Total Final Energy Consumption. CCUS = Carbon Capture, Utilisation and Storage. 'Behaviour' refers to energy service demand changes linked to user decisions (e.g. heating temperature changes). 'Avoided demand' refers to energy service demand changes from technology developments (e.g. digitalisation). 'Other fuel shifts' refers to switching from coal and oil to natural fas, nuclear, hydropower, geothermal, concentrating solar power or marine energy. 'Hydrogen' includes hydrogen and hydrogen-based fuels.
Source: IEA (2021). Net zero by 2050.

Energy transition commitments by major IOCs

- European IOCs have all committed to reach net zero emissions by 2050. Scientists say that the deadline will keep the temperature rise to less than 2°C.
- European majors, including BP and Shell, have pledged to reach net zero scope 3 emissions by 2050. They plan to tackle the problem by phasing out the production of refined products with cash flows from oil and gas to back investments in renewable energy, primarily in wind and solar.
- By contrast, major U.S. oil and gas companies are pushing to implement carbon tax. They did not provide any clear stance and commitments to scope 3 emissions.
- ExxonMobil aims for 30% reduction of upstream business, and 40-50% reduction of methane emissions by 2025.
- Chevron aims for more than 5% reduction in carbon intensity across all three scopes by 2028.

FIGURE 11

Net zero goal by major IOCs

Companies	Net zero goal
Shell	Shell's target is to be a net zero emissions energy business by 2050.
ExxonMobil	ExxonMobil aims to achieve net-zero emissions from its operated assets by 2050. It endorses a carbon tax to reduce hydrocarbon use and scope 3 emissions.
Chevron	Chevron intends to be net zero in scope 1 and 2 emissions from its own operations by 2050.
TotalEnergies	TotalEnergies SE aims to achieve net zero across all three scopes by 2050.
ConocoPhillips	ConocoPhillips aims to reach net zero scope 1 and 2 emissions by 2050. ConocoPhillips endorses a carbon tax to reduce demand to lower scope 3 emissions.
equinor	Equinor plans to achieve net zero by 2050.
bp	BP intends to be net zero by 2050 through a combination of oil and gas production cuts and increased investment in renewable energy.
ENBRIDGE	Enbridge aims to achieve net zero GHG emissions from its operations by 2050.
eog resources	EOG is targeting net zero scope 1 and 2 emissions by 2040.
PIONEER NATURAL RESOURCES	Pioneer's ambition is to achieve net zero in carbon emissions by 2050.
Woodside Energy	Woodside Energy targets to reduce their net equity Scope 1 and 2 greenhouse gas emissions, including a 15% reduction by 2025 and 30% by 2030, towards their aspiration to achieve net zero by 2050 or sooner.

Source: S&P, Sustainability reports

Global policy alignment is key

- The revised Trans-European Networks for Energy (TEN-E) regulation aims to renovate, decarbonize, and interconnect the member states' cross-border energy infrastructures so that the EU can achieve its 2050 climate neutrality objectives. The revised regulation also aims to continue ensuring market integration, competitiveness, and security of supply.
- New rules will close support for the latest natural gas and oil projects and introduce mandatory sustainability criteria for all projects. This will eventually simplify and accelerate permitting and authorization procedures.
- The new and revised rules highlight the role of energy from renewable sources regarding all assets, including smart gas grids. This will provide a prospect for non-binding cooperation in areas dedicated to offshore grid planning.
- Governments must work together in an effective and mutually beneficial manner, to implement coherent measures that cross borders. This includes sensibly managing job creation in the domestic market and communicating local commercial advantages, including the mutual need for deployment of clean energy technology worldwide.
- Accelerating innovation, developing international standards, and coordinating the scale-up of clean technologies is necessary for linking national markets. Cooperation must recognize differences in the stages of development of different countries and the varying situations of different parts of society.
- For many developing economies, accomplishing net zero emissions will be challenging and expensive without international aid and support. For many developing countries, the pathway to net zero without international assistance is also not clear.
- Technical and financial support is needed to fully utilize key technologies and infrastructure. Without greater international collaboration and cooperation, global CO2 emissions will not drop to net zero by 2050.

FIGURE 12

Key regulations introduced in 2021-2022, non-exhaustive

Regulation	Requirement
EU: Sustainable finance regulations*	From 2021 financial market participants must report on sustainability practices at the entity and product level. A new proposal introduced in 2021 will expand and tighten company reporting on non-financial metrics. From January 2022 in-scope companies must report eligibility with the EU taxonomy; alignment reporting begins in 2023.
UK: Mandatory TCFD reporting	From April 2022 TCFD reporting became mandatory for the largest companies and financial institutions.
U.S.: Proposed disclosure rules	In March 2022 the Securities and Exchange Commission proposed rules to require company climate risk and carbon emissions disclosures and to tighten fund naming requirements to prevent greenwashing.
China: Mandatory environmental reporting	From February 2022 listed companies and bond issuers must publish carbon emissions and other environmental data.

* Comprising the Sustainable Finance Disclosures Regulation, the Corporate Sustainability Reporting Directive and the EU Taxonomy for Sustainable Activities.
Notes: ESG = environmental, social and governance; TCFD = Task Force on Climate-related Financial Disclosures.

Source: IEA

- Comprising the Sustainable Finance Disclosures Regulation, the Corporate Sustainability Reporting Directive and the EU Taxonomy for Sustainable Activities.

Notes: ESG = environmental, social and governance; TCFD = Task Force on Climate-related Financial Disclosures.

Key highlights

- Industry leadership must find a balance between reliability, affordability, security, shareholder returns, and renewables.
- Energy industry leadership teams must walk the line carefully, in order to do the right thing for their stakeholders and the world's environmental needs.
- The share of renewables to fulfill global energy demand continues to grow.
- As an alternative to coal, the investments in reliable transition fuels include new funding support for nuclear and LNG.
- Hydrogen's utilization will be a lower percentage of the overall energy mix, with a focused application around heavy-duty commercial fleet fueling and fuel switching for large industrial complexes.
- Differences across regions and countries must be a key consideration.
- Global alignment must exist and not disadvantage companies that border the country.
- Sustainable finance has taken an increasingly prominent role in climate policy discussions, driving environmental factors into investment decision-making.

SCOPE 3 EMISSIONS

LARS FALCH
TOM ERDKAMP
SIMON BROD
THOMAS SCHOOT
IGOR LELIEVELD
EVA HOFTIJZER
KIM SILLEKENS
DEBARGHYA MUKHERJEE

Monitoring and reducing scope 3 emissions is crucial to achieve a net-zero society

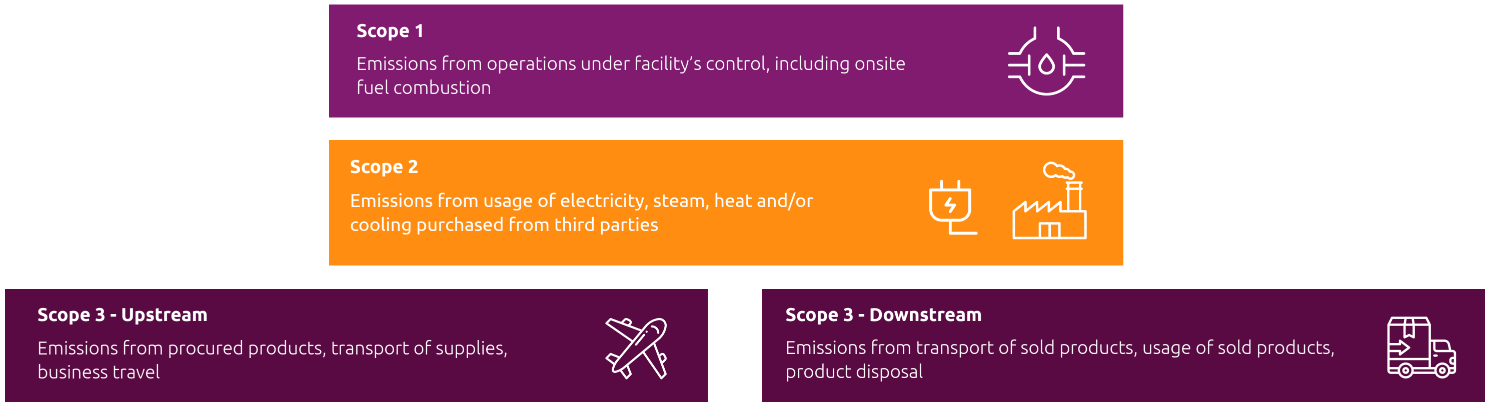
1. Scope 1, 2, and 3 explained

Scope 1, 2, and 3 emissions

In line with a growing urgency to reduce greenhouse gas (GHG) emissions as much as possible, most companies have been focusing on reducing emissions from operations under their direct ownership or control (scope 1) and emissions from their usage of electricity, steam, heat and/or cooling purchased from third parties (scope 2). However, indirect emissions in the company's value chain (scope 3), also referred to as value chain emissions, are most often left untouched.

FIGURE 1

Scope 1, 2, 3



Source: ghgprotocol.org

Scope 3 upstream and downstream emissions

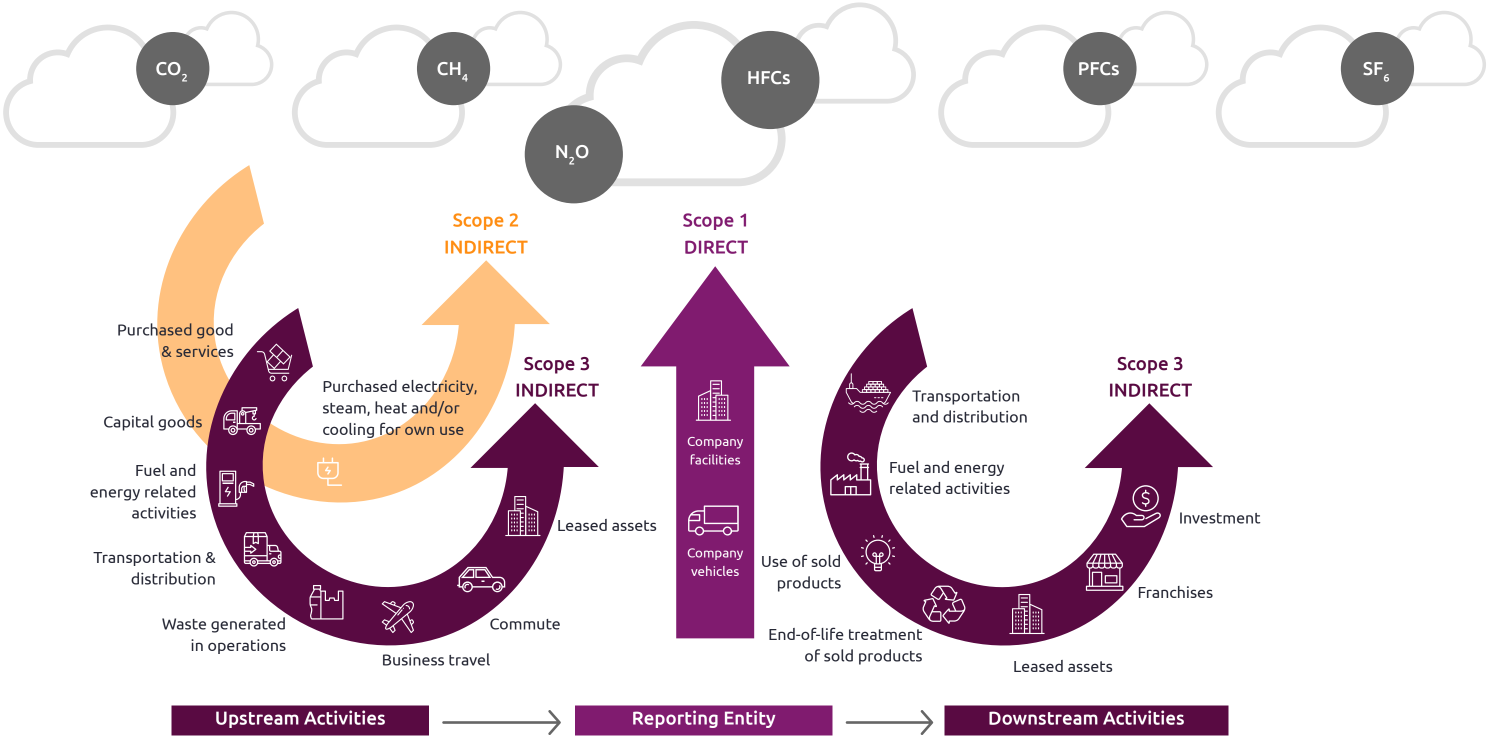
Within scope 3 emissions, a distinction is made between upstream and downstream emissions, as visualized in Figure 1. Upstream activities refers to emissions from the manufacturing of procured products, transport of supplies, and business travel, while downstream activities refers to emissions from transport of products, usage of products sold, and products disposal.

15 reporting categories

Scope 3 is additionally broken down into 15 distinct and mutually exclusive reporting categories, with the intention to provide companies with a systematic framework to measure, manage, and reduce emissions across their value chain. Besides the visualization of 15 categories, distributed over upstream and downstream activities, Figure 2 shows how the three scopes relate to each other and to the emissions across the value chain.

FIGURE 2

Overview of GHG Protocol Scopes and emissions across the value chain



Source: ghgprotocol.org

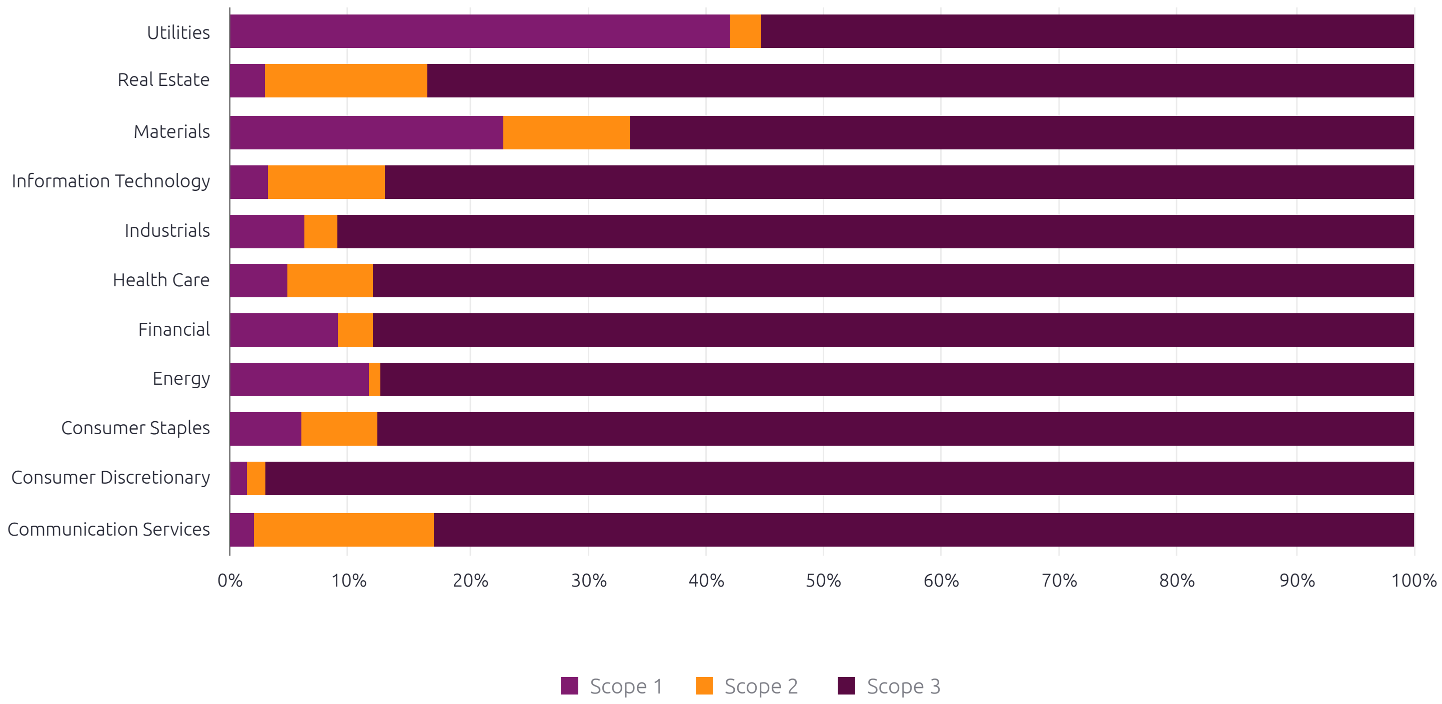
2. Scope 3 emissions are not widely monitored or reported, but have a huge impact - larger than scope 1 and 2 combined

Scope 3 emissions account for 75% of GHG emissions

Scope 3 emissions make up for the majority of corporate emissions in most sectors, accounting for 75% of companies' GHG emissions on average.[1] This means that most of the corporate emissions are related to scope 3 emissions; these emissions vary by sector, as visualized by the weighted average carbon intensity per sector in the MSCI ACWI index[2] in Figure 3. While sectors such as Utilities and Materials display a higher proportion of scope 1 and 2 emissions relative to other sectors, the emissions in the other sectors are predominantly driven by scope 3 emissions

FIGURE 3

Carbon intensity breakdown by sector and emission scope



Source: UBS Asset Management, MSCI. Index Holdings as of 28 February 2022, ESG data as of 02 March 2022

1 https://cdn.cdp.net/cdp-production/cms/guidance_docs/pdfs/000/003/504/original/CDP-technical-note-scope-3-relevance-by-sector.pdf?1649687608

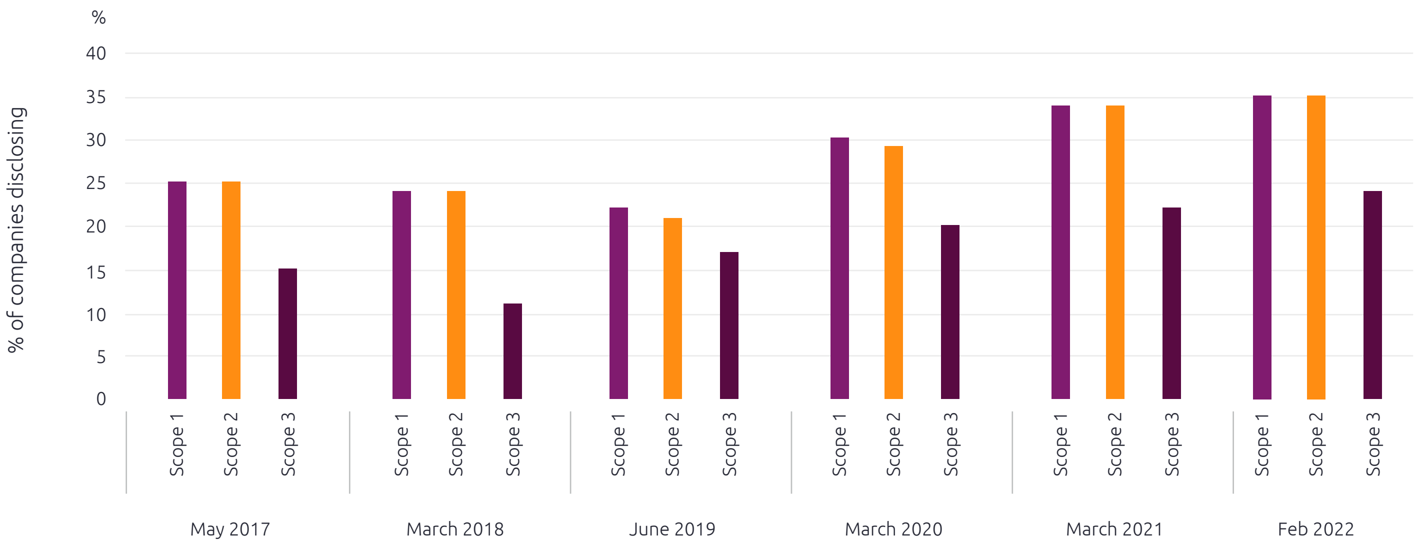
2 The MSCI ACWI (All Country World Index) IMI (Investable Market Index) captures large, mid, and small cap representation across 23 Developed Markets (DM) and 24 Emerging Markets (EM) countries

Less than 25% of organizations report scope 3 emissions

It is a given that GHG emissions are a key input in climate-related metrics. Nonetheless, Figure 4 shows that in February 2022 fewer than 40% of companies reported scope 1 and 2 emissions. Additionally, despite the huge impact scope 3 is undeniably having, scope 3 emissions are currently even less monitored or reported on. The number is slowly growing over the years, but fewer than 25% of companies disclosed scope 3 GHG emissions.[1,2]

FIGURE 4

GHG disclosure rates for MSCI ACWI IMI constituents



MSCI ACWI IMI constituents' disclosure rates, as of respective dates.

Note:

1. The MSCI ACWI (All Country World Index) IMI (Investable Market Index) captures large, mid and small cap representation across 23 Developed Markets (DM) and 24 Emerging Markets (EM) countries
2. Total number of companies included in this research within MSCI ACWI IMI constituents ~ 9,200

Source: MSCI, ESG Research LLC

Challenges of reporting on emissions

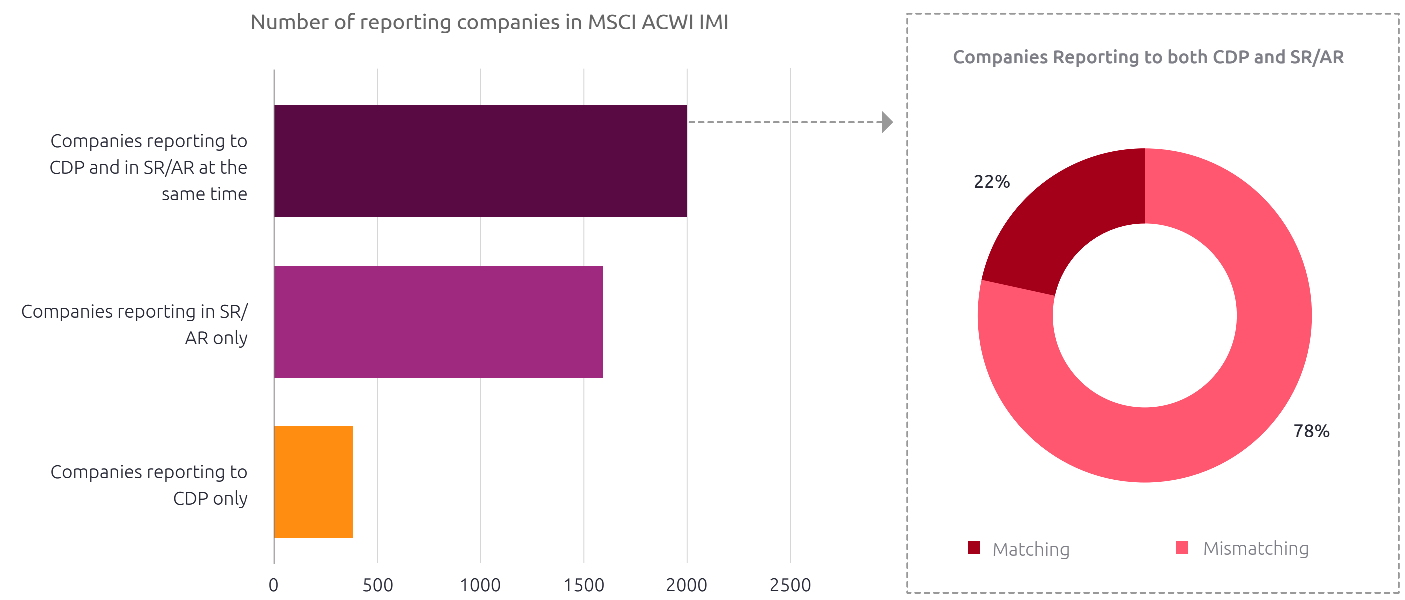
In addition to a low percentage of companies reporting their emissions, data quality has proven to be of an issues as well. Inconsistencies were found in emissions data reported to environmental organization CDP3, as per a recent study4. A global team of researchers found instances of errors, omissions and rounding issues in emission data reported to CDP. Reporting data - broken down into five categories including business lines, region and type of greenhouse gas - did not add up to the total reported emissions for 30% of these companies. Furthermore, 22% of companies that reported emissions data both to CDP and in their annual report or sustainability report had a reporting mismatch, as shown in figure 5. This points to inconsistencies between the two datasets.

Moreover, research5 highlights a large reporting gap, with 69% of companies not disclosing scope 3 emissions when reporting to CDP.

The lack of measuring and disclosing scope 3 emissions makes the impact of corporate sustainability negligible. There are ongoing developments for measuring and disclosing scope 1, 2 and 3 emissions, however, scope 3 emissions are often ignored in a company's approach to going carbon neutral. This is due to a variety of reasons, such as lack of legislation and large depth and breadth of data required with cooperation across the full supply chain. The lack of action in reporting scope 3 emissions hinders efforts to improve a company's sustainability performance.

FIGURE 5

Companies reporting by source for MSCI ACWI IMI



Note:

1. CDP formerly known as the Carbon Disclosure Project, CDP is an international non-profit organization based in the UK, Germany, and the US that helps companies and cities disclose their environmental impact
2. SR = Sustainability Report; AR = Annual Report
3. The MSCI ACWI (All Country World Index) IMI (Investable Market Index) captures large, mid and small cap representation across 23 Developed Markets (DM) and 24 Emerging Markets (EM) countries

Source: MSCI

3. Scope 3 emissions in the energy sector

Approximately 31 billion tons of CO_2 per year is emitted from fossil fuel production and use.

[Source: https://www.carbonbrief.org/global-co2-emissions-have-been-flat-for-a-decade-new-data-reveals/; Capgemini analysis].

In the extraction and use of fossil fuels, around 10% of emissions are from production and transportation of the fuels, and around 90% are from burning the fuel itself. For companies that produce oil, natural gas, or coal, that means that their scope 3 emissions are an order of magnitude larger than their scope 1 and 2 emissions. The aggregated scope 3 emissions of this industry are, in effect, the total global CO_2 emissions from burning fossil fuels.

The size of these emissions presents a unique challenge for the oil, gas, and coal industries when it comes to monitoring, reporting, and eliminating scope 3 emissions:

- Eliminating scope 3 emissions implies abandoning their business completely and converting to selling products from renewable energy sources, or converting on a massive scale to products where the carbon has been captured and sequestered, even though customers may not want those products. Fuel producers can argue that they will convert when customers ask them to. Nevertheless, some oil companies have pledged reductions in scope 3 emissions.
- Scope 3 emissions for the energy production sector are almost equal to the global total CO_2 emissions from fossil fuels. As such, it adds little information to publish them as scope 3 emissions per company.

The table below shows, for a selection of large companies, what their scope 3 commitments are to date. Note that non-fossil fuel companies are setting themselves stricter targets.

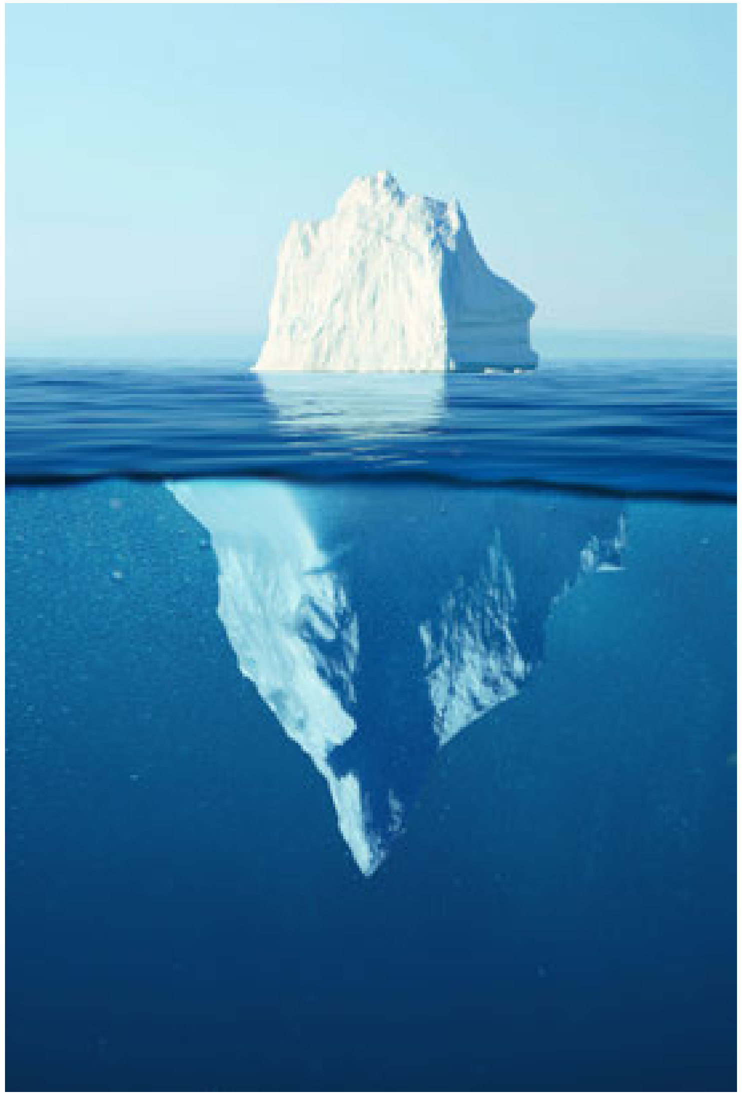


FIGURE 6

European and U.S. O&G Companies emission goals and targets

Company	Market Cap ($ Bn)	Climate Goal	Scope 1	Scope 2	Scope 3	Interim Goal
Shell	420.4	Shell's target is to become a net zero emissions energy business by 2050.	Target 2050	Target 2050	Target 2050	Shell is targeting 50% reduction in absolute scope 1 and 2 emissions by 2030 and plans to reduce scope 3 carbon intensity of the products it sells by 20% by 2030, by 45% by 2035, and by 100% by 2050.
ExxonMobil	349.6	ExxonMobil aims to achieve net zero emissions from its operated assets by 2050. It endorses a carbon tax to reduce hydrocarbon use and scope 3 emissions.	Target 2050	Target 2050	No Goal	ExxonMobil plans to reduce scope 1 and 2 emissions from its Permian basin operations to net zero by 2030. Permian accounts for 40% of Exxon's U.S. production.
Chevron	317.1	Chevron intends to be net zero in scope 1 and 2 emissions from its own operations by 2050.	Target 2050	Target 2050	No Goal	Chevron targets a more than 5% reduction in carbon intensity across all three scopes by 2028.
TotalEnergies	132.1	TotalEnergies SE aims to achieve net zero across all three scopes by 2050.	Target 2050	Target 2050	Target 2050	TotalEnergies plans to decrease scope 1 and 2 emissions by 40% by 2030, as compared to 2015 levels. TotalEnergies aims to reduce scope 3 emissions related to sales of petroleum products in 2030 by more than 30% from 2015 levels. TotalEnergies targets a 50% reduction in methane emissions by 2025 and 80% by 2030 with an eventual goal of zero methane emissions.
ConocoPhillips	129.6	ConocoPhillips aims to reach net zero scope 1 and 2 emissions by 2050. Conoco endorses a carbon tax to reduce demand to lower scope 3 emissions.	Target 2050	Target 2050	No Goal	ConocoPhillips plans to reduce its scope 1 and 2 emissions by 40-50% by 2030 from a 2016 baseline. The company aims to cut methane emissions 10% by 2025 from a 2019 baseline and eliminate routine flaring by 2025.
equinor	121.5	Equinor plans to achieve net zero by 2050.	Target 2050	Target 2050	Target 2050	Equinor plans to cut its scope 1 and 2 emissions by 50% by 2030. The company aims to reduce net carbon intensity, including emissions from the use of old products, by 20% by 2030 and 40% by 2035.
bp	95.6	BP intends to be net zero by 2050 through a combination of oil and gas production cuts and increased investment in renewable energy.	Target 2050	Target 2050	Target 2050	BP plans to cut the methane intensity of its production by 50% by 2050. Capital investment in renewables, like wind and solar, plus vehicle charging companies is expected to double from $2.2 billion in 2021 to roughly $5 billion by 2030.
ENBRIDGE	93.3	Enbridge plans to achieve net zero GHG emissions from its operations by 2050. It is pursuing new investments in solar and offshore wind projects, as well adding hydrogen and renewable natural gas in its natural gas distribution system.	Target 2050	Target 2050	No Goal	Enbridge aims to reduce scope 1 and 2 emissions intensity from operations by 35% by 2030.
eog resources	69.8	EOG is targeting net zero scope 1 and 2 emissions by 2040.	Target 2040	Target 2040	No Goal	By 2025, EOG will reduce methane emissions to 0.06% of production while ending routine flaring. Also, by 2025, EOG plans to cut its greenhouse gas intensity rate by 21% and methane emissions by 85% from 2017 levels.
PIONEER NATURAL RESOURCES	60.7	Pioneer's ambition is to achieve net zero in carbon emissions by 2050.	Target 2050	Target 2050	No Goal	Pioneer plans to cut greenhouse gas intensity by 50% and methane intensity, specifically, by 75% by 2030 as compared to 2019 levels. The company aims to limit flaring to less than 1% of natural gas production.

Source: Secondary research, S&P

Note: 1. Climate Goal = Net-zero carbon emissions target goal | 2. Interim goal = Adoptions of temporary goals set in order to achieve Net-zero target

4. New legislation on scope 3 reporting

Scope 3 emissions present an opportunity for companies to accelerate the road to net zero by collaborating with their partners across the value chain to reduce their carbon footprint. However, this requires significant effort of all parties to realize any related benefits. In the current situation, companies are still struggling to kick start these efforts. Hence, involvement of governmental institutions is becoming more crucial to accelerate the road to decarbonization. Recently, there is a trend visible which shows that governmental institutions across different geographies are slowly establishing legislation which requires companies to report on their scope 3 emissions.

Global legislation overview

As part of the United Nations Framework Convention on Climate Change (UNFCCC), its Kyoto Protocol and the Paris Agreement, the geographies mentioned in figure 7 are all required to report to the UN on their (1) greenhouse gas emissions (annually) and (2) on their climate policies and measures and progress towards the targets (regularly). Furthermore, a trend is visible in which the geographies on an individual level also take measures around legislation.

- **U.S.:** In the United States, the U.S. Securities and Exchange Commission (SEC) has enacted the climate risk disclosure rule which would require three categories of disclosure: (1) material climate impacts; (2) greenhouse gas emissions; (3) any targets or transition plans. The proposed rule would require companies to report audited scope 1 and scope 2 emissions and would also require scope 3 disclosures if they are material or if the filer has a target.[3]
- **EU:** In Europe, multiple initiatives have started on the European Union level to reach the goal of becoming climate neutral in 2050. The EU is set to adopt the Corporate Sustainability Reporting Directive (CSRD) in October 2022, amending the previously applicable Non-Financial Reporting Directive (NFRD). The CSRD supports the European Green Deal, a set of policy measures intended to combat the climate crisis by transforming the EU into a modern, resource-efficient, and competitive economy, with no net emissions of greenhouse gases by 2050.[4,5]
- **APAC:**
  - **Australia**, has a national framework for reporting and disseminating company information about greenhouse gas emissions, energy production, energy consumption, and other information specified under the National Greenhouse and Energy Reporting Act (NGER legislation). Scope 3 greenhouse gas emissions are not reported under the NGER scheme, but can be used under Australia's National Greenhouse Accounts.[6]
  - **China** issued the Guidance for Enterprise ESG Disclosure standards, effective as of June 1st, 2022. In many cases, the guidance requires the disclosure of specific quantitative data, including a list of greenhouse gases and wastewater and gas pollutants.[7]
  - **India** has introduced new reporting requirements on ESG parameters called the Business Responsibility and Sustainability Report (BRSR). On May 10th, 2021, the Securities and Exchange Board of India (SEBI) issued a circular implementing new sustainability-related reporting requirements for the top 1,000 listed companies by market capitalization.[8]

Figure 7 shows that the above-mentioned regions are taking action in implementing legislation, pushing companies to report on scope 3 emissions. Legislation around emission registration is a step in the right direction in achieving the climate goals that have been agreed upon. However, ensuring the reduction of scope 3 emissions requires more than just legislation and that means that a few hurdles still need to be addressed:

- Companies and countries need to be able to monitor scope 3 emissions, which requires the right tools, technologies, and measures to do so.
- A large depth and breadth of data is required to conduct proper reporting on scope 3. Currently the data quality is low and guestimates are used for scope 3 emissions. This makes it difficult to set the targets because there are different ways to measure scope 3 and they are not globally and/or regionally aligned.
- There is cooperation required between all companies across the full value chain as one single company cannot do it by themselves.

3 SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors, Washington D.C., March 21, 2022 (https://www.sec.gov/news/press-release/2022-46)

4 https://ec.europa.eu/clima/eu-action/climate-strategies-targets/progress-made-cutting-emissions/emissions-monitoring-reporting_en

5 https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

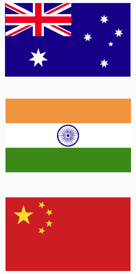
6 https://www.dcceew.gov.au/climate-change/emissions-reporting/tracking-reporting-emissions#toc_0

7 https://www.globalelr.com/2022/06/china-to-introduce-its-first-esg-disclosure-standard/

8 https://www.sebi.gov.in/legal/circulars/may-2021/business-responsibility-and-sustainability-reporting-by-listed-entities_50096.html

FIGURE 7

Legislation and Regulations increasingly require measuring, reporting, monitoring Scope 3 emissions

Major Geography	Scope 3 Regulation/Legislation
 USA	• SB 260 requires U.S.-based companies — those doing business in California and generating more than $1 billion in gross annual revenue — to disclose all their greenhouse gas emissions to the California Secretary of State's office. • U.S. Securities and Exchange Commission (SEC) climate risk disclosure rule would require three categories of disclosure: material climate impacts; greenhouse-gas emissions; and any targets or transition plans. The proposed rule would require reporting of audited scope 1 and scope 2 emissions and would also require scope 3 disclosures if they are material or if the filer has a target. • The proposed rule would apply to U.S. 10-K filers, as well as foreign private issuers who file 20-F forms with the SEC. Large companies would have to disclose most of this information as of fiscal year 2023 (filing year 2024). Smaller companies would have a year-long grace period until fiscal year 2024. For scope 3 emissions, the SEC would provide an additional year beyond those deadlines, allowing companies to lean on scope 1 and 2 filings by other companies in the prior year.
 EU	• As part of the EU Green Deal and the ambitious Sustainable Finance strategy, the European Commission (EC) published on April 21, 2021, its revisions to the Non-financial Reporting Directive (NFRD), which is now called the Corporate Sustainability Reporting Directive (CSRD). The scope of the directive is considerably extended to apply to more European and non-European companies listed and operating in the EU regulated markets. • Companies are required to start reporting from 2024 as part of CSRD. Reporting must comply with mandatory EU sustainability reporting standards and be accompanied by external verification. • EU is set to adopt the CSRD in October 2022, amending the previously applicable NFRD. The CSRD supports the European Green Deal, a set of policy measures intended to combat the climate crisis by transforming the EU into a modern, resource-efficient, and competitive economy, with no net emissions of greenhouse gases by 2050. • The European Climate Law writes into law the goal set out in the European Green Deal for Europe's economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, as compared to 1990 levels.
 APAC	AUSTRALIA • National Greenhouse and Energy Reporting Act 2007 (NGER Act) is a single national framework for reporting and disseminating company information about greenhouse gas emissions, energy production, energy consumption and other information specified under NGER legislation. • Scope 3 greenhouse gas emissions are not reported under the NGER scheme but can be used under Australia's National Greenhouse Accounts. Australian National Greenhouse Accounts publishes a series of comprehensive reports and databases that estimate and account for Australia's greenhouse gas emissions estimates from 1990 onwards. INDIA • Securities and Exchange Board of India (SEBI) decided to introduce new reporting requirements on ESG parameters called the Business Responsibility and Sustainability Report (BRSR). • On May 10, 2021, they issued a circular implementing new sustainability-related reporting requirements for the top 1,000 listed companies by market capitalization. CHINA • With effect from June 1, 2022, the Guidance for Enterprise ESG Disclosure (the Guidance), published by Beijing-based think tank China Enterprise Reform and Development Society (CERDS), is seeking to become the first, and definitive, China-focused ESG disclosure standard.

Note: As parties to the UNFCCC, its Kyoto Protocol and the Paris Agreement, the above-mentioned geographies (EU including its member countries) are required to report to the UN annually on their greenhouse gas emissions and regularly on their progress related to climate policies, measures and targets ('biennial reports' and 'national communications')

The most difficult part of mitigating scope 3 emissions is the supply chain."

Francesco Starace
CEO Enel – Conversations for Tomorrow,
Quaterly Review Quarterly, N°5 — 2022

5. Digital solutions and tech tools to monitor and report on scope 3

For the majority of companies, scope 3 emissions represent the largest part of their total footprint, accounting for 75% of companies' GHG emissions on average.[9] This means that to actually make an impact on the reduction of GHG emissions, scope 3 emissions should not be disregarded.

Before making an effort to reduce scope 3 emissions, companies need to find a way to identify, report, and track scope 3 emissions. With the use of emerging digital tools, the identification and monitoring of scope 3 emissions becomes more transparent. This makes it possible to identify the "hot spots" that need to be focused on to start communication across the value chain and foster collaboration on minimizing the carbon footprint. In this way, the right digital tools can enable companies to implement effective scope 3 emissions programs. However, it requires close collaboration with partners across the value chain to reduce the impact on the climate, as one company's scope 3 emissions can be another company's scope 1 emissions.

Industry 4.0 technologies like blockchain, AI and IoT can help create solutions that make the tracking and reporting of scope 3 emissions more reliable, consistent, and transparent.[10]

- **Blockchain:** Blockchain technology ensures that all players across the value chain can generate and share data in a secure way; data can also be labeled, which helps clarify ownership and improve supply chain traceability.
- **Artificial intelligence (AI):** With AI-enabled systems, it becomes possible to receive data from smart sensors that are placed within the equipment to identify and alert on issues. In this way, AI can help flag issues before they arise, enabling predictive maintenance and therefore improving supply chain sustainability.
- **Digital twin:** AI makes it possible to simulate future states and digital twins allow the possibility to model and evaluate the impact of emissions reduction initiatives. In this way, it can help to capture dynamic data on emissions within supply chains and automate measurement and reporting of emissions.
- **ID and digital tracing:** With Auto ID and traceability technologies, businesses can track materials and components of products to authenticate the source.
- **Internet of Things (IoT):** IoT sensors can be used to gather data on supply chain issues and therefore detect the most fuel-efficient route for goods to reduce last mile emissions. In this way, generated data can be measured for the purpose of carbon accounting and auditing.

Emerging technologies can help companies measure their scope 3 emissions by simplifying data collection, identifying hot spots, and tracking scope 3 emissions across supply chains. However, to make an impact on the decarbonization of the value chain, a combination of digital tools, analytical capabilities, and value chain collaboration are crucial.

9 https://cdn.cdp.net/cdp-production/cms/guidance_docs/pdfs/000/003/504/original/CDP-technical-note-scope-3-relevance-by-sector.pdf?1649687608
10 https://www.theguardian.com/the-whole-picture/2022/jul/07/seeing-into-the-future-six-ways-cutting-edge-tech-can-help-monitor-sustainability

Source: Sustainability reports

CORPORATE POWER PURCHASE AGREEMENTS (CPPA)

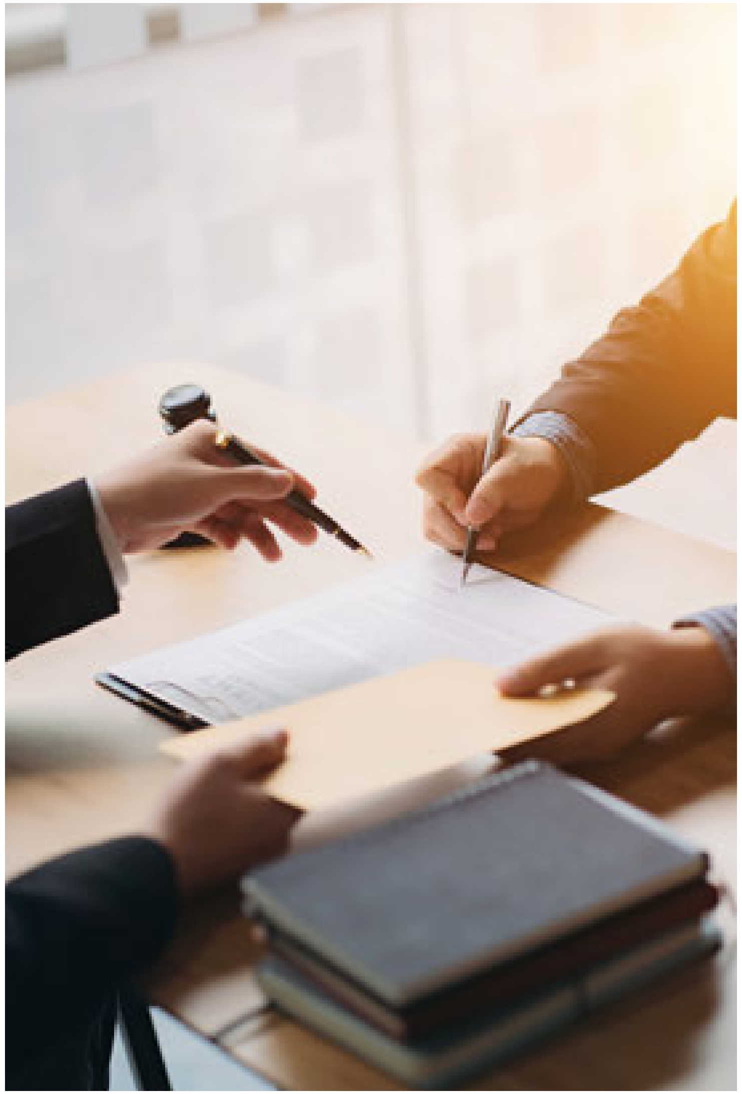
ANNE-SOPHIE HERBERT

Corporate PPA volume reached 31.1 GW volume in 2021 (a 24% increase from 2020 to 2021), confirming the appetite of corporates for renewable energy sourcing

The new Corporate PPA market showed a 24% volume increase between 2020 and 2021[1]

- The geographical footprint is still driven by the U.S. market, reaching +20.3 GW in 2021, despite a decline observed in 2020. Virtual PPAs remain the preferred option.
- The Asian market continues its progressive annual growth at the same order of magnitude as observed since 2015.
- This growth dynamic is expected to continue in the coming years, driven by corporates' sustainability commitments (RE100, SBTi targets, etc.).

1 BNEF, 2022

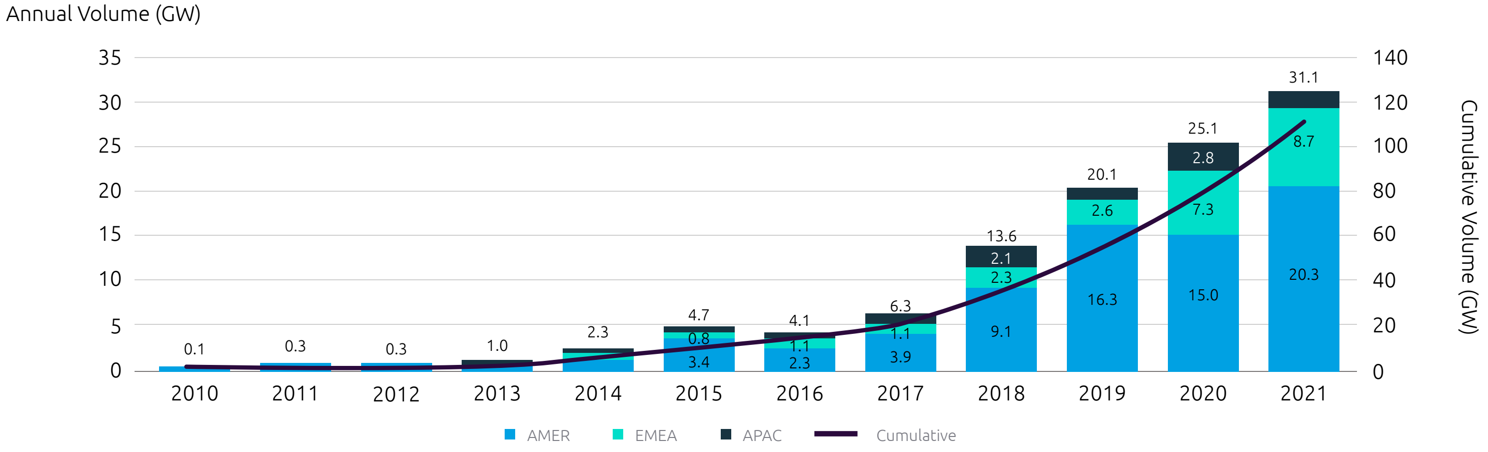


The European market broke PPA additions record with an 8.7 GW increase in 2021[2]

- Europe now represents 18.5 GW of cumulative capacity.
- Solar PPAs continue to grow steadily (+2.1 GW in 2021 vs. +1.7 GW in 2020), while wind PPAs experience a huge increase from +1.8 GW in 2020 to +3.5 GW in 2021. Combined wind and solar projects are more and more observed (+0.8 GW in 2021), demonstrating the diversity of options chosen by corporates.
- As in 2020, the Nordics (Sweden, Norway, Finland) (+6,4 GW with a majority of wind PPAs) and Spain (+4.2 GW with a majority of solar PPAs) dominate the PPA addition market. They are followed by Germany and U.K., which have a more balanced PPA mix with ~60-65% of wind and 20-25% of solar.

FIGURE 1

Evolution of global new PPA volumes by region



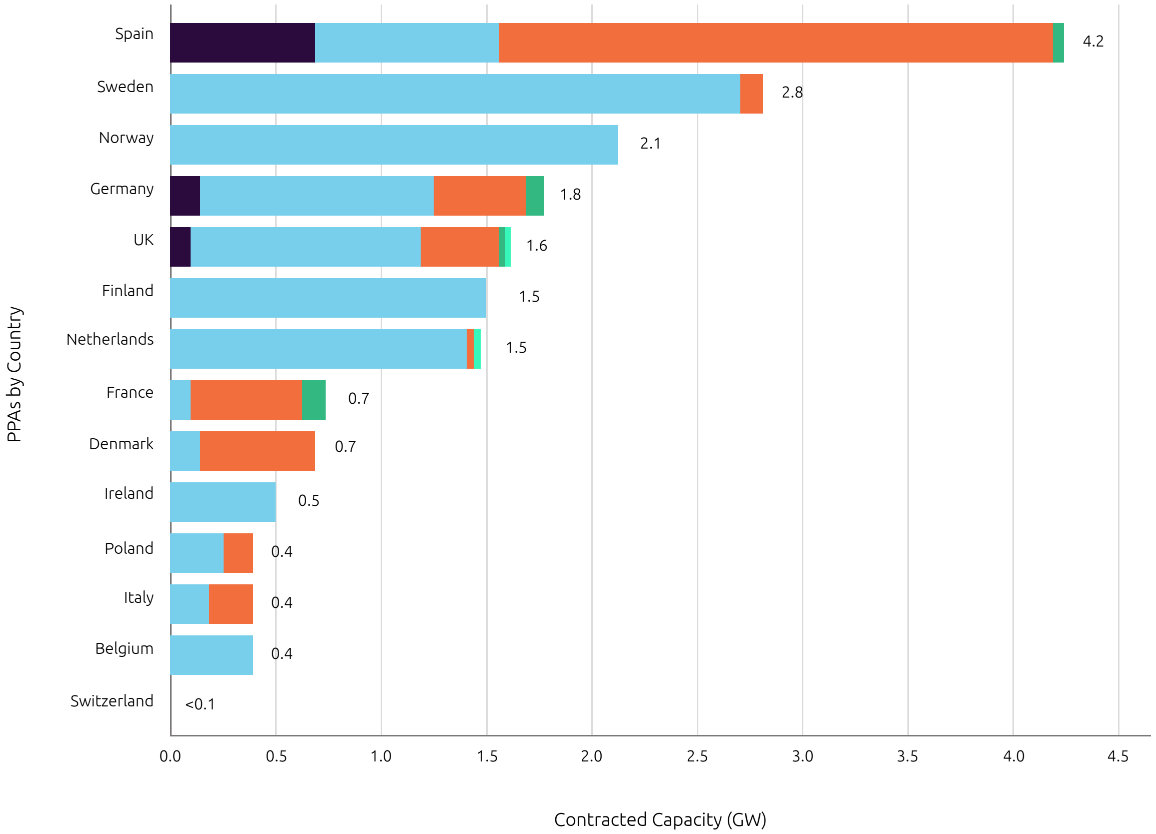
Note: Onsite PPAs excluded. APAC volume is an estimate. Pre-reforms PPAs in Mexico and sleeved PPAs in Australia are excluded. Capacity is in MW DC.

Source: BloombergNEF 2022

2 Renewable Energy Buyers Toolkit, RE-Source, 2022

FIGURE 2

European PPA technologies volumes by country



Source: Renewable Energy Buyers Toolkit, RE-Source, 2022

ICTs and GAFAM continue to dominate the PPA market.

- In 2021, Amazon was the top PPAs buyer, followed by Microsoft and Meta, representing a total of 14.3 GW[1,3].
- The same trend is observed in Europe with ICTs adding +2.8 GW of PPAs in 2021, followed by companies from heavy industry (+1.3 GW in 2021)[2].
- Other sectors progressively grow PPA volumes. Transport and Telecoms, for example, account for 1.3 GW and 1.0 of cumulative volume, respectively, with more than the half contracted only since 2018.

3 31 GW record corporate PPAs in 2021, www.pveurope.eu

PUBLIC SUPPORT TO RENEWABLES DEVELOPMENT FROM SUBSIDIES TO CFD MECHANISMS REPOWER EU

MAXIME GARDELLIN
LAURE REOSENBLIEH
SANDRA HAHN DURRAFFOURG
ZOE BERCHEM
CHRISTINE LE BIHAN-GRAF

Support mechanisms for the development of renewables in Europe have recently undergone a significant evolution

The renewable energy targets for the energy mix in the European Union (EU) are binding and increasing.

The EU has been addressing issues surrounding renewable energy development since the late 2000s.

The publication, Renewable Energy Road Map - Renewable energies in the 21st century: Building a more sustainable future (2007), marked the first time the European Commission defined binding targets for the member states in this field.

In 2009, the First Renewable Energy Directive (the RED I Directive) set the following binding target: By 2020, at least 20% of the community's gross final energy consumption and at least 10% of the community's final energy consumption in the transport area should come from renewable energy sources.

In the RED I Directive, the European Commission stated that public support was "…necessary to reach the community's objectives with regard to the expansion of electricity produced from renewable energy sources…for as long as electricity prices in the internal market do not reflect the full environmental and social costs and benefits of energy sources used."

Member States have therefore been required to develop national renewable energy action plans. In order to achieve their objectives, the RED I Directive identified mechanisms that could be implemented, including public support schemes.

The targeted proportions of renewable energy in the European energy mix have become progressively more ambitious.

In 2018, the RED I Directive was replaced by the RED II Directive. The RED II Directive establishes a new binding renewable energy target for the EU by 2030: With an upward revision clause by 2023, and 14% of the share of renewable fuels in transport, at least 32% of the EU's final energy consumption should come from renewable energy by 2030.

In 2021, the European Commission once again proposed to increase its renewable energy production targets. The aim was to align the targets with ambitions set out in the legislative package, enabling the implementation of the Green Deal for Europe. The Green Deal plans to make Europe climate neutral by 2050 by providing clean, affordable, and secure energy.

On July 14, 2021, the European Commission published a new legislative package, Fit-for-55. The EU raised its climate ambition by committing to reduce its emissions by at least 55% by 2030. The binding target for renewable energy production in the EU's energy mix was raised to 40% by 2030.

In France, the first targets were set in 2005 (21% by 2010) and adjusted in 2009 (23% by 2020). In 2015, the law on energy transition had increased the renewable energy production proportion to reach 32% by 2030, which is within France's final gross energy consumption.

The EU's binding target for renewable energy production by 2030 is 40%.

The current geopolitical and energy contexts bring about a need for energy sovereignty and independence. It is therefore even more imperative to achieve European climate objectives and rapidly accelerate the deployment of renewable energies.

Support mechanisms for renewable energies were initially implemented by the Member States. This was so that binding targets set by the EU regulation and their own national renewable energy action plans could be achieved. Accelerating the deployment of renewable generation capacity is also a current focus, in order to limit the EU's dependence on Russian fossil fuels.

While reducing the EU's dependence on energy imports was already one of the objectives set by the European Commission in the 2000s, Russia's invasion of Ukraine has accelerated the European authorities' commitment to transforming the European energy system. Their aim is to phase out current dependence on Russian fossil fuels.

Russia is the main EU supplier of natural gas. In 2020, 45% of natural gas was imported from Russia.

The current energy situation in the Member States requires the development of renewable energies, as well as climate considerations.

In Germany, the situation is more critical. In 2021, Russia accounted for 55% of Germany's gas imports, and 40% in the first quarter of 2022.

In France, nuclear power plants are less available which puts more pressure on the French electricity market. Since 2021, this has had a significant negative impact on electricity production.

The European Commission has announced its commitment to cease buying fossil fuels from Russia before 2030. In May 2022, the European Commission presented to the European Parliament and the European Council a plan entitled, REPowerEU. This plan aims to improve and strengthen actions related to energy sovereignty and security of supply, as well as energy storage.

REPowerEU accelerates Europe's transition to clean energy by focusing on the diversification of supplies and the quick replacement of fossil fuels.

The current boom in market prices is transforming the renewables' economic model and accelerating their transition to a market economy.

Since the beginning of the Ukrainian conflict, the energy sector has been under significant under pressure. The energy sector destabilizes energy wholesale market prices, which have faced disruptions since 2021. Since the economic recovery following the Covid-19 health crisis, prices have increased significantly. This is due to supply constraints and a higher demand induced by the electrification of the energy mix.

The rising market prices (resulting from constraints on supply and the increase in demand) are transforming the economic model of renewable energies and accelerating their transition to a market economy. This implies little intervention by the state.

As a result, developers currently have a strong economic incentive to sell renewable energy directly to the market.

According to a well-established position of the European Commission, Member States support schemes for renewables should be reformed.

In 2013, a communication which gives guidance to Member States on public interventions in the electricity market, was published. The European Commission emphasized that "renewable energy – both wind and solar – was for a long time a new technology that needed state intervention to develop". Yet, "with technological progress, [and] investment costs in solar panel falling and production expanding, many Member States have started a reform of their support schemes for renewables". For example, the Commission advises Member States to replace feed-in tariffs with incentive-based schemes (see below).

The evolutions in the renewable energy sector (within the current context) have recently led to structural changes in the related support mechanisms.

1. Until very recently, renewable energy projects relied on support mechanisms, as developers were guaranteed project profitability.

Since the early 2000s, a variety of support mechanisms have been introduced in Europe, in order to create, develop, and mature the renewable energy production sector: the example of France.

A feed-in tariff is a widespread mechanism for supporting renewable energy in Europe.

When the feed-in tariff was first set up, its objective was to create and develop sustainable renewable electricity production sectors (which did not exist in the early 2000s). It was (and still is) based on public support for electricity producers, enabling them to make significant investments in technologies which were not yet technically and economically mature, due to their high costs.

To achieve this objective, feed-in tariffs were set at levels that allowed producers to attract investors, and finance the costs of developing, constructing, and operating power generation facilities. The development of these facilities was backed by debt, in which the amount was based on the operating income of the facilities, i.e., the level of the feed-in tariff.

These feed-in tariffs were initially set up for the solar and wind power sectors.

In France, feed-in tariffs allow any eligible renewable energy producer to sign a purchase obligation contract with a mandatory buyer. Under this framework, the mandatory buyer purchases all the electricity produced for the duration of the contract (20 years) in return for a tariff. The tariff's setting is governed by law. Its level is determined by a joint order of the ministers responsible for the economy and energy (the tariff orders), or the specifications of the corresponding calls for tenders.

The feed-in-tariffs are also a key support mechanism in other EU countries, such as Germany and Spain.

The feed-in-tariffs have gradually given way to the CFDs (Contract for Difference) premium mechanism, which is an ex-post support mechanism.

The CFDs-premium mechanism allows eligible producers to receive a premium. This is so they can compensate for the difference between the revenues from the sale of electricity on the market and have a reference for the level of remuneration.

French renewable energy production facilities are supported by these two mechanisms, which are imposed on the mandatory buyer.

The objective of the feed-in tariffs and CFDs-premium mechanisms is to guarantee eligible producers a remuneration, independent of the market price of electricity.

The difference between these two mechanisms is that the CFDs-premium aims to familiarize renewable energy producers with the market mechanisms, in order to facilitate their final entry into these markets. Both types of contracts can be signed under two procedures: A tariff window or a competitive bidding procedure.

While most of the renewable electric energy projects are supported by feed-in tariffs or CFDs-premium mechanisms, other types of financial support are available, such as investment subsidies and tax incentives.

In addition to the feed-in tariff and CFDs-premium mechanisms, France implements investment subsidy mechanisms (e.g., for heat producer projects), as well as tax measures (e.g., to allow individuals to deduct from their income tax the expenses incurred for the purchase of equipment that intends to use renewable energy to produce heat or cold).

Finally, there are several upstream support actions designed to encourage French innovation in the field of renewable energy. These include calls for projects organized by the French National Research Agency (ANR), the French Environment, and the Energy Management Agency (ADEME). There are also support actions for demonstrators and pilot operations, through calls for expressions of interest, and calls for projects under the Future Investment Program (PIA). These aim to stimulate employment, boost productivity, and increase the competitiveness of French businesses.

2. With a recent revision of existing support mechanisms and a rapid transition to a market economy, a paradigm shift has taken place.

2.1. In order to limit the cost of renewables energy deployment, the support mechanisms for renewable energy have been revised. This has been encouraged by the European Commission and carried out in Europe: the example of photovoltaic solar in France and Italy.

Support for renewable energies has led to the existence of a speculative bubble, resulting in heavy expenditure for public finances.

To remedy this situation, a trend towards reducing the levels of existing renewable energy support mechanisms (mainly regarding feed-in tariffs) has gradually emerged from the Member States.

This trend has been encouraged by the European Commission, whose guidelines set out the principle of effectiveness of state aid measures, designed to target "situations where they can deliver a significant improvement that the market is unable to deliver on its own".

As a response to the boom in the photovoltaic energy sector, in 2014, an Italian legislator reduced the incentives granted to operators. As a result, financial incentives for installations with a nominal power of more than 200 KW were reduced by about 35%, despite the 20-year agreements between the Italian energy agency Gestore dei Servizi Energetici (GSE) and the operators.

On November 7, 2020, in France, a measure was inserted into the Finance Act for 2021, reducing the feed-in tariffs for electricity produced by some solar installations. This measure proposed a reduction in the feed-in tariffs for electricity produced by certain photovoltaic installations for contracts that concluded between 2006 and 2010. The parliamentary debates show that the French legislator adopted this measure to deal with tariffs that have become exceptionally advantageous for producers. Indeed, the feed-in tariffs proposed between 2006 and 2010 were close to €600 per kilowatt-hour over 15 or 20 years, while the installation costs of photovoltaics were divided by four the same period.

These revisions to support mechanisms call into question these mechanisms' stability, and more broadly, the trust in state-supported policies.

The principles of legal certainty and protection of legitimate expectations are essential principles of EU law, which the Member States are required to respect. The preamble of the RED II Directive also specifies that support mechanisms for renewable energies must be stable and predictable, so as not to affect the cost of financing capital, the cost of developing projects, and, more broadly, the overall cost of deploying renewable energies in the EU. Support policies should therefore not be subject to frequent or retroactive changes.

In 2014, preliminary questions were raised by the Italian court during the review of financial incentives. The EU's Court of Justice clarified that while there is nothing to prevent national legislation from amending an aid scheme by reducing feed-in tariffs, it must comply with the principles, provided that the objectives of legal certainty and protection of legitimate expectations allow the objectives of renewable energy proportions and decarbonization to be met.

Yet, it is difficult for the Member States to demonstrate that these targets have been achieved effectively. For example, although the market for renewable energy has grown significantly in recent years, several studies and opinions of environmental authorities show that the Member States (including France) have not put in place sufficient measures to reach these targets.

2.2. Project developers are now seeking to quit support mechanisms, so they can sell directly to markets. This shows a decline in the attractiveness of the contractual relationships, which were established before the price increase.

Due to a sharp increase in electricity purchase prices within the wholesale market, support mechanisms for renewable energy production are becoming less attractive for producers.

This puts into question the durability and attractiveness of the contractual relationships established between buyers and producers of renewable energy that took place before the price increase.

Until now, the feed-in tariff offered producers an excess return. However, some of the tariffs set in the current feed-in contracts may become less competitive than market prices. Producers who hold or are eligible for feed-in contracts or CFDs-premium contracts are therefore tempted to turn away from support mechanisms and sell the electricity they produce directly to the market.

Given the high price of the kilowatt per hour on the wholesale market, producers find themselves being indebted to EDF-OA (EDF Purchase Obligations). However, they are supposed to find themselves in the opposite scenario, as they usually receive a premium to compensate for the difference between the income from the sale of electricity on the market, and a reference level of remuneration.

It is important to note that it is impossible to rule out the possibility that such behavior will weaken the position of producers in the event of a market downturn (whether in the medium or long-term). The duration of the windfall effect is difficult to estimate and could be limited in time. In this case, support mechanisms could become attractive again in a few months or years.

Despite the declining attractiveness of these support mechanisms, both the market price environment and the emergence of new attractive contractual tools have contributed to the paradigm shift in the support of renewables.

Today, renewable energy producers (who only had support mechanisms to guarantee the profitability of their installation over a long period) are provided with several tools such as C-PPAs to sell their electricity. This is carried out through long-term contractual mechanisms, at a level close to €70-80/MWh.

C-PPAs are direct purchase agreements for renewable electricity between a producer with an existing or new generation facility, and an end user (an offtaker). These contracts can also be part of a three-way relationship between a generator and a buyer who, while not the end-user, is in the same group of companies as the end-user.

Another example of an agreement is the sleeved C-PPA. These contracts are like traditional C-PPAs; however, the end-user usually retains a supply contract with an electricity supplier for its residual consumption, to cover its electricity consumption over the volume of electricity purchased under the C-PPA (a top-up supply contract).

It is also worth noting that C-PPA may be financial or virtual.

Both CPPAs take the form of a CFD, whereby the consumer agrees to pay the difference between a negotiated reference price (strike price) and a market price (usually a spot price) for each megawatt-hour produced and sold on the market.

Virtual CPPAs do not aim to sell energy, but rather provide an additional payment equal to the difference between the reference price and the market price.

2.3. There is currently a dichotomy between mature and emerging industries, that still rely on support mechanisms to successfully scale up, a prime example being hydrogen.

Today, the maturity of solar and onshore wind sectors has reached a similar level of competitiveness to that of fossil fuels. While these sectors seem to be gradually losing interest in support mechanisms, other emerging sectors are particularly reliant on such mechanisms.

For some emerging technologies, public subsidy mechanisms remain essential to guarantee a reasonable level of profitability and a transition of scale.

This is the case for offshore wind energy. In France, this sector still benefits from the feed-in tariff, although these tariffs are becoming more and more competitive as the technology matures. The same is true for floating wind power.

The development of low-carbon hydrogen is another example of the need to put support measures in place.

The REPowerEU plan have set a target of 10 million tonnes of domestic renewable hydrogen production, and 10 million tonnes of imports by 2030, with the aim of replacing natural gas, coal, and oil in hard-to-abate industries and transportation.

Given the current cost of hydrogen production, national initiatives need to be taken to achieve these goals. The aim is to compensate for the real competitiveness deficit of hydrogen that is produced by electrolysis, which cannot be covered by private investment support mechanisms alone.

Spain (in October 2020) and Germany (in June 2021) adopted a hydrogen roadmap. Respectively, €8.9 billion and €7 billion are to be dedicated to the development of a national hydrogen market in these countries.

In 2020, France announced an investment plan of nearly €9 billion in the sector, through the National Strategy for Hydrogen and their post-Covid-19 recovery plan until 2030.

In addition, the ADEME (the French National Agency for Sustainability) calls for projects that encourage economies of scale. They do this by creating territorial hubs and supporting projects that aim to develop or improve components and systems related to the production and transport of hydrogen.

France has also notified the European Commission of the new support mechanisms that compensate for the cost differential and support the price of hydrogen.

The European Commission has also made low-carbon hydrogen a priority, through the Important Common European Interest Project (IPCEI) scheme.

The IPCEI scheme is a European research and innovation support mechanism which relies on a communication from the Commission (published in 2014, revised in 2021). The revision sets out the criteria for eligible state aid to large-scale cross-border projects. Projects that are eligible include those that have overcome market failures, and enabled breakthrough innovation in strategic sectors, technologies, and infrastructure investments. Eligibility also extends to projects that have created positive spill-over effects for the EU economy.

In 2020, the IPCEI regarding the hydrogen technology value chain was set up. This was to support research and development, the first industrial development, and the industrialization of electrolyzers. Furthermore, it encouraged the production and deployment of low-carbon hydrogen in hard-to-abate industries.

As part of this IPCEI, 35 companies with activities in one or more Member States will participate in 41 projects. The Member States will provide up to €5.4 billion in public funding, which is expected to unlock an additional €8.8 billion in private investments.

2.4 The legislation is no longer used to create new financial support mechanisms. Rather, Member States now use it to simplify authorization procedures for renewable energy projects.

The REPowerEU plan has identified that accelerating the deployment of renewables to replace fossil fuels in housing, industry, and power generation, is a necessary step towards achieving EU energy independence.

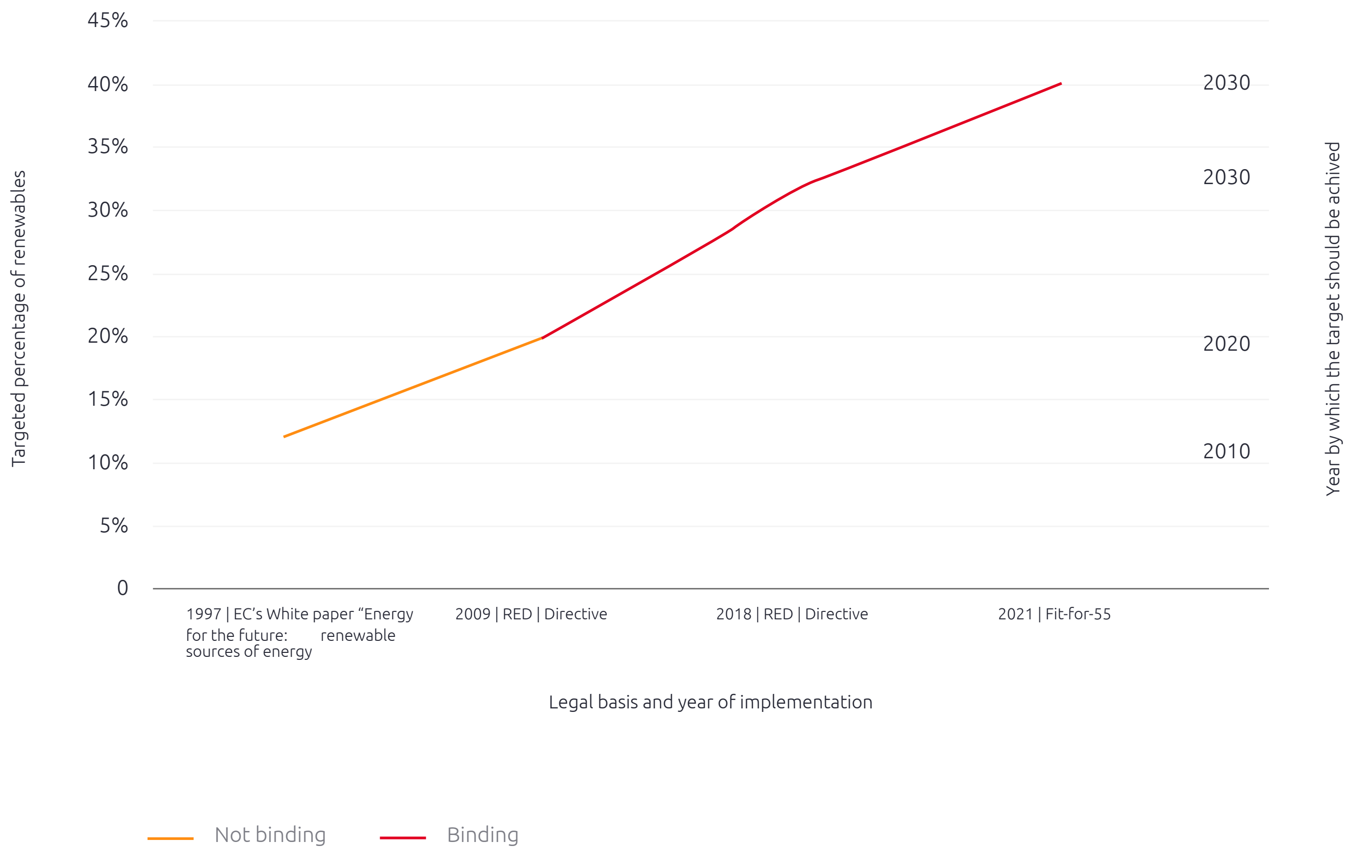
For example, the plan involves doubling the European solar photovoltaic capacity by 2025 and installing 600 GW of generation capacity by 2030.

In order to address climate and energy independence issues, the European Union and the Member States have set increasingly ambitious objectives. As a result, public financial mechanisms are no longer favored by governments to accelerate the deployment of projects.

In the REPowerEU plan, the Commission recommends taking action to address the slow and complex approval procedures for renewable energy projects: "the complexity, diversity and excessive length of these procedures are a major obstacle to the much-needed rapid deployment of renewable energy and the development of a more affordable, secure and sustainable energy system in the Union". These barriers were already targeted by EU authorities, who simplified the targets set in the RED I Directive (reinforced by the RED II Directive). Alongside the publication of this REPowerEU recommendation, a legislative proposal was adopted, which sought to amend and strengthen the directive on administrative procedures.

FIGURE 1

Evolution of the Commission's target for the percentage of renewable energy in the European energy mix over time and corresponding legal basis.



Bearing this in mind, the French government started working on a bill to accelerate the deployment of renewable energies. This bill especially aims at easing the procedures, notably the simplification of the environmental evaluation procedure and the increase of the electronic public vote. It also provides for the diversification of the location of solar panels (obligation of equipment on the big parking lots, possibility of installation on the abandoned roads) and grouping the debates regarding offshore wind.

Germany also adopted a legislative package, Osterpaket (July 2022), that had a similar objective. This package amends the German Renewable Energy Act, Erneuerbaren-Energien-Gesetz (EEG), with the aim of increasing the level of bidding for wind and solar power, and to simplify the permitting process for installations through a dedicated onshore wind bill. The German government seeks to increase the amount of land in the country available for onshore wind development to 2% by the end of 2032, and to simplify the application process.

Through creating zones favorable to the development of projects, authorization procedures have eased, and the phenomenon of land shortage has been resolved. This is an important lever for project developers that some Member States have already begun to use.

Conclusion

Since their implementation 20 years ago, public support mechanisms for renewable energies have evolved significantly. Initially, they were mainly financial – through subsidies and tax incentives. However, the transition to a market economy has encouraged developers to operate outside the framework of these mechanisms and sell directly to the market. Consequently, this has forced public authorities to diversify such mechanisms. Financial support remains necessary for some technologies (due to their degree of maturity), and therefore these mechanisms intend to be partly material. Today, there is a prominent will at both the national and European level to simplify the procedures for granting renewable energy, which are often perceived as a major obstacle to accelerating the development of support mechanisms.

NORTH AMERICA (USA, CANADA)

EMISSIONS, CARBON TAXES, RENEWABLES AND ENERGY EFFICIENCY MEASURES

ELFIJE LEMAITRE
ALEXANDER RODRIGUEZ
SARA STRITHARAN
SWETANTA LAHIRI
ANIMESH BOSE

U.S. energy consumption: Petroleum will remain the most consumed fuel in the U.S., due to its widespread use in transportation and industrial processes

According to estimates from the U.S. Energy Information Administration (EIA), petroleum and other liquids will be the most used fuels in the U.S. from 2021-2050, with 2050 projected to be about 14% higher than 2021.

- In 2021, U.S. petroleum consumption averaged about 19.78 million barrels per day (b/d), including about a million b/d of biofuels.
  - In 2021, petroleum consumption in the U.S. was about 8% higher than the 2020 level, primarily due to the recovery of the U.S. economy from the effects of the Covid-19 pandemic.
- Gasoline is the number one petroleum product consumed in the United States.
  - In 2021, the average consumption of finished automotive gasoline was approximately 8.8 million b/d (369 million gallons per day), equivalent to about 44% of the U.S. total petroleum consumption.
- Distillate fuel oil, including diesel fuel and heating oil, is the second most consumed petroleum product, while hydrocarbon gas liquids (HGL) are the third most consumed petroleum category in the United States.
  - In 2021, the average distilled fuel oil consumption was about 3.94 million b/d (669 million gallons per day), while the average consumption of HGL in 2021 was about 3.41 million b/d.
  - Distillate fuel oil and HGL account for 29% and 17%, respectively, of the total petroleum consumption.

Coal-fired generation continues to fall while generation from renewables increases.

- As per EIA's Short-Term Energy Outlook, U.S. power plants will consume 482 million short tons of coal in 2022, lower than 2021's coal consumption of 501 million short tons.
  - The reduction in coal consumption is primarily due to supply constraints, such as rail transportation issues and limited coal availability.
- Renewable energy is expected to generate 22% of U.S. electricity in 2022 and 24% in 2023, compared to 20% in 2021.

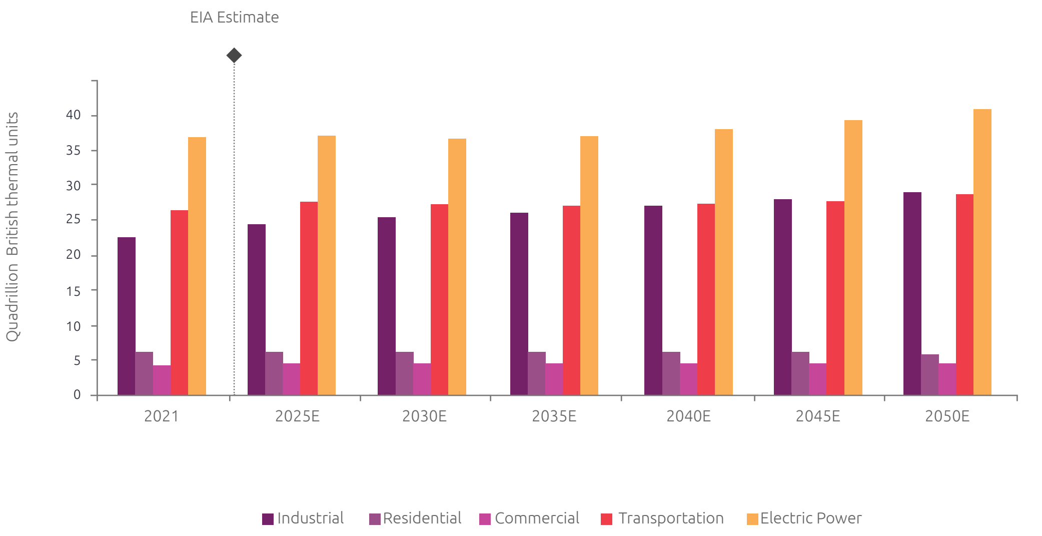
https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/coal/060722-eia-lowers-2022-us-coal-export-projection-amid-war-uncertainty

https://www.eia.gov/energyexplained/oil-and-petroleum-products/use-of-oil.php

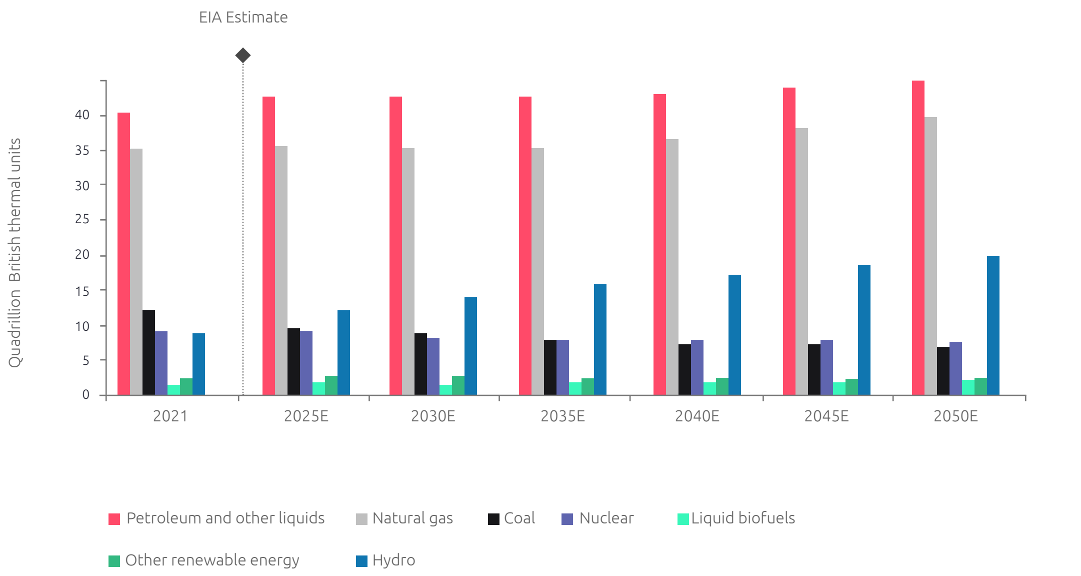
FIGURE 1

U.S. energy consumption by sector, 2021-2050E (quadrillion British thermal units),
Energy consumption by fuel type, 2021-2050E (quadrillion British thermal units)

Energy consumption by sector (2021-2050E)



Energy consumption by fuel type (2021-2050E)



Source: US EIA Annual Energy Outlook, 2022
Link: https://www.eia.gov/outlooks/aeo/

U.S. energy-related emissions: CO_2 emissions will begin rising after 2037 due to increasing energy requirements stemming from economic growth

EIA projects that U.S. energy-related carbon dioxide (CO_2) emissions will fall to 4.5 billion metric tons in 2037, then rise to 4.7 billion metric tons in 2050.

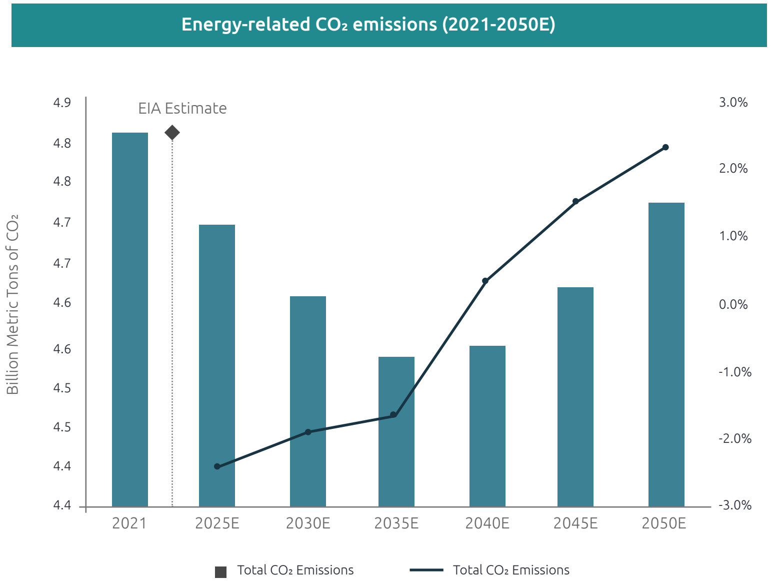
- Population growth at a rate of 0.4% per year and economic growth of 2.2% per year are the primary reasons for U.S. energy consumption growth.
- Coal and petroleum, which account for most of the U.S. CO_2 emissions, increased by 181 MMmt (9%) and 126 MMmt (14%) from 2020 to 2021, respectively.
  - As per EIA, CO_2 emissions in 2021 were 274 million mt.
  - This number was 5% lower than the pre-pandemic level of 5.13 billion mt. in 2019 and it was 19% lower (1.14 billion mt) than the 2007 level of 6 billion mt., a historical peak.
- In 2021, major reasons that led to increased energy-related CO_2 emissions (to 4.9 billion metric tons) were travel growth coupled with increased demand for electricity.
  - This total was 5% below pre-pandemic levels.

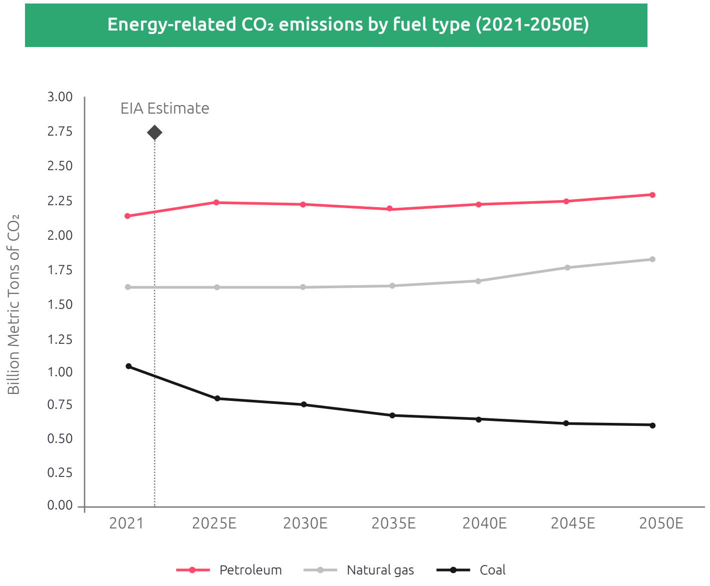
- The reduction in projected emissions from 2022 to 2037 is primarily due to a reduction in carbon intensity (CO_2 per unit energy consumption) in the electric power sector, while the increase in emissions from 2037 to 2050 is primarily due to increased energy consumption from industrial growth.

- Carbon capture, utilization and storage (CCUS) will become more relevant over the next few decades, as economic growth spurs the creation of more CO_2 emissions in the future.

FIGURE 2

U.S. energy-related CO_2 emissions outlook though 2050E (billion metric tons CO_2)
Energy-related CO_2 emissions by fuel, 2021-2050E (billion metric tons CO_2)





Source: US EIA Annual Energy Outlook, 2022
Link: https://www.eia.gov/outlooks/aeo/

https://www.hellenicshippingnews.com/u-s-energy-related-co2-emissions-rose-6-in-2021/
https://cleanenergynews.ihsmarkit.com/research-analysis/us-energyrelated-co2-emissions-remained-below-prepandemic-leve.html

U.S. energy-related emissions: Texas is the highest emitter of CO_2 among all states due to its high industrial share

In 2019, the U.S. EIA report found that 41 states successfully reduced their carbon emissions from 2005 to 2016, while nine states increased their emissions levels.

- Larger geographic states like Texas and California lead the pack in terms of emission levels.
- Ohio and Georgia are states that lean heavily on automotive manufacturing and steel production but have taken measures to reduce emissions significantly.

Texas, the leading energy-producing and energy-consuming state, emits the most CO_2 of all states; it observed a slight decline (0.2%) in CO_2 emissions.

- The industrial sector, including its refineries and petrochemical plants, accounts for most of the energy consumed in Texas.
- Texas is the leading crude oil and natural gas producing state, with 31 petroleum refineries that can process almost 5.9 million barrels of crude oil per calendar day, which was 32% of the nation's refining capacity as of January 2021.
- In 2021, Texas accounted for 43% of the nation's crude oil production and 25% of its marketed natural gas production. Texas is expected to increase production over the next few years, driven by the geopolitical situation between Russia and Ukraine, and increased global demand, especially from Europe.

Washington D.C. is the lowest CO_2 emitter and has no CO_2 emissions from coal.

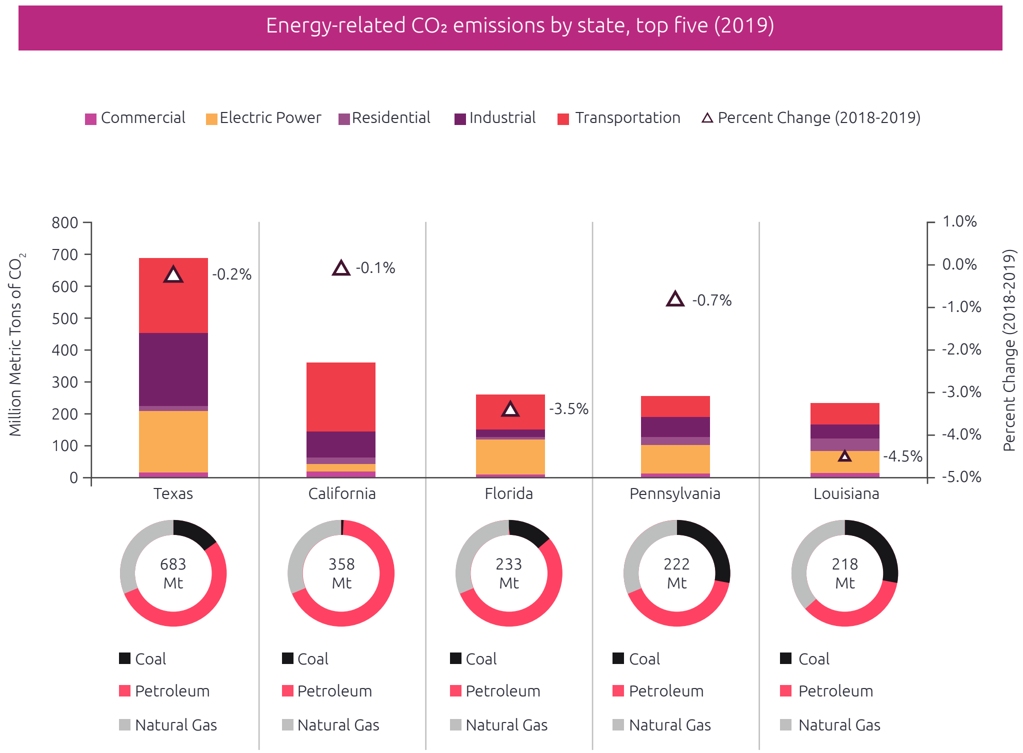
- In 2019, D.C. increased its renewable portfolio standard requiring 100% of the city's electricity to come from renewable sources by 2032, including at least 5.5% from solar energy.
- Most of the electricity generated in the District of Columbia comes from small-scale solar photovoltaic panels on homes and commercial buildings.
- D.C. has more electric vehicle charging stations than motor gasoline stations, and the city's per capita gasoline expenditures are lower than any state.

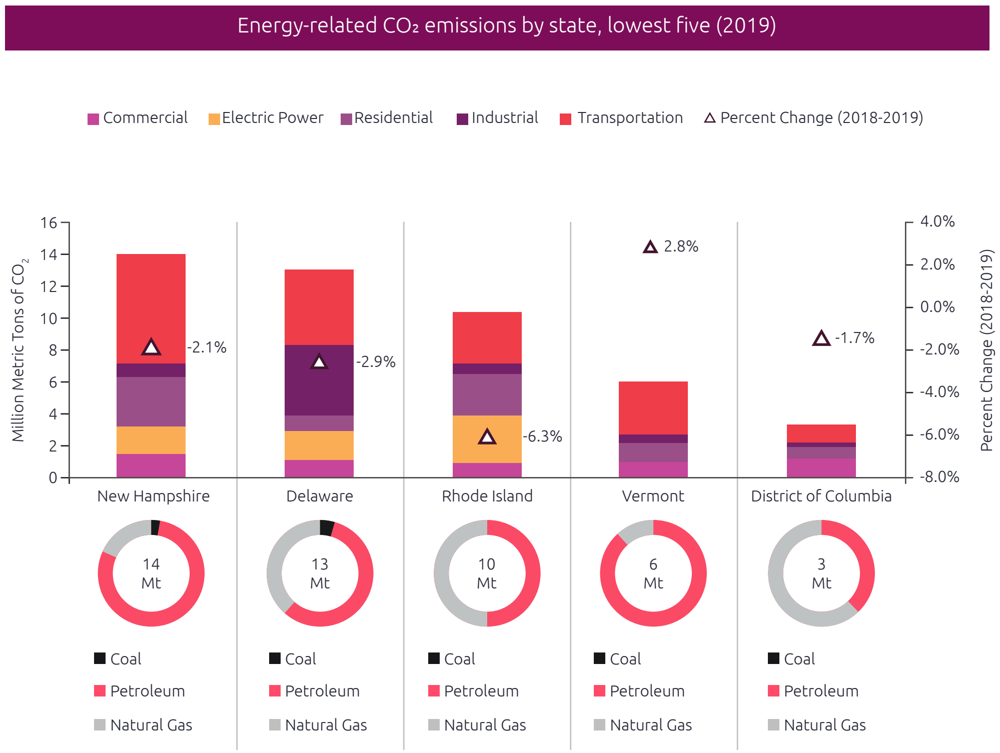
In terms of per capita CO_2 emissions, Wyoming emits the most.

- The United States Geologic Survey (USGS) reported Wyoming produced 57% of all fossil fuels produced on federal lands. The state produces about 40% of the country's coal.

FIGURE 3

U.S. state profiles: Energy-related CO_2 emissions





Source: EIA Review, March 2022
Link: https://www.eia.gov/environment/emissions/state/

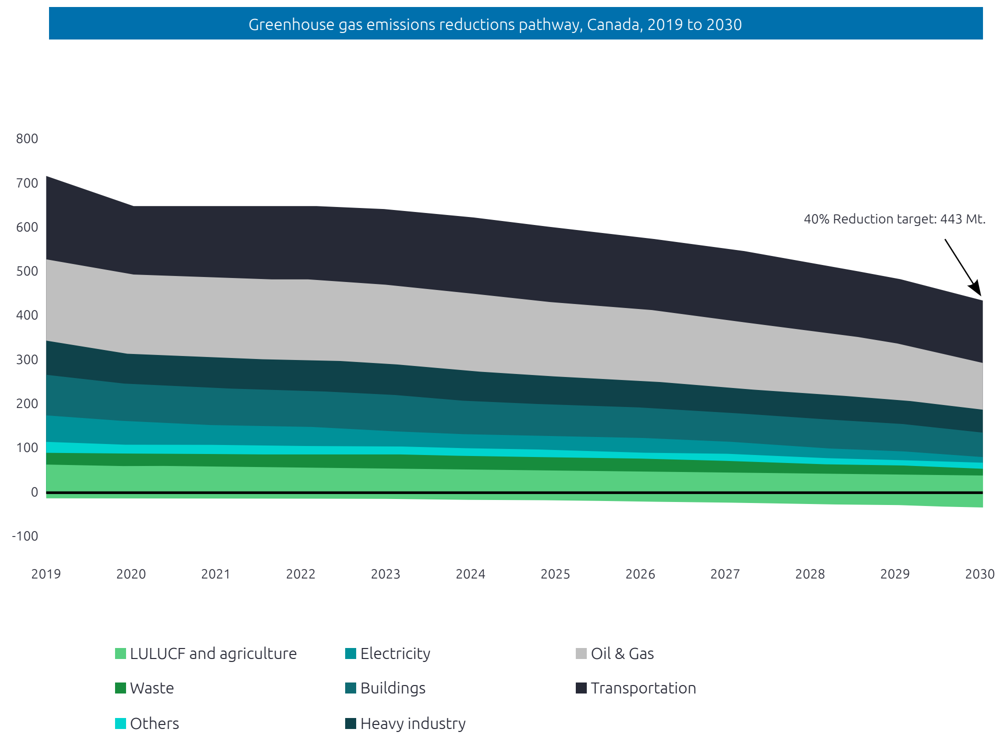
Canada energy-related emissions: Canada sets aggressive targets for 2030 emissions reduction goal as its average temperatures are rising at twice the global average

The government of Canada launched the 2030 Emissions Reduction Plan in March 2022. The plan provides a roadmap for the Canadian economy to achieve its emissions reduction target of 40% to 45% below 2005 levels by 2030.

- It means a reduction from 739 megatons of carbon dioxide equivalent ($MtCO_2e$) in 2005 to between 406 $MtCO_2e$ and 443 $MtCO_2e$ in 2030.
- In a previous plan, Canada had committed to reducing its GHG emissions by 30% below 2005 levels by 2030.
- The 2022 Emission Reduction Plan is the first issued under the Canadian Net Zero Emissions Accountability Act.
  - The review of the progress under the plan will be provided in reports produced in 2023, 2025, and 2027.
  - From 2035 to 2050, additional targets and plans will be developed.

FIGURE 4

Canada: Projected GHG emissions in 2030



Sources of emissions reductions contributing to reaching the 2030 Target

Sector	Projected emissions reductions in 2030 (megatonnes of CO_2 equivalent)
Buildings	31
Oil & Gas	50
Electricity	104
Heavy Industry	35
Transportation	17
Waste & Others	28
Agriculture	1
Land Use, Land Use Change and Forestry	30

Note: These projections do not include further commitments from provinces and territories.

Source: Environment and Climate Change Canada (2021) A Healthy Environment and a Healthy Economy. Environment and Climate Change Canada (2022) Canada's Greenhouse Gas and Air Pollutant Emissions Projections 2021
Link: https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/ghg-projections/2022/greenhouse-gas-emissions-projections.pdf

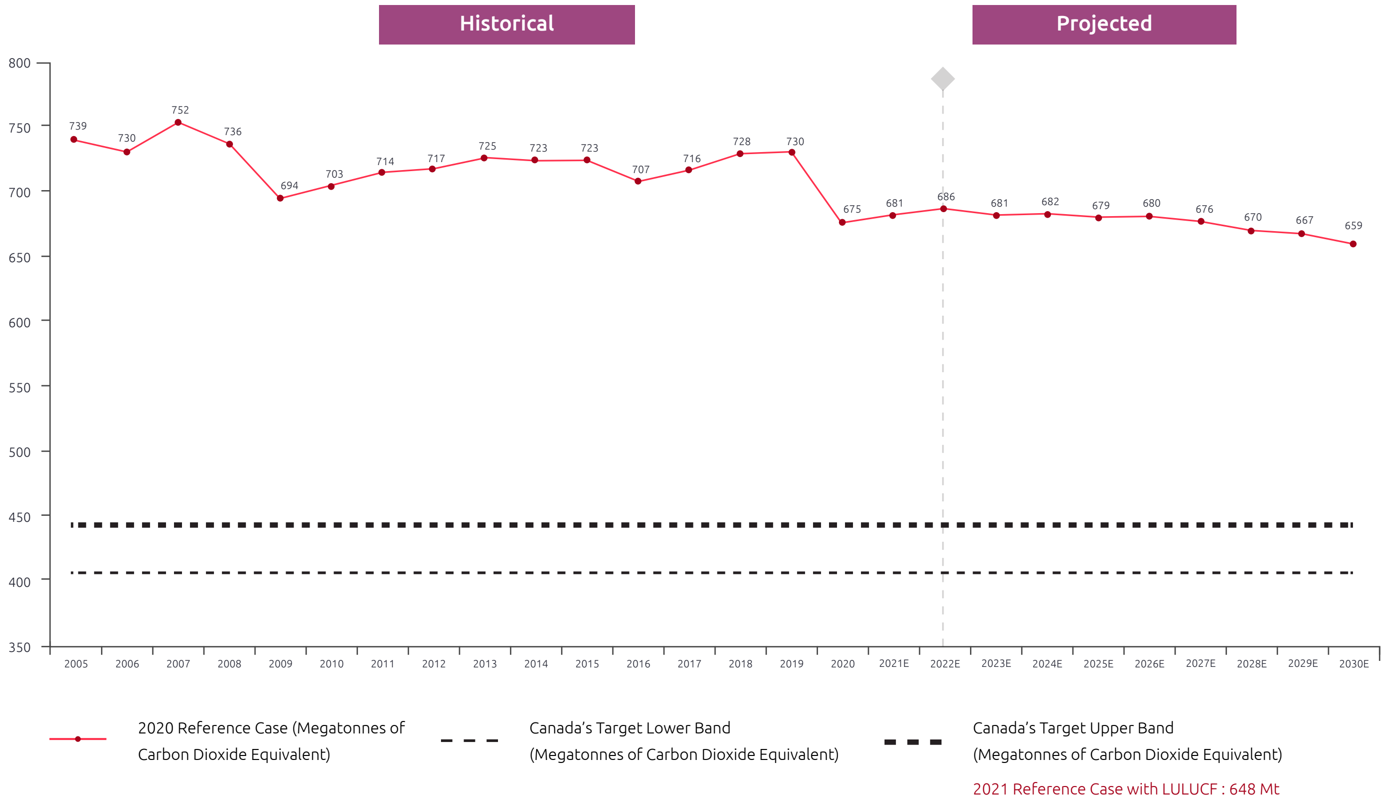
https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030/sector-overview.html#sector3

Emissions from electricity are projected to be the largest source of reduction to reach the 2030 emissions reduction goal.

- More than 80% of Canada's electricity is produced from non-emitting sources, and now the Canadian government plans to transform the remaining generation to clean sources, which will reduce GHG emissions.
- To meet Canada's 2030 emissions reduction target, the government of Canada plans to invest an additional USD $600 million in the Smart Renewables and Electrification Pathways Program to support renewable electricity and grid modernization projects.
- It will also invest USD $250 million to support predevelopment work for large clean electricity projects in collaboration with the provinces.
- To meet the 2030 emissions reduction target, the government of Canada also plans to work with provinces and utilities to establish a Pan-Canadian Grid Council to promote clean electricity infrastructure investments.

FIGURE 5

Canada: Historical GHG emissions and projections, 2005-2030 (Megatons of CO_2e)



LULUCF*: Land Use, Land Use Change and Forestry | Note: The Reference Case scenario of 2020 is the "with measures" scenario as defined by the United Nations Framework Convention on Climate Change.

Source: Environment and Climate Change Canada (2021) A Healthy Environment and a Healthy Economy. Environment and Climate Change Canada (2022) Canada's Greenhouse Gas and Air Pollutant Emissions Projections 2021
Link: https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/ghg-projections/2022/greenhouse-gas-emissions-projections.pdf

Canada carbon pricing: Canada increased its carbon taxes by 240% through its"Healthy Environment and Healthy Economy Plan"

In February 2021, the federal government launched its review of the output-based pricing system (OBPS) regulations. The consultation paper proposes an annual tightening rate of up to 2% for facilities under the OBPS from 2023 (depending on carbon leakage risk).

- The fuel charge rates are based on a carbon price of CAD $50 (USD $40)/$tCO_2e$ in 2022.
- The recent revision to the policy extended the price trajectory until 2030, with the minimum rate increasing by CAD $15 (US$ 12)/tCO_2e each year until it reaches CAD $170 (USD $136)/$tCO_2e$ in 2030.
- In March 2021, the Supreme Court of Canada gave the federal government constitutional permission to impose a carbon price on the provinces.
- In August 2021, the federal government released updates to its benchmark, which confirms the minimum national carbon prices for the period of 2023 to 2030 and strengthens the minimum national stringency criteria for carbon pricing systems in Canada.

Provinces/territories and the system that applies in each:

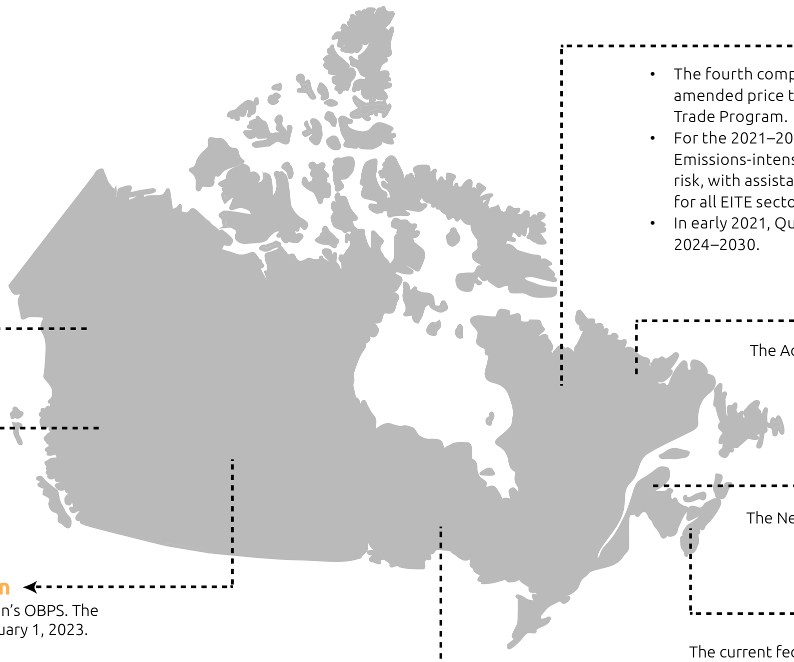
- **Newfoundland and Labrador:** Provincial carbon tax and OBPS
- **Nova Scotia:** Cap-and-trade
- **Prince Edward Island:** Provincial fuel charge, federal OBPS
- **New Brunswick:** Provincial fuel charge, provincial OBPS as of January 1, 2021
- **Quebec:** Cap-and-trade
- **Ontario:** Federal fuel charge, provincial OBPS as of January 1, 2022
- **Manitoba:** Federal backstop
- **Saskatchewan:** Federal fuel charge, provincial OBPS on some sectors, federal OBPS on others
- **Alberta:** Federal fuel charge, provincial OBPS
- **British Columbia:** Provincial carbon tax
- **Yukon:** Federal backstop
- **Northwest Territories:** Territorial carbon tax
- **Nunavut:** Federal backstop

https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work.html

FIGURE 6

Canada carbon pricing developments

Carbon pricing developments in Canadian provinces and territories



Québec

- The fourth compliance period began in January 2021 and new regulations took effect, including amended price tiers for allowances in the reserve account, to align with the California Cap-and-Trade Program.
- For the 2021–2023 period, assistance was adjusted based on each sector's carbon leakage risks. Emissions-intensive trade exposed (EITE) sectors are categorized as having low, medium, or high risk, with assistance factors of 90%, 95%, and 100% respectively. Prior to 2021, assistance factors for all EITE sectors were set at 100%.
- In early 2021, Québec also announced potential changes to the free allocation rules for the period 2024–2030.

British Columbia*

On April 1, 2021, BC's carbon tax rate rose from CAD 40 to CAD 45/tCO2e. The rate is scheduled to increase to CAD 50/ tCO2e on April 1, 2022. BC recently committed to exceeding the federal backstop rate, which is scheduled to rise to CAD 170 by 2030.

Newfoundland and Labrador

The Adjustments to carbon tax rates took effect on July 1, 2021.

Alberta

The fixed-price compliance option under the Technology Innovation and Emissions Reduction Regulation increased from CAD 40 (USD 32)/tCO2e in 2021 to CAD 50 (USD 40)/tCO2e in 2022.

New Brunswick

The New Brunswick OBPS has replaced the federal OBPS in this jurisdiction.

Saskatchewan

Changes to the federal backstop have forced a redesign of Saskatchewan's OBPS. The province is currently developing OBPS 2023, to be implemented on January 1, 2023.

Nova Scotia

The current federal approval for the province's carbon pricing system expires after 2022 and Nova Scotia is reviewing options for post-2022 carbon pricing. Nova Scotia held a public consultation in 2021, which covered carbon pricing as well as broader environmental goals and climate change policies.

Ontario

Ontario transitioned from the federal OBPS to the Ontario Emissions Performance Standards program as of January 1, 2022.

Source: State and Trends of Carbon Pricing, 2022, World Bank
Link: https://openknowledge.worldbank.org/bitstream/handle/10986/37455/9781464818950.pdf?sequence=7&isAllowed=y

North America climate performance: In 2022, the U.S. edges higher by six places, while Canada drops two places in the Climate Change Performance Index (CCPI)

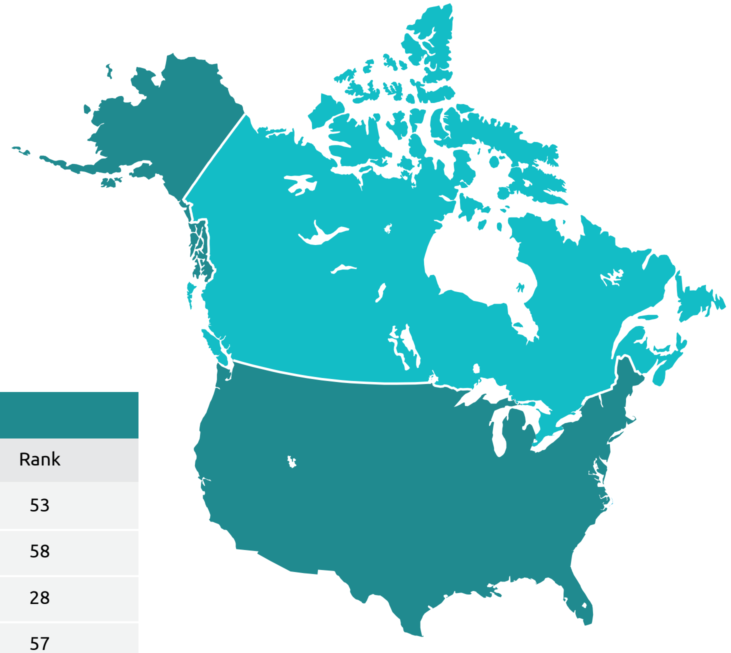
In the 2022 CCPI, the United States moves higher to the 55th position from last year's 61st ranking, but it remains lower than most developed economies.

- The U.S. slowly improves its spot at the bottom of 2022's CCPI.
- The U.S. receives very low ratings in the GHG emissions, renewable energy, and energy use categories, with a medium rating for climate policy.
- U.S. climate policies and performance is changing constantly:
  - After a loose climate policy under the Trump administration, the new Biden administration took climate change matters seriously and set a target to reduce U.S. GHG emissions by at least 50% below 2005 levels by 2030.
  - Despite the political change, the current climate policies are insufficient to deliver necessary emissions reductions.
  - The measures to achieve the 2030 GHG target and the U.S. GHG per capita are also not aligned with a well-below-2°C benchmark and consequently receive ratings of low and very low, respectively.
  - Insufficient policies on low-carbon infrastructure and power grids hamper the growth of renewable energy, which is currently rated at very low, although there has been some growth in offshore wind.
  - Despite government plans to cut fossil fuel subsidies, the absence of a coal phase-out date is a serious obstacle to achieving a zero-emissions power grid by 2035 and a net zero economy by 2050.

In 2022, Canada skips two places downward in the CCPI ranking, to 61 out of 64 positions.

- Ranked among the worst performing countries in the 2022 CCPI, Canada fell another three places since last year.
- Canada ranked below par in nearly all categories, placing 59th among greenhouse gas emitters, 54th in renewable energy and 64th in overall energy use. In climate policy, it ranked 35th, a comparatively better position.
- The prominent disparity between Canada's higher ranking on climate policy and low ranking in the other three categories used by the CCPI methodology indicates a disconnect between action and policy.

Canada	
Indicators	Rank
Renewable energy	54
Energy Use	64
Climate policy	35
GHG emissions	59



United States	
Indicators	Rank
Renewable energy	53
Energy Use	58
Climate policy	28
GHG emissions	57

https://ccpi.org/ranking/
https://ccpi.org/wp-content/uploads/CCPI-2022-Results-1.pdf
https://ccpi.org/country/usa/
https://ccpi.org/country/can/

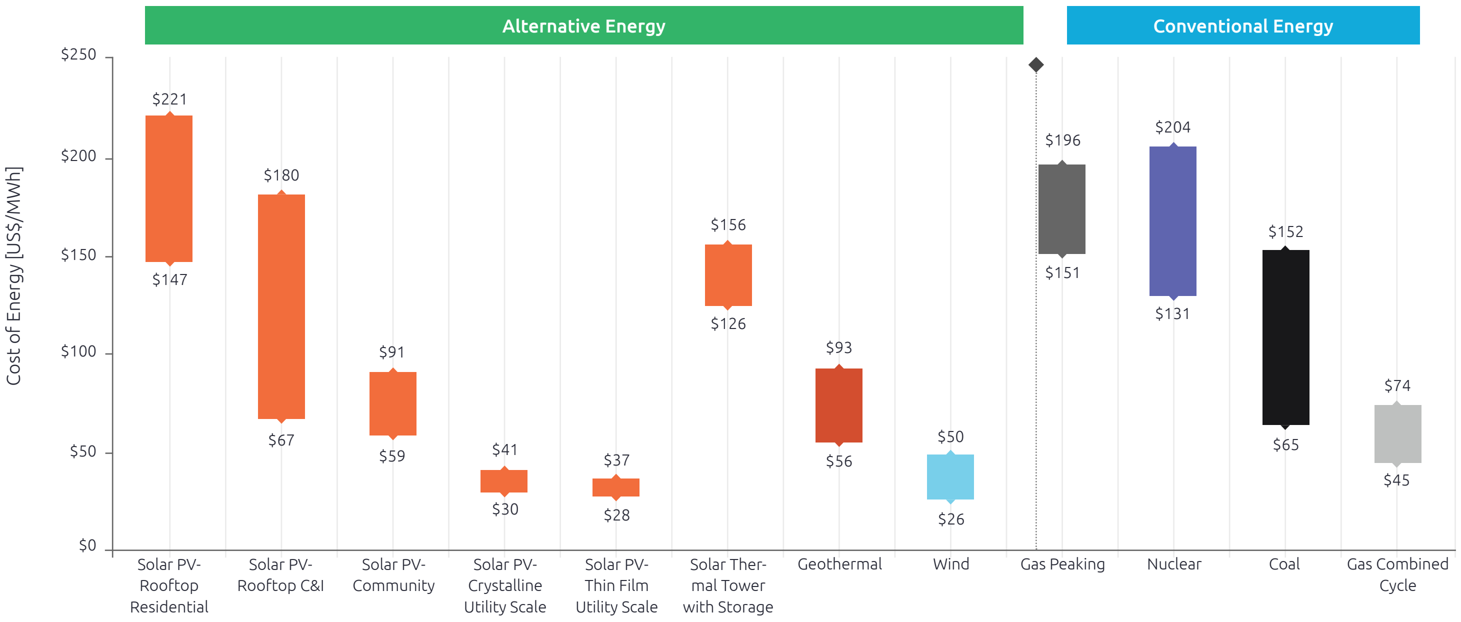
U.S. levelized cost of energy: The cost reduction for renewables continues, but at a lower rate as the industries are becoming mature

According to Lazard's Levelized Cost of Energy Analysis (LCOE) (Version 15.0) released in October 2021, solar and wind are the most affordable sources of electricity.

- Lazard's unsubsidized LCOE analysis shows, out of all considered renewable and conventional energy sources, utility-scale solar (thin-film and crystalline silicon), and wind have the lowest LCOE.
- Utility-scale crystalline silicon photovoltaic (PV) comes in at anywhere from $30 to $41/MWh.
  – Utility-scale thin-film PV ranges from $28 to $37.
- Wind registers the lowest possible LCOE over the largest range from $26 to $50/MWh.
  – However, the estimated implied midpoint of LCOE for offshore wind stands at $83, assuming a capital cost range of approximately $2,500 to $3,600/kW.
- Gas peaking comes in at $151 to $196/MWh.
  – Gas combined cycle is $45 to $74/MWh.
- Nuclear is $131 to $204/MWh.
- Coal is $65 to $152/MWh.

FIGURE 7

U.S. unsubsidized LCOE, 2021 (US$/MWh)



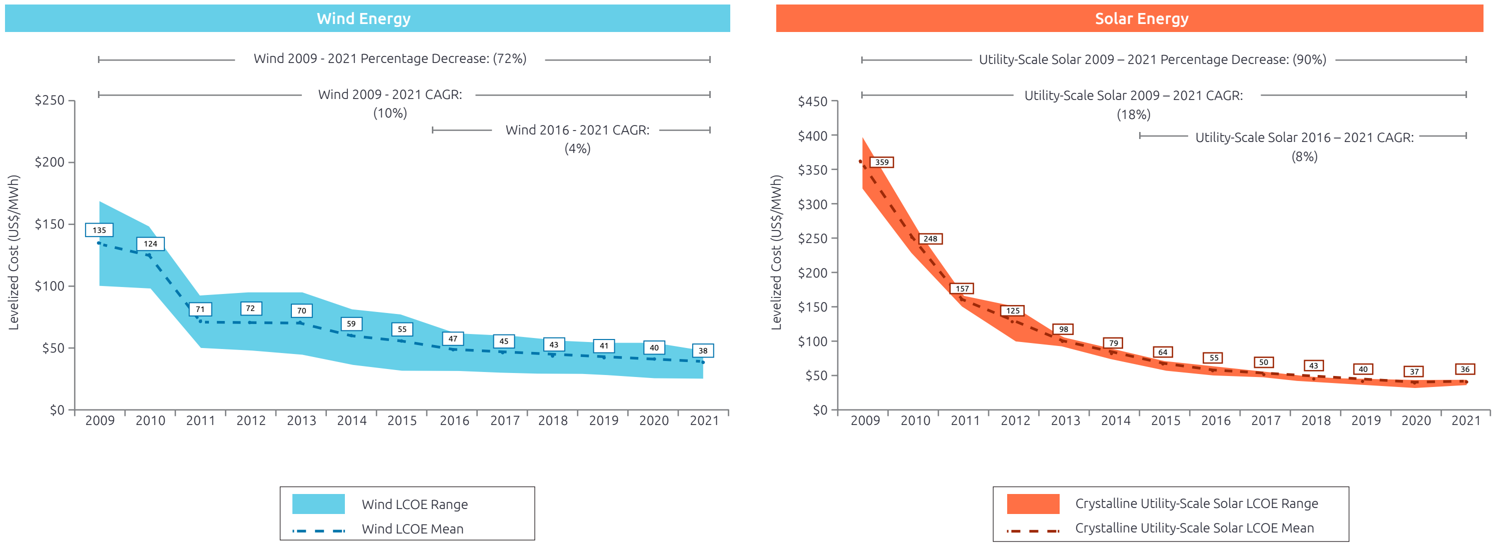
Source: Lazard - Levelized Cost of Energy, Version 15.0 (October 2021)
Link: https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf

The LCOE for wind and utility-scale solar have decreased

- The LCOE in the U.S. for generating energy from wind and utility-scale solar projects fell by 5% and 3%, respectively, over the past year.
- Costs for utility-scale solar have been falling more rapidly (about 8% per year) compared to wind (about 4% per year) over the past five years (2016-21).
- Solar energy capacity has a growth rate of more than 25% YoY since 2020 and is projected to continue growing with battery storage technology becoming cheaper over time.

FIGURE 8

U.S. historical alternative LCOE declines, 2009-2021 (US$/MWh)



Source: Lazard - Levelized Cost of Energy, Version 15.0 (October 2021)
Link: https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf

https://openknowledge.worldbank.org/bitstream/handle/10986/33809/9781464815867.pdf?sequence=2&isAllowed=y

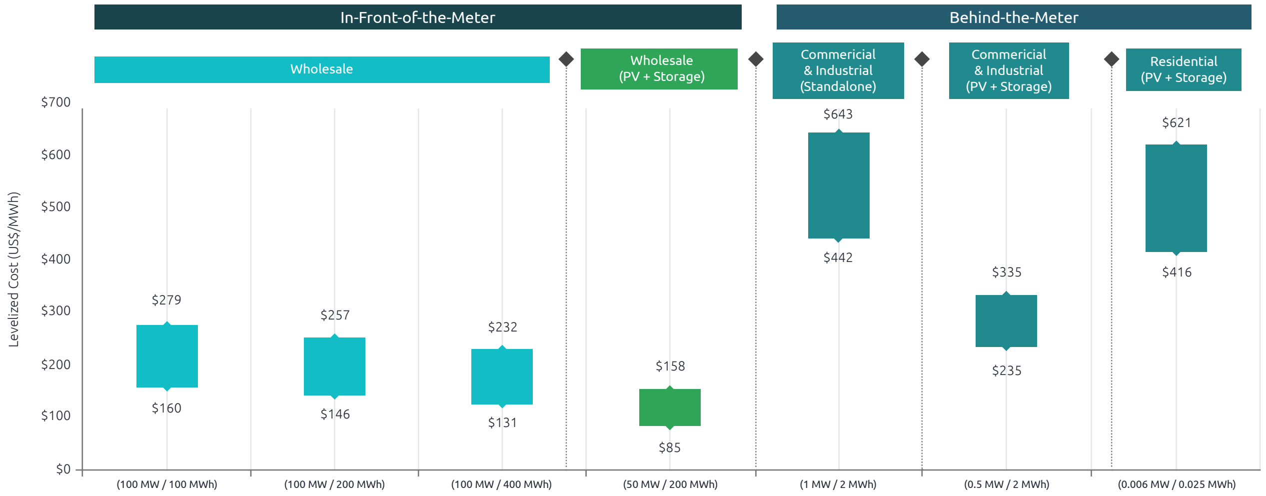
U.S. levelized cost of storage: Storage costs have gone down, especially for shorter-duration applications, mainly driven by evolving preferences in the industry regarding battery chemistry

According to Lazard's Levelized Cost of Storage (LCOS) (Version 7.0) released in October 2021, storage costs have declined across most use cases and technologies, particularly for shorter-duration applications.

- Project economics analyzed for standalone, behind-the-meter applications remain relatively expensive without subsidies.
  – However, utility-scale solar PV+ storage systems are becoming increasingly attractive.
- Interest in longer-duration technologies continues to increase with the expectation of greater penetration of renewable energy generation.
  – However, adoption remains limited as the wholesale market lacks the necessary technology and duration-specific price signals.
- Hybrid applications are becoming more valuable and, by extension, widespread as grid operators begin adopting Estimated Load Carry Capability (ELCC) methodologies which drive increasing deployment of hybrid resources (e.g., storage paired with solar) to mitigate resource intermittency.
- It is expected that storage co-located with solar will be the most attractive in the U.S. midwest and the Southwest Power Pool (SPP) region.
- Currently, developers are focusing on markets in the western U.S. (California), western Europe, and South America for long-duration storage projects, as intermittent renewable energy like solar and wind production in these areas is gaining ground in the face of declining traditional generation.
- Under the new Inflation Reduction Act of 2022, the current investment tax credit, which helped push solar and wind power to the mainstream, will be extended for ten years for projects that begin construction before 2025, including standalone energy storage with a capacity of at least 5 kWh. This will incentivize more standalone energy storage installations, driving an increased demand for battery energy storage systems.

FIGURE 9

U.S. unsubsidized LCOS, 2021 (US$/MWh)



Note: Lazard's LCOS analysis evaluates storage systems on a levelized basis to derive cost metrics based on annual energy output

Source: Lazard - Levelized Cost of Storage Analysis, Version 7.0 (2021)
Link: https://www.lazard.com/media/451882/lazards-levelized-cost-of-storage-version-70-vf.pdf

HOME

U.S. utility net zero commitments: Most U.S. utilities set their net zero targets on or before 2050

Despite U.S. power companies setting a carbon neutral goal for 2050 or before, groups tracking the utilities' progress warn that the industry is not transitioning fast enough.

Table: 1 U.S. Utility net zero commitments (1/4)

Existing net zero target	Industry	Market Cap	Climate goal	Scope 1	Scope 2	Scope 3
Duke Energy Corp.	Electric utility	79.41	Aims to reduce carbon emissions from the power side of its business by at least 50% by 2030 from 2005 levels.	Target 2050 for its power business, target 2030 for gas distribution	Not addressed*	Not addressed
Southern Co.	Electric utility	75.46	Aims to reduce its carbon emissions 50% by 2030 from 2007 levels and plans to achieve net zero carbon emissions by 2050.	Target 2050	Not addressed	Not addressed
Dominion Energy Inc.	Multi-utilities	61.68	Aims to achieve net zero carbon and methene emissions from all its electric and gas business by 2050.	Target 2050	Not addressed	Not addressed
Exelon Corp.	Electric utility	42.38	Plans to cut operations-driven emissions by at least 50% below 2015 levels by 2030, including methene from its utilities that operate natural gas distribution systems.	Target 2050	Target 2050	Not addressed
American Electric Power Co. Inc.	Electric utility	47.67	Aims to reduce carbon emissions 80% by 2030 from 2000 levels.	Target 2050	Target 2050	Not addressed
Sempra	Multi-utilities	48.14	Sempra's San Diego Gas & Electric and SoCalGas subsidiaries are committed to achieving net zero GHG emissions by 2045.	Target 2050 for Sempra, 2045 for California subsidiaries	Target 2050 for Sempra, 2045 for CA subsidiaries	Target 2050 for Sempra, 2045 for CA subsidiaries
Xcel Energy Inc.	Electric utility	36.82	Aims to reduce emissions 80% by 2030 from 2005 levels and reach net zero in both electricity and natural gas business by 2050.	Target 2050	Target 2050	Target 2050
Public Service Enterprise group Inc.	Multi-utilities	29.80	Aims to reach net zero emissions for utility operations by 2030. The goal will soon cover Scope 3 emissions as well.	Target 2030	Target 2030	Not addressed

Table: 1 U.S. Utility net zero commitments (2/4)

Existing net zero target	Industry	Market Cap	Climate goal	Scope 1	Scope 2	Scope 3
Eversource Energy	Electric utility	28.53	Aims to be carbon neutral on a companywide basis by 2030	Target 2030	Target 2030	Target 2030, limited to employee business miles
WEC Energy Group Inc.	Multi-utilities	30.46	Plans to reduce carbon emissions 80% by the end of 2030 from 2005 levels and to have a carbon-neutral electric generation fleet by 2050. Also plans to reach net zero methane emissions from its natural gas distribution system by 2030 and phase out coal generation by 2035.	Target 2050	Not addressed	Not addressed
Consolidated Edison Inc.	Multi-utilities	32.21	Plans to achieve 100% clean electricity by 2040.	Target 2040	Not addressed	Not addressed
DTE Energy	Multi-utilities	23.56	Aims to cut carbon emissions from its electric utility 50% by 2028 from 2005 levels to reach net zero emissions by 2050.	Target 2050	Not addressed	Target 2050, all emissions from suppliers and customers
PPL Corp.	Electric utility	19.97	Plans to cut emissions 70% from 2010 levels by 2035 and to reach net zero by 2050.	Target 2050	Target 2050	Not addressed
Edison International	Electric utility	23.24	Plans to cut GHG emissions 40% by 2030 below 1990 levels, and to deliver 100% carbon free by 2045.	Target 2045	Target 2045	Not addressed
Ameren Corp.	Multi-utilities	22.20	Aims to achieve net zero carbon emissions by 2050. Its interim targets are a 50% carbon reduction by 2030 below 2005 levels.	Target 2050	Not addressed	Not addressed
Entergy Corp.	Electric utility	22.07	Aims to reduce its emissions rate by 50% by 2030 from 2000 levels and to achieve net zero emissions by 2050.	Target 2050	Not addressed	Target 2050, including both electricity and gas business
FirstEnergy Corp.	Electric utility	21.55	Plans to reduce 30% of GHG emissions by 2030 from 2019 levels and to achieve carbon neutrality by 2050.	Target 2050	Not addressed	Not addressed
PG&E Corp.	Electric utility	26.37	Plans to cut GHG emissions 40% by 2030 from 1990 levels and to reach carbon neutrality by 2045.	Target 2045	Target 2045	Target 2045

Table: 1 U.S. Utility net zero commitments (3/4)

Existing net zero target	Industry	Market Cap	Climate goal	Scope 1	Scope 2	Scope 3
Avangrid Inc.	Electric utility	17.37	Aims to lower its emission intensity 35% by 2025 from 2015 levels and to be carbon neutral by 2035.	Target 2035	Not addressed	Not addressed
CMS Energy Corp	Multi-utilities	18.56	Plans to reach net zero emissions from its electricity fleet by 2040, and by 2030 for natural gas distribution business.	Target 2040 for its electricity business, target 2030 for natural gas distribution	Target 2040	Target 2040 for selected categories such as PPA
CenterPoint Energy Inc.	Multi-utilities	18.51	Aims to reach net zero for Scope 1 and 2 emissions by 2035 and reach 20-30% reduction in natural gas usage the same year.	Target 2035	Target 2035	Not addressed
Evergy Inc.	Electric utility	14.51	Plans to reduce carbon emissions 70% by 2030 from 2005 levels and to reach net zero by 2045.	Target 2045	Not addressed	Not addressed
Alliant Energy Corp.	Electric utility	14.17	Plans to reduce carbon emission from its power generation 50% by 2030 from 2005 levels and net zero emissions by 2050.	Target 2050	Not addressed	Not addressed
NRG Energy Inc.	Electric utility	8.50	Aims to achieve a 50% reduction in GHG emissions by 2025 from 2014 levels and to reach net zero emissions by 2050.	Target 2050	Target 2050	Target 2050 for employee business travel
UGI Corp.	Gas utility	8.59	Aims to reduce emissions from its operations by 55% by 2025 below 2020 levels and achieve net zero emissions by 2050.	Target 2050	Not addressed	Not addressed
Pinnacle West Capital Corp.	Electric utility	7.88	Plans to achieve 100% carbon-free electricity by 2050. Also aims to have renewable generation account for 45% of its resource mix by 2030.	Target 2050	Target 2050	Not addressed
NextEra Energy Inc.	Electric utility	153.78	Aims to reduce its carbon emissions rate 67% by 2025 from 2005 levels, roughly equivalent to a 40% reduction in absolute emissions.	N/A	N/A	N/A

Table: 1 U.S. Utility net zero commitments (4/4)

Existing net zero target	Industry	Market Cap	Climate goal	Scope 1	Scope 2	Scope 3
Atmos Energy Corp.	Gas utility	15.52	Has a goal to reduce methene emissions by 50% from 2017 to 2035 from its distribution system mains and services.	N/A	N/A	N/A
NiSource Inc.	Multi-utilities	11.47	Plans to reduce GHG emissions by at least 90% by 2030 and methene emissions from pipelines by 50%, both from 2005 levels. Plans to phase out all coal generation by 2028.	N/A	N/A	N/A
OGE Energy Corp.	Electric utility	7.68	Plans to reduce company-wide carbon emissions 50% below 2005 levels by 2030 and retire 95% of its coal fleet by 2050.	N/A	N/A	N/A

- All major U.S. utilities have set their net zero emissions targets:
  - With growing pressure from investors and state climate mandates, the power industry continues to close coal-fired plants and ramp up investments in renewable energy sources.
- But in the absence of national clean energy mandates, many utilities are already falling behind their newly-minted climate goals.
- U.S. power plant carbon emissions in 2020 declined 40% since their peak in 2006 – suggesting a shift to clean energy is already happening.
- Only four utilities (Public Service Enterprise Group Inc., Eversource Energy, CenterPoint Energy Inc., and Avangrid Inc.) have promised to decarbonize their operations by 2035, the target year the Biden administration set for the industry.

Source: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/path-to-net-zero-progress-by-us-utilities-too-slow-67951606

U.S. carbon pricing: Most carbon pricing developments in the U.S. are taking place on the subnational level

Carbon pricing developments are happening in California, Hawaii, Massachusetts, Oregon, Pennsylvania, and Washington through the Regional Greenhouse Gas Initiative (RGGI) and the Transportation and Climate Initiative Program.

Table: 2 Summary of recent developments in key carbon pricing initiatives in various U.S. states (1/2)

Jurisdiction	Key developments
California	• California's Cap-and-Trade Program is one of the key policies aimed at reducing state-wide GHG emissions to 40% below 1990 levels by 2030. In 2017, the legislature extended the state's Cap-and-Trade Program from 2020 to 2030 with the passage of Chapter 135 of 2017 (AB 398, E. Garcia). • On May 10, 2022, California Air Resources Board (CARB) released its updated Draft 2022 Scoping Plan. The 2022 Scoping Plan focuses on the technologically feasible and cost-effective approaches to achieve the GHG target of the state. To achieve both the 2030 GHG target and carbon neutrality, the CARB presents four alternative scenarios backed by extensive modeling, out of which CARB staff recommended alternative three as the proposed scenario, which aims to achieve carbon neutrality by 2045. • The alternative three closely align with existing statutes and executive orders on GHG reduction and employs a broad portfolio of existing and emerging fossil fuel alternatives and clean technologies.
Hawaii	• Hawaii's climate change policies are being coordinated under the state's Climate Change Mitigation and Adaptation Commission as mandated by Act 32, Session Laws of Hawaii 2017. One option being considered is carbon pricing. • Carbon tax bills were introduced in the 2020, 2021, and 2022 (HB2278, SB2732) sessions, though they have not passed. • The State Energy Office, a member of the commission, released a carbon tax study in February 2021. The report modeled different policy packages to assess the impact on emissions; it considered revenue recycling options to address the distributional impacts of carbon price.
Massachusetts	• In 2020, the Massachusetts Limits on Emissions from Electricity Generators system reduced the share of allowances distributed through a free allocation from 75% to 50%. After an adjustment to account for bank allowances, the remainder was distributed via auctions. The system assumed full auctioning in 2021 • In 2021, Massachusetts finalized a new climate program establishing climate targets for 2030. In 2022, the total amount of emission allowances is fixed at eight $MtCO_2e$ (ETS only).
Oregon	• In December 2021, the Environmental Quality Commission (EQC) adopted the Climate Protection Program (CPP) rules, which began in January 2022. The CPP places a cap on GHG emissions from local distribution companies like suppliers of liquid fuels and propane and natural gas utilities. • The annual cap on emissions from covered fuel suppliers will be based on average 2017-2019 reported emissions. For 2022, the sectoral cap on emissions for covered fuel suppliers will be 28.2 $MtCO_2e$. By 2035, the cap will decline to 15.0 $MtCO_2e$ and by 2050 to 3 $MtCO_2e$.

Table: 2 Summary of recent developments in key carbon pricing initiatives in various U.S. states (2/2)

Jurisdiction	Key developments
Pennsylvania	• In May 2021, Pennsylvania's Department of Environmental Protection released its final draft CO_2 Budget Trading Program. The proposed regulation is largely consistent with the system design features of the Regional Greenhouse Gas Initiative (RGGI) Model Rule. The start date for Pennsylvania's ETS and its linkage to RGGI is expected to be in 2022. • It is estimated that Pennsylvania's power sector will emit approximately 40.2% of emissions covered under RGGI when the state becomes a part of the program. Therefore, Pennsylvania's inclusion would significantly increase the size of RGGI's carbon market.
Washington	• In May 2021, Governor Jay Inslee signed the Climate Commitment Act (CCA) into law, which launched an economy-wide cap-and-invest program beginning in January 2023. • The cap aligns with the state's legislated greenhouse gas emission limits – covering industry, energy, and fuel suppliers with emissions over 25,000 tCO_2e/year. • The Washington Department of Ecology is the administrative authority for the program and will adopt annual allowance budgets to be distributed through a combination of auctions (held as often as quarterly) and free allocation.
Regional Greenhouse Gas Initiative (first multi-state cap-and-trade program for carbon emissions in the U.S.)	• The final regulation to establish an ETS in Pennsylvania covering CO_2 emissions from the power sector and to join RGGI was released in May 2021. Pennsylvania's share of emissions in the 2022 RGGI cap is approximately 45%. • An emissions containment reserve (ECR) began operating in 2021. It is an automatic adjustment mechanism that adjusts the cap downward when carbon prices are lower than expected. • On February 2, 2021, RGGI states also announced a plan for a third program review to analyze program successes, impacts, potential additional reductions to the cap post-2030, and other design elements. The review is expected to be concluded in 2023..
The Transportation and Climate Initiative Program (a regional collaboration of 13 Northeast and Mid-Atlantic States and the District of Columbia)	• In June 2021, four participating jurisdictions – Connecticut, Massachusetts, Rhode Island, and Washington D.C. – published a final Model Rule for the implementation of the TCI-P; reporting emissions and fuel shipment data under the program is scheduled to start in 2022. The program puts a cap on CO_2 emissions from gasoline and on-road diesel fuel. However, in H22021, most of these states stopped participating in the proposed TCI-P. • According to the final memorandum of understanding (MOU), TCI-P's first compliance period will begin on or after January 1, 2023, as at least three jurisdictions have completed the necessary legal processes to implement their individual programs. Following recent developments, it is unlikely that the implementation of TCI-P will continue in its current form.

Source: https://carbonpricingdashboard.worldbank.org/map_data

U.S. renewable energy capacity: Wind and solar have accounted for more than 99% of the new additions in renewable energy capacity in the last year

In 2021, the U.S. renewable energy capacity additions set another new record with a total of 37 GW, largely from solar and wind installations.

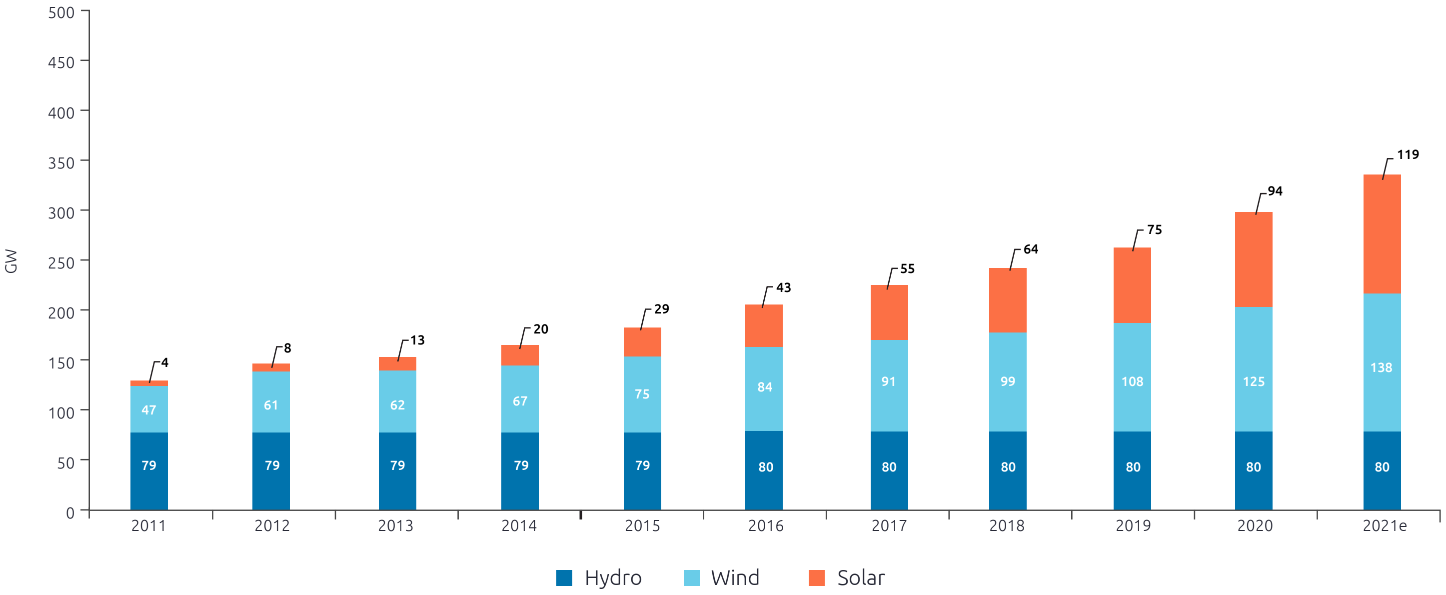
- Wind and solar hold more than 99% of total new renewable capacity additions for 2021, while biomass, geothermal and new hydro capacity additions totaled just under 80 MW.
- In 2021, solar posted another successful year with a record addition of 24.2 GW, 30% larger than at the end of 2020.
  - For the third year in a row, solar accounted for the largest share of new capacity added to the U.S. grid.
  - Growth would have been more, but many projects were delayed due to supply chain constraints; hence continued growth is expected in 2022 and beyond.
- The Covid-19 pandemic positively impacted the wind build in 2021.
  - Due to tight supply chains or lockdown-related delays, some projects scheduled for completion in 2020 were pushed back to the following year.
  - The good part for the developers was the IRS allowed projects to receive tax credits even if they didn't achieve commissioning until 2021.
  - Finally, 2021 was the third biggest year ever for wind build.

In 2021, drought conditions in California and the Northwest pushed hydro generation to fall from the previous year's 35% to 29% of total renewable output.

However, during the evening rush hour in California, hydropower output rose to 10% of total generation.

FIGURE 10

U.S. cumulative renewable energy capacity, 2011-2021 (GW)



Source: BNEF ~ Sustainable Energy in America Factbook, 2022
Link: http://www.bcse.org/factbook/#
https://openknowledge.worldbank.org/bitstream/handle/10986/33809/9781464815867.pdf?sequence=2&isAllowed=y

Supply chain headaches also defined 2021.

- Global shipping networks were disrupted after the worldwide lockdown, with several parts unable to reach destinations due to lack a of ships, port lockdowns, or labor shortages and delays.
- Workers were also in short supply in 2021 and raised the cost of engineering, procurement and construction (EPC) contracts.

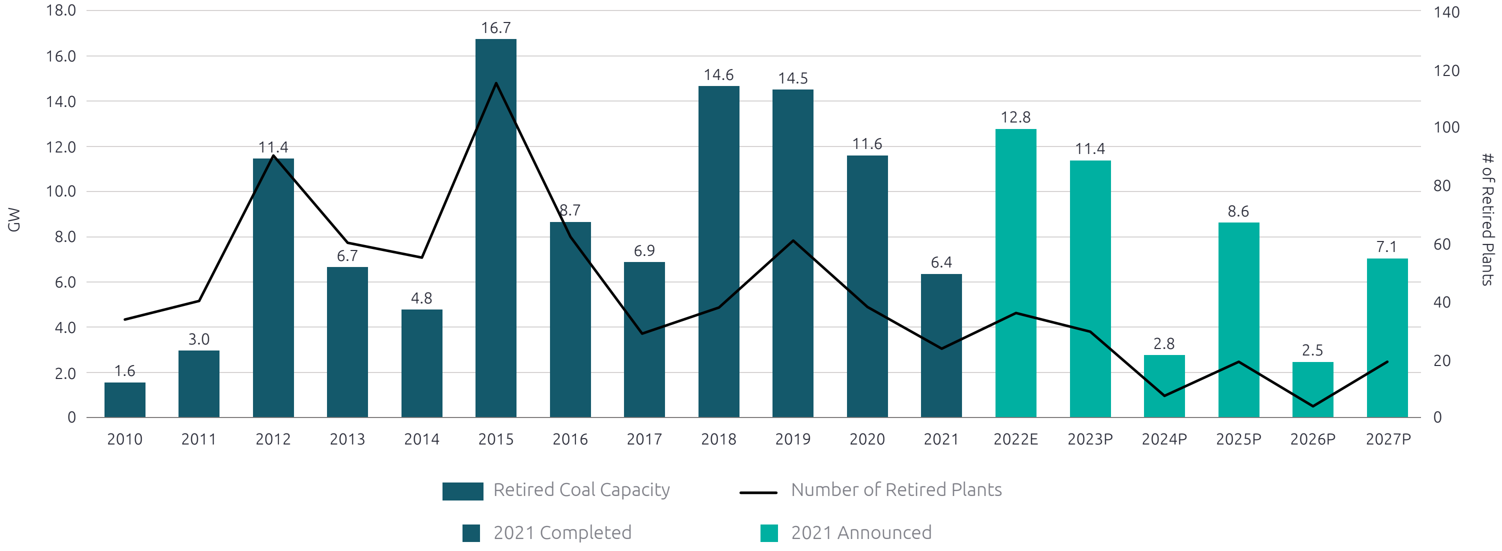
U.S. coal-fired plant retirements: U.S. coal-fired generating capacity is set to take a continuous plunge in the coming years in advance of tough environmental rules

According to EIA, coal-fired plants will account for about 85% of total U.S. power capacity scheduled for retirement this year (2022), with natural gas and renewables taking a greater share of the supply.

- As of January 2022, there were 240 operational coal-fired power plants in the U.S.
- U.S. power plant operators were scheduled to retire about 12.8 GW of coal-fired generating capacity in 2022 out of the total 14.9 GW capacity set to be retired.
- The largest coal power plant scheduled to go out of service in 2022 is the 1,305 MW William H. Zimmer plant in Ohio.
- The reduction in the cost of wind and solar generation along with low natural gas prices left coal power a high-priced, higher-emissions source of electricity.
- Under price pressure from renewable generation and national interest in low-emission fuels, utilities plan to shutter 45 GW of coal power from 2022 through 2027, as per EIA data.
- However, even in states where these factors are less prevalent, utilities are announcing plans to retire coal in favor of lower-cost natural gas, renewables, and energy storage.

FIGURE 11

U.S. completed and announced conventional steam coal plant retirements (GW)



Source: EIA Electric Generator Inventory, 2022
Link: https://www.eia.gov/electricity/data/eia860m/

Coal plant operators are still looking for new technology to sustain coal-fired generations

- Coal plant operators are hoping for carbon capture technology, which would become cheap enough to allow them to burn coal with much lower carbon emissions, but the technology has not yet been sufficiently established.

https://www.statista.com/statistics/859266/number-of-coal-power-plants-by-country/

U.S. battery storage: Expansion of battery storage application beyond ancillary services fueled the growth in 2021 3X

As per the EIA 2021 early release, U.S. energy storage capacity tripled in 2021.

- In 2021, battery storage capacity in the United States increased from 1,438 MW in 2020 to 4,631 MW.
- The growth was driven by the addition of 3,202 MW of capacity through 106 utility-scale batteries commissioned for commercial operation.
  - About 78% of battery storage capacity added in 2021 was built in regional transmission organizations (RTOs) service areas, consistent with historical averages.
- Grid-scale projects were the major part of the installations.
- But private and residential projects also contributed 436 MW due to rising demand in regions that suffer from unstable power, including California, Puerto Rico, and Texas.
- EIA noted the expansion of the storage use cases is the primary reason for this growth.
  - Since 2016, batteries have been used to provide ancillary services, but arbitrage, load management, and the consumption of excess renewable generation applications saw significantly increased levels of participation.
- Utility-scale storage capacity in the U.S. was less than 500 MW in 2016 but falling battery prices have helped the storage projects to grow.
  - But that trend may be reversing, as the BloombergNEF report expects the global battery prices to rise slightly this year (2022), to an average of $135/kWh.
  - The rising cost of metals (like lithium, cobalt, and nickel) and supply chain constraints are behind the rise in price, compounded with Covid-19 supply chain constraints.
- The continued expansion of grid-connected solar and wind capacity creates commercial opportunities for battery storage as a major resource and as an ancillary service.
  - More than 93% of battery capacity that went online in 2021 was co-located with solar, reaching 1,086 MW of capacity and reflecting continued industry growth in combined renewable and storage capacity.
- Most projects completed in 2021 were lithium-ion battery systems with two to four hours of energy storage capacity.

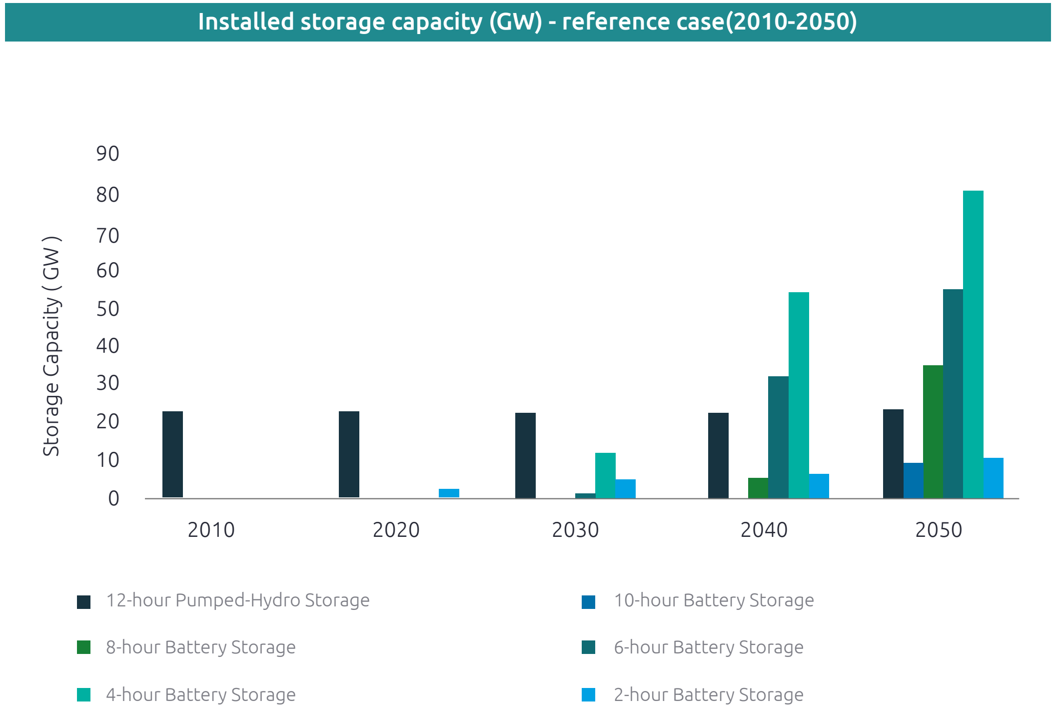
As per Wood Mackenzie's forecast, U.S. energy storage market capacity is expected to reach 54.9 GW (cumulative) by 2026.

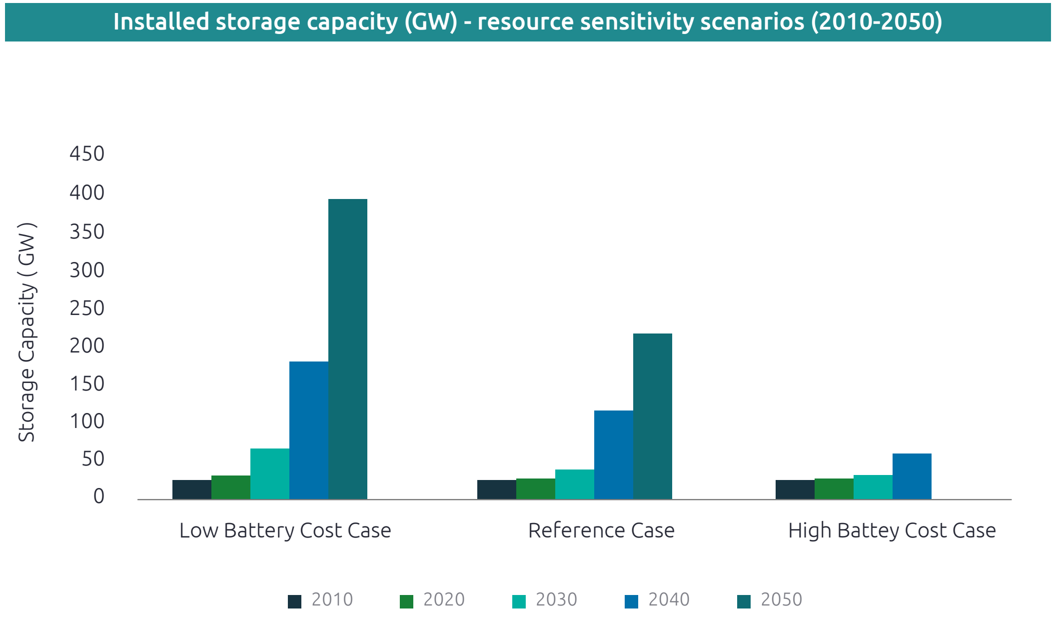
- The grid-scale market will not show significant movement in the short term.
  - Market disruptions from anti-dumping and countervailing duties (AD/CVD) on solar tariff petitions significantly reduce hybrid project estimates in 2022, and to a lesser extent in 2023, even after the two-year moratorium on solar tariffs announced by President Biden.
- The residential segment is expected to grow to 2.1 GW/5.7 GWh annually in 2026.
  - Residential forecasts assume that CA's NEM 3.0 will be in-line with the California Public Utilities Commission (CPUC) December 2021 NEM 3.0 proposed decision, which is now expected to be implemented on a delayed timeline.
  - The delay produces solar forecast upside but slightly lowers the CA storage forecast because storage pairing rates will not increase until 2023-2024.
- Non-residential storage will near 1 GW annually in 2026.
  - The non-residential forecast for 2022 has been downgraded due in part to AD/CVD-related procurement delays.
  - A meaningful share of residential solar-plus-storage projects that had not yet procured solar equipment will be pushed to 2023, impacting paired storage.

https://cleanpower.org/resources/u-s-energy-storage-monitor/

FIGURE 12

U.S. battery storage





Source: Storage Futures Study
Link: https://www.nrel.gov/news/program/2021/grid-scale-storage-us-storage-capacity-could-grow-five-fold-by-2050.html

U.S. Oil & Gas operators: Securing the license to operate

Focusing on GHG emissions related to their own activity

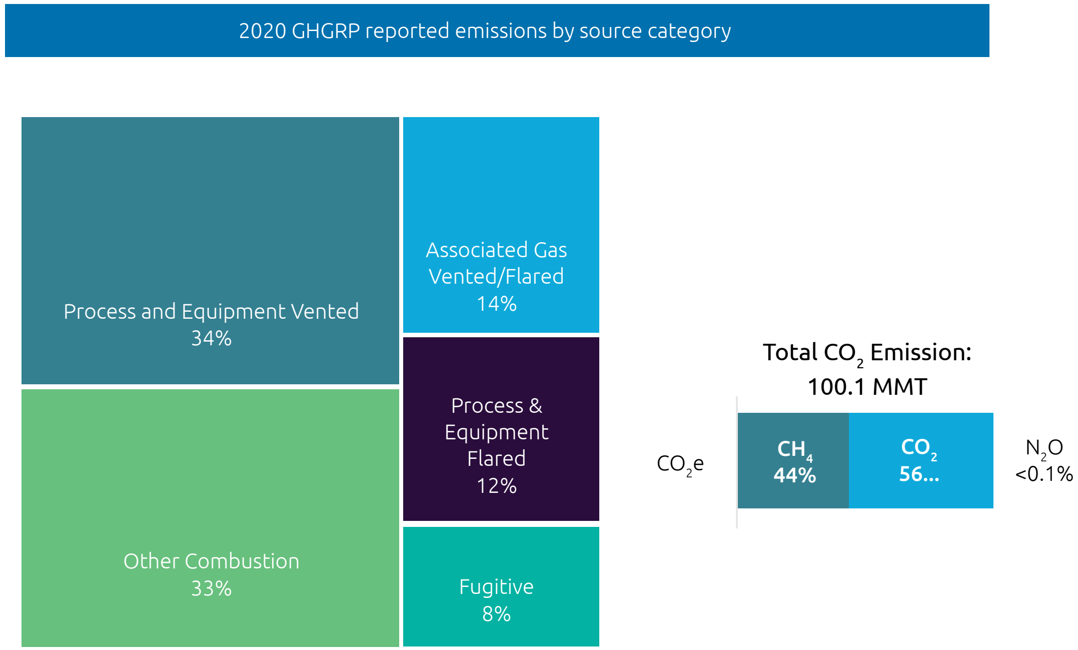
- In October 2021, the U.S. EPA released 2020 GHG data for all Oil & Gas companies collected under the Greenhouse Gas Reporting Program (GHGRP). As per the data, in 2020, a total of 2,377 facilities conducting Oil & Gas activities (production to distribution) accounted for GHG emissions of 316 million $MtCO_2e$, which represents 12.1% of total GHG emissions reported to the GHGRP.
- GHG emissions only from production activity accounted for 100.1 MMT of CO_2e. Four energy companies – Exxon Mobil, ConocoPhillips, Hilcorp, and Occidental Petroleum – were the top sources of both greenhouse gas emissions in general and methane emissions in the U.S.
- A report by Clean Air Task Force, based on the EPA's GHGRP data, grouped the emission sources into five categories (Figure 13), out of which process and equipment vented sources are responsible for the highest (34%) GHG emissions.
  - Out of all other equipment vented alternatives, pneumatic controllers were the largest source of reported production methane emissions, accounting for 62% of total emissions.

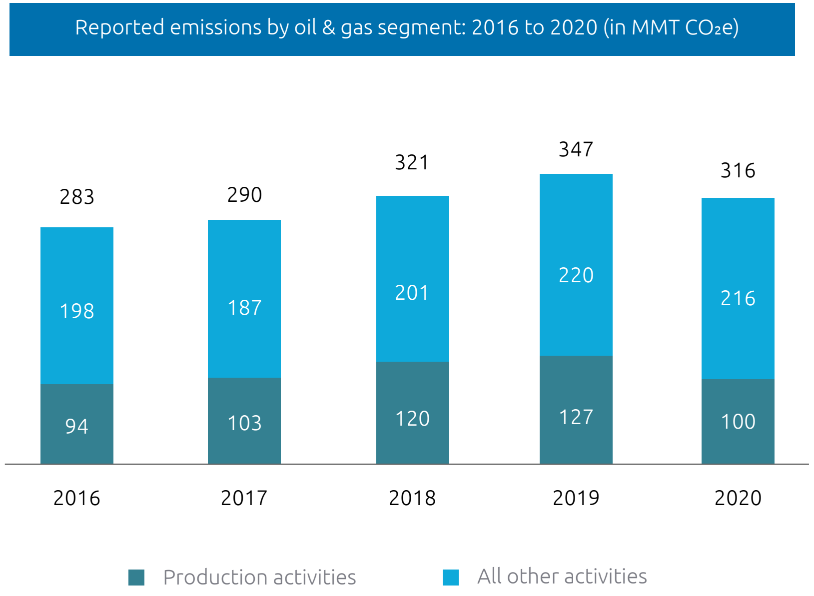
- **Government initiative:** At the end of 2021, the EPA proposed new methane regulations for Oil & Gas companies that would limit emissions of methane from the facilities.
  - As per the EPA projection, the regulation, once in action, will eliminate 41 million tons of methane emissions, equivalent to 920 million metric tons of carbon dioxide, between 2023 and 2035.
- **Company level initiatives:** To reduce GHG emissions in the production process, Oil & Gas operators are focusing on two main aspects: reducing GHG emissions related to their own energy consumption and minimizing methane leakages. Below are the instances from the highest GHG producers:
  - ExxonMobil plans to invest to further reduce scope 1 and 2 GHG emissions from its operations as a move towards its net zero by 2050 commitment.
  - Hilcorp successfully reduced emissions intensity by approximately 37% from 2019 to 2020.
  - Occidental Petroleum is aiming to invest up to $1 billion to provide services and technologies that pull CO_2 out of the air and bury it underground.
  - ConocoPhillips in the Bakken is working to implement several MACC (marginal abatement cost curve) projects aimed at reducing routine flaring.

https://thehill.com/policy/energy-environment/3559506-four-companies-are-top-sources-of-us-green-house-gas-methane-emissions-report/

FIGURE 13

U.S. oil & gas operators: GHG emissions from production activity





Source: Benchmarking Methane and Other GHG Emissions (2022) by Clean Air Task Force, US EPA
Link: https://www.ceres.org/sites/default/files/reports/2022-07/OilandGas_BenchmarkingReport_2022%20%281%29.pdf
https://www.epa.gov/system/files/documents/2021-10/subpart_w_2020_sector_profile.pdf

Reducing GHG emissions related to their own energy consumption

Electrification:

- In order to reduce GHG emissions, Oil & Gas operators are planning to electrify their operations with low-carbon power, like renewable powers, hydrogen, natural gas with carbon capture and storage (CCS), or other emerging technologies.
- Major U.S. Oil & Gas companies are heavily investing in renewable energy by either developing projects or signing power purchase agreements (PPAs) with the project developers.
  - In 2018, ExxonMobil added 500 megawatts of wind and solar from Danish renewable energy company Orsted. Another U.S. Oil & Gas giant Chevron, signed its own 500 MW project, with the energy generation to be split between the Permian, Argentina, and Kazakhstan.

Digitalization:

- In addition to a net reduction in GHG emissions from electrification, the Oil & Gas industry is anticipated to track and improve the energy used for hydrocarbon extraction and transformation.
- Energy management systems and digital twins are becoming a standard for assets management of Oil & Gas companies. Digital twins play a key role in monitoring GHG emissions and environmental impact, enabling scope 1 optimization.
- Digital twins in the Oil & Gas Industry:
  - Digital twins enable process optimization, simultaneous risk management, analytics of the health of assets, and “what if” scenario planning; they can also be used to detect faults.
  - Digital twins help Oil & Gas companies by providing information that improves productivity and environmental performance by integrating sustainability elements when optimizing production, minimizing energy use, and reducing emissions.
  - It provides a platform to help companies achieve their net zero commitments by reducing emissions from conventional energy sources and improving the economic viability of low-carbon energy.
  - It also provides transparent emissions reporting, which enables better investor environmental social and governance (ESG) analysis and improved shareholder value.

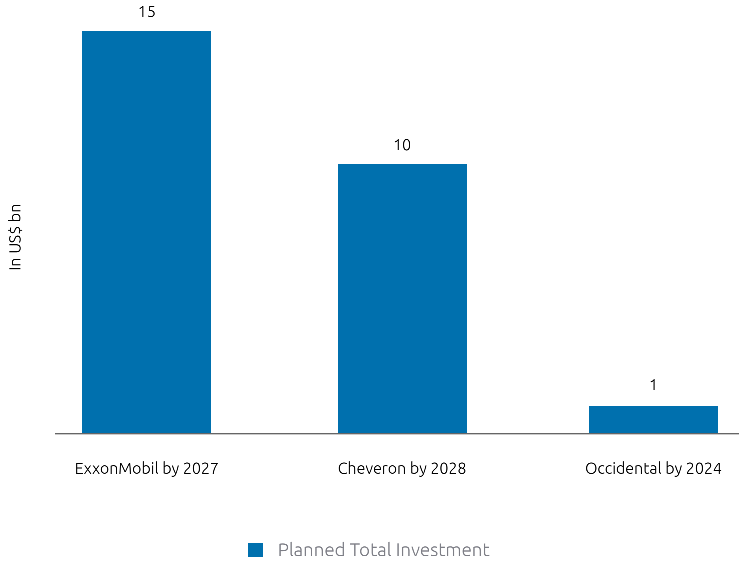
Entering new business: Renewables

Oil & Gas majors are expanding their businesses into the renewable energy sector.

- Among technologies that Oil & Gas companies seem particularly well-suited to capitalize on are biofuels, offshore wind, hydrogen, and CCUS.
- To preserve the current business model, American Oil & Gas companies are heavily focusing on **carbon capture technology.**
  - Eleven Oil & Gas companies are planning for a large-scale carbon capture and storage hub in the Houston industrial area, which is expected to capture about 100 million metric tons of CO_2 annually from refineries, chemical plants, and power generation facilities in the area by 2040.
  - U.S. shale major, Continental Resources, plans to invest $250 million in a large carbon capture and sequestration (CCS) project, targeting more than two dozen ethanol producers in the U.S. Midwest.
  - ExxonMobil has also announced $3 billion in carbon capture investments over the next five years.
- **Biofuels & hydrogen** reduce greenhouse gas emissions from commercial transportation, an important alternative for a lower-carbon future.
  - ExxonMobil is investing $125 million in Global Clean Energy, a producer of camelina, to advance its renewable diesel production.
  - Chevron invested $3.15 billion to acquire Renewable Energy Group (REG), a producer of bio-based diesel.
  - Chevron plans to invest around $2.5 billion in hydrogen and grow hydrogen production to 150,000 tons annually, whereas ExxonMobil produces around 1.3 million metric tons of hydrogen annually.
- With decades of offshore engineering, manufacturing, and installation know-how, offshore Oil & Gas companies are focusing more on **offshore wind** to make core activities more sustainable.
  - U.S. oil major Chevron invested in offshore wind power after signing a deal with Norway's Moreld to help develop the turbine technology of tech firm Ocergy.
  - In comparison to U.S. oil firms, European oil firms are more aggressive in investing in offshore wind in the U.S.
  - Three European oil giants, Equinor, BP, and Royal Dutch Shell, are outbidding renewable developers to capture the untapped U.S. offshore wind market.

FIGURE 14

Planned investment in clean energy by the US oil & gas majors



Source: Secondary Search
Link: https://corporate.exxonmobil.com/News/Newsroom/News-releases/2021/1201_ExxonMobil-announces-plans-to-2027-doubling-earnings-and-cash-flow-potential-reducing-emissions ; https://www.rechargenews.com/energy-transition/chevron-to-invest-2-5bn-in-green-and-blue-hydrogen-by-2028-reveals-senior-executive/2-1-1240852

https://corporate.exxonmobil.com/News/Newsroom/News-releases/2021/1109_Why-we-are-investing-15-billion-in-a-lower-carbon-future

CHINA EMISSIONS, CARBON TAXES, RENEWABLES AND ENERGY EFFICIENCY MEASURES

ALEXANDRA BONANNI
SWETANTA LAHIRI
NUPUR SINHA

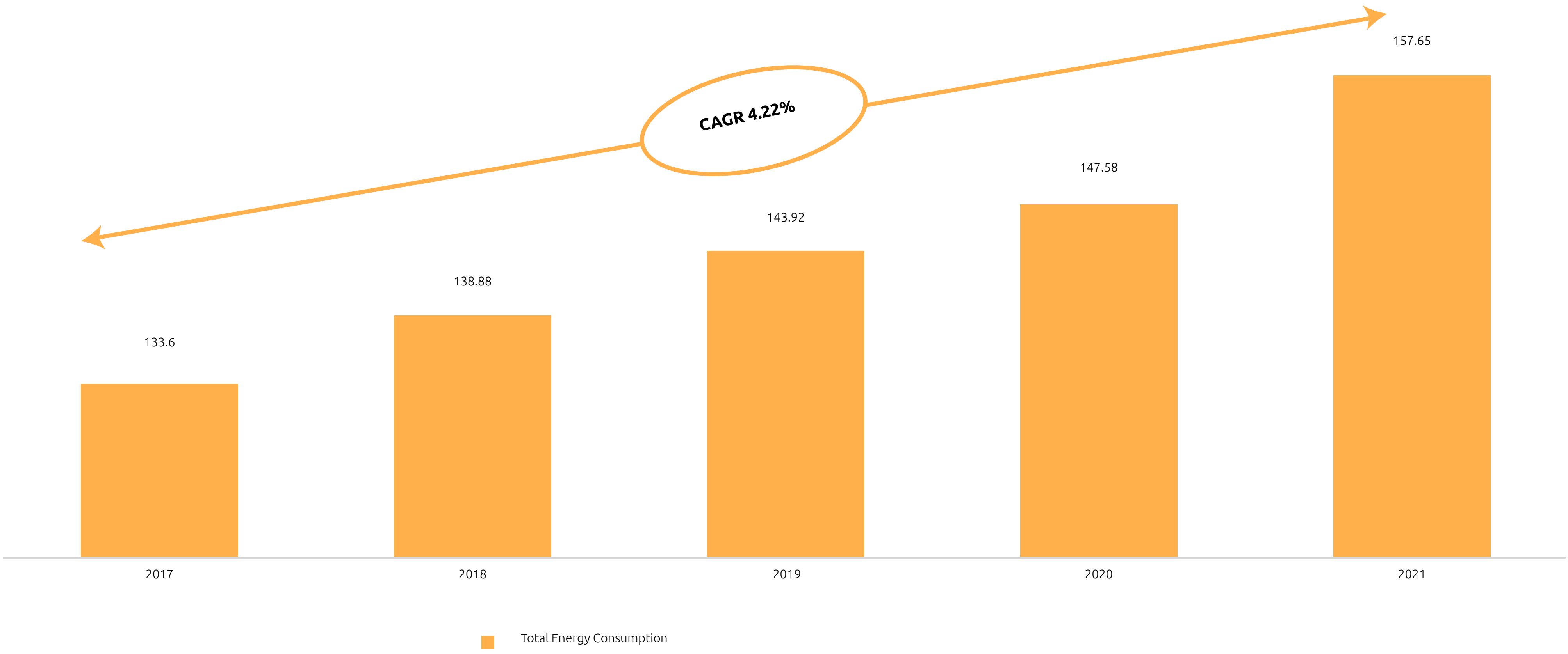
China: The country's emergence from the Covid-19 pandemic has increased demand for electricity, leading to an increase in consumption

In 2021, demand for electricity in China grew by 10% compared to 2020. Total primary energy consumption in exajoules (EJ) has grown at a CAGR of 4.22% between 2017-2021. Energy consumption increased by 6.8% in 2021 compared to 2020.

- Electricity demand rose as Covid-19 restrictions were eased, leading to a rise in industrial activities.
- In terms of total primary energy consumption by fuel, coal has occupied an important position in 2020 and 2021, contributing around 56% and 54.65% respectively.
- China experienced the biggest growth in coal usage in 2021 since 2011.
- According to the National Bureau of Statistics (NBS), China has been the world's largest coal burner, using 5.24 billion tonnes of standard coal in 2021, an increase of 5.2% from 2020.
- In 2022, the consumption of power is expected to rise by approximately 5-6%.
- The end of uncertainties around the Covid-19 pandemic and the rise in temperatures are the two main factors responsible for the increase in power consumption.
  - According to the Chinese government, heat waves have hit different parts of China since June 2021.
  - China's national observatory has issued an alert for high temperatures in 12 provinces and regions.
  - Some regions like East China's Shandong Province and North China's Hebei Province are expected to reach over 400 Celsius.
- In the first half of 2022, power consumption was expected to increase by 3.5-4.5%, as compared to 2021.
- National Development and Reform Commission (NDRC) China, is taking appropriate measures to ensure a stable power supply by considering the role of each type of fuel.

FIGURE 1

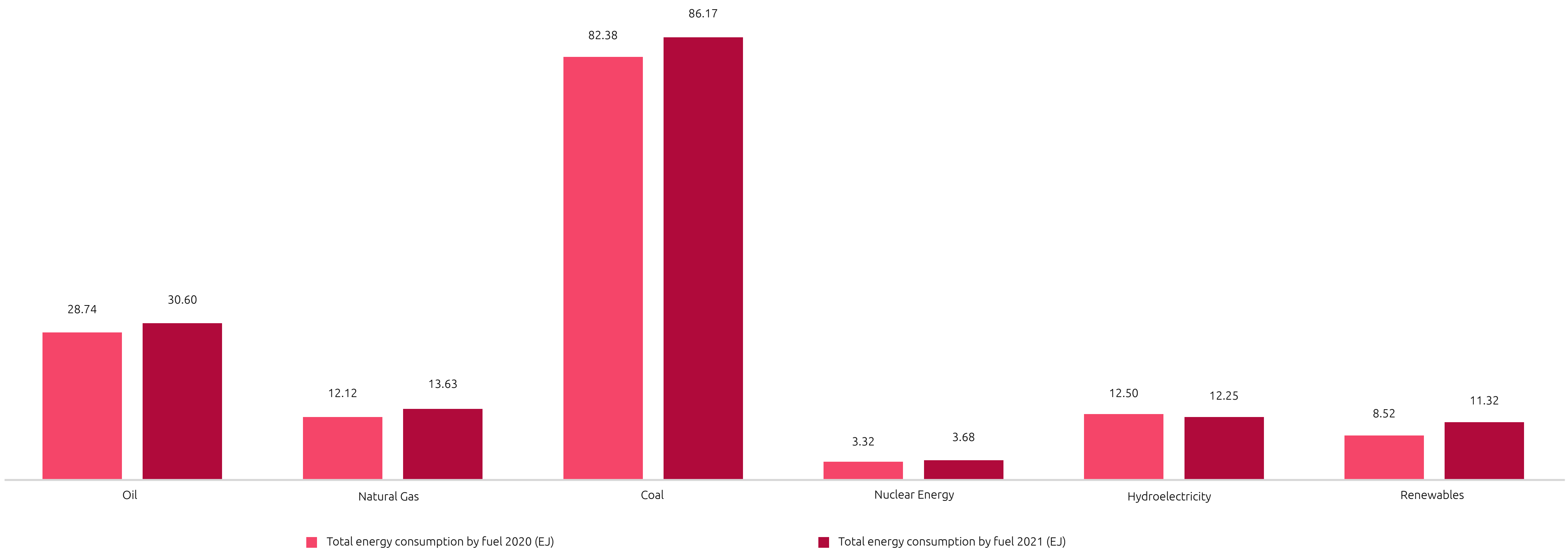
Total energy consumption in China in EJ



Source: bp Statistical Review of World Energy 2022 | 71st edition
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf
Note 1: In this Review, primary energy comprises commercially traded fuels, including modern renewables used to generate electricity
Note 2: Energy from all sources of non-fossil power generation is accounted for on an input-equivalent basis

FIGURE 2

Total primary energy consumption in China by fuel in EJ



Source: bp Statistical Review of World Energy 2022 | 71st edition
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf
Note 1: In this Review, primary energy comprises commercially traded fuels, including modern renewables used to generate electricity
Note 2: Energy from all sources of non-fossil power generation is accounted for on an input-equivalent basis

China: Electricity mix

As per the China Energy Portal in 2021:

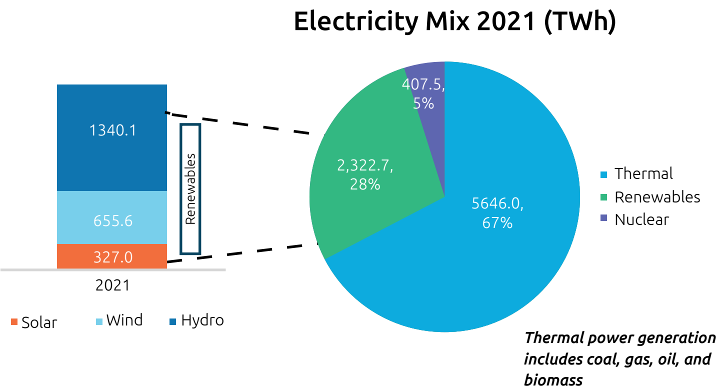
- Total power production in 2021 stood at 8,376,800 GWh compared to 7,626,400 GWh in 2020. This represents a 9.8% year-over-year (YOY) change.
- In 2021, the thermal sector (including coal, gas, oil, and biomass) accounted for 67% of power generation, contributing around 5,646.0 TWh.
- Renewables (including solar, wind, and hydro power) accounted for 28% and contributed around 2,322.7 TWh in total power generation in 2021.
  - Hydro contributed 1,340.1 TWh in total power generation.
  - Solar contributed 327 TWh in total power generation.
  - Wind contributed 655.6 TWh in total power generation.

Growth in power generation (GWh) by fuel type for 2021 vs. 2020:

- Thermal accounted for 5,645,300 GWh in total generation in 2021 vs. 5,177,000 GWh in 2020, representing YOY growth of 9.1%.
- Hydro holds the second spot and accounted for 1,340,100 GWh in total generation in 2021 vs. 1,355,300 GWh in 2020, representing YOY contraction of 1.1%.
  - In China, total potential for hydropower is estimated at up to 600 GW.
  - New hydropower projects in China include: Lianghekou (3,000 MW) and Yangfanggou (1,500 MW) on Yalong River; Wudongde (10,200 MW) and Baihetan (16,000 MW) on Jinsha River.
- Nuclear accounted for 407,500 GWh in total generation in 2021 vs. 366,200 GWh in 2020, representing YOY growth of 11.3%.
- Wind accounted for 655,600 GWh in total generation in 2021 vs. 466,500 GWh in 2020, representing YOY growth of 40.5%.
- Solar accounted for 327,000 GWh in total generation in 2021 vs. 261,100 GWh in 2020, representing YOY growth of 25.2%.

FIGURE 3

China's energy mix 2021



Source: China Energy Portal

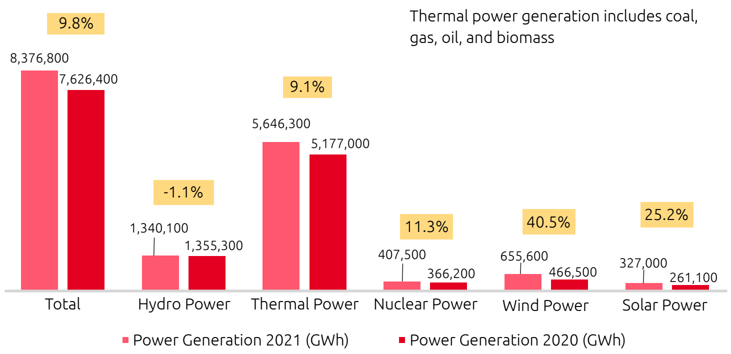
Link: https://chinaenergyportal.org/en/2021-electricity-other-energy-statistics-preliminary/

Due to rapid urbanization in China, electricity consumption in the country is expected to rise as demand for electricity among residents and industries also increases. The share of electricity for energy consumption will be approximately 40% by 2030 (up from ~5% in 1990).

- According to new plans, by the year 2060, 42% of power in China will come from solar and nuclear.
  - In 2025 the figure is estimated to be 6%.
- China is in the process of adding nuclear and solar capacity and anticipates adding the equivalent of 20 new reactors by 2025. This is enough solar power for 33 million homes (110 GW).

FIGURE 4

YOY growth in power generation in China



Source: China Electricity Council

Link: https://chinaenergyportal.org/en/2021-electricity-other-energy-statistics-preliminary/

Though there has been a push to further the use of renewables for energy consumption, coal has taken center stage due to the energy crisis in the country.

- The 9.1% increase in the use of thermal power in electricity generation can be attributed to a growing reliance on fuel for offsetting the power crisis in the country.
  - In mid-2021, China was able to effectively restrict the expansion of coal.
  - But later, the price of coal increased as a result of friction with the planned price of electricity in China.
  - To improve energy security, China is considering adding new coal generation projects.
- During 2021 and the first quarter of 2022, new developments in the coal sector included:
  - Six provinces account for 65.7% of new coal.
  - More than 50% of the total non-CHP (non-cogeneration) coal-fired power plants approved during this time period were designed to "supplement shortcomings in local power generation."

China is in the process of incorporating advanced technology in coal to increase the efficiency of coal-fired power plants that will lead to reduction in emissions.

- Shanghaimiao coal-fired power plant:
  - Known as the Temple Project, this plant is equipped with denitrification, desulfurization, and dust removal systems to reduce emissions.
  - Construction of the plant included safety, high efficiency, low carbon, and environmental protection considerations.
  - The plant is designed to use pulverized coal.
  - The advanced ultrasupercritical boilers are generally made applicable to systems with a generation capacity of approximately 400 MW and usually function at throttle pressures of approximately 3,500 psi (24.1 MPa) or more. They produce steam temperatures in the range of 1,100°F (595°C).

The share of nuclear energy is increasing in the electricity generation mix in China.

- The share of nuclear energy increased 11.3% in 2021 as compared to 2020. This can be attributed to China's objective of reducing carbon emissions.
- According to the 14th Five-Year Plan in China, installed capacity of nuclear is expected to reach 70 GW by 2025.
- According to nuclear experts in China, the country will need approximately 300-500 nuclear reactors by the end of 2050 to accomplish the government's target of net-zero carbon emissions.
- A positive step towards this goal is the deployment of the world's earliest pilot project to use China's indigenous third-generation nuclear energy technology, Hualong One, also known as the HPR1000.
  - China is only the fourth country to bring indigenous Generation III nuclear power technology to market, following the U.S., France, and Russia.

China: Power consumption and generation capacity by fuel type

As per the China Energy Portal in 2021:

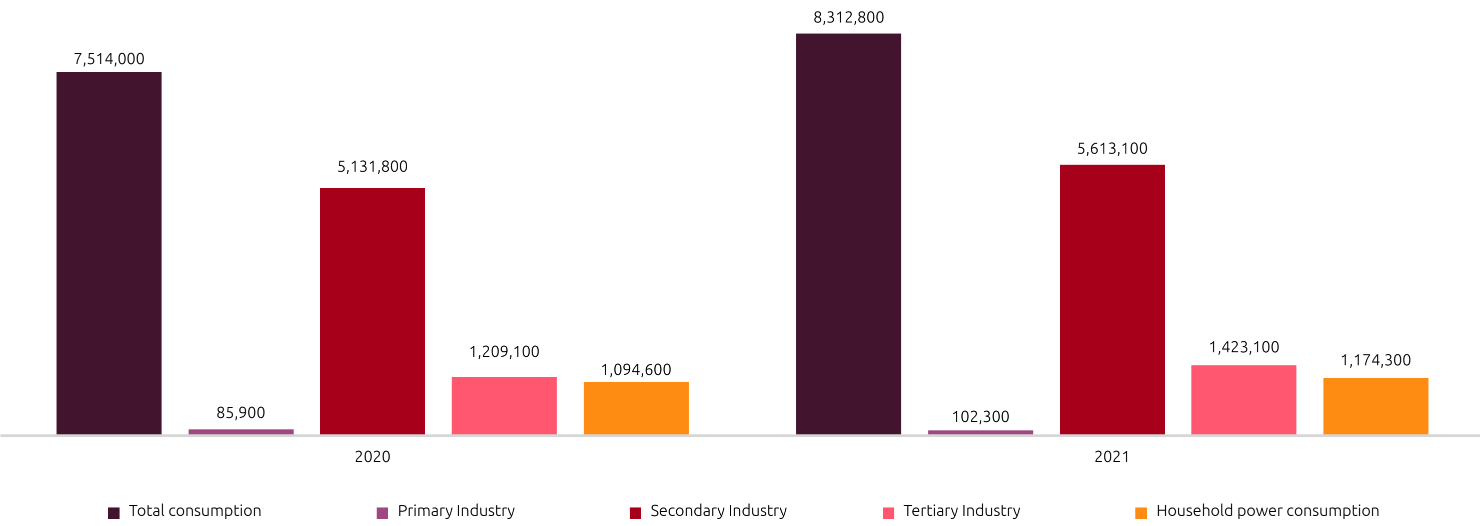
- Total power consumed in China in 2021 was 8,312,800 GWh compared to 7,514,000 GWh in 2020, representing 10.6% of YOY growth.
- Different sets of industries consume power and distribute it further, such as primary, secondary, tertiary and household power consumption.
  - Primary industry consumed 102,300 GWh of power in 2021 compared to 85,900 GWh in 2020, representing YOY growth of 19%.
  - Secondary industry consumed 5,613,100 GWh of power in 2021 compared to 5,131,800 GWh in 2020, representing YOY growth of 9.4%.
  - Tertiary industry consumed 1,423,100 GWh of power in 2021 compared to 1,209,100 GWh in 2020, representing YOY growth of 17.7%.
  - Household power consumed 1,174,300 GWh of power in 2021 as compared to 1,094,600 GWh in 2020, representing YOY growth of 7.3%.

Growth in installed generation capacity by fuel type (MW):

- The solar power sector witnessed the highest YOY growth in 2021, adding 53,000 MW and reaching a total installed generation capacity of 306,560 MW.
- Among renewables, the wind power sector held second place when it comes to installation capacity of power generation. In 2021, it added around 46,830 MW of solar generation reaching 328,480 MW in total solar, representing 16.6% YOY growth.
- Thermal added another 50,540 MW of generation capacity in 2021, reaching 1,296,780 MW of total thermal capacity.
- Hydro and nuclear sectors added 20,640 MW and 3,370 MW in 2021, representing YOY growth of 5.6% and 6.8%, respectively.
- There was also an improvement in China's fuel mix due to the fast installation of renewable energy.

FIGURE 5

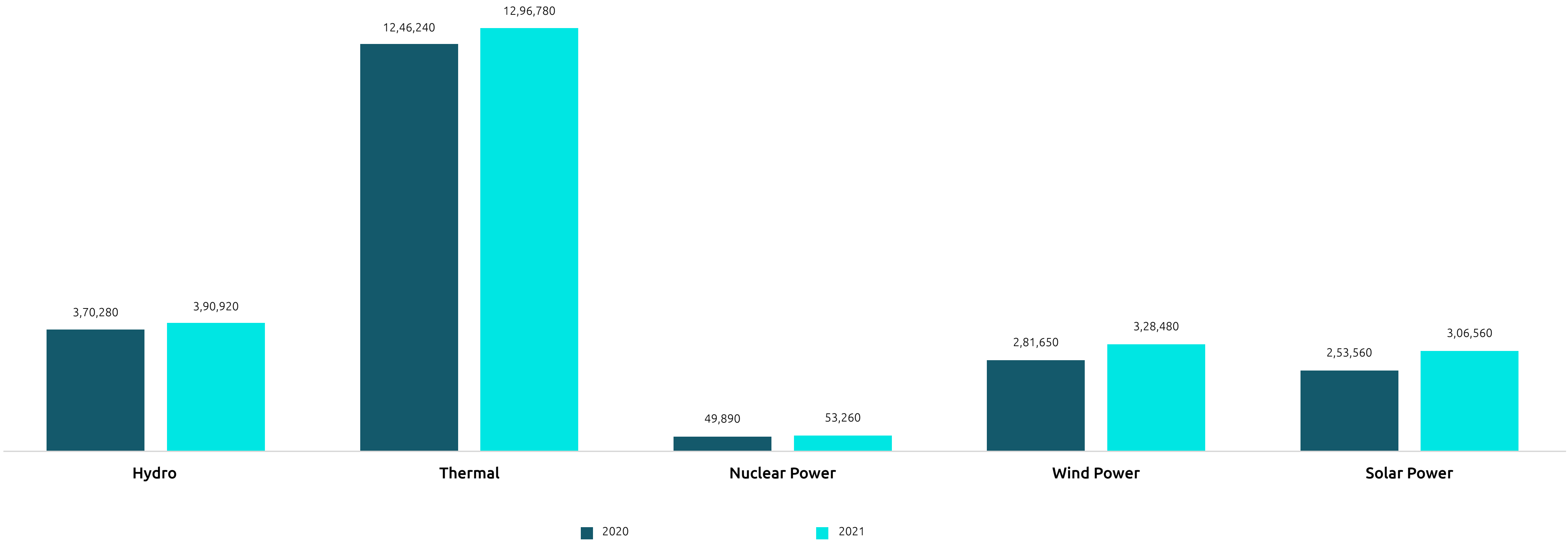
China: Total power consumption (GWh)



Source: China Energy Portal
Link: https://chinaenergyportal.org/en/2021-electricity-other-energy-statistics-preliminary/

FIGURE 6

China: Installed generation capacity by fuel type (MW)



Source: China Energy Portal
Link: https://chinaenergyportal.org/en/2021-electricity-other-energy-statistics-preliminary/

China: Renewable and nuclear energy

According to the China Energy Portal, from January to September 2021, the country produced 1,744,800 GWh of renewable electricity, including nuclear.

- From January to September 2021, China generated 1,441,700 GWh of renewable electricity through hydro, solar, and wind sources.
  - Solar contributed around 136,200 GWh in total renewable electricity generation, whereas wind and hydro contributed 402,500 GWh and 903,000 GWh, respectively.
- Nuclear power production stood at 303,100 GWh, contributing around 17% of total electricity generation for this period.

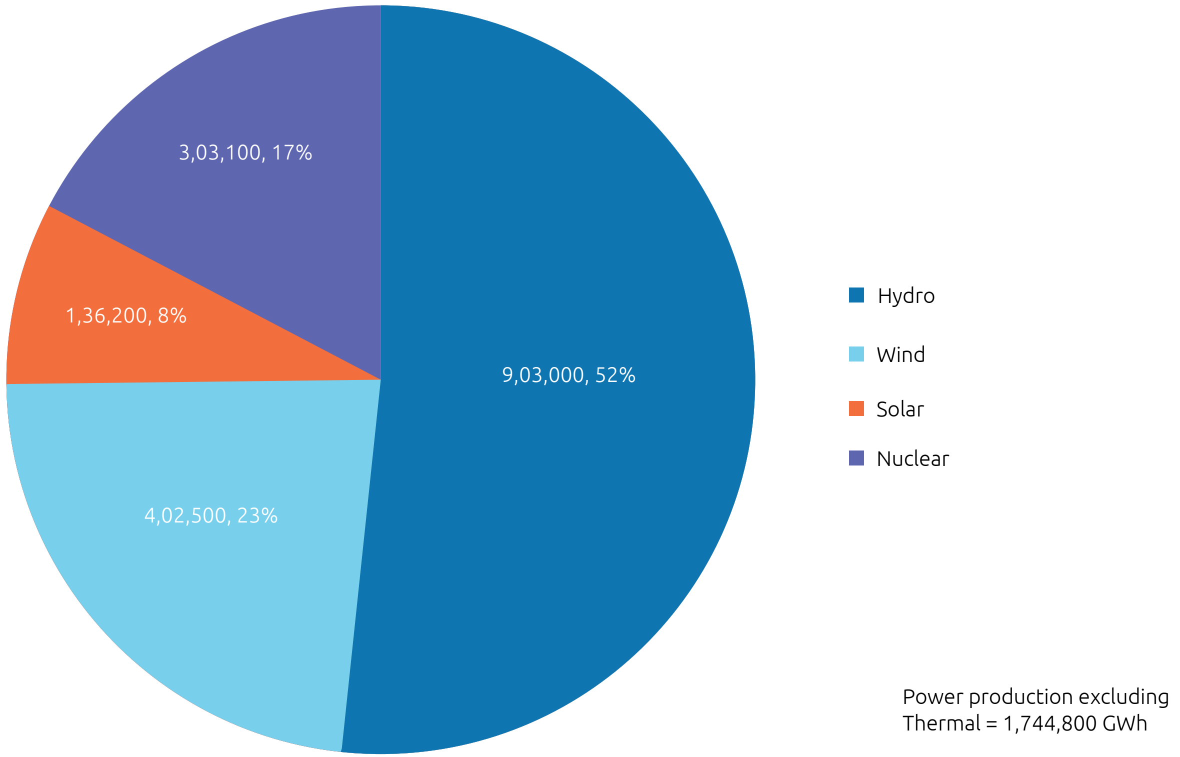
According to the China Energy Portal, from January to September 2021, the total installed capacity of renewable energy sources, including nuclear, was 1,012,410 MW.

- For this period, the total installed capacity for renewable electricity through hydro, solar, and wind sources was 959,150 MW.
  - Solar contributed around 278,350 MW in total installed capacity, whereas wind and hydro contributed 297,270 MW and 383,530 MW, respectively.
- Installed capacity in nuclear energy stood at 52,260 MW, contributing around 5% of total installed capacity from January to September 2021.

- China aims to serve 33% of national power consumption through renewable sources by 2025; the country aims for non-hydro renewables to contribute around 18%.

FIGURE 7

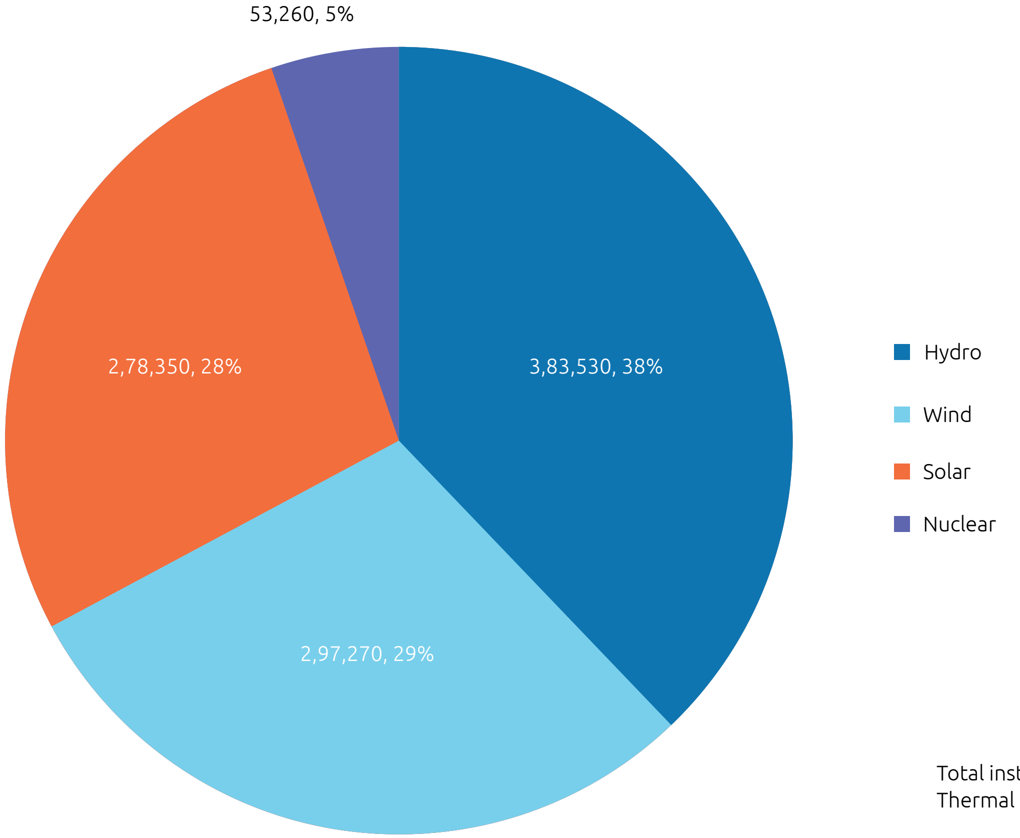
China: National renewable power production (GWh): January 2021 to September 2021



Source: China Energy Portal
Link: https://chinaenergyportal.org/en/2021-q3-electricity-other-energy-statistics/

FIGURE 8

China: Total installed capacity (MW): January 2021 to Sepember 2021



Total installed capacity excluding Thermal = 1,012,410 (MW)

Source: China Energy Portal
Link: https://chinaenergyportal.org/en/2021-q3-electricity-other-energy-statistics/

Overview of renewable energy projects in China

Project Name	Project type	Location	Installed Capacity	Key excerpts
Baihetan hydropower project	Hydroelectric power station	Sichuan and Yunnan Province, China	16 GW	• The Baihetan power station started operating with the commissioning of the first two 1GW turbines in June 2021, while the third and fourth generating units were put into operation in the following month. • It was fully commissioned in July 2022. • Upon completion, the project became the second biggest power station globally after the Three Gorges Dam.
Hardliangbao hydropower Station	Run-of-the-river hydroelectric power plant	Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China	1.1 GW	• The construction of the project started in the year 2019 and is expected to be completed in April 2025. • The project is being developed by Huaneng Sichuan Hydropower Company, with a total investment of $1.96 billion.

China has selected Gobi Desert as the destination for expanding their renewable capacity by 2030.

- The country aims to install 450 GW of renewable energy capacity, greater than twice the installed wind and solar generating fleet in the U.S.
- 100 GW of this new capacity is currently under construction.
- Along with these desert projects, China is undertaking measures to enhance rural grid transmission and is encouraging village cooperatives to invest in renewable power and share the profits accordingly.

According to the National Energy Administration (NEA) of China, the country is set to add 108 GW of solar power by the end of 2022.

- According to a report published by Asia Europe Clean Energy Advisory (AECEA), the most important contributor to this target will be distributed solar; this includes the commercial and industrial (C&I) segments, as well as residential customers and the 'GW-Bases'.
- From January to April 2022, 45 GW of modules were exported, accounting for almost half of 2021's export volumes.

- The 14th Five-Year Plan in China estimates that around 3.3 trillion TWh will be generated from renewable sources by 2021.

Overview of nuclear energy projects in China

Project Name	Location	Key excerpts
Construction of two new nuclear reactors	Sanmen, Zhejiang Province	• In June 2022, the official construction of the first of two CAP1000 pressurized water reactors planned as Phase II of the site in China's Zhejiang province commenced. • After the completion of two units in Phase II, the Sanmen plant is projected to have an installed capacity of 5,000 MWh and will generate 40,000,000 MWh each year.
Construction of two new nuclear reactors	Haiyang, Shandong Province	• China Nuclear Industry 24 Construction Company is responsible for the construction of the Haiyang Phase II nuclear island. • With the construction of the new reactors, the final heating capacity is estimated to reach 200 million square meters, which will promote zero-carbon heating.
Construction of two new nuclear reactors	Lufeng, Guangdong province	• Two reactors totaling 2000 MW are planned to help meet rising demand in Guangdong province. • The plant is capable of housing six 1,000 MW reactors.

China: Coal

China is the world's biggest producer and consumer of coal. It is used for activities such as heating, cooking, electricity generation, and steel making.

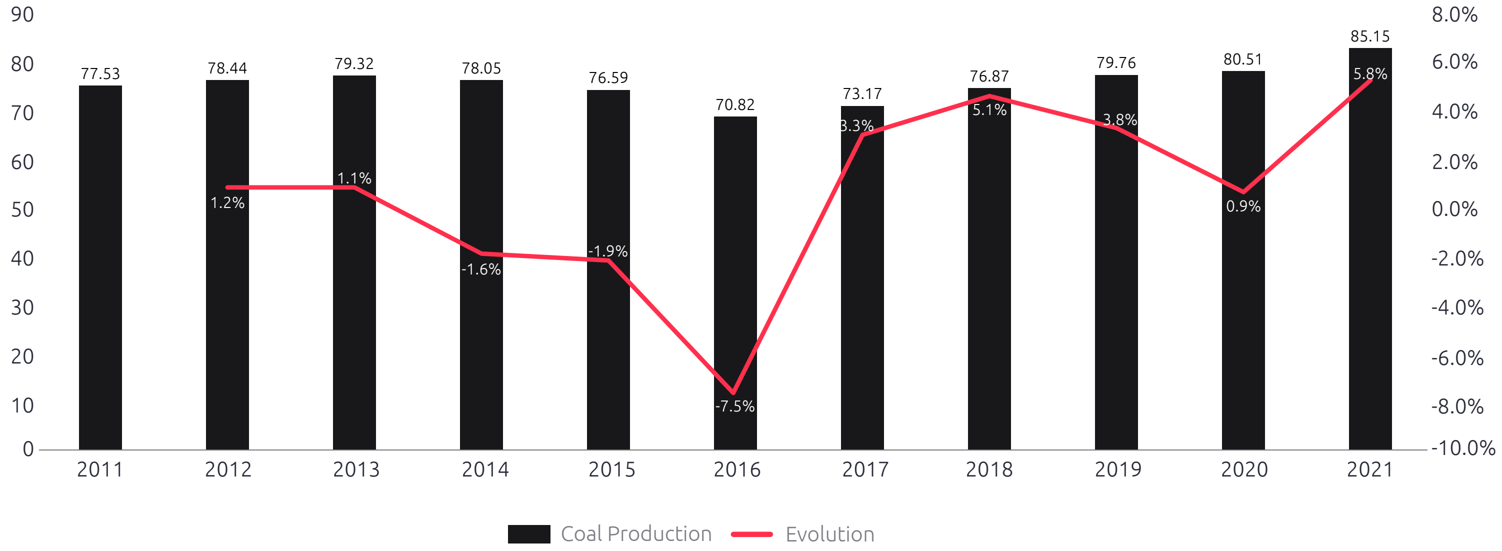
- Coal production in China has been on the rise in the last decade, from 77.53 EJ in 2011 to 85.15 EJ in 2021.
  - In 2021, total coal production in China stood at 85.15 EJ, a 5.8% rise as compared to 2020.
- The rise in coal production can be attributed to state policies encouraging miners to accelerate mining to help avoid an energy crisis.
- Chinese coal production reached an all-time high in 2021, which experts believe might have an adverse impact on climate change.

Total coal consumption in China reached 86.17 EJ in 2021, an increase of 4.6% as compared to 2020.

- The heat wave in China increased demand for electricity, giving rise to the increase in coal consumption.
  - Recurrent heatwaves in northern and central provinces in China resulted in extraordinary electricity demand, as residents in the Henan, Shandong, and Hebei regions turned to air conditioners.
  - According to Greenpeace, China is in the process of setting up new coal plants in the country.
  - Coal plants with a total capacity of 8.63 gigawatts were approved by Chinese authorities in the first quarter of 2022.

FIGURE 9

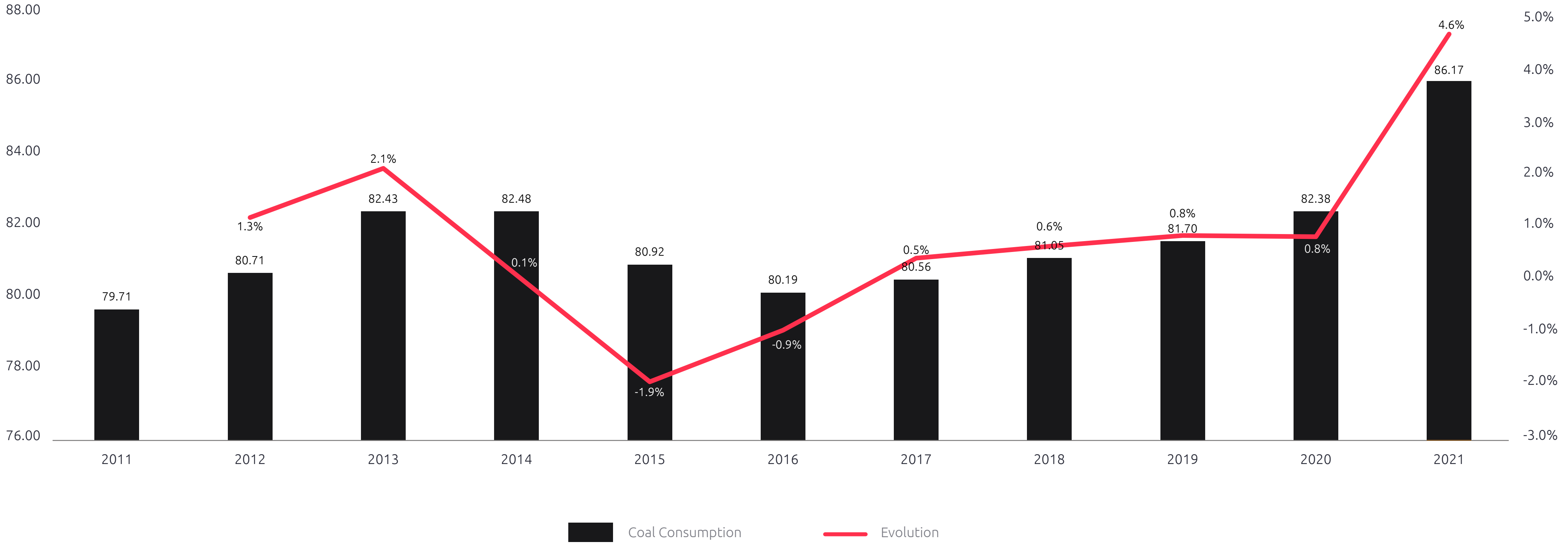
Total coal production in China in EJ



Source: BPStats
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

FIGURE 10

Total coal consumption in China in EJ



Source: BPStats
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

China: Coal

In 2021, the value of coal exported from China stood at $504.4 million, an increase of 15.8% as compared to 2020.

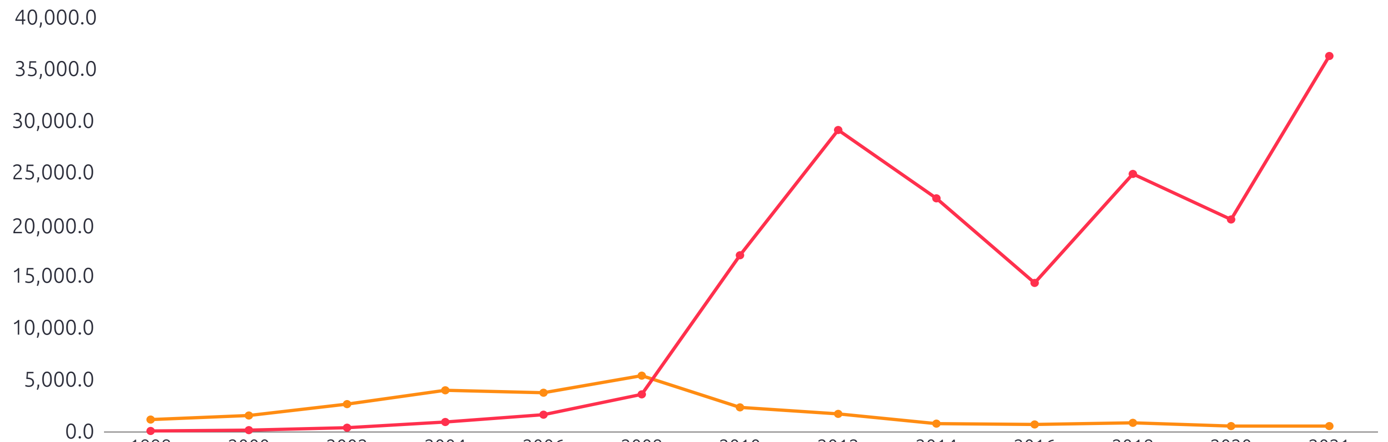
- The increase in coal exports can be attributed to the increase in coal production in China in 2021.
- Most of the coal exported from China is in the form of coal briquettes. A briquette is a compressed block of coal dust or other combustible biomass material used for fuel and kindling to start a fire.
- The major destinations of coal briquette exports from China are Malaysia, South Korea, Indonesia, Japan, and Taiwan.
- The steadily growing export markets for coal briquettes in China between 2019 and 2020 were the United States, Indonesia, and Republic of the Congo.

In 2021, the value of coal imported by China stood at $35,795.5 million in 2021, an increase of 77% as compared to 2020.

- The increase in coal imports can be attributed to the increase in the buying of thermal coal.
- Due to political reasons, China imposed bans on the import of several products, including coal from Australia.
- In the absence of coal from Australia, China is buying coal from countries such as Indonesia, South Africa, Russia, and Colombia to fulfill demand.
- According to the Argus' consultancy division, it is estimated that Chinese thermal coal imports will be 276.6 million tonnes in 2022 and 270.5 million tonnes in 2023.

FIGURE 11

Coal imports and exports in China (USD million)



	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020	2021
Export	1,067.7	1,468.3	2,532.9	3,814.5	3,672.0	5,237.8	2,241.8	1,568.0	696.0	698.2	787.4	435.7	504.4
Import	68.4	68.6	328.4	885.8	1,620.8	3,543.5	17,016.3	28,728.6	22,167.9	14,091.8	24,485.4	20,217.9	35,795.5

Export Import

Source: General Administration of Customs in China; SCMP; CEIC Data
https://www.scmp.com/economy/china-economy/article/3121426/china-coal-why-it-so-important-economy
https://tradingeconomics.com/china/exports-of-coal
https://www.ceicdata.com/en/china/usd-import-by-major-commodity-value/import-coal--lignite

China has nearly doubled its coal imports from Russia amidst the Russia and Ukraine war.

- Between March and April 2022, China's coal imports from Russia stood at 4.42 million metric tonnes.
- Russia has become China's second-biggest supplier of coal since that time. It currently accounts for 19% of coal imports, up from the 14% share it had in March 2021.
- According to the General Administration of Customs, in June 2022, China brought in 6.12 million tonnes of coal from Russia. This coal was purchased at a much lower price due to the war.
- Prices for Russian coal with a heating value at 6,000 kilocalories stand at around $173-176 per tonne compared to $400 per tonne for benchmark Newcastle coal.

China: Oil production

In China's energy mix, coal will continue to account for the highest share. However, oil always occupies the second position in China's overall primary energy consumption.

- China's oil production has declined from 4,074 thousand barrels daily (b/d) in 2011 to 3,994 thousand barrels in 2021.
  - Compared to 2020, total oil production in China increased by 2.4% and stood at 3,994 (thousand barrels daily) in 2021.
  - This slightly higher output can be attributed to expansion in refining capacities. Also, since there was a reduction in imports, the refineries in China produced more oil products to compensate.
  - In 2021, China added about 200,000 b/d of operational capacity, which was mostly contributed by Zhejiang Petroleum and Chemical's phase 2 project.

China's major oil projects:

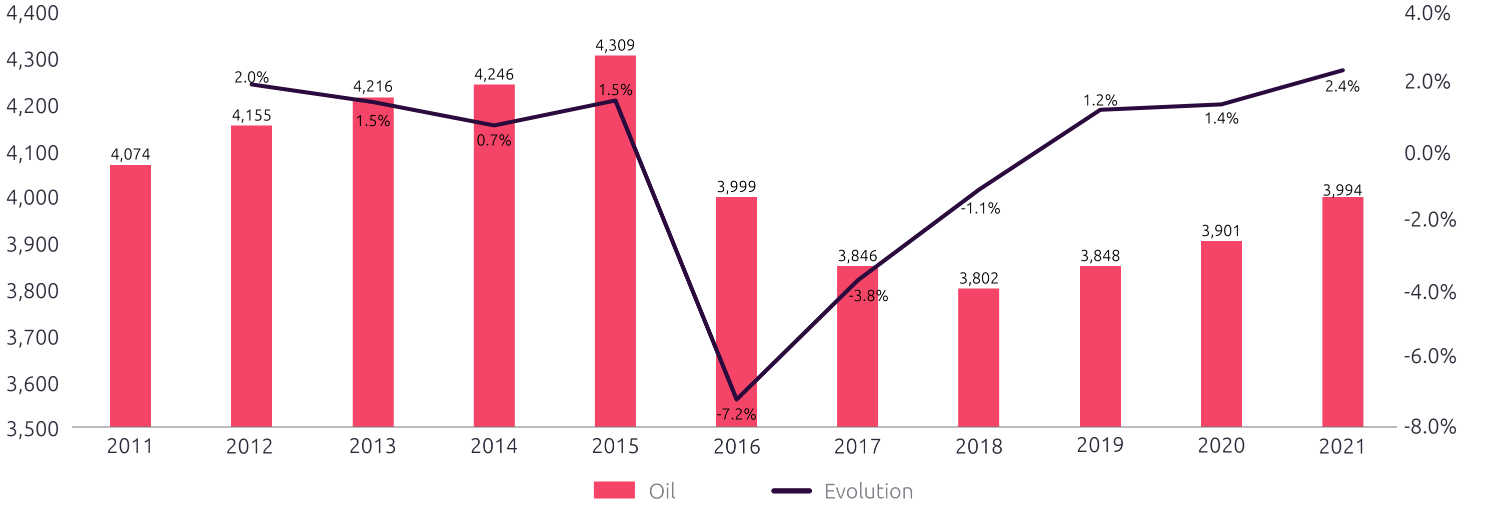
- Megaproject in Shangdong (June 2022): The project is home to around 26% of China's refining capacity and is an important destination for Saudi Aramco's crude oil exports. Saudi Aramco's efforts in increasing their production capacity to approximately 13 million barrels per day of crude oil will result in China achieving energy stability and security.
- ExxonMobil' Final Investment Decision (FID) for Mega China Petchem Project (November 2021): ExxonMobil decided to build a multi-billion-dollar petrochemical complex in the province of Guangdong in the southern part of China. The project includes a flexible feed steam cracker, three performance polyethylene lines, and two differentiated performance polypropylene lines. After completion, the total capacity would be 1.6 million tonnes per year.

There has been a decrease in oil imports in China

- According to the China Petroleum and Chemical Industry Federation (CPCIF), total crude imports decreased in 2021 to 513 million metric tons, a fall of 5.3% year-on-year the first time this figure has fallen in the past 20 years.
  - The fall in imports can be attributed to a decrease in energy dependency due to expansion in domestic production resulting from continuous field exploration and exploitation.
  - China National Offshore Oil Corporation (CNOOC), China's top offshore oil and gas driller, has planned capital expenditure of approximately ¥90 billion ($14.14 billion) in 2021 and ¥100 billion ($14.48 billion) for 2022. The percentage of allocations are as follows: exploration (20%), development (57%), production (21%) and others (2%).

FIGURE 12

China: Total oil production (thousand barrels daily): 2011-2021



Source: BPStats

https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Note: *Includes crude oil, shale oil, oil sands, condensates (lease condensate or gas condensates that require further refining) and NGLs (natural gas liquids – ethane, LPG and naphtha separated from the production of natural gas). Excludes liquid fuels from other sources such as biofuels and synthetic derivatives of coal and natural gas. This also excludes liquid fuel adjustment factors such as refinery processing gain. Excludes oil shales/kerogen extracted in solid form.

China: Subsidies on renewables and electric vehicles (EVs)

In 2022, ¥2.7 billion ($0.39 billion) has been allocated by China's Ministry of Finance additionally to subsidize renewable electricity prices.

- The breakdown of the subsidies include:
  - Wind power: ¥1.47 billion ($219 million)
  - Photovoltaic: ¥1.25 billion ($186.9 million)
  - Biomass: ¥28.9 million ($4.3 million)
- These additional subsidies would be applicable in 11 provinces in China, including Xinjiang, Inner Mongolia, Jilin, Shanxi, Zhejiang, Guangxi, Hunan, Sichuan, Guizhou (city), Yunnan, Gansu, Qinghai, and Chongqing (city).

According to the International Forum for Rights and Security (IFFRAS), a Canada-based think tank, China has decided to end subsidies on new wind and solar projects effective August 2021.

- China's subsidy policies mostly cover the excessive installation and production costs of renewable energy (including solar and wind).
  - The stopping of subsidies can be attributed to the Finance Ministry's subsidy payment backlog of around $62 billion in 2021.
- But, according to IFFRAS, the end of subsidies could have an adverse impact on the fight against climate change.

According to estimates, China spent around ¥100 billion ($14.8 billion) on electric vehicle (EV) subsidies between 2009 and 2021:

- In early 2022, the subsidies for all-electric cars were brought down by 30% from ¥15,840 to ¥11,088 ($1,645) and were set to finish at the end of 2022, two years behind the original schedule.
- Prior to that, the threshold of maximum price (¥300,000) and minimum range (300 km/186 miles) was applied, which narrowed the eligibility for subsidies.
- The purchase tax (available since 2014) was planned to expire as well, but may remain at 0% or increase to 5%, instead of the planned 10% in 2023.
- An announcement by the Guangdong government brought some good news: consumers who buy a new electric car to replace another car will get a subsidy of ¥10,000 ($1,513) in May and June 2022.

Other than subsidies, there are also facilities for tax exemption put forward jointly by the Ministry of Finance (MOF), the State Taxation Administration (STA), and the Ministry of Information and Industrial Technology (MIIT) in 2021:

- The MOF, STA and MIIT issued the Exempting Vehicle Acquisition Tax for New-Energy Vehicles on April 22, 2020.
- Tax exemption is applicable for EV manufacturers when they upload their 'Motor Vehicle Factory Qualification Certificate' for approval to the MIIT.

China: Renewable tariffs

China achieved a record in installing solar photovoltaic (PV) and offshore wind facilities in 2021 as Feed-in-Tariffs (FIT) were stopped as of December 31, 2021.

- The installations hit a record number in 2021 as the government ended the subsidized FIT of ¥850/$134/MWh for offshore wind farms at the end of 2021.
- Projects connected to the power network in 2021 and in the future need to take the lower on-grid tariff available to coal-fired power.
- According to the National Energy Administration (China), 54.9 GW of PV projects came into production/operation in China in 2021. This is a record high, up 14% from 2020.
- Residential PV installations amounted to 21.5 GW in 2021, compared with just above 10 GW in 2020.

2021 was a good year for China with respect to offshore wind projects as FIT expired at the end of the year.

- According to a report published by Windpower Intelligence, the expiration of FIT led to several gigawatts of offshore wind capacity being added in the final days of December 2021.
- A total capacity of approximately 3.5 GW was added before the expiry.
- Some of the major projects which were brought online in the Rudong complex include 350 MW at Rudong H2 and 400 MW at Rudong H6.
- Some of the major projects which were brought online in the South China Sea include 400 MW at Shenquan I and 300 MW at Yangxi Shaba.

China has planned a dual tariff system for Shandong's gas-fired power to enhance demand for gas.

- The dual mechanism splits the on-grid tariff into two parts: 1. A fixed tariff basis on the gas-fired power plants' fixed operating cost; 2. A floating tariff basis for the variations in the feedstock cost of gas-fired power plants.
- The primary objective is to give utilities a certain amount of flexibility to pass on elevated fuel costs to consumers and provide a cushion to gas-fired power plants from rising natural gas prices.
- The two-part tariff mechanism will facilitate utilities to operate at a level which is higher than the breakeven levels and play a better role in peak shaving during the high power consumption periods. In turn, this will give impetus to the development of gas-fired power plants in China.

China is in the process of augmenting the hydropower storage plans to fulfill climate objectives, but the inadequate tariff system poses a problem.

- Due to inadequate power tariff incentives and geological hindrances, China's installed pumped storage stood at 31.5 GW by the end of 2020, 20% lower than the 40 GW target set out in the 13th Five-Year Plan.
- The National Energy Administration stated plans to double pumped storage capacity to more than 62 GW by 2025.
- Further, it wants to expand capacity to 120 GW by 2030. However, this would be difficult if a proper tariff mechanism similar to the one available for solar and wind energy is not in place.
- According to experts, there is an effort from the central authorities to double storage, but unfortunately, the provinces have been slow to act due to the absence of peak power tariffs.

HOME

China: New renewable tariff and pricing structure

Onshore wind power projects achieved full grid parity in 2021						
[Right] Project Approval Time [Below] Grid Connection Time		2016-17	2018	2019	2020	2021
COD by Dec 2020	Formula	Fixed Feed-in Tariffs (Encourage voluntary grid-parity)		Tender Price under Price Ceilings (Encourage voluntary grid-parity)		Grid-Parity provincial coal-fired power prices
	Rate (¥/kWh)	0.47, 0.5, 0,56, 0.61	0.4, 0.45, 0.49, 0.57	<0.34, <0.39, <0.43, <0.52	<0.29, <0.34, <0.38, <0.48	
COD after Dec 2020	Formula	Grid-Parity provincial coal-fired power prices	Grid-Parity provincial coal-fired power prices	Tender Price under Price Ceilings (Encourage voluntary grid-parity)		
	Rate (¥/kWh)			<0.34, <0.39, <0.43, <0.52	<0.29, <0.34, <0.38, <0.48	
COD after Dec 2021	Formula			Grid-Parity provincial coal-fired power prices		
	Rate (¥/kWh)					

Mounted PV projects reached grid parity in 2021						
[Right] Project Approval Time [Below] Grid Connection Time		2018 (05.31)	2018 (05.31) – 2019 (05)	2019 (05-12)	2020	2021
COD by Dec 2020	Formula	Fixed Feed-in-Tariffs	Fixed Feed-in-Tariffs	NA	NA	Grid-Parity provincial coal-fired power prices
	Rate (¥/kWh)	0.55, 0.64, 0.75	0.5, 0.6, 0.7			
COD after Dec 2020	Formula	NA	Fixed Feed-in-Tariffs			
	Rate (¥/kWh)		0.5, 0.6, 0.7			
COD after Dec 2021	Formula		Tender Price under Price Ceilings	Tender Price under Price Ceilings	Tender Price under Price Ceilings	
	Rate (¥/kWh)		<0.4, <0.45, <0.55	<0.4, <0.45, <0.56	TBD (<0.35, 0.4, 0.5)	

Source: Energy Iceberg Collected from NEA, NDRC, MoF Policy (2018-20)

Link: https://energyiceberg.com/china-renewable-power-price/

Note: Grid Parity: Selling at local coal-fired power prices and no more national subsidy; COD: Commercial Operations Date

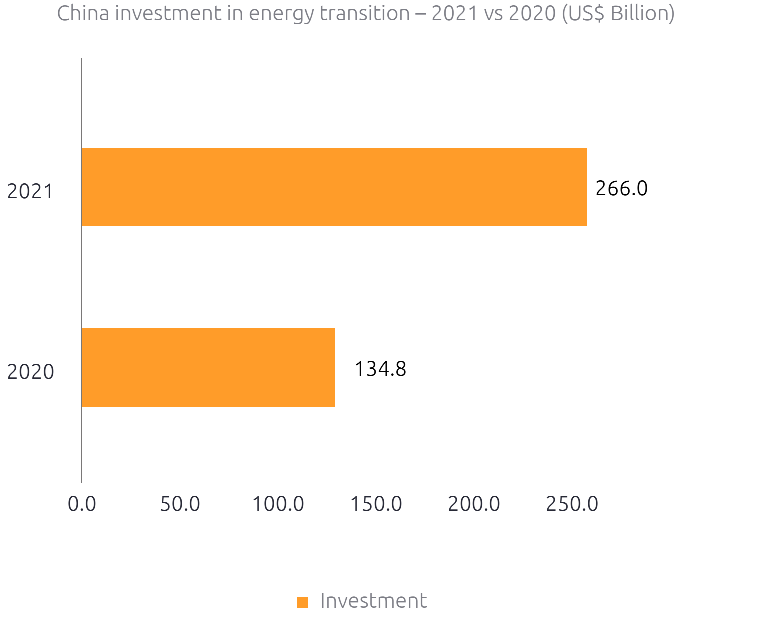
China: Measures and investments across the energy sector to support energy transition

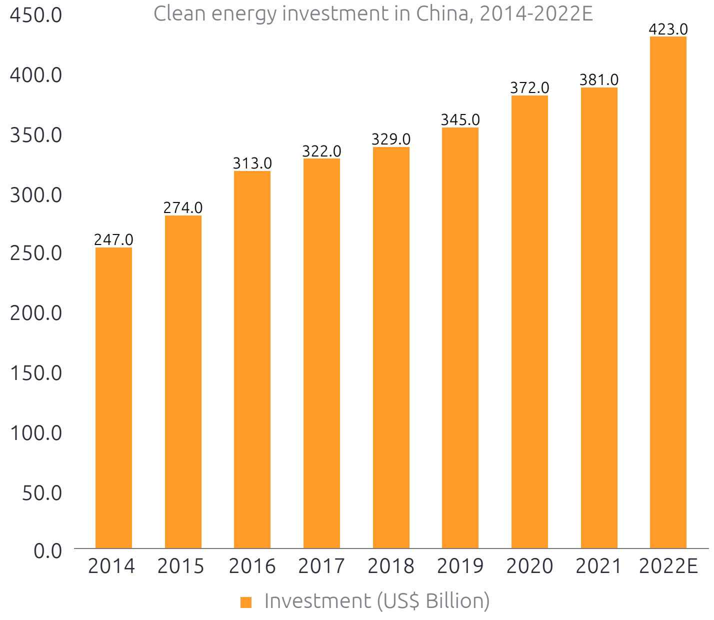
China's energy transition investment in 2021 increased by 97.3% and stood at $266 billion; This strengthens China's position as the leading country in invested funds. In terms of global investment in energy transition, China was followed by the United States ($114 billion), Germany ($47 billion), United Kingdom ($31 billion), France ($27 billion), Japan ($26 billion), India ($14 billion), Republic of Korea ($13 billion), Brazil ($12 billion), and Spain ($11 billion). The measures in China for energy transition include but are not limited to:

- Reducing the production of coal and shutting down some mines for safety reasons.
- Reforming green bond financing to exclude fossil fuel projects.
- Generating investments in electricity storage and providing support for hydrogen-powered vehicles.
- Major investments in the energy grid. In 2021, investments in power grids stood at ¥533 million, an increase of 4.5% as compared to 2020.
  - Between 2021 and 2025, it is estimated that China is going to invest approximately ¥6 trillion ($896 billion) in power grids and related industries.
- Providing support for solid-state battery projects (sodium-ion).
- China announced a 70% quota for green and modular housing in urban construction.
- Expansion of Emissions Trading Scheme (ETS) by creating a national data collection network to measure CO_2 emissions.
- Creating a differentiated carbon tax and extended emissions market.

FIGURE 13

Investment in energy transition and clean energy investment in China

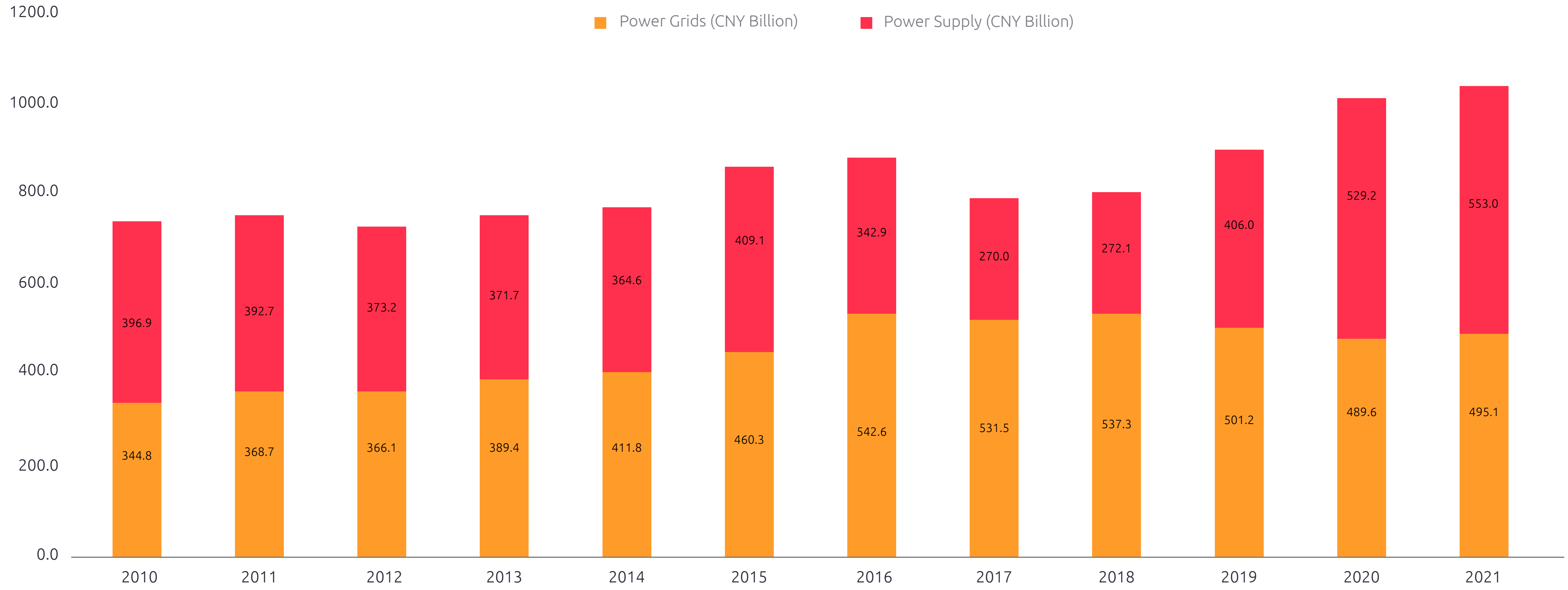




Source: BloombergNEF; IEA
https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends_Free-Summary_Jan2021.pdf
https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-Exec-Summary-2022.pdf
https://www.iea.org/reports/world-energy-investment-2022/overview-and-key-findings

FIGURE 14

Investments in completed electric power construction projects (CNY billion)



Source: Statista
https://www.statista.com/statistics/302305/china-full-investment-in-power-construction/#:~:text=In%202021%2C%20China%20invested%20approximately,in%20power%20supply%20infrastructure%20projects.

Domination of China in the global solar PV supply chains

Over the last ten years, the capacity for global solar PV manufacturing has shifted from Japan, United States, and Europe to China.

- The country has invested around $50 billion in enhancing the new PV supply capacity, which is approximately ten times greater than Europe.
  - This has created several jobs in the solar PV value chain.
- China holds a share of approximately 80% in every stage of the manufacturing process of solar panels, including polysilicon, ingots, wafers, cells, and modules.
- The top 10 suppliers of solar PV manufacturing equipment are based in China.
- This is not only helping China in terms of energy transition, but also helping the rest of the world by bringing down the cost of solar PV.

China exports a lot of PV products.

- China exported solar PV panels worth $30 billion in 2021.
- The country played an instrumental role in making Malaysia and Vietnam major exporters of PV products through investments in these countries.
- Continuous innovation in terms of new technologies led by China has cut emissions intensity of solar PV manufacturing by 50% since 2011.
- Solar PV manufacturing energy-related CO_2 emissions accounted for only 0.15% of energy-related global CO_2 emissions in 2021.
- The cost of manufacturing PV products in China is 35% lower than in Europe, 20% lower than in the United States, and 10% lower than in India.

China: CO_2 emissions and net-zero target

In China, CO_2 emissions from energy stood at 10,523 million tonnes of carbon dioxide, a 5.5% increase as compared to 2020.

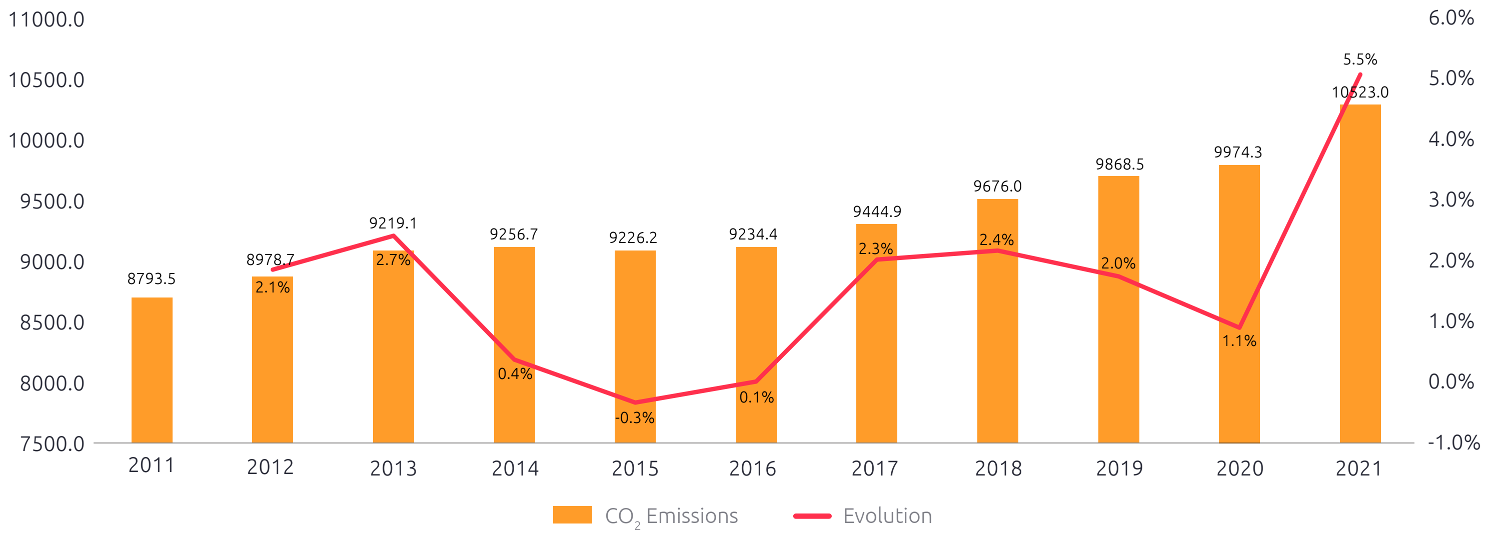
- The rise in emissions can be attributed to a sharp increase in the demand for electricity in 2021 due to recovery from Covid-19 and the steady rise in temperatures.
- As demand increased, coal was used to fulfill more than 50% of the rise in electricity demand, as growth of low-emission sources slowed.
- The per capita CO_2 emissions in China is now more than the average in advanced economies.
- On a per capita level, CO_2 emissions in developed economies have decreased to 8.2 tonnes on average, versus 8.4 tonnes in China.

Strategy to achieve the net-zero goals (2021-2025):

- During the 14th Five-Year Plan in China, the country has adopted the following targets:
  - During 2021–2025 period, energy and carbon intensity are estimated to decrease by 13.5% and 18%, respectively, per unit of GDP.
  - Other targets include but are not limited to: increasing the share of days with good air quality in cities to 87.5% (from 87% in 2020); improving the share of surface water at or better than grade III to 85% (from 83.4% in 2020); and increasing forest coverage to 24.1% (from 23.2% in 2019).
  - The proportion of non-fossil fuels in primary energy consumption is set at 20% as compared to 15% in the previous plan.

FIGURE 15

China: CO_2 emissions from energy (million tonnes of carbon dioxide): 2011 - 2021



Source: BPStats
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

China: Solutions for reducing CO_2 emissions

System balancing is a method to reduce CO_2 emissions which can be done by integrating source, grid, load and storage, and multi-energy complementarity. In 2021, NEA China developed guidelines on promoting the integration.

- The guidelines include: increasing reliance on regional power market and services; liberalizing market-centric transactions; using emerging technologies such as 5G to bolster unified dispatch; and bringing mechanisms for generation, power users, energy storage, and virtual power plants to participate in the market.
- To optimize the scale ratio of several power sources and maximize power output and efficiency, there are two types of hybrid projects in China which are being promoted:
  - Western and rural regions: The existing traditional power plants are being used for large-scale hybrid energy bases, combining wind, solar, hydropower and storage/wind; solar, coal and storage/wind; or solar hydropower, coal and storage.
  - Towns, industrial parks and large public facilities: Facilities such as airports, hospitals and similar public places can incorporate a combination of conventional and renewable sources such as wind, solar, geothermal energy, and biomass.

There is an effort to develop a synchronized power system through the integration of grid, load (demand), source (supply), and storage through facilitating technologies and power market reform.

- Zhejiang, Qinghai Inland and Fujian have been selected as demonstration zones for this new power system.
  - In early 2022, Zhejiang put forward the plan to build a 'Provincial Demonstration Zone' for a new power system with new energy as the mainstay.

Challenges faced by China in achieving Net-Zero targets and the mitigation strategies:

- Data granularity and quality: Though a national-level Carbon Emission Accounts and Datasets (CEADs) has been established by China, the country needs to enhance data collection methodologies. It is necessary for China to produce data that matches the quality of international standards. Some of the standards include the Partnership for Carbon Accounting Financials and the Paris Agreement Capital Transition Assessment.
- Inadequate funding: Energy transition efforts have been traditionally funded through bank loans. But in the prevailing conditions, longer-dated, blended equity, and debt structured financing is required. According to a report published by the World Economic Forum (WEF), China faces a shortfall of ¥44 trillion in green financing over the next four decades.
- Inadequate policy support: The limits for production of blast furnace steels vary, with large-scale state-owned enterprises in East China tending to have more flexibility than SMEs in the country's northeast. Therefore, a clear policy is required to address this issue.

According to a document published in October 2021 on the measures undertaken by China to achieve carbon neutrality, the country looks forward to steadily increasing the share of non-fossil energy usage to approximately 20% by 2025, 25% by 2030, and over 80% by 2060.

- By the end of 2025, China's CO2 emissions per unit of GDP will decrease by 18% from the 2020 level; by the end of 2030, it will drop by approximately 65% compared with the 2005 level.
- By the end of 2025, China's energy consumption per unit of GDP will decrease by 13.5% from the 2020 level; the forest coverage rate will reach 24.1%, while the forest stock volume will rise to 18 billion cubic meters.

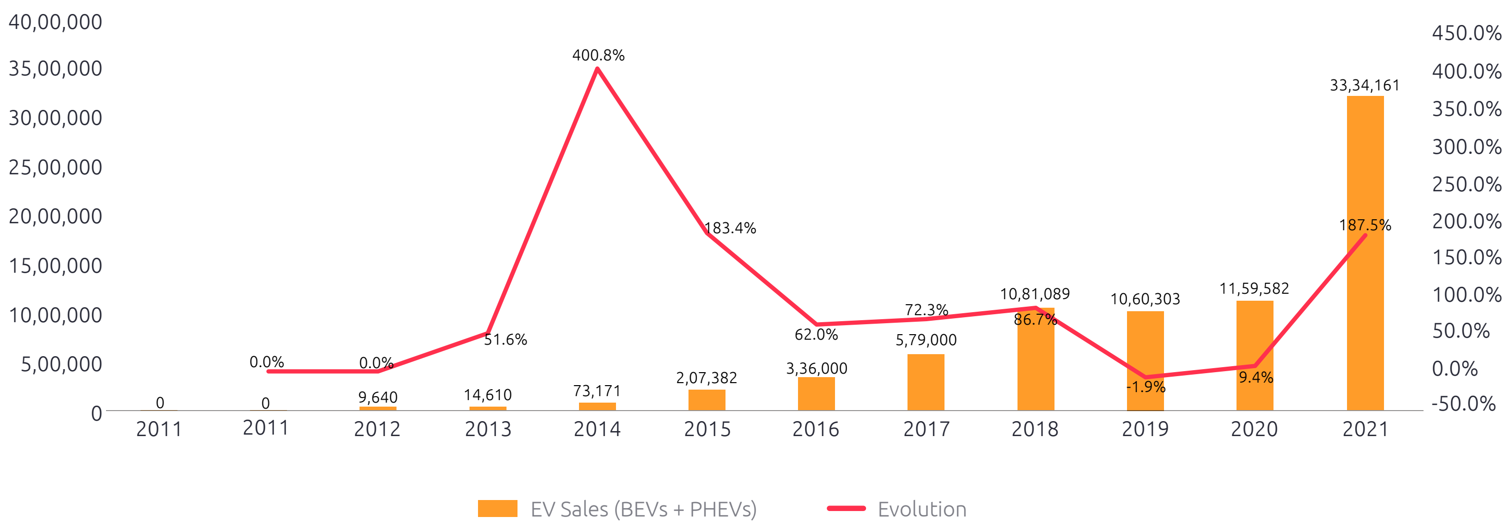
China: Electric vehicle sales and market

In 2021, EV sales surged 187.5% and stood at 3,334,161 units. Stock of EVs also increased by 74% in 2021 and stood at 7,842,829.

- In 2021, out of every 100 passenger cars sold in China, approximately 15 were "new energy vehicles" (NEVs) — a combination of battery-electric vehicles and hybrids.
- The homegrown brands in China such as XPeng and NIO, as well as traditional automakers like Geely and BYD, saw a growth in sales in 2021.
- Sales of Tesla also grew exponentially in China, with the country ranking third in annual sales.
- According to China Passenger Car Association (CPCA), BYD sold 584,000 EVs in 2021, more than double its 2020 sales number.
- This growth can be attributed to the favorable policies undertaken by the Chinese government from 2010 to 2016, including subsidies.
- The Chinese government is aiming to make EVs the dominant car segment in the country.
- To support EVs, China also has a robust network of charging infrastructure.
  - According to the China Electric Vehicle Charging Infrastructure Promotion Alliance, there were more than 2.6 million charging stations throughout the country in 2021, an increase of 70% from 2020.
  - China is planning to build several charging stations for supporting 20 million EVs by the year 2025.

FIGURE 16

EV Sales in China



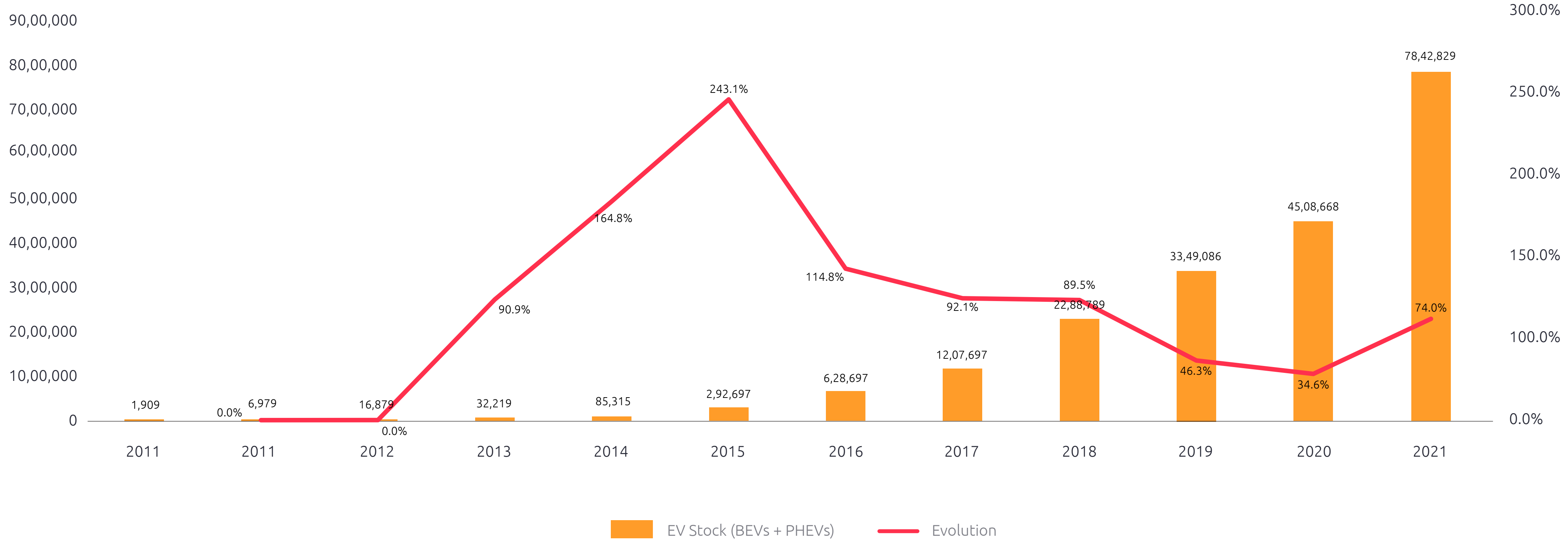
Source: IEA, 2022

https://www.iea.org/articles/global-ev-data-explorer

Note: BEVs are battery electric vehicles. PHEVs are plug-in hybrid electric vehicles.

FIGURE 17

EV Stock in China



Source: IEA, 2022
ttps://www.iea.org/articles/global-ev-data-explorer
Note: BEVs are battery electric vehicles. PHEVs are plug-in hybrid electric vehicles.

China: Hydrogen overview

China has several ambitions with respect to global green technology.

- According to estimates, the share of hydrogen in China's energy consumption would be around 10%-12% by 2050.
- China occupies the number one position in the world for hydrogen production with an annual output of 33 million tons, more than one-third of global demand.
- China produces brown and gray hydrogen with the help of coal or gas (60% and 20% of production, respectively), resulting in high CO2 emissions.
- According to recent forecasts, China will reach 38 GW of electrolyzer capacity by 2030; by the same year, China's premier hydrogen lobbying organization has asked the government to install as much as 100 GW.
- As compared to German and EU strategies, which prioritize green hydrogen, China's strategy is color-agnostic and only plans for green hydrogen to overtake gray and blue hydrogen after 2030.

China's industrial policy gives impetus to China's creation of a solid hydrogen economy.

- China's industrial policy for hydrogen is mainly focused on evolving and demonstrating fuel-cell vehicles.
- Central-government funding also provisions for the growth of fuel cell vehicles (FCVs), including via a program offering financial rewards to city clusters for the industrialization of core fuel cell technologies.
- Approximately ¥1.7 billion will be given to local governments that meet certain targets. However, the share of FCVs within China's energy transition objectives depends on the supply of low-carbon hydrogen. Currently, the majority of the hydrogen used to power them is produced with the help of fossil fuels.

China is undertaking measures for preparing a launchpad for hydrogen takeoff.

- According to the International Energy Agency and Mission Innovation, China's investment in hydrogen increased six-fold between 2018 and 2020.
- Beginning in 2016, the government of China announced 66 National Key R&D Programs (NKPs) projects concentrating on hydrogen technologies, with a total estimated value between ¥1.75 and 5 billion.
- Several research programs involved important State Key Laboratories, which also contribute to the development of hydrogen technologies.
  - For example, in 2019, the laboratory on catalysis at the Dalian Institute of Chemical Physics, which is part of the Chinese Academy of Sciences (CAS), developed and trialed a new generation of catalyst for highly efficient alkaline electrolysis.

Corporates are pushing forward with building China's green hydrogen capabilities.

- As of 2021, China's State-Owned Enterprises (SOEs) had plans to enlarge their operations in the hydrogen-related industry, including production, storage, refueling, or related businesses.
- According to estimates, Sinopec expects to produce 500,000 tons of hydrogen every year from renewable energy sources by 2025 and plans to expand its system of hydrogen transport pipelines.
  - Sinopec is constructing green hydrogen production facilities in Ordos, Inner Mongolia, and Kuqa, Xinjiang, with scheduled annual outputs of 10,000 and 20,000 tonnes respectively. These projects are will be operational by June 2023.

China: Key hydrogen policies in China

January 5, 2017: National Development and Reform Commission (NDRC) proposed development of primary research projects in hydrogen

April 25, 2019: Research Institute China Center for Information Industry Development (CCID) announced "the era of hydrogen is coming"

October 11, 2019: Premier of the People's Republic of China, Li Kequiang, encouraged the commercialization of hydrogen energy

October 18, 2019: Ministry of Education of the People's Republic of China (MOE) designated a specialization for "hydrogen technology" for vocational colleges

August 2020: NDRC designated hydrogen as a strategic emerging industry

December 21, 2020: Energy whitepaper promoted development of hydrogen technology

March 13, 2021: 14th Five-Year plan recognized hydrogen as frontier technology

October 23, 2021: Hydrogen became an integral part of the nation carbon peaking and neutrality plan

November 29, 2021: 14th Five-Year plan for energy innovation laid down R&D priorities for hydrogen

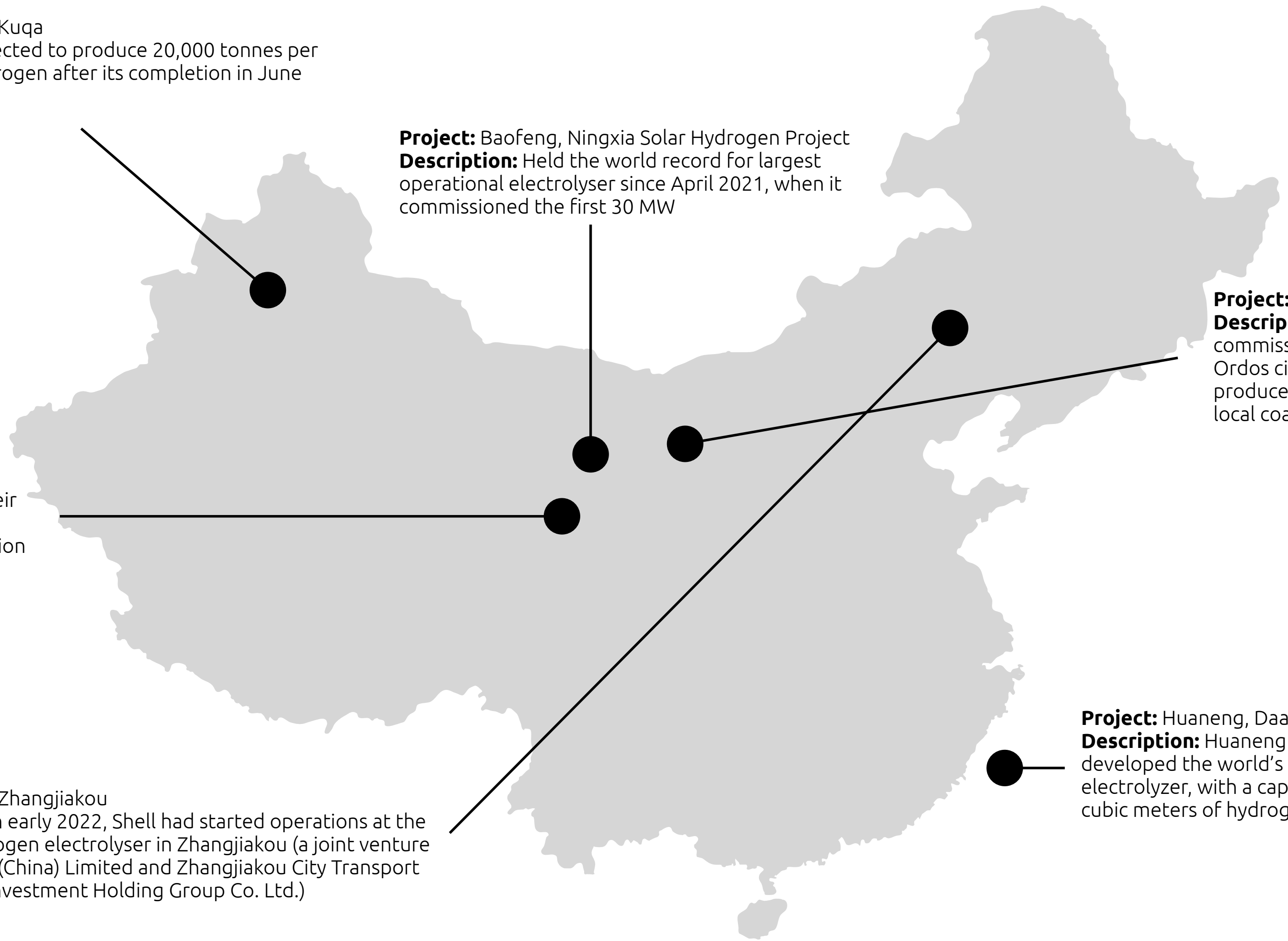
January 26, 2022: President of People's republic of China Xi Jinping called to speed up the development of hydrogen energy

March 23, 2022: NDRC released the national hydrogen development plan

China green hydrogen projects

Project: Sinopec, Kuqa
Description: expected to produce 20,000 tonnes per year of green hydrogen after its completion in June 2023

Project: Baofeng, Ningxia Solar Hydrogen Project
Description: Held the world record for largest operational electrolyser since April 2021, when it commissioned the first 30 MW



Project: Sinopec, Ordos
Description: The company is expected to commission its first green hydrogen project in Ordos city in northern China in mid-2022. It will produce 10,000 tpa of green hydrogen for use at a local coal-based chemical plant.

Project: DICP, Lanzhou Liquid Sunshine Project
Description: Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences and their collaborators industrialized the liquid solar fuel production through the “Liquid Solar Fuel Production demonstration Project

Project: Huaneng, Daan
Description: Huaneng Energy declared that it had developed the world’s largest single-cell alkaline electrolyzer, with a capacity of 1,300–1,500 normal cubic meters of hydrogen per hour.

Project: Shell, Zhangjiakou
Description: In early 2022, Shell had started operations at the power-to-hydrogen electrolyser in Zhangjiakou (a joint venture between Shell (China) Limited and Zhangjiakou City Transport Construction Investment Holding Group Co. Ltd.)

INDIA EMISSIONS, CARBON TAXES, RENEWABLES AND ENERGY EFFICIENCY MEASURES

ALEXANDRA BONANNI
SWETANTA LAHIRI
NUPUR SINHA

India's energy sector overview: India has one of the most diversified energy sectors in the world

There has been a steady increase in electricity generation in India from 2010 to 2020

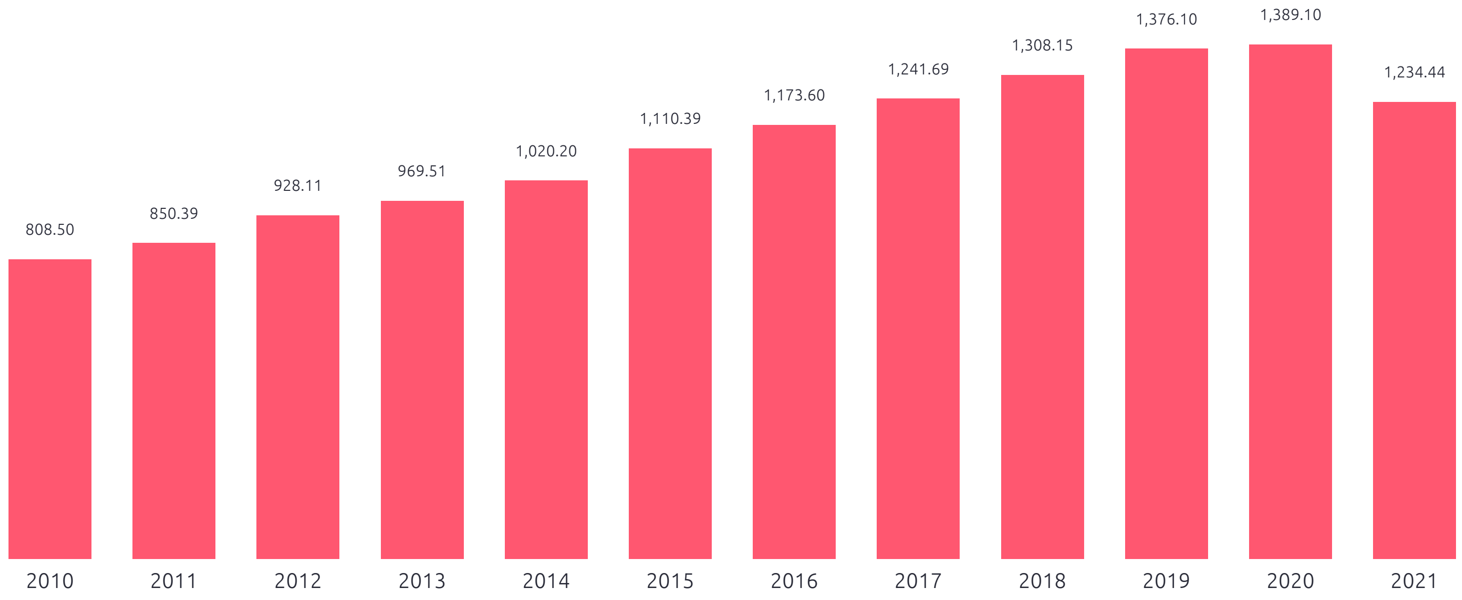
- Expansion of the economy, rapid urbanization, growth in population, and industrialization will increase energy demand in the future
  - Under the current national policy scenario, India is expected to have a GDP of around $8.6 trillion by 2040, resulting in a massive increase in energy consumption
  - According to the International Energy Agency (IEA), the share of electricity in India's final energy consumption is set to rise from 17% to 24% by 2040
  - Within the next 20 years in the Stated Policies Scenario (STEPS), solar power will witness significant growth and will almost match coal's share in the power generation mix
  - As of 2020, 96.7% of Indian households had access to electricity
  - The remaining 2.4% of households which do not have access to electricity are mostly concentrated in the states of Uttar Pradesh, Madhya Pradesh, Rajasthan, and Bihar

There was a decrease in total electricity generation by 154.66 billion units (BU) in 2021 as compared to 2020 due to disruption from the Covid-19 pandemic

- Before the Covid-19 pandemic, India's energy demand was estimated to rise by almost 50% between 2019 and 2030
- During the Covid-19 lockdown in 2020, power supply fell by 25% as compared to 2019 on the respective dates, (March 24 and April 19)
- Several states in India imposed a lockdown during the second wave of Covid-19 in 2021, which affected industrial and commercial power demand
- During the third wave of Covid-19, India's power consumption growth remained subdued at 2.2% year-on-year reaching 105.54 BU by February 2020
- The solar energy sector was also affected by the Covid-19 pandemic due to implementation issues including supply chain bottlenecks
- The pandemic also resulted in a 60% drop in solar installations

FIGURE 1

Total electricity generation (including renewables) in BUs



Source: Indian Brand Equity Foundation (IBEF)

Link: https://www.ibef.org/industry/power-sector-india#:~:text=%2C%20and%20manpower).-,India%20is%20the%20third%2Dlargest%20producer%20and%20second%2Dlargest%20consumer,the%20over-all%20installed%20power%20capacity

*BU, equal to terrawatt hour (TWh), a unit of energy used in India to measure annual power generation

Some major achievements in India's power and energy sector over the past four years include:

- The Government of India launched the Pradhan Mantri Sahaj Bijli Har Ghar Yojana, "Saubhagya" to increase household access to electricity. Under the scheme, 28.2 million households have been electrified as of March 2021
- Achieved cost savings of INR 19,295 crore ($2.5 billion) by distributing 7,217 thousands LED tube lights, 367,900 thousands LED bulbs and 2,359 thousands energy-saving fans (as of March 2022)
- According to the National Infrastructure Pipeline 2019-25, projects in the energy sector accounted for the highest share (24%) of the total overall capital expenditure of INR 111 lakh crore ($1.4 trillion)
- In 2019, India achieved a rank of 22 in the World Bank's Ease of Doing Business - "Getting Electricity" ranking, a huge step forward since their rank of 137 in 2014

During 2022, it is estimated that the peak demand could rise to 215,000 MW as a result of increased industrial production and residential consumption

Increasing power demand in India

- With India's emergence from the Covid-19 pandemic, power demand rose significantly due to an increase in industrial activities
  - On April 8, 2022, the peak power demand met during the day was 199.58 GW
  - Though the maximum peak power demand was less than what was recorded on April 8, 2022, the numbers were still on the higher side as the average demand met between April 4 and April 13 stood at 195.43 GW
  - The peak power demand met during the day on April 20, 2022, was 197.28 GW
  - The power demand on April 25, 2022 increased by 0.89% and stood at approximately 199 GW compared to April 20, 2022

Industrial transformations in India have led to an increase in energy demand

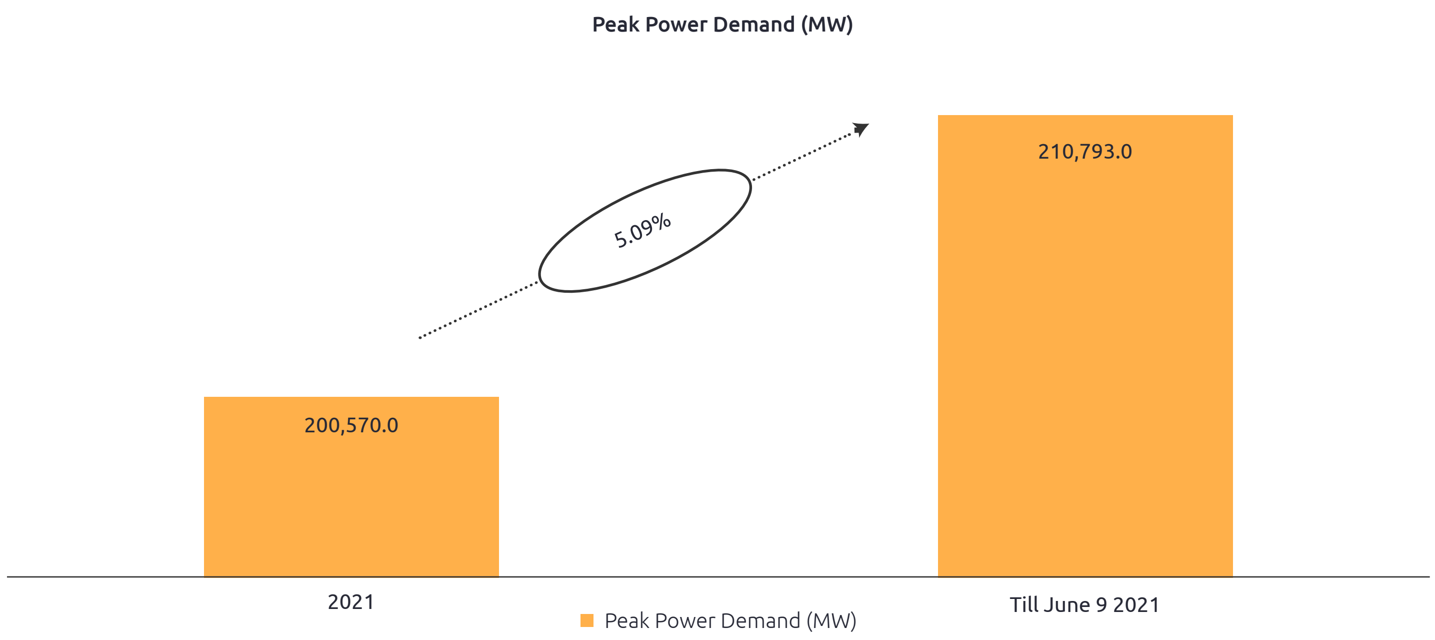
- The share of the industry sector in total final energy consumption stood at 36% in 2019 compared to 28% in 1990
- Industrial activities were down due to the Covid-19 pandemic in the earlier part of 2020
- There was some recovery in the later part of 2020 as lockdowns eased
- Industrial production may be on the lower side in the short-term outlook, but in the long-term outlook, it is estimated that industrial production will grow, giving rise to more electricity demand
- In the STEPS, the growth in real industrial value-added (contribution of private industries to overall GDP) can be attributed to materials-intensive investments in infrastructure and productive equipment and material
- By 2040, industrial value-added will increase more quickly than the production of physical outputs such as cement and steel

The residential sector in India also contributes to the rise in energy demand

- Over the next two decades, India's building space will increase significantly. As a result, demand for cooling will also increase, which in turn will give rise to, increase in demand for energy consumption
  - The residential floor space is expected to increase from less than 20 billion square meters in 2020 to more than 50 billion by 2040
- By 2040, personal computers, air conditioners, and washing machines are expected to become much more common, especially in urban areas
- In STEPS, by 2040, the total stock of air conditioners could rise to 670 million and India is expected to consume around 650 terawatt-hour (TWh) of electricity for cooling alone

FIGURE 2

Yearly comparison of peak power demand in India



Source: Ministry of Power

Link: https://www.timesnownews.com/business-economy/industry/indias-peak-power-demand-at-new-high-of-210793mw-article-92124592#:~:text=The%20All%20India%20electricity%20demand,recorded%20on%20July%207%2C%202021

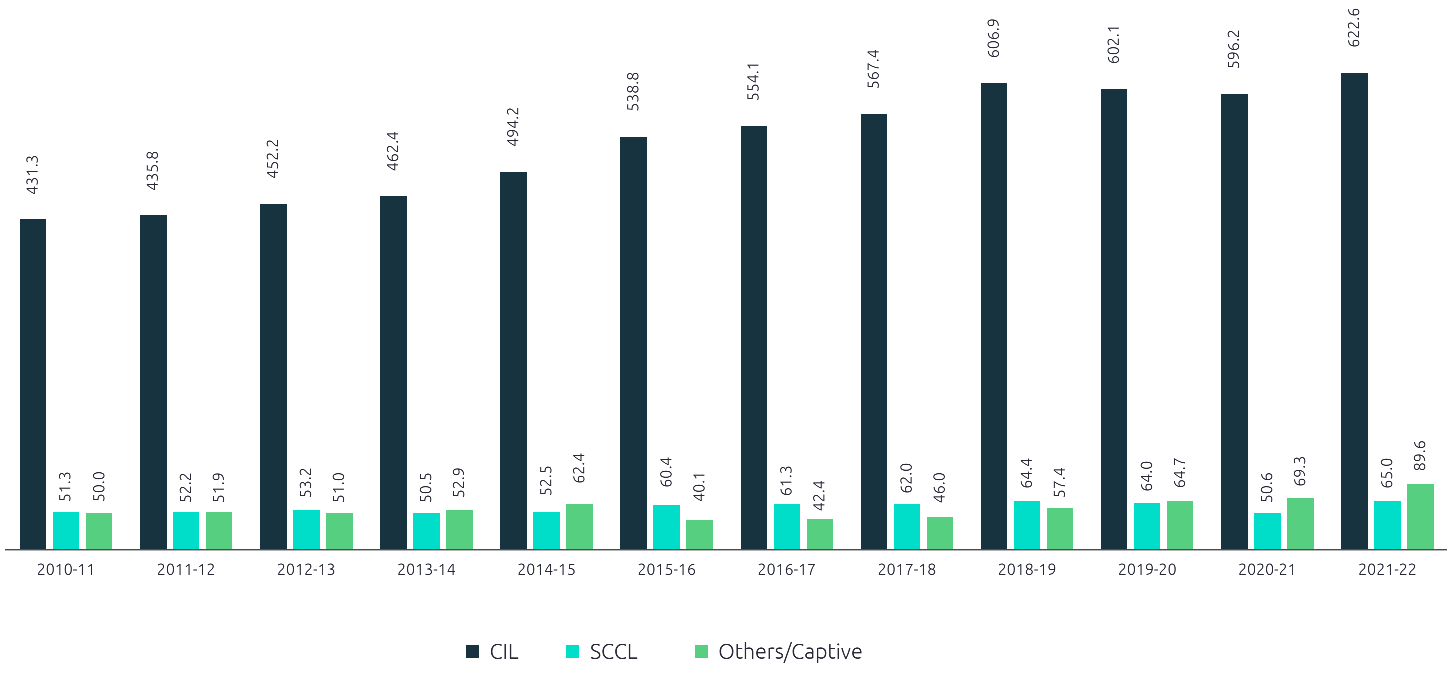
The coal management problem in India has led to a power crisis

India faced a power crisis in October 2021 as power stations' supply of coal dwindled to just four days of operation. In May 2022, station supply dropped to six days, as reported by the Ministry of Power

- According to the Resource Adequacy Plan and Load Generation Balance (LGBR) Report 2022-23, published by Central Electricity Authority (CEA) in March 2022, the requirement for energy was 1,23,713 MUs
- However, the consumption was 4% more, 1,29,187 MUs. Similarly, in April 2022, the actual consumption was 1,34,701 MUs against a demand of 1,26,283 MUs
- According to the Center for Research on Energy and Clean Air (CREA) analysis, only an additional 9 MT could have filled the demand supply gap
- There would not have been any problem if coal was sufficiently stocked in the thermal power stations. Despite an increase in raw coal production by 8.54% YoY, India still experienced this crisis, which can be attributed to improper management

FIGURE 3

Production of raw coal by company - quantity in million tonnes



Source: Failure to load: India's power crisis is a coal management crisis, CREA, May 2022

Link: https://energyandcleanair.org/wp/wp-content/uploads/2022/05/Failure_to_Load_CREA_May_2022-1.pdf

India's mineable capacity exceeded 1,500 million tonnes as of 2021. But the actual production was around 777.26 MT in 2021, representing only 52% of the total mineable capacity

- The Coal India Ltd (CIL) & Singareni Collieries Company Limited (SCCL) mines had a total vendible/dispatchable coal stock of 65.35 MT on March 31, 2022, compared to 104.39 MT on March 31, 2021
- In March 2022, transportation of coal by railways fell 6.19% compared to March 2021
- Also, the total load of coal put into the rakes was lower in March and April 2022 as compared to the same months in 2021
- It was also found that in the past few months, CIL missed the average loading targets for the rakes

Evidence suggests that the power crisis in India is not due to inadequate power generation capacity but bottlenecks in management, which can be mitigated with the following measures:

- Utilizing existing assets rather than building new ones
- Optimizing coal transportation so that the coal stocks can be built up in the power stations before the monsoon starts
- Properly managing the coal mines to guarantee sufficient supply
- Reducing waste of electricity by running awareness campaigns for effective demand-side management
- Focusing more on renewable energy by realigning the energy mix

The deterioration of financial health of the power distribution companies (Discoms) has also contributed to the power crisis

- Liabilities of Discoms have increased to INR 1,096.4 billion ($13.72 billion) which the organization owes to power companies
- Therefore, to avoid more liabilities, the Discoms are not very comfortable with buying power at an exorbitant rate, leading to regular load shedding

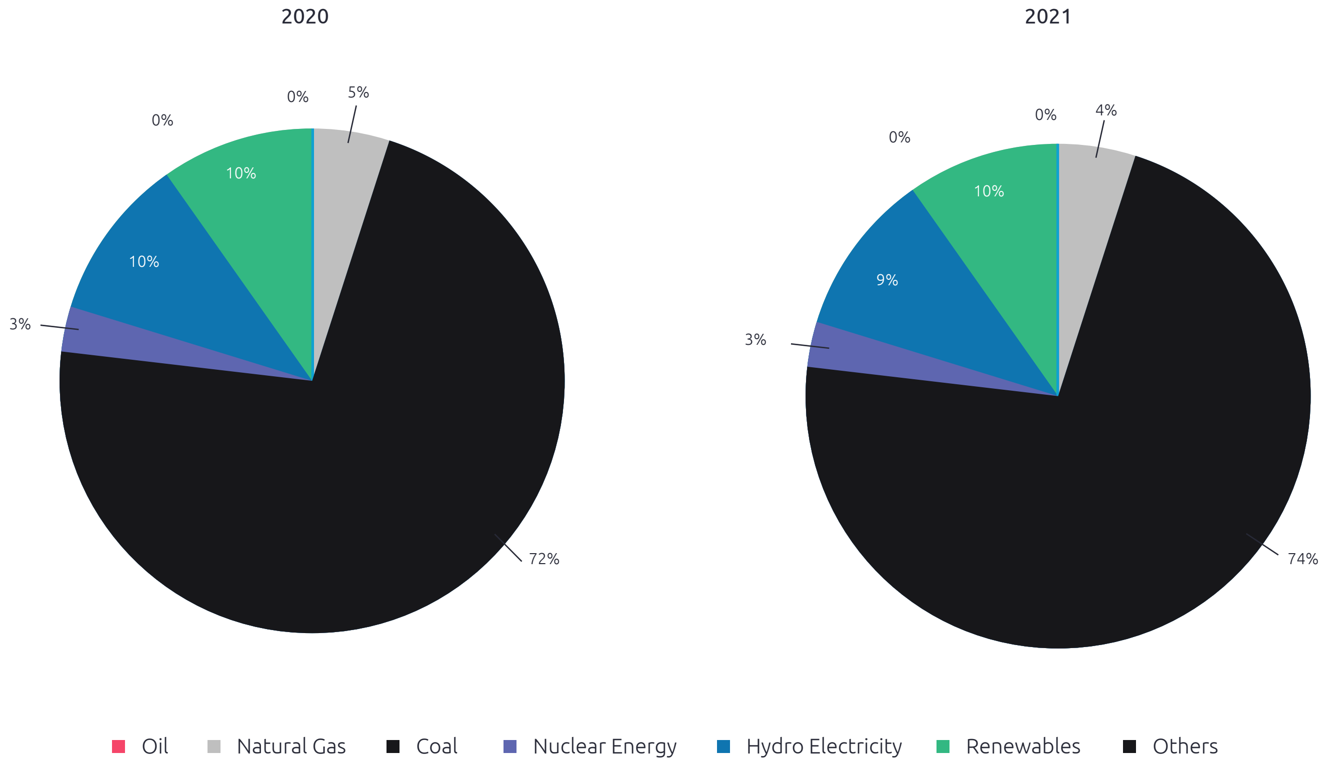
Energy mix: Coal continues to account for ~74% of energy generation in 2021

Coal and renewables capture the maximum share in energy generation by fuel

- **Coal:** In 2021, electricity generated from coal was around 74%. Coal is one of the most abundant and important fossil fuels in India. The domestic energy market will be dominated by coal for years to come
  - In 2021, primary energy consumption from coal in Exajoule (EJ) was around 57%
- **Oil & Gas:** In 2021, electricity generated from oil & natural gas was around 4%. Though natural gas is a cleaner fuel than coal, it is not as clean as renewables. Experts have cautioned that achieving over capacity in the natural gas sector could lead to assets getting marooned
  - In 2021, primary energy consumption from oil & gas in EJ was around 33%
- **Hydropower:** In 2021, electricity generated from hydro power was around 9%. In India, hydro power plants are classified into two groups: Plants with capacity of 25 MW or below capacity (small hydro power); Plants with capacity of 25 MW or above (large hydro power). Excluding small hydro projects (SHPs), India has an estimated hydropower potential of 1,45,320 MW
  - In FY 2021, primary energy consumption from hydro power in EJ was around 4%

FIGURE 4

Electricity generation by fuel in TWh (2020-2021)



Source: BPStats 2022

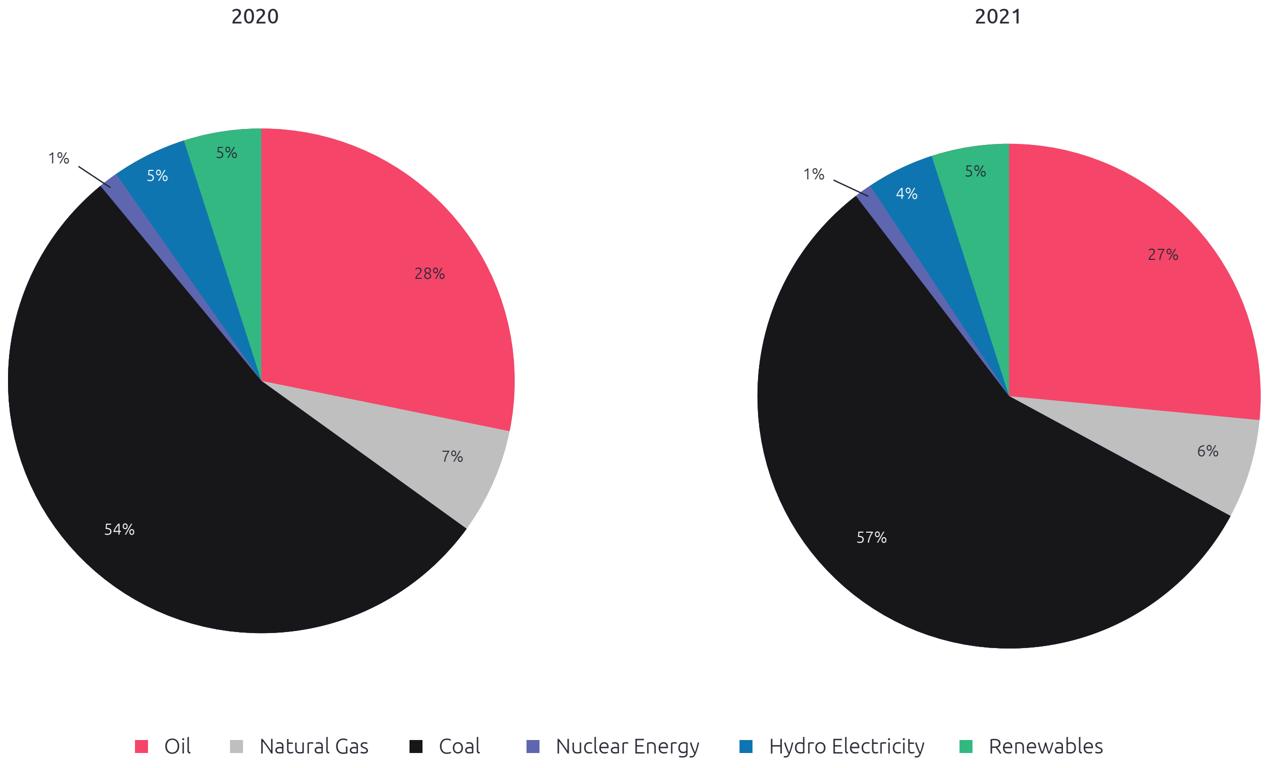
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

*TWh: Terawatt-hour (TWh), a measure of electrical energy, 10^{12} watt-hours

- **Nuclear:** In 2021, electricity generated from nuclear energy was around 3%. India's capacity to generate power from nuclear energy is still low. This can be attributed to the fact that 18 of 23 nuclear power reactors have a capacity of less than 300 megawatt electrical (Mwe)
  - In 2021, primary energy consumption from nuclear power in EJ was around 1%
- **Renewables:** In 2021, electricity generated from renewables was around 10%. After coal, renewables have achieved an important position in electricity generation in India. The increase in importance for renewables can be attributed to the Government of India's target of reducing the country's total projected carbon emissions by one billion tonnes by 2030
  - In 2021, primary energy consumption from renewables in EJ was around 5%

FIGURE 5

Primary energy consumption by fuel in EJ (2020-2021)



Source: BPStats 2022

Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

*EJ: Symbol for exajoule, an SI unit of work or energy equal to 1018 joules

Oil production in India is dominated by two state-owned exploration and production companies: Oil and Natural Gas Corporation (ONGC) and Oil India

The oil and gas sector is among the most prominent core industries in India. It plays a major role in influencing decision-making within all other major sectors of the economy

- India is expected to be one of the largest global contributors to non-Organization for Economic Co-operation and Development (OECD) petroleum consumption growth. Seaborne crude oil imports in India crossed 4.8 million barrels per day in April 2022
- As of September 1, 2021, the capacity of India's oil refineries stood at 248.9 million metric tonnes per annum (MMTPA), making it the second-largest refiner in Asia
- In January 2022, the production of India's crude oil stood at 32.2 MMT
- In 2021, India's consumption of oil products stood at 201.26 MMT, an increase of 3% as compared to FY 2021
- Between October-December 2021, India imported liquefied natural gas (LNG) amounting to 7.9 billion cubic meters (BCM)
- Exports of petroleum products from India reached 56.8 MMT worth $21.41 billion in 2021
- There was a rise in crude oil import from $94.3 billion in 2022 (April to January), as compared to $70.72 billion in 2017 (April to January)

FIGURE 6

Total oil production (thousand barrels daily) (2011-2021)

Source: BPStats 2022

Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Reasons for the fall in India's crude oil and natural gas production

India's domestic crude oil production has been declining consistently. In 2021, total oil production stood at 746 (thousand barrels daily), which is 6.7% lower than 2020

- India is heavily dependent on imports to meet its oil demands (around 85% comes from imports)
- The over reliance of imports has increased India's crude oil import bills and broadened trade deficits
- The demand for oil increased; at the same time, domestic production could not be increased, which is why India is heavily dependent on imports
- The major reason for the fall in crude oil output can be attributed to India's dependency on aging wells and no major discoveries in the recent past
- Total oil production by ONGC in 2022 was 19.45 million tonnes, which is 13.82% lower than the target
- An inspection-related shutdown affected the production of oil at ONGC in 2022

Some of the major initiatives taken by the Government of India to promote the oil and gas sector:

- In the later part of 2021, the Government of India announced its efforts to reduce crude oil imports. The strategies include:
  - Improving energy efficiency and conservation measures;
  - Emphasizing on demand substitution;
  - Prioritizing biofuels; and
  - Increasing the production of oil and gas domestically
- There have also been efforts to increase the exploration and production of oil and gas in the country. This includes several policy-related measures, such as a Hydrocarbon Exploration and Licensing Policy, Policy for Extension of Production Sharing Contracts, Policy for Early Monetization of Coal Bed Methane and others

The future:

- In the Union Budget 2022-23, the customs duty on certain important chemicals such as acetic acid, heavy feed stocks, and methanol for petroleum refining were reduced
- Ethanol, which is extracted from sugarcane, is being added to petrol to decrease the dependence on imported oil

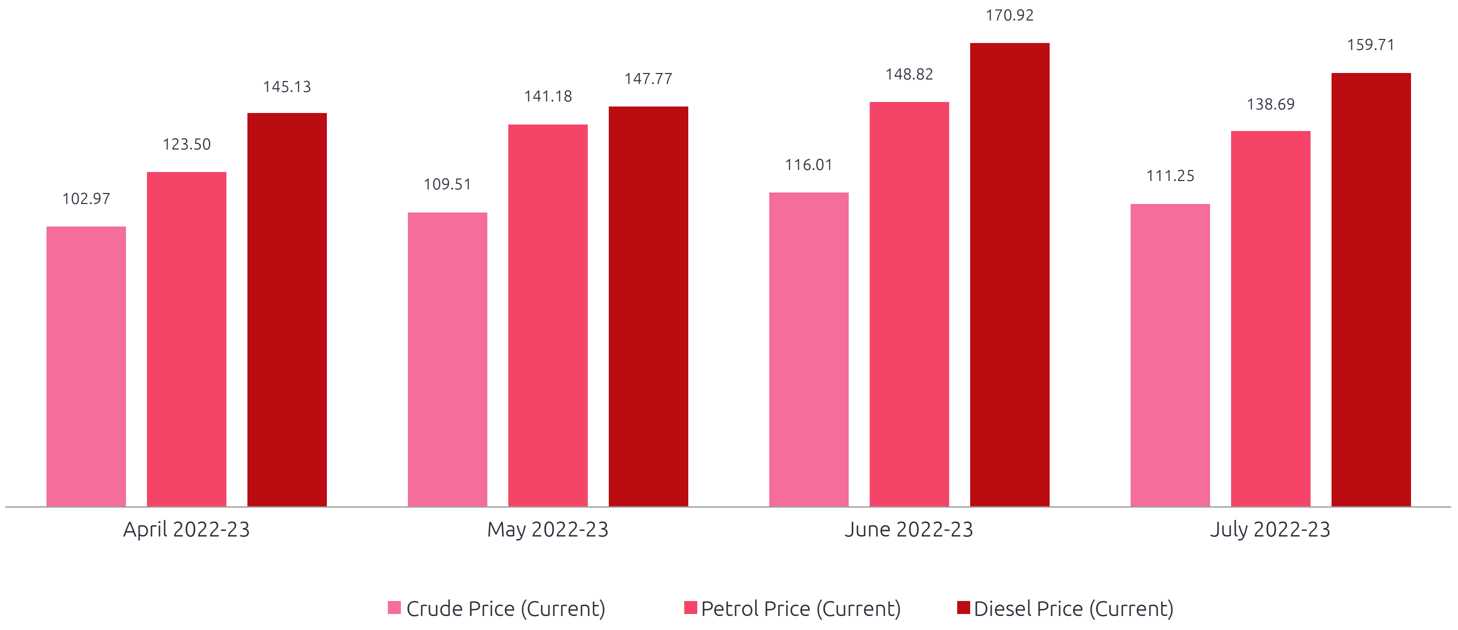
The increase in crude, petrol, and diesel prices due to the Russia-Ukraine war is impacting the Indian economy

India's oil imports from Russia

- India imports 85% of its oil and a significant amount of thermal coal from various other countries, including Russia
- In 2021, the total coal import from Russia stood at 1.8 million tonnes
- India imported around 43,400 barrels per day (bpd) of oil from Russia in 2021, which was around 1% of its overall imports (0.2% of Russia's natural gas exports)
- Gas Authority of India Limited (GAIL) has a 20-year partnership with Gazprom (started in 2018) to buy 2.5 million tonnes of LNG
- No government-to-government (G2G) arrangement for oil trade between India and Russia is available
- Indian Oil Corporation purchases most of the crude oil from Russia
- In the April-May 2022 period, Russia was India's 6th largest import partner
- In several of the previous years, it had occupied the 20th position

FIGURE 7

Crude Oil FOB Price (Indian Basket), Petrol (FOB) International Price and Diesel (FOB) International Price - ($/bbl.)



Source: Petroleum Planning and Analysis Cell, Ministry of Petroleum and Natural Gas, Government of India

Link: https://www.ppac.gov.in/content/149_1_PricesPetroleum.aspx

The Organization of the Petroleum Exporting Countries (OPEC+) which also includes Russia as an important member, is unable to ramp up production due to the Russia-Ukraine war, leading to a rise in prices. The impact of rising oil prices has an adverse effect on India. Some of the impacts include:

- Rise in pump prices and LPG
  - There was a rise in petrol and diesel prices in the later part of 2021, though impact was limited by cutting down the excise duty
  - This was a result of the rise in crude oil prices
- Inflation rates in India will be impacted by the rise in oil prices
  - According to a report published by the Bank of Baroda, if crude oil prices increase by 10%, the Wholesale Price Index (WPI) will rise by 0.9%
- Rupee depreciation
  - According to Forex traders, the rise in crude oil prices has a negative impact on investor sentiments
- Trade deficit position will also be impacted
  - A report by S&P Global Platts Analytics, highlighted the fact that if there is a 10% rise in oil prices, that could lead to a $15 billion current account deficit

- Rise in Aviation Turbine Fuel (ATF) prices
  - In February 2022, the cost of ATF also increased by 8.5% due to the rise in oil prices
- Impact on other companies
  - Since the war has pushed oil prices upwards, even the companies which use formalin oil and RDB oil as inputs was impacted
  - The price of vegetable oil, which is used in various consumer products such as anti-caking agents and soaps, is suffering from inflationary pressure

Russia is not willing to sign deals with Indian oil buyers due to inadequate supply caused by the war

- Various reports suggest that the Russian company Rosneft has refused to supply oil to Indian refineries due to lack of supply
- This will lead Indian refiners to buy more expensive oil from the spot market

The National Action Plan on Climate Change (NAPCC) has eight missions within its purview

The pandemic resulted in an economic standstill. This resulted in a 7.2% reduction in CO_2 emissions in 2020. A five-fold strategy — which is termed as the panchamrita – was announced by the Prime Minister of India at the 26th Conference of Parties (CoP26) for achieving Net Zero emissions by 2070

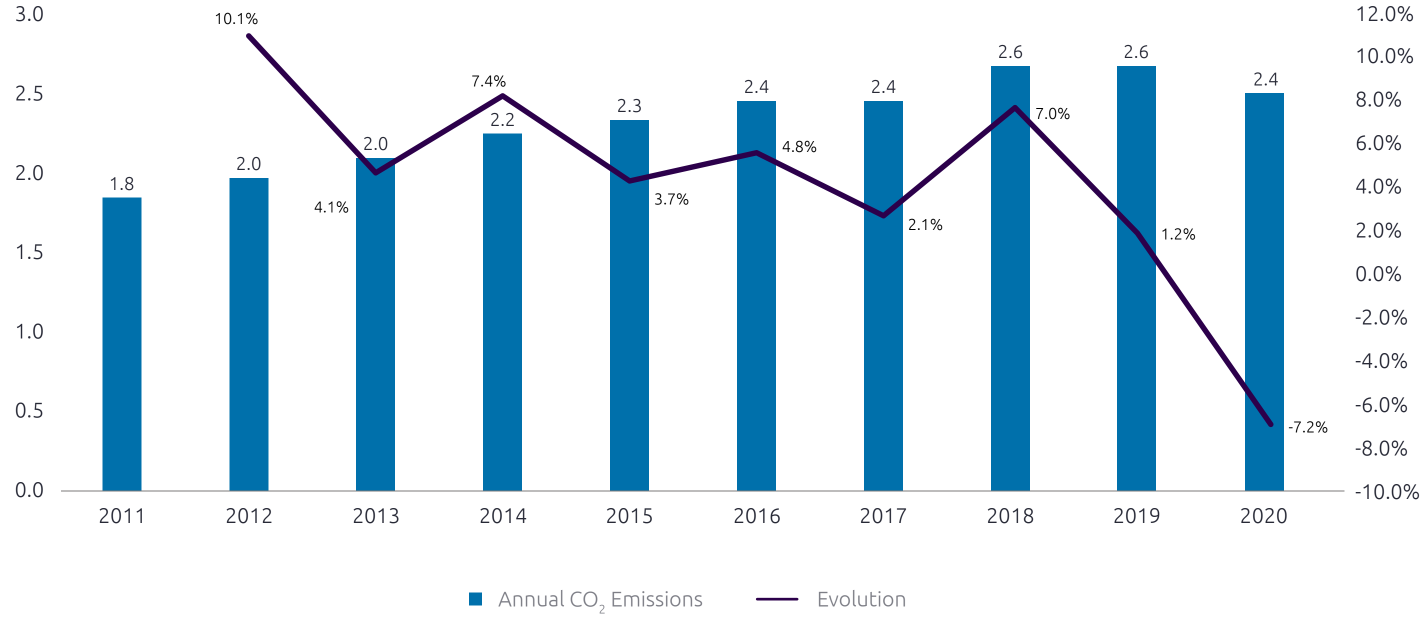
- India has committed to bring its non-fossil energy capacity to 500 GW by the year 2030
- India is committed to fulfil 50% of its energy requirements from renewable energy by 2030
- India is going to limit the total projected carbon emissions by one billion tonnes between now and 2030
- India will reduce the carbon intensity of its economy by less than 45% by 2030
- All of these initiatives would contribute to reaching the net zero target, which India is aiming to achieve by 2070

National Action Plan on Climate Change (NAPCC)

- The fundamental objective of the NAPCC is to outline the issues relating to climate change, as well as counter measures and mitigation strategies. Some of the major principles of the NAPCC are as follows:
  - Devising a sustainable development strategy to combat climate change and protect vulnerable sections of society
  - Leveraging sustainability for attaining economic growth
  - Formulating strategies for efficient demand-side management
  - Mitigation and adaptation of greenhouse gas emissions by deploying relevant technologies
  - Promoting sustainable development by bringing in new forms of market structure and regulatory mechanisms
  - Implementing programs through the inclusion of local governments and civil society in decision-making and promoting public-private partnerships (PPPs)
  - Collaborating with international institutions for research and transfer of technologies on climate-related matters

FIGURE 8

Annual CO_2 Emissions in India (2011-2020) (billion tons)



Source: Our Word in Data, India
Link: https://ourworldindata.org/co2/country/india

Strategies for decarbonizing India's energy sector

- Maximizing renewable energy production, including the utilization of the untapped potential of offshore wind, by introducing certain incentives such as production-linked subsidies on rotor blades
- Introducing carbon capture technologies
- Promoting green hydrogen with the help of demand-side incentives such as production-linked subsidies for electrolyzers
- Initiating steps towards transforming the electricity grid from a one-way centralized carrier of electricity to a more decentralized grid which will have the capability to move electricity in two directions
- Incentivizing large-scale decarbonization projects
- Supporting green financing by developing a robust framework

Despite the efforts to move away from coal, it will remain an important fuel in India

States such as Gujarat, Maharashtra, Chhattisgarh, and Karnataka did not build new coal power plants between 2019 to 2021

- Several other states in India have the potential to move away from new coal power due to a mix of environmental and socio-economic factors, especially given the rapidly increasing cost competitiveness of new renewables
- 326 GW of coal projects have been cancelled in India since 2015, including more than 250 GW of shelved capacity
- For every 1 GW of coal that has gone into operation, almost 7 GW have been scrapped
- Since the cost of building new coal-based power plants is higher in India than most other countries, it is difficult to make coal-fired power economically viable
- Running coal-based power plants has become more expensive given that the average coal plant load factors have fallen steadily in recent years, from 61% in 2018 to 53% in 2021

According to the Coal Ministry's statement in the Rajya Sabha of the Parliament of India, energy transition away from coal in India will not happen in the "foreseeable future"

- According to the Economic Survey 2021-22, coal demand is estimated in the range of 1.3-1.5 billion tonnes by 2030, a rise of 63% from current demand
- This conflicts with the agreement extended at the Glasgow Climate Summit in November 2021 to "phase down" the use of coal
- There were controversies regarding the wording of the pact at Glasgow which got changed at the last minute
- Officials from the Environment Ministry and Ministry of External Affairs representing India mentioned on the last day of the summit, that 'phase out' got modified to 'phase down,' the latter phrase also being included in the the U.S.-China joint statement released during the summit

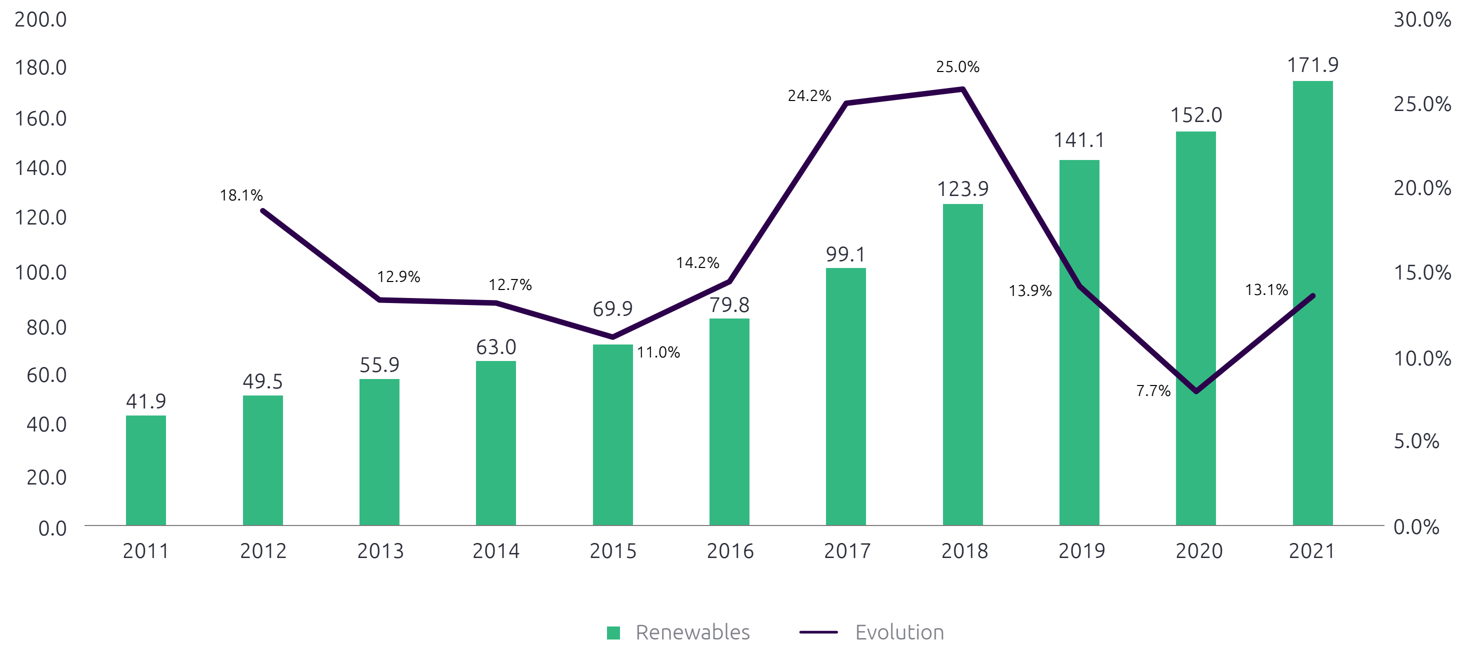
Renewable power generation: Solar and wind energy continue to grow

Growth trends across the renewable energy sector vary. However, India's renewable energy progress is possible largely due to timely energy market reforms and policy decisions

- India has seen exponential growth in its renewable energy sector from 2017 to 2021, due to a highly conducive policy environment, a steady influx of capital, falling prices, and new technologies
- India's renewable energy growth between 2011-2021 was 15.16% CAGR. It involved an investment of $64.4 billion according to the REN21 Renewables 2020 global status report
- Some of the major programs and schemes are as follows:
  - Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM)
  - Production Linked Incentive (PLI) Scheme
  - Solar Parks Scheme
  - Roof Top Solar Programme Phase-II
  - Central Public Sector Undertaking (CPSU) Scheme
  - Off-Grid Solar PV Applications Programme Phase III
  - Atal Jyoti Yojana (AJAY) Phase-II

FIGURE 9

Renewable Energy Generation (TWh)



Source: BPStats 2022
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Policies and initiatives by the Government of India give impetus to the renewable sector. Some of the major policies and initiatives include:

- Waiver of Inter State Transmission System (ISTS) charges for inter-state sale of solar and wind power for projects set to be commissioned by June 30, 2025
- Discoms have been mandated to issue and maintain letters of credit (LCs) for building investor trust
- National Hydrogen Mission for making India the worldwide hub for Green Hydrogen export and production
- PM-KUSUM, solar rooftop and CPSU for strengthening the domestic manufacturing ecosystem
- Support from One Sun – One World – One Grid (OSOWOG) in developing a worldwide grid through which clean energy can be transferred anytime, anywhere
- The launch of the International Solar Alliance (ISA) by the Prime Minister of India, and the President of France. ISA is the first international intergovernmental organization headquartered in India

According to data published in early 2020, India committed approximately $156.09 billion to support various energy types through policies both new and amended.

Commitments include:

Amount	Type	Number of policies
$37.89 billion	Unconditional fossil fuels	29
$8.17 billion	Conditional fossil fuels	7
$8.92 billion	Unconditional clean energy	28
$32.34 billion	Conditional clean energy	18
$68.77 billion	Other energy	15

Renewable capacity:

India installed 147.122 GW of renewable capacity to date. The country's target is to install 500 GW of renewable energy capacity by 2030

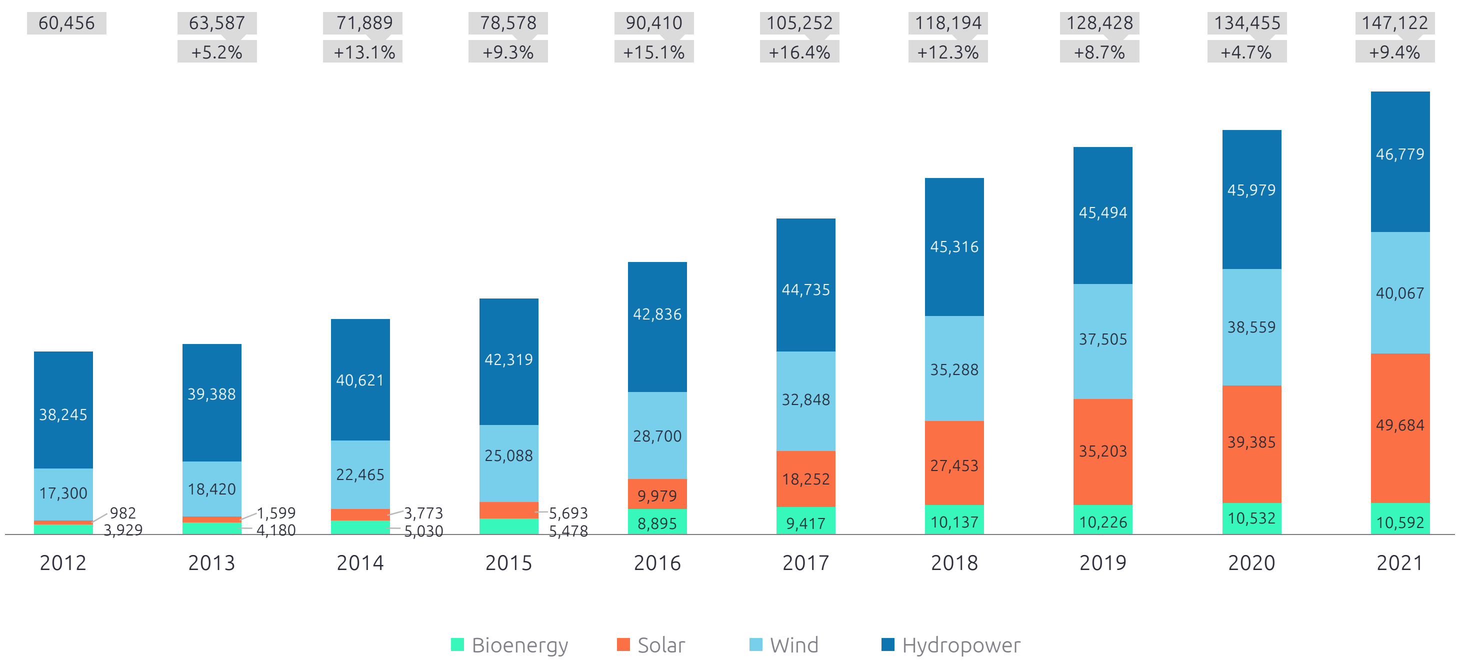
According to the Renewable Energy Country Attractive Index 2021, India holds the third position.

India's renewable installed capacity has grown at a CAGR of 10.39% between 2012-2021

- India has installed 147.122 GW of renewable capacity. The country aims to install about 175 GW worth of renewable energy by the end of 2022 with a goal of 500 GW by 2030
- In 2021, India had the:
  - 4th largest installed capacity of renewable energy worldwide
  - 4th largest installed capacity of wind power worldwide
  - 5th largest solar installed capacity worldwide
- Approximately 63 GW of renewable energy capacity is under construction
- According to Investment Information and Credit Rating Agency of India Limited (ICRA), by 2023, India's renewable energy generation capacity is assumed to be around 16 GW

FIGURE 10

Renewable installed capacity (MW)



Source: IRENA, 2022

Link: https://www.irena.org/

According to data released by the Department for Promotion of Industry and Internal Trade (DPIIT), FDI investments to the Indian non-conventional energy sector stood at $11.6 billion from April 2000 to March 2022.

According to the REN21 Renewables 2020 Global Status Report, renewable energy programs and projects in India attracted investments of $64.4 billion during the 2014-2019 period

- In December 2021, Maharashtra State Electricity Distribution Company Limited (MSEDCL) awarded a contract to Tata Power, India's largest energy provider, to set up a 300 MW wind-solar hybrid power plant
- In October 2021, Adani Green Energy Ltd. (AGEL) acquired SB Energy India for $3.5 billion in an effort to strengthen its position in the renewable energy sector in India
- In July 2021, National Thermal Power Corporation Renewable Energy Ltd. (NTPC REL), NTPC's fully-owned subsidiary, floated a tender to domestic manufacturers to build India's first green hydrogen fueling station in Leh, Ladakh

There has been an adverse effect of Covid19 on the demand for electricity in India.

The demand for electricity decreased by 23% YOY between April 2020 and April 2021.

In Q2 FY2022, the demand for electricity increased to 366 BU, up from 338 BU for FY 2020. The increase can be attributed to the ease in Covid-19 rectrictions followed by the commencement of industrial activities.

- The measures undertaken for additional renewable capacity was affected by supply chain hindrances and restriction on labor movement due to the pandemic
- Logistics and raw material costs increased significantly, leading to a demand-supply mismatch
- The Discoms were severely affected by the Covid-19 pandemic as collection and billing efficiency were remarkably hampered during the pandemic
- During the first wave of the pandemic, the bounce-back period was shorter compared to the following waves
- However, the number of installations increased in 2022, which can be attributed to the continuation of the renewables auction during the pandemic

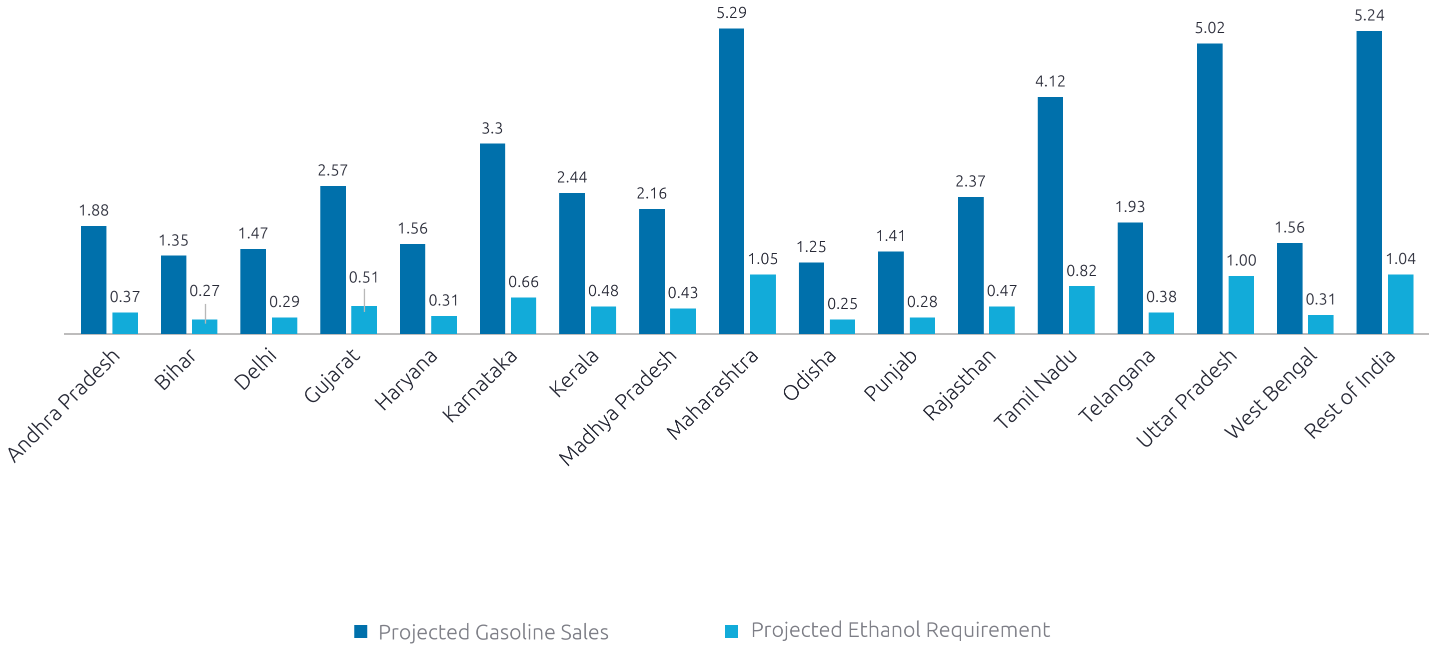
India has undertaken several measures to fulfil its ambition of E-20 by Ethanol Supply Year (ESY) 2025

India's Biofuel Policy 2018

- India moved up its average target of 20% ethanol blended with gasoline to 2025 from 2030; this includes the commencement of sales of E-20 blended gasoline starting in April 2023
- The targets would be met through the following initiatives:
  - Achieving a growth trajectory in domestic biofuel production (First generation [1-G] Second generation [2-G] and Third generation [3-G])
  - Increasing the use of multiple feedstock
  - Giving impetus to biofuel blending to supplement diesel and gasoline use in machinery and vehicles, as well as in stationary and portable power applications

FIGURE 11

Annual ethanol requirement in 2025 for E-20 (billion liters)



Source: United States Department of Agriculture, Foreign Agricultural Service, Biofuels Annual Report, India
Link: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_New%20Delhi_India_06-07-2021

Increasing fuel ethanol national blend rate from 10% in 2022 to 20% by 2025

- Increasing the commitment towards redirecting surplus sugar to boost ethanol production
  - To achieve this goal, the government of India decreased its subsidy on sugar from under Maximum Admissible Export Quota from $82/metric ton (MT) to $55/MT
  - The Government of India made an amendment to the Sugarcane Control Order of 1966 to give space for the establishment of stand-alone ethanol units to enhance production
  - As per the estimates of the Government of India, by investing around $41.16 million to increase the production of ethanol, domestic ethanol production capacity will increase from the current 4.26 billion liters to 6.15 billion liters
  - However, for achieving E-20 by 2025, India would require an estimated output of 9 billion liters, implying that India will need to create 3 billion liters of additional ethanol production capacity in the next four years

The status of other biofuels

- The Ministry of Science and Technology's Department of Biotechnology (DBT) is focusing on cellulosic ethanol (2G) technology development including lignin valorization, algal biofuels, waste biomass to energy, biobutanol, and biohydrogen
- There has been an effort to convert Municipal Solid Waste (MSW) into drop-in-fuels. (A drop-in fuel is a synthetic and completely interchangeable substitute for conventional petroleum-derived hydrocarbons; it does not require engine, fuel system or fuel distribution network adaptation)
- Though there are technologies to convert waste into biofuels, only five projects with a cumulative capacity of 74.7 MW have been approved by the government of India as of January 2021
- Efforts are underway to establish 5,000 compressed bio-gas (CBG) plants in India with a cumulative capacity of 15 MMT by 2023/24

Indian states face integration bottlenecks in reaching the 2030 renewables target

Technical challenges include:

- As wind and solar sites are concentrated in a few states, transmission becomes a challenge
- The data generating capacities of the states are weak, especially with respect to solar and wind forecasts
- Electric vehicles (EVs) and air conditioners are expected to drive up electricity demand
- The Standard Operating Procedures (SOPs) for coal generation plants are not flexible
- There is still an emphasis on coal generators or hydropower, as compared to wind and solar
- Issues related to distributed energy sources (such as EVs and solar rooftops) include voltage fluctuations, reverse flows, inadequate visibility of new and existing installations, bottlenecks, and forecasting challenges
- Inadequacy of a unified planning model is conspicuous in India

Regulatory, market, and policy challenges include:

- Inadequate market signal for power system elasticity and a dearth of service regulations
- Insufficient compensation for wind and solar curtailment, which can adversely affect the confidence of investors
- A dearth of grid codes for ensuring support system security for VRE plants
- Coal power plants are not compensated if investment in increased flexibility is required by the state
- Extreme emphasis on power plants running on coal reduces the development of lower carbon sources, such as renewables
- Conventional power plants require long-term contracts which can increase an economic burden
- The short-term wholesale market lacks liquidity
- The financial stability of Discoms are affected by the integration of renewables
- The chance of increasing end-user electricity tariffs due to rise in transmission charges and other market inefficiencies

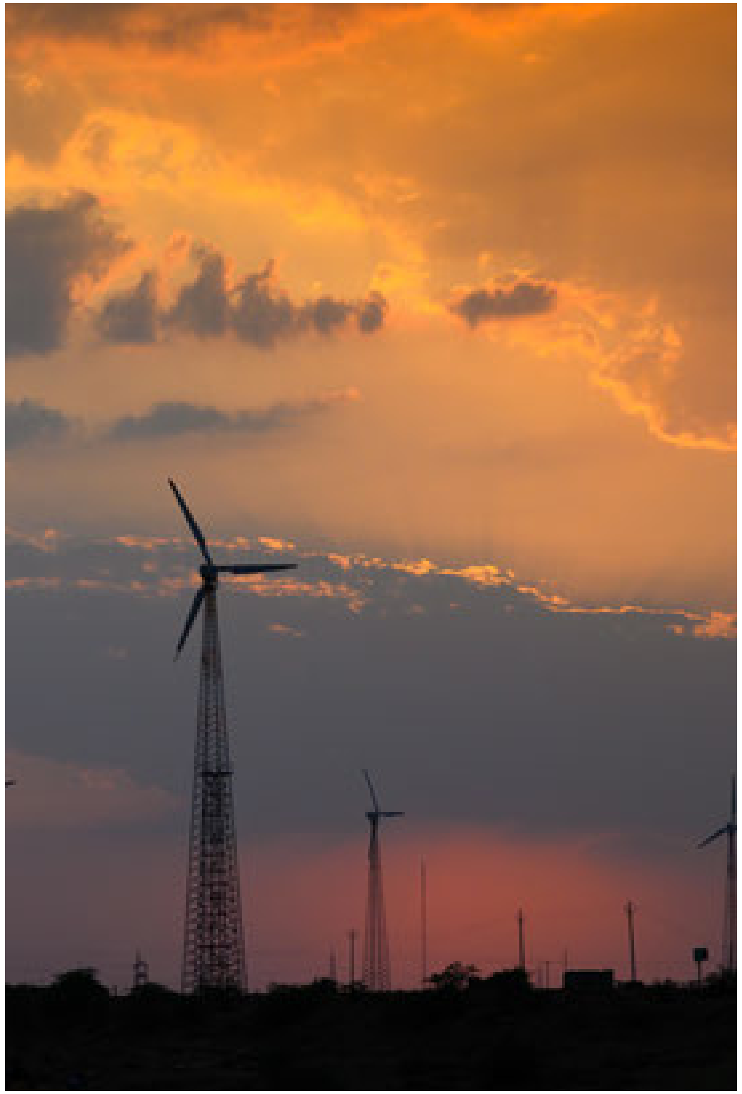
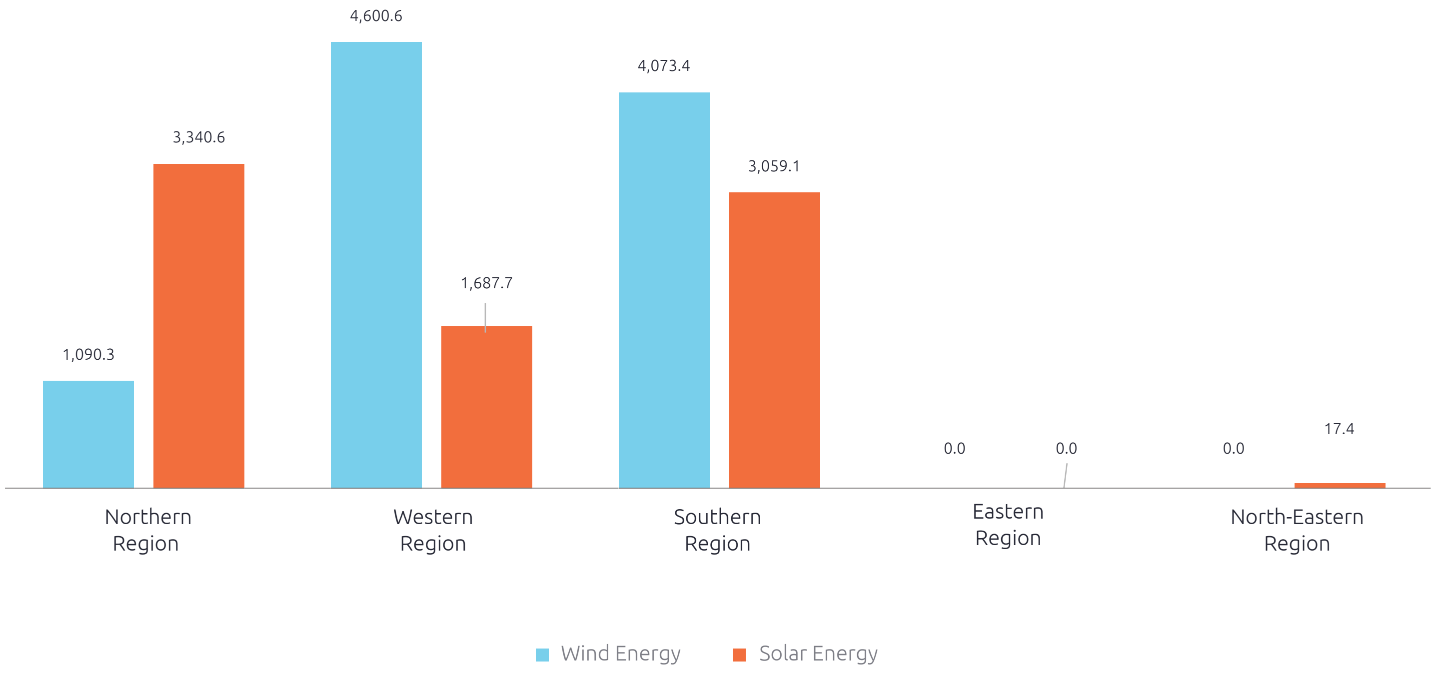


FIGURE 12

Provisional renewable energy generation report



Source: Renewable Energy Project Monitoring Division, CEA – May 2022
Link: https://cea.nic.in/renewable-generation-report/?lang=en

The bottlenecks, priorities and solutions with respect to renewables integration are different for each state in India

- The most popular renewable capacity additions in India include wind and solar energy. Projects continue to be generally concentrated in the following states: Tamil Nadu, Gujarat, Rajasthan, Karnataka, Maharashtra, Andhra Pradesh, Telangana, Punjab, Kerala, and Madhya Pradesh
- Wind has always dominated the scenario, but currently there are more solar-related projects in the pipeline
- The above-mentioned states are encountering system integration challenges due to a higher share of Variable Renewable Energy (VRE)

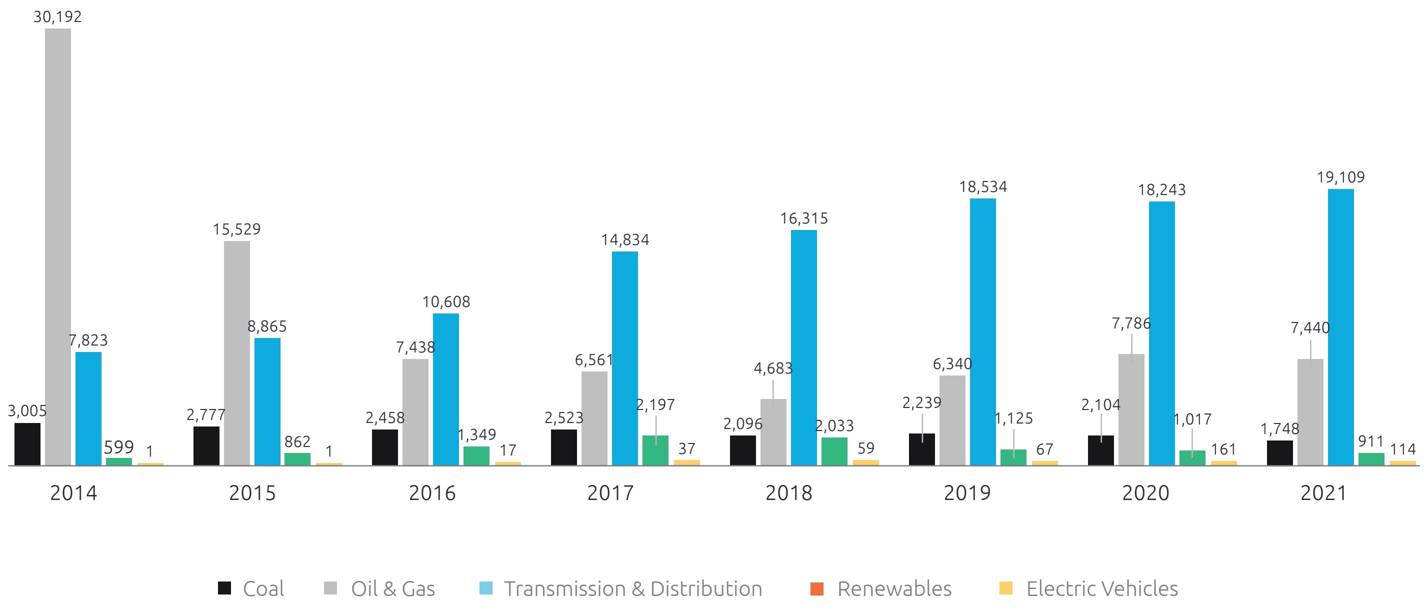
Subsidies are increasing in the Transmission & Distribution sector, but decreasing in the renewable sector

Compared to 2020, the total amount of subsidies was approximately the same as in 2021. This figure has been stagnant since 2019.

- **Coal:** There has been a decline of 17% as compared to 2020, due to an amendment to the Environment Protection Act
- **Oil & Gas:** There has been a marginal fall in subsidies in this sector
- **Transmission & Distribution:** Efforts of the state governments in enabling low-cost electricity to agricultural and residential consumers have increased the number of subsidies in this sector
- **Renewables:** The decrease in benchmark and installation costs year-on-year, along with the slow and steady fall in accelerated depreciation benefits as assets age, have caused subsidies to decline in this sector
- **EV:** EV subsidies represent barely 1% of the total subsidies being provided across all the sectors, though this concept is still at a very nascent stage

FIGURE 13

Total quantified energy subsidies in India



Source: Mapping India's Energy Subsidies 2022

Link: https://www.iisd.org/system/files/2022-05/mapping-india-energy-policy-2022.pdf

The majority of subsidies is provided in the Transmission & Distribution (T&D) sector, amounting to around $ 19.1 billion; this accounts for 65% of the total subsidies in FY 2021

- After the Covid-19 lockdown was eased, the demand for electricity increased
- At that point, most of the state governments brought in several subsidy schemes for industrial and retail users
- In the future, subsidies in the T&D sector are likely to increase, as driven by increased demand, resulting in the higher cost of subsidies
- The Green Energy Corridor Scheme received a new lease of life as the Cabinet approved the second phase. This will bolster the renewable energy transmission grids. Total Central assistance for the next five years amounts to $500 million

Between 2014 and 2021, subsidies for renewables reached the highest mark in 2017. Since then, the figure has fallen 59%.

- The quantifiable subsidies for renewable energy include: accelerated depreciation for wind and solar; generation-based incentives for wind and solar; lower GST and customs duty for wind power; and waiver of the interstate transmission system (ISTS) charges for solar and wind power
- A huge gap exists between the 2030 targets in the renewable sector and the current trends in India. To address this gap, India would need a deployment of 11 GW of wind power and 25 GW of solar PV per year
- It is important to ensure the right infrastructure if India wants to meet its renewable energy targets in 2030; this includes support in manufacturing high-efficiency solar PV modules
- In August 2021, the government announced a mission for green hydrogen to strengthen its production and use. This is intended for separating emissions from growth in industries such as fertilizers, steel, heavy duty transport and refineries

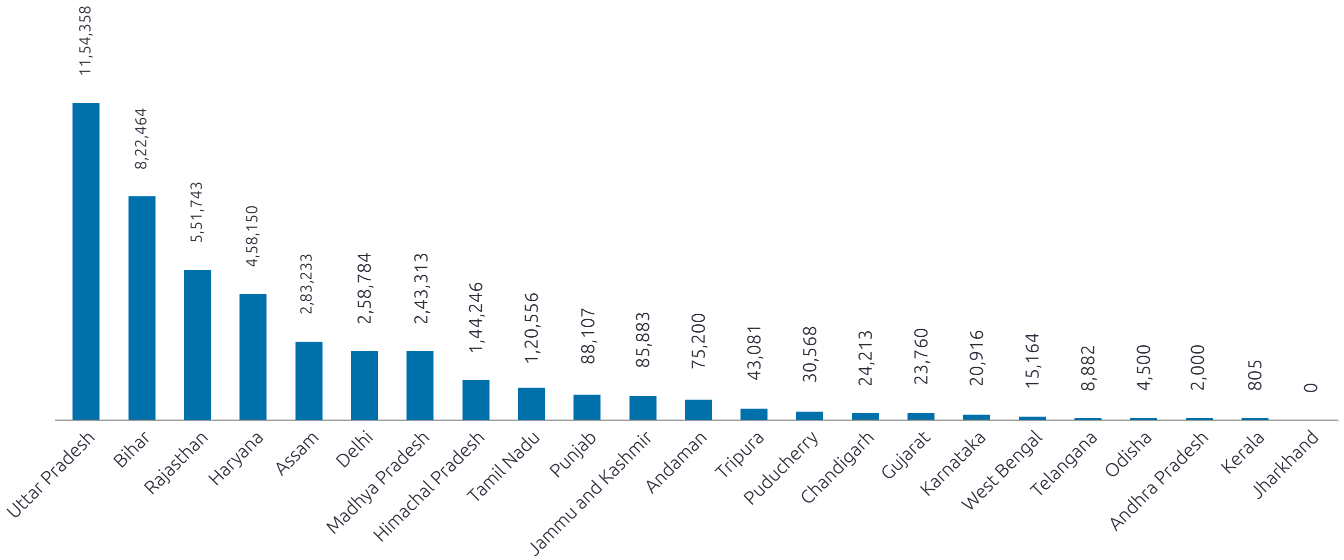
Smart metering marks the beginning of digitization in the energy & utilities sector in India

As of June 2022, approximately 4.6 million smart meters have been installed throughout the country, according to the National Smart Grid Mission, Ministry of Power

- From the point of view of distribution companies, smart meters can help them in maximizing revenues, while consumers can regulate and monitor their energy use
- Other advantages of smart meters include remote billing and metering, implementation of off-peak and peak tariffs, and proper management of demand-side usage
- Modernization of energy would be possible if India could install around 25 million smart meters in the next four to five years
- The installation of smart meters has the potential to facilitate the transition to a more efficient system

FIGURE 14

Smart meter implementation status (as of June 2022)



Source: National Smart Grid Mission, Ministry of Power, Govt of India
Link: https://www.nsgm.gov.in/en/sm-stats-all

India's Green Grids Initiative:

- In collaboration with the United Kingdom, India has launched the Green Grids Initiative-One Sun One World One Grid (GGI-OSOWOG) project for creating an integrated global electricity grid
- This program is aimed at sending renewable energy to countries with an energy deficit

This could act as a model for how developed countries can help developing countries in minimizing emissions and meeting the objective of limiting global warming to 1.5° Celsius

- The solar spectrum may be divided into two broad zones: far east, which includes countries such as Myanmar, Vietnam, Thailand, Laos, and Cambodia; and far west, which includes the Middle East and Africa. In this model, India is in the middle

A plethora of initiatives driven by digital technologies, if undertaken by the Central Government, can augment grid management, metering and energy accounting

- The losses faced by the Indian Discoms can be minimized with the help of an Advanced Metering Infrastructure (AMI) enabled by Internet of Things (IoT) devices
- Improving the utility's network and outage management capabilities can be successfully done through Advanced Distribution Management Solutions (ADMS)
- A Unified Revenue Management System can be incorporated by the Discoms to minimize the commercial inefficiencies
- Advanced analytics can help in demand forecasting and load management
- Enhancing Enterprise Asset Management (EAM) with the help of Asset Performance Management (APM) capabilities can help optimize the asset management of the entire operation
- Real-time monitoring of assets with the help of Unmanned Aerial Vehicles (UAV) or drones can lower management and operational costs
- Virtual Reality/Augmented Reality/Mixed Reality (VR/AR/MR) and Blockchain technologies have been shown to improve efficiency for the sector

Attaining energy efficiency through smart metering

With the advent of smart metering technology, consumers in India will soon experience a change in how they pay and receive their bills. To give it a proper shape, a scheme amounting to INR 3,050 billion ($ 38.17 billion) was announced in the union budget for FY 2022.

- Smart metering helps manage demand response (DR), which is a method that facilitates the adjustment of demand, allowing customers to take part in responding to changing grid conditions
- Discoms can effectively utilize the data collected from smart meters to enable quicker detection of outages in the system, as well as identification of load theft

The smart meter implementation program quantifies the benefits through billing efficiency, loss reduction, and revenue increases.

According to the data published on the National Smart Metering Program Dashboard, the average increase in Discoms' revenue was 20.50% (a total increase of INR 301 ($ 3.77) per month per meter. Additional highlights include:

- Aggregate Technical & Commercial (AT&C) loss reduction: 11-36%
- Increase in revenues: INR 2.64 billion ($33 million) per annum
- Pre-paid meters: 140-150% increased revenues in the state of Bihar

Tata Power Delhi Distribution Limited (TPDDL): Smart metering and automated DR pilot

- ITPDDL, which operates in the National Capital Region (NCR) in India, is a privately owned Discom. TPDDL conducted India's first smart meter-based automated DR pilot which was aimed at determining peak demand along with grid stress management
- The program approached consumers with a sanctioned load of 100 kVA; Total participation included 162 high -end consumers
- Seventeen DR events were organized with automated DR infrastructure, such as servers and site controllers
- Intimations regarding the load were transmitted to the consumers through text message on a real-time basis
- Prior to the event, the load shed potential was estimated to be 12 MW. But after the DR events, a maximum shed of 7.2 megavolt-amperes (MVA) was observed
- The consumers who participated in the event reaped some benefits due to the relay of information on a real-time basis
- The consumers could also monitor violations with respect to power factors and load
- The availability of a web-based consumer portal with consumption data helped increase transparency, which improved confidence among consumers
- Broadly speaking, the provision of detailed information to consumers enables them to make better-informed decisions to control their electricity use and increase monetary savings

AUSTRALIA
EMISSIONS, CARBON TAXES, RENEWABLES AND ENERGY EFFICIENCY MEASURES

VINNIE NAIR
NICOLE ALLEY
MONICA VASWANI
ISHANDEEP

This article will focus on climate change, emissions trends, and the associated regulatory environment and challenges in Australia, including carbon taxes and the influence of carbon pricing mechanisms on energy efficiency. It will also discuss how the major oil & gas companies are evolving and shifting their strategies away from fossil fuels.

The climate in Australia is changing

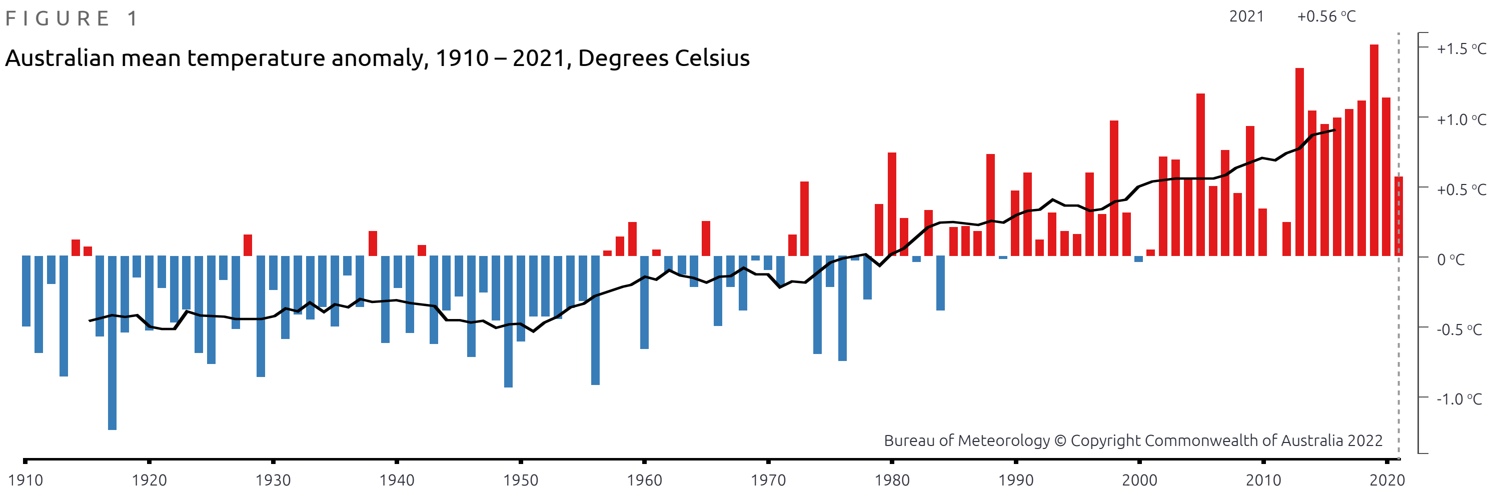
Despite 2021 being Australia's warmest year since 1980, it was also the country's coldest year on record since 2012. In fact, Australia is warming more quickly than the rest of the world, with a 1.4°C increase in temperature since 1910[1].

Dangerous and widespread flooding has been reported over the past few years in the eastern parts of Australia, particularly in New South Wales. Flood events that would normally take place once every 100 years are now becoming a common occurrence throughout the eastern seaboard[2]. The main cause of this type of weather in Australia was deemed to be the La Nina cycle and the climate crisis.

509.7 mm of rain fell in Australia in 2021, which is 9% more than the country's average of 466.0 mm as measured between 1961 and 1990. Significant rainfall deficits existed at the beginning of 2021 for the time period beginning in April 2020.

FIGURE 1

Australian mean temperature anomaly, 1910 – 2021, Degrees Celsius



Source: Annual climate statement 2021

http://www.bom.gov.au/climate/current/annual/aus/#tabs=Temperature

1 https://www.downtoearth.org.in/blog/climate-change/2021-was-one-of-the-hottest-years-on-record-and-it-could-also-be-the-coldest-we-ll-ever-see-again-81216

2 https://www.theguardian.com/australia-news/2022/mar/04/are-eastern-australias-catastrophic-floods-really-a-one-in-1000-year-event

Emissions

The burning of fossil fuels in electricity generation and the heat and transport sectors accounts for approximately 90% of the world's carbon emissions. In 2021, 40% of total emissions came from coal, 32% from oil, 21% from natural gas, 5% from cement production, and 2% from flaring and other sources.[3]

Responsible for just over 1% of the world's emissions, Australia ranks as the 14th highest emitter.[4]

In terms of sector contribution, energy generation for electricity accounts for most of Australia's emissions, followed by transportation, agriculture, and industrial operations.

Through the national greenhouse gas inventory, the Australian government tracks the progress of the nation's greenhouse gas emissions.

A look at 2021 emissions projections

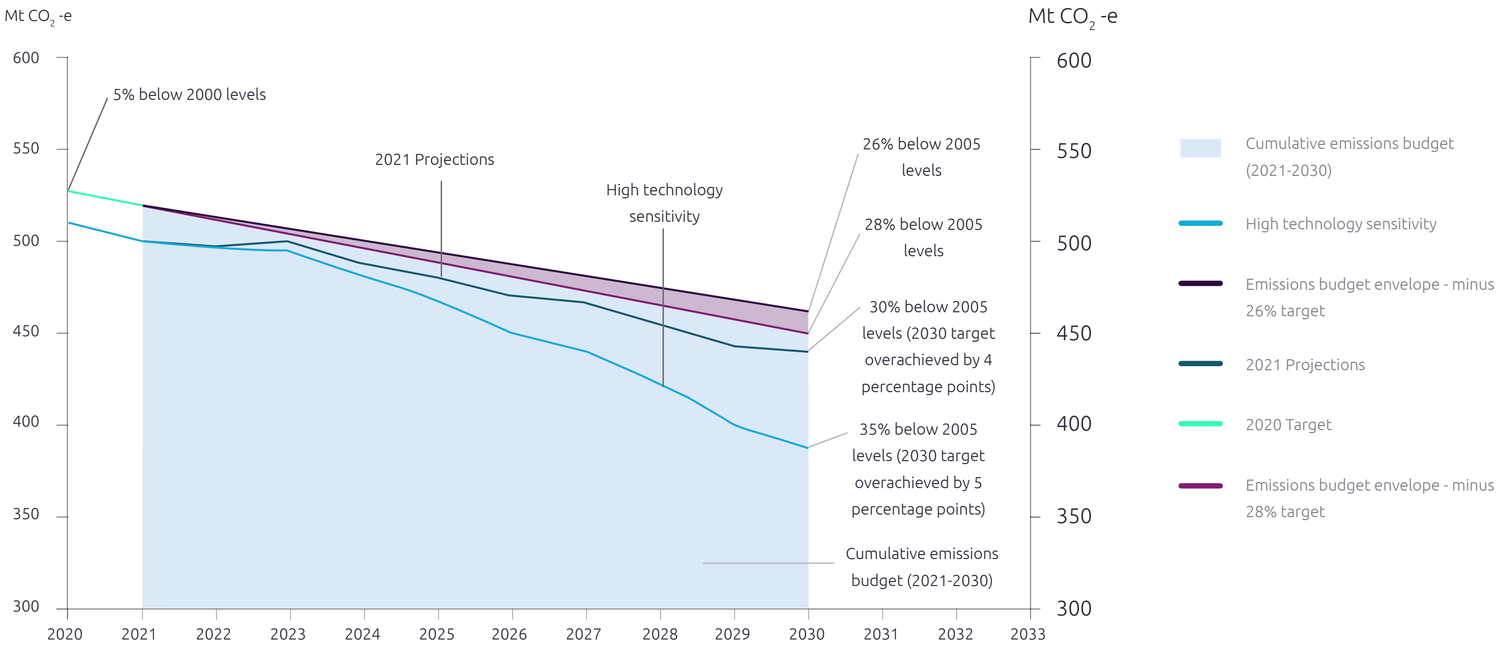
Australia is progressing well against its emissions reductions goals and is expected to surpass its 2030 emissions reduction target of 26-28% below 2005 levels by 4-9%[5 6]. Since 2018, Australia's forecast position against the 2030 target has improved by 843 Mt CO_2-e, which is equivalent to removing 14.9 million passenger vehicles from the road for more than 19 years.

3 https://www.csiro.au/en/research/environmental-impacts/climate-change/climate-change-qa/sources-of-ghg-gases
4 https://www.csiro.au/en/research/environmental-impacts/climate-change/climate-change-qa/sources-of-ghg-gases
5 https://www.dcceew.gov.au/climate-change/publications/australias-emissions-projections-2021#:~:text=Australia%20measures%20progress%20towards%20its,e%20from%202021%20to%202030.
6 https://www.theguardian.com/environment/2021/nov/02/scott-morrison-tells-cop26-australia-will-exceed-2030-target-in-bid-to-fend-off-criticism

Progress in emissions projections witnessed in 2021 were primarily due to:
- $1.6 billion in new technology-focused emissions reduction measures in the Australian government's 2021-2022 budget
- Continued strong uptake of renewables
- Latest forecasts on energy consumption and land clearing

FIGURE 2

Australia's cumulative emissions reduction task to 2030, Mt CO_2-e



Source: Australia Government: Australia's emissions projections 2021, Secondary search
https://www.industry.gov.au/sites/default/files/October%202021/document/australias_emissions_projections_2021_0.pdf

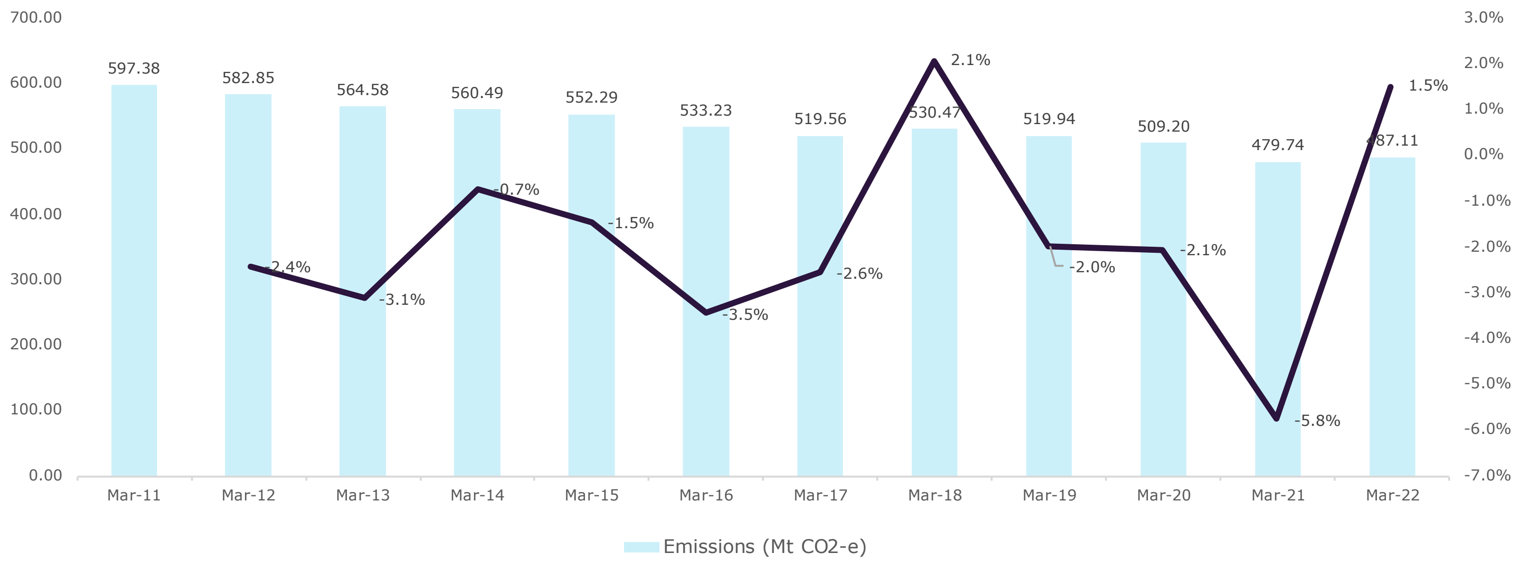
Where have we landed in 2022

Estimated emissions were approximately 487.1 Mt CO_2-e in March 2022, an increase of 1.5%, or 7.4 Mt CO_2-e, from March 2021[7]. The following factors caused this increase in emissions:

- Increased transport emissions (up 5.4% to 4.6 Mt CO_2-e)
- Increased emissions from stationary energy (excluding electricity) (up 3.7% to 3.7 Mt CO_2-e)
- Increased fugitive emissions (up 1.2% to 0.6 Mt CO_2-e) reflecting increased venting and flaring in oil & gas
- Increased emissions from agriculture (up 4.4% to 3.3 Mt CO_2-e) due to ongoing drought recovery

FIGURE 3

Australia's annual emissions, March 2011 – March 2022 (Mt CO_2-e)



Australia government: National Greenhouse Gas Inventory Quarterly Update: December 2021
https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-update-december-2021

7 https://www.dcceew.gov.au/sites/default/files/documents/nggi-quarterly-update-march-2022.pdf

In the electricity sector, emissions have fallen since they peaked in 2009, reflecting acceleration in renewable deployment and gradual displacement of coal as a fuel source. Still, emissions remained 23.2% above 1990 levels in the year to March 2022.

- The 3.1% decrease in emissions from the electricity sector in March 2022, reflected a decrease of 3.9% in coal generation, a decrease of 7.9% in gas generation, and an increase of 18.5% in supply from renewable sources in the National Electricity Market (NEM) compared to the previous year.
- Electricity sector emissions are experiencing a long-term decline, down 24.6% (52 Mt CO2-e) since June 2009[8].

FIGURE 4

Emissions from the electricity sector, by quarter, March 2010 to March 2022

Source: Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2021, https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-update-december-2021

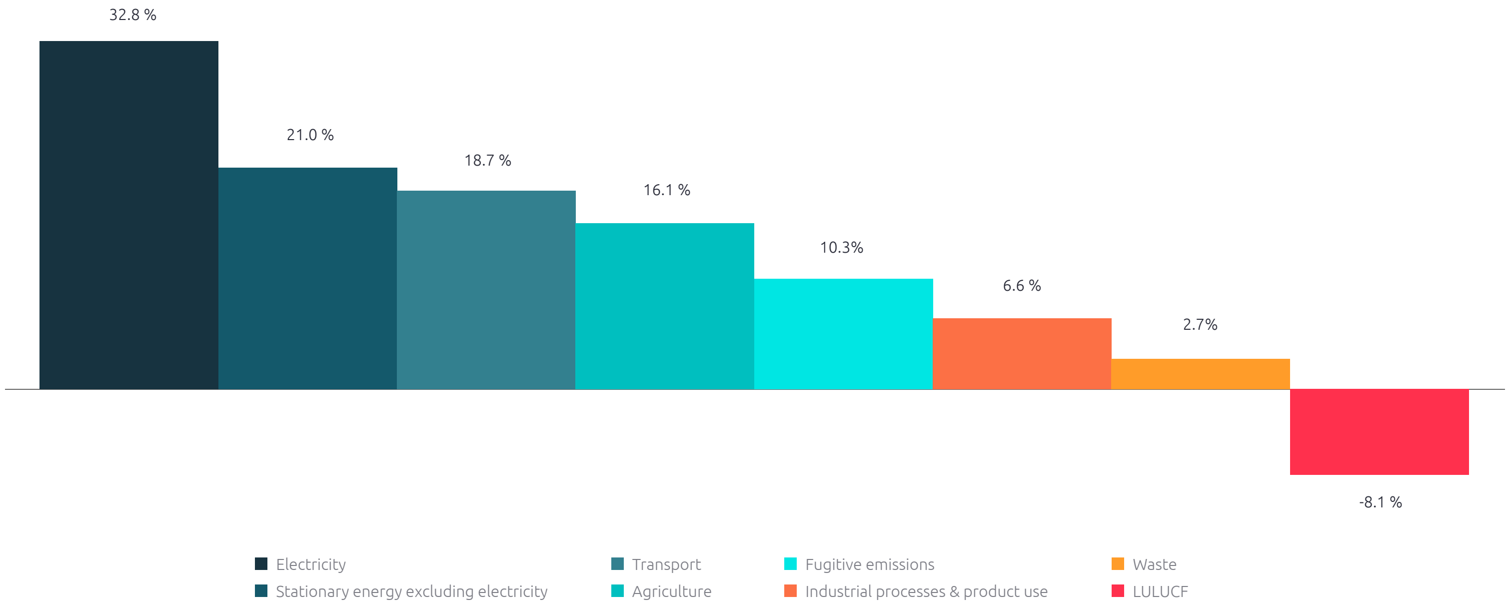
8 https://www.dcceew.gov.au/sites/default/files/documents/nggi-quarterly-update-march-2022.pdf

CO_2 emissions account for approximately 71% of total emissions, the largest share of aggregate emissions in Australia. Electricity generation is the largest source of emissions, accounting for 32.8% in March 2022. By 2030, emissions from electricity are expected to be 88 Mt CO_2-e, or 55% less than they were in 2005[9].

NEM emissions in Q2 2022 decreased 0.5% as compared with the Q1 2022.

FIGURE 5

Share of total emissions, by sector, for the year to December 2021

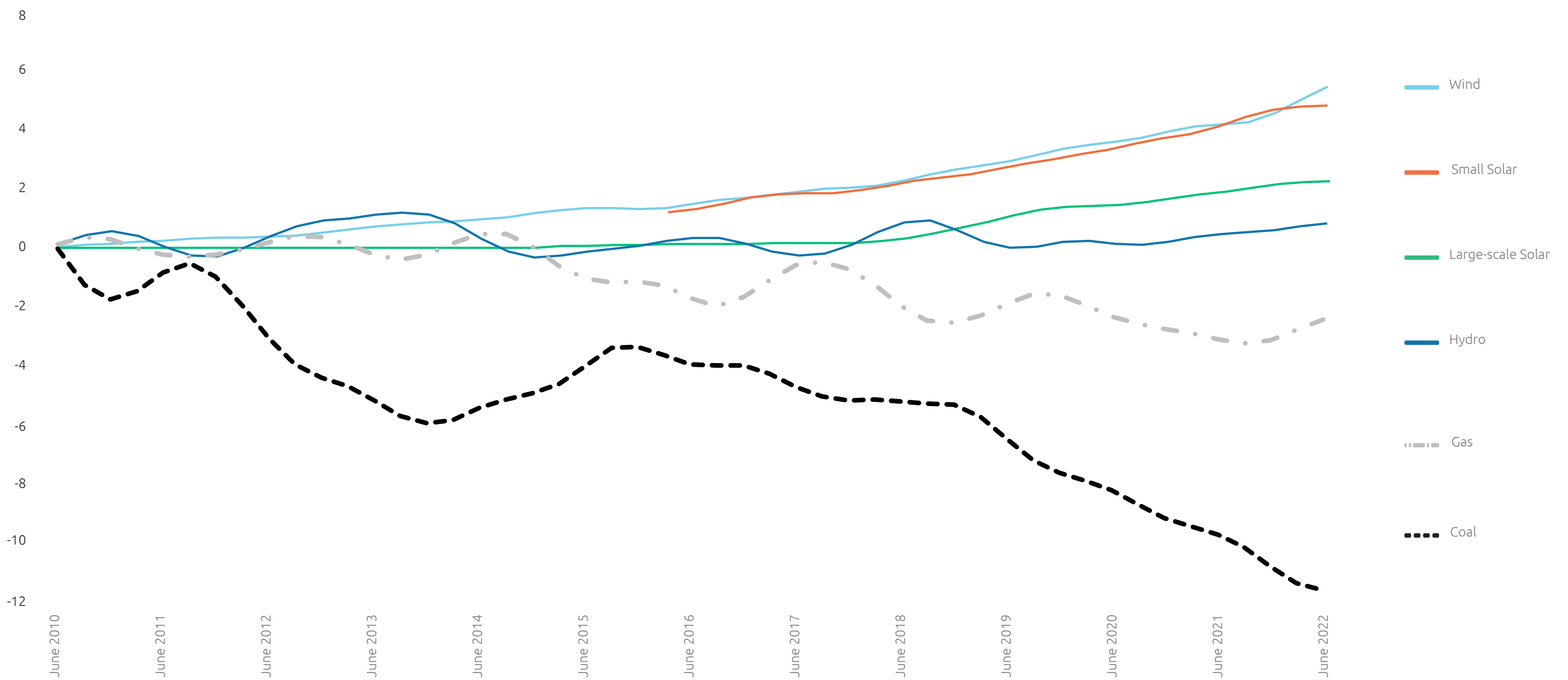


9 https://www.industry.gov.au/sites/default/files/October%202021/document/australias_emissions_projections_2021_0.pdf

Source: Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2021, * Land Use, Land Use Change and Forestry

FIGURE 6

Cumulative change in electricity generation in the NEM, trend, by fuel, by quarter, June 2010 to June 2022



Source: Australia government: National Greenhouse Gas Inventory Quarterly Update: March 2022

However, since September 2008, there has been a 28% (or 32.8 Mt CO_2-e) decline in quarterly emissions of carbon dioxide to 84.5 Mt CO_2-e in March 2022.

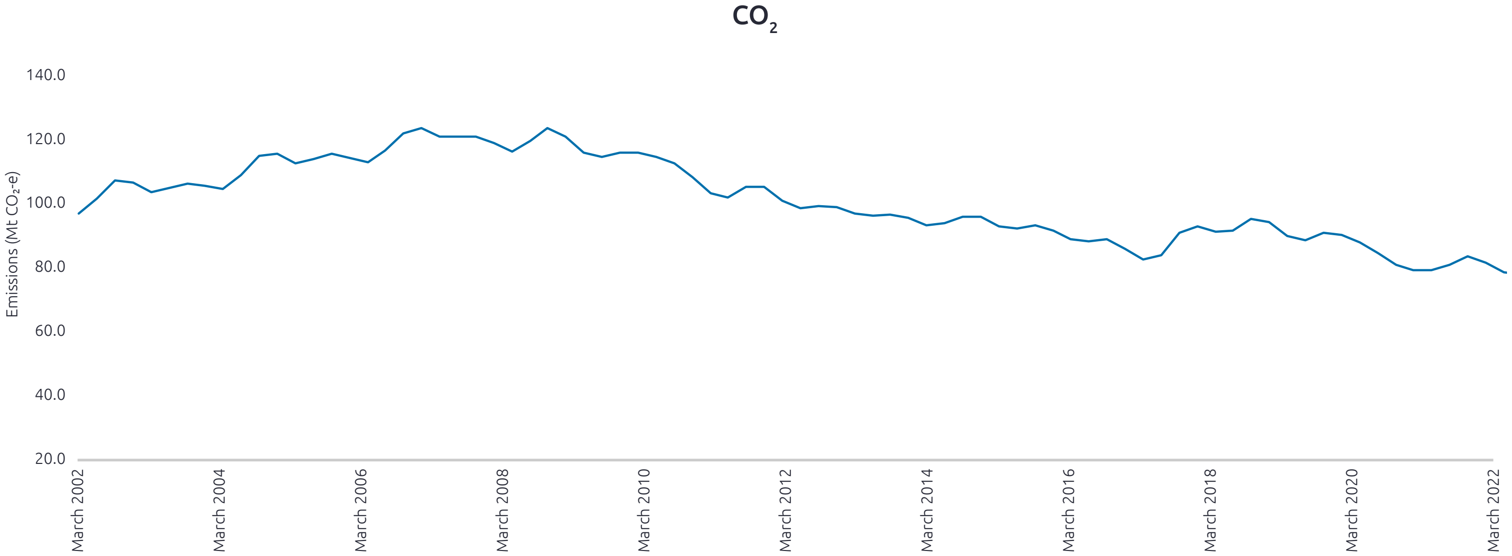
This long-term decline in CO_2 emissions is due to the ongoing shift in the generation of electricity away from coal and towards renewable fuel sources, as well as decreasing emissions in the land sector[10]. Against these downward forces, the long-term growth of emissions from transport activity and the expansion of LNG exports have placed upward pressure on the figures.

The uptake of renewable energy in the electricity sector is a major contributor to emission reductions in the most recent policies and action plans.

In May 2022, the newly elected Australian Prime Minister, Anthony Albanese, sought to push the climate change agenda by introducing legislation that would commit Australia to reducing carbon emissions by 43% below 2005 levels by 2030 and achieve net zero emissions by 2050[11]. At the time of writing this article, the federal government passed its Climate Change Bill in the lower house. This bill makes into law Labor's 2030 target of a 43% reduction in greenhouse gas emissions on 2005 levels.

FIGURE 7

Emissions, by quarter, by gas, trend, March 2002 to March 2022



Source: Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2021
https://www.industry.gov.au/sites/default/files/June%202022/document/nggi-quarterly-update-december-2021.pdf

10 https://unfccc.int/topics/land-use/workstreams/land-use--land-use-change-and-forestry-lulucf
11 https://www.business-standard.com/article/current-affairs/australian-pm-albanese-commits-to-cut-43-carbon-emissions-by-2030-at-quad-122052400162_1.html

Challenges associated with meeting the targets

Despite the expansion of renewable energy, Australia's per capita coal emissions, at 4.04 tonnes annually, are nearly four times higher than the world average as of May 2022.

According to projections made by the government in October 2021, emissions reduced in 2021 as coal production momentarily decreased, reflecting lower prices as a result of Covid-19 outbreaks and China's import restrictions.

According to Australia's 2021 emissions projections, emissions were expected to bounce back in 2022 and 2023 as coal production returns to previous levels. From 2023-2030, emissions are projected to remain relatively unchanged as production increases in metallurgical coal are offset by declines in thermal coal[12].

How are the major oil & gas companies evolving

Traditional oil & gas supermajors have embarked on a journeys to become multi-energy companies, integrating renewables and looking at unconventional synergies while reducing their reliance on pure hydrocarbons or oil & gas. This shift in business model is blurring the lines between energy and utilities companies and will see some of the supermajors become utilities in the future. Shell, for example, has stated the company's ambition to become the world's largest utility company[13].

Firms such as bp, Ampol, Engie, Shell and BHP each have their own net zero ambitions either by 2045 or 2050. Some of the key themes emerging from this ongoing energy transition include: divestments of high-carbon, emissions-intensive generation facilities; acquiring "green" or "clean" companies; other green energy investments; strategic partnerships in renewables generation, including wind, solar, and green hydrogen hubs; and becoming a low-carbon provider of power (batteries) for electric vehicles.

12 https://www.industry.gov.au/sites/default/files/October%202021/document/australias_emissions_projections_2021_0.pdf
13 https://www.ft.com/content/87cfc31e-44e7-11e9-b168-96a37d002cd3

Oil & gas majors transition to new energy

bp Australia looks to repurpose a former oil refinery site for green hydrogen production

bp is looking at producing green hydrogen at the site of a recently closed oil refinery in Western Australia. Alongside Macquarie Capital, bp is assessing plans to transform the former site of Australia's largest oil refinery into a clean-energy hub that could produce and distribute zero-emissions fuels, including "green" hydrogen.

bp Australia President Frédéric Baudry stated on the move, *"bp is committed to developing solutions that will help accelerate the energy transition in Australia. With our unique capabilities, bp can offer increasingly complex, multi-energy solutions to its partners and customers through their decarbonisation journey."*

Ampol Australia is reducing its carbon footprint and developing new energy solutions

- As Australia's leading transport energy provider, the company believes that they have a significant role to play in the energy transition. The company is working on its goal to develop the leading EV charging network in the Australia by 2030, including a fleet offer for business customers.
  - In May 2022, the company reached a significant milestone in its transformation for the future with the launch ofits electric vehicle charging solution, AmpCharge.
  - AmpCharge will service customers both at home and on the road. By leveraging existing Ampolinfrastructure and customer relationships, AmpCharge will ensure EV drivers can recharge wherever and whenever they need.
- In 2021, Ampol unveiled a strategy to eventually shift from a traditional petrol and diesel retailer to a low-carbon provider of power (batteries) for electric vehicles and hydrogen by utilizing its refining sites and nationwide distribution network.

BHP divested its oil and gas portfolio and transferred its assets to Woodside Energy Group in June 2022.

- With this transaction, the company took a major step to weight its portfolio more towards commodities with a decarbonization upside. That includes copper for renewable energy, nickel for electric vehicles, potash for sustainable farming, iron ore and metallurgical coal for steel-all of which are needed to modernize global infrastructure and enable energy transition.
- In April 2022, BHP signed a renewable Power Purchase Agreement with Ene| Green Power, the renewable subsidiary of Enel Group. Underthe agreement, BHP will supply approximately 315 GWh per year of renewable electricity for 12 years, via its Flat Rocks Wind Farm Stage One. This represents 100% of the outputof the facility and includes energy and LGCs.
  - The renewable energy provided by Enel Green Power will further support BHP'sefforts to decarbonize its nickel operations and enable the supply of low-carbon intensity nickel to its customers in the EV and battery storage markets.

Shell is helping to shape Australia's renewable energy landscape with investments in the Gangarri Solar Farm in Queensland and the successful utility solar developer, ESCO Pacific.

- The company is also investing in decarbonization through its acquisition of Select Carbon, a specialist company that partners with farmers, pastoralists and other landowners to develop projects focused on absorbing carbon in the natural landscape.
- In February 2022, Shell completed its acquisition of green power company Powershop Australia.
- The Powershop deal is in line with Shell's aim to become a leading provider of clean power-as-a-service. This acquisition broadens its customer portfolio in Australia to include households.
- In March 2022, Shell Australia made its first investment in wind through a 49% share and strategic partnership with Westwind.

Engie is diversifying its generation capacity and focusing on investing in renewable energy.

- The company is working on creating smarter, safer and more sustainable environments through its technologically progressive, efficient service solutions.
- It has divested all high-carbon, emissions-tensive generation facilities in the Asia Pacific region.

AUSTRALIAN PERSPECTIVE ON DIGITAL TWINS- THE POWER OF DATA AND AI

VINNIE NAIR
NICOLE ALLEY

What is a digital twin?

A digital twin is a virtual representation that serves as the real-time digital counterpart of a physical object or process. Though the concept first emerged decades ago (the first instance is attributed to Michael Grieves at the University of Michigan in 2002), the first practical definition of a digital twin originated at NASA in 2010, in an attempt to improve the physical-model simulation of spacecraft[1].

In the last few years, this concept has returned to the limelight and has driven deep specializations in particular industries –including the utilities industry. In the electricity industry, the term "digital twin" represents an accurate model of linear assets, zone substations, vegetation management, and other electrical assets. Most recently, the application of this concept in the linear asset management space has gained significant traction, and has consequently yielded significant benefits to utilities.

Why linear assets?

For some utilities in Australia, linear assets form a significant proportion of the Regulatory Asset Base (RAB). For example, certain Distribution Network Service Providers (DNSPs) in rural Australia have a significantly high ratio of poles per customer, and therefore very few customers are serviced per kilometer of powerline[2]. Due to their rural and sparse geography, these utilities are also under enormous pressure to continuously service customers and manage climate-related events such as bushfires and floods.

Creating a digital twin from these assets can help these businesses shift from reactive asset management, to an insight-led and data-driven approach.

The phrase, "a place for everything and everything in its place" has been commonly used to describe the practice of managing linear assets for a utility. Due to the tight correlation between managing the asset and the geospatial location, these asset classes have been a challenge for large asset management system vendors. Furthermore, this makes the management of this particular asset class difficult. There are also issues with getting a clear financial picture, breaking down costs per segment, and managing capital projects effectively.

How can you leverage a digital twin?

With some creativity and imagination, a digital twin has the power to reinvent the management of linear assets. The most beneficial use cases can be categorized under two major headings:

1. Increasing safety: The ability to simulate the impact of a natural disaster on the grid (such as bushfires or floods) to reduce the amount of time field crews spend in high-risk scenarios. This improves safety outcomes and metrics, such as Lost Time Injury Frequency Rate (LTIFR)[3].
2. Reducing OPEX: Through intelligent intervention and routing of work orders in the field, schedules per field crew are optimized, in turn reducing operational expenditure.

1 https://en.wikipedia.org/wiki/Digital_twin#cite_note-1
2 https://www.essentialenergy.com.au/media-releases/mr-30042019#:~:text=Essential%20Energy's%20footprint%20also%20includes,1.6%20power%20poles%20per%20customer
3 https://www.safeworkaustralia.gov.au/data-and-research/industry-benchmarking

Increasing safety

Safety is paramount and non-negotiable for every utility around the world. Once a digital model of the electrical network is built, the prime benefit could be the ability to conduct a "what-if" analysis across the network. This could have many applications, ranging from prevention of bushfires, to protecting critical assets from flood risk.

A common method of preventing bushfires (which is used at several utilities) is calculating the probability of dead trees falling across a conductor and starting a fire. Overlaying the vegetation map layer onto the digital twin view of the network could provide an initial level of insight. The addition of extra layers of input data such as soil type, vegetation growth profile, temperature, and wind velocity, could enrich the data set even more.

In 2021, Australia experienced several one-in-100-year flood events. Powerful physics-based digital twin platforms have the power to simulate the rate of rise of flood waters and work out how quickly they could encroach upon critical assets. If these analytics were applied practically to a utility's service territory with a high population density, lives could be saved and significant outages avoided.

Reducing OPEX

Using powerful physics engines that take in GIS and LiDAR data provides utilities with an engineering-grade, 3-D understanding of their network. This also ensures technology advances are utilized to the fullest.

Using these engines to do a whole network analysis to predict bushfires and floods protects the most critical assets, and capitalizes on advances in AI and ML.

These advances in technology and platforms can take a utility to the next level of efficiency by providing accurate insights and analytics. However, it is not enough.

For utilities to reach their full potential, these insights and analytics need to reduce operational expenditure and improve System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) indexes[4]. This is the holy grail for utilities.

Implementing digital twins

How do utilities achieve SAIDI and SAIFI improvements?

The key to successfully implementing a digital twin platform is integration.

The digital twin platform should not be considered as a separate analytics tool used solely to provide insights and perform complex "what if" analysis. It should be considered a central part of the utility, and treated no differently than any other core system within a utility's IT landscape, like GIS, ERP, Asset Management, and the Distribution Management System.

There are great benefits in the seamless integration of the digital twin platform and the core systems. These include:

- Sharing of GIS data models which reside in the data/GIS platform
- Sharing of electrical network models and integrating with tools such as SINCAL and PSCAD
- Routing of predictive maintenance type work orders (pole, conductor, and cross arm replacements) and integrating with asset performance modules in an Asset Management System
- Routing of out-of-cycle inspections (due to bushfires or flood situations) and integrating with the work queuing / work order management systems
- Establishing one platform to bring together the electrical and the mechanical models
- Enabling rapid fixing of vegetation defects on the network and integrating with the Vegetation Management System

Summary:

In summary, a digital twin platform must be regarded as part of the whole system and seen as an extension of a utility's core IT landscape. Therefore, it must be seamlessly integrated. This can bring tremendous benefits and move the asset management dial from operating in the proactive and predictive modes, to being financially optimized.

4 https://www.ensto.com/company/newsroom/articles/saidi-and-saifi-indices-guiding-towards-more-reliable-distribution-network/#:~:text=SAIDI%20%3D%20total%20duration%20of%20interruptions,for%20a%20group%20of%20customers

SOUTH EAST ASIA EMISSIONS, CARBON TAXES, RENEWABLES AND ENERGY EFFICIENCY MEASURES

ALEXANDRA BONANNI
ISHANDEEP
PRATIK RAJMANE
NUPUR SINHA

In 2021, the largest decline in CO_2 emissions was seen in Hong Kong. Vietnam has undertaken various initiatives to reduce greenhouse gas emissions

Hong Kong, Singapore, Malaysia, Taiwan, Vietnam, and the Philippines have shown a decline in CO_2 emissions in 2021. The largest decline was shown by Hong Kong, followed by Vietnam.

- **Hong Kong's emissions declined from 68.1 $MtCO_2$ in 2020 to 64.6 $MtCO_2$ in 2021**
  - In 2021, the government announced Hong Kong's Climate Action Plan 2050. It outlined decarbonization strategies such as net-zero electricity generation, energy saving and green buildings, green transport, and waste reduction, which will lead Hong Kong in its carbon neutral goal for 2050.
  - The government promotes various green buildings and energy saving measures. In March 2021, the government announced Hong Kong's Roadmap on Popularization of Electric Vehicles (EVs).
  - The roadmap aims for zero vehicular emissions by 2050, with a vision of Zero Carbon Emissions, Clean Air, and a Smart City.

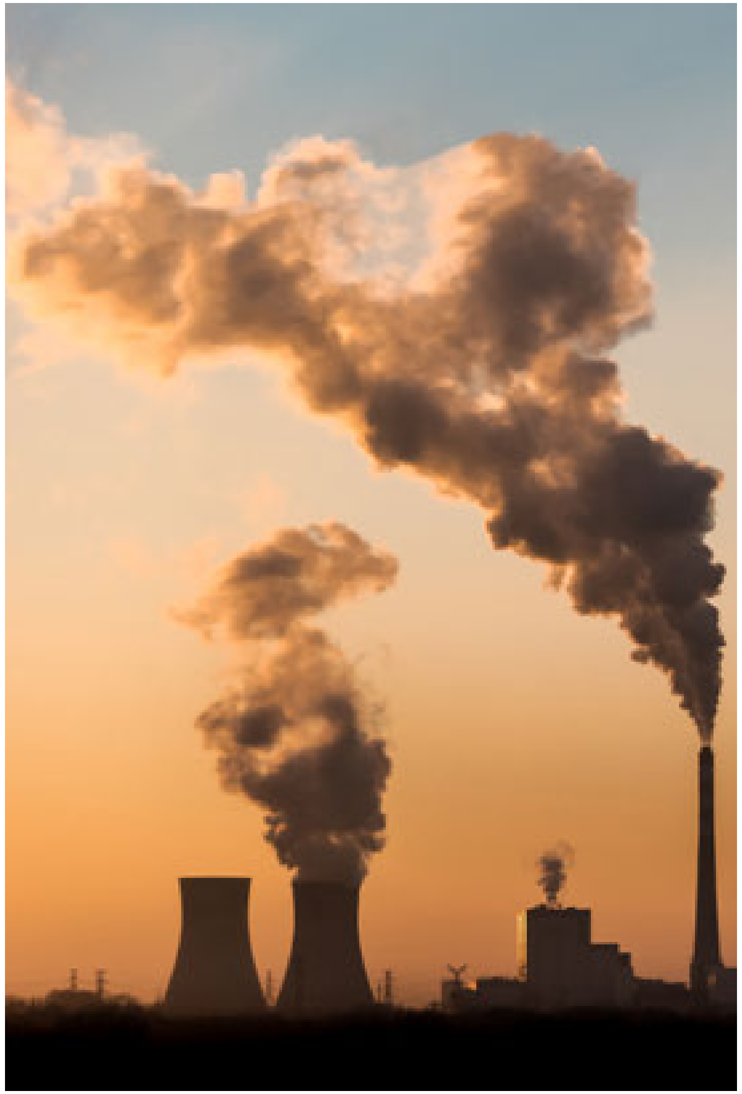
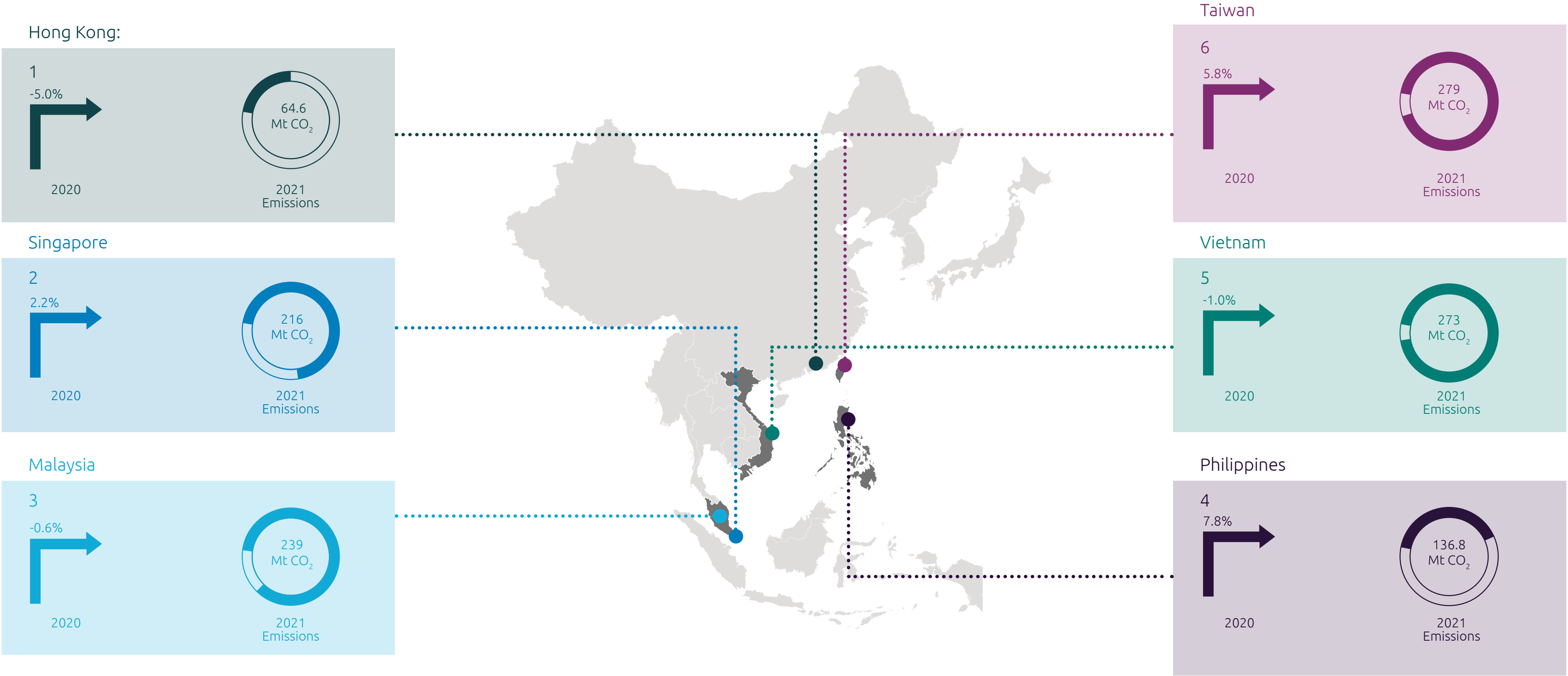


FIGURE 1

Energy-related CO_2 Emissions Growth, 2021 (million tons CO_2)

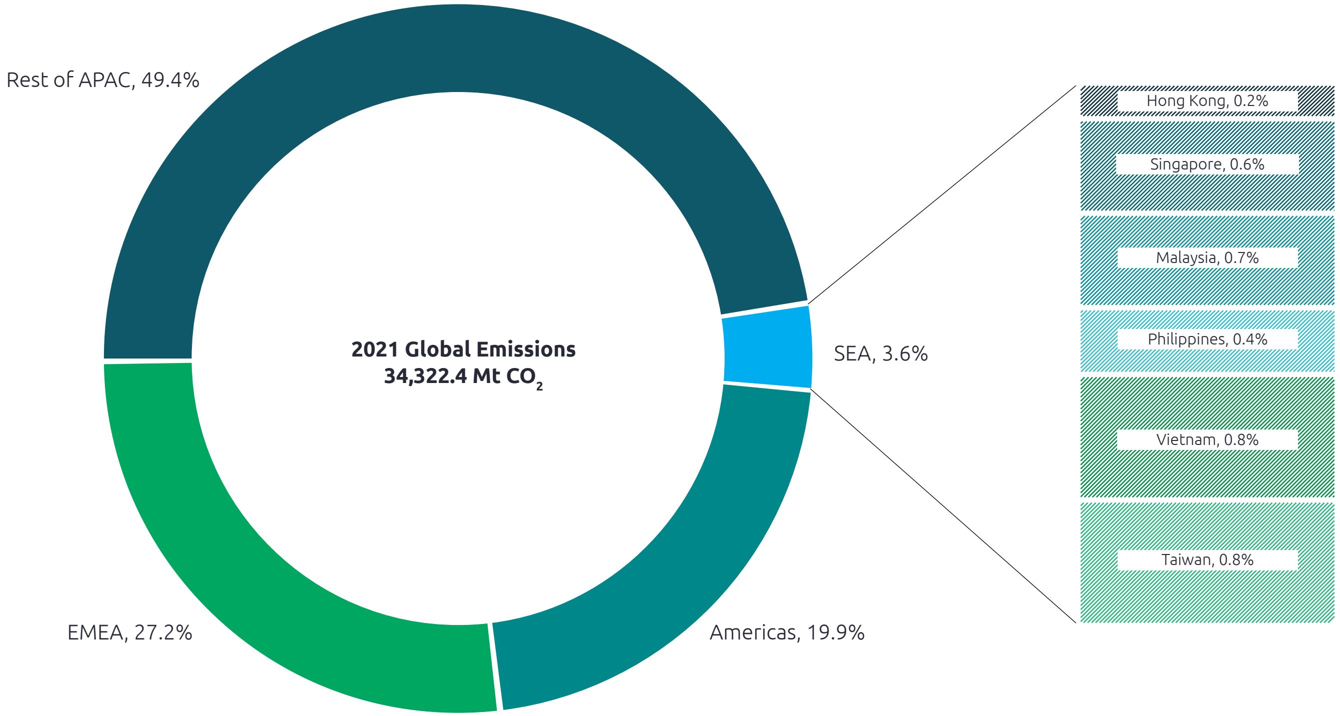


Source: BP Statistical Review of World Energy, 2022
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

- **Vietnam has undertaken various initiatives to reduce greenhouse gas emissions**
  - In January 2022, Vietnam issued Decree 6/2022/ND-CP providing regulations to control greenhouse gas emissions and protect the ozone layer.
  - Vietnam focuses on the reduction of energy consumption in construction, encouraging the development of green and more sustainably-focused structures.
  - The government plans to complete and upgrade the National Strategy on Climate Change, including net-zero emissions and reducing emissions of methane gas.
  - Additionally, the U.S. is funding Vietnam with $36 million for the Low Emission Energy Program. USAID will help Vietnam embrace clean energy using advanced technologies while improving energy performance and increasing competition in the energy sector.
- **Singapore's Ministry of Foreign Affairs stated that Singapore accounts for around 0.11% of global carbon emissions**
  - The country has made significant efforts to reduce emissions domestically
  - About 95% of Singapore's electricity is generated from natural gas, the cleanest fossil fuel
  - Singapore has also implemented policies to cap vehicle growth and manage vehicular emissions.
  - The country's small size and high population density limits its ability to draw on alternative energy such as solar, wind, or nuclear.

FIGURE 2

Southeast Asia's Share in Global Emissions, 2021 (million tons CO_2)



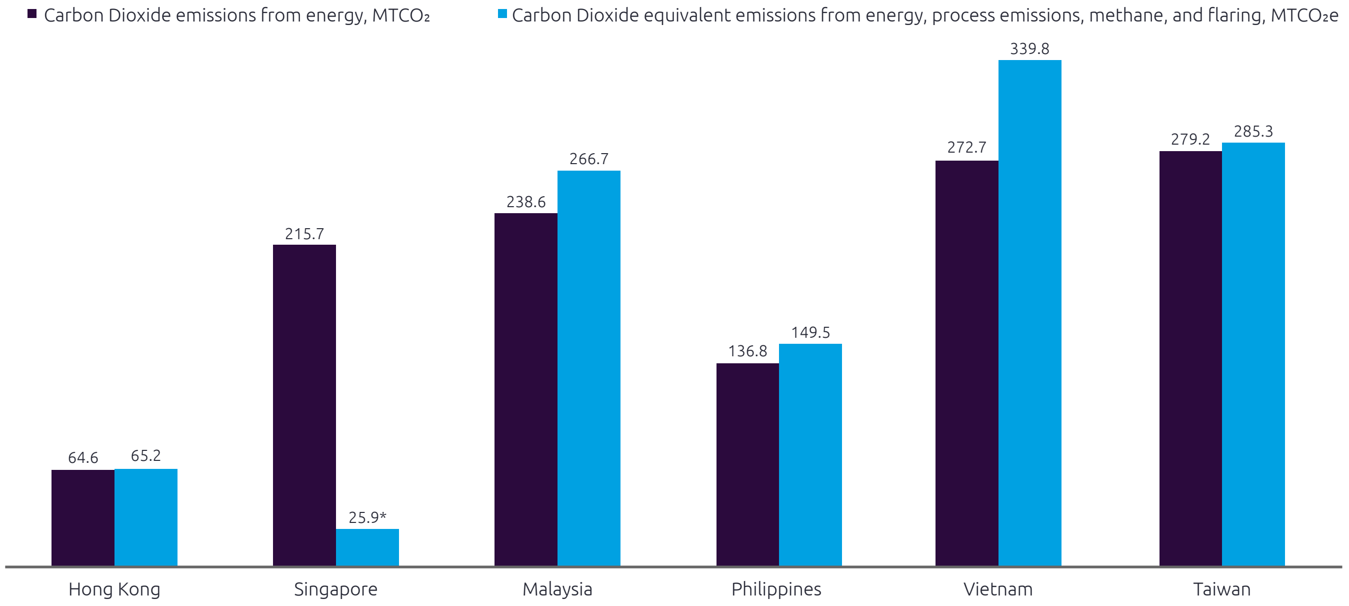
Source: BP Statistical Review of World Energy, 2022
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Governments across Southeast Asia have set out long-term plans for a more secure and sustainable future

- **In 2021, under the 12th Malaysia Plan, Malaysia set a target to become carbon neutral by 2050**
  - Malaysia upgraded its Nationally Determined Contribution (NDC) target to reduce the intensity of Greenhouse Gas (GHG) emissions by 45% by 2030 unconditionally.
  - A net-zero emissions target by 2050 was tabled at COP26.
- **Taiwan targets zero carbon emissions within 30 years**
  - Taiwan has announced plans to enhance its carbon-reduction measures.
  - Although the territory introduced a Greenhouse Gas Reduction and Management Act in 2015, it has yet to make any real impact, with many related implementation steps still under discussion.
  - The GHG Reduction and Management Act aimed to deliver a 50% cut in emissions by 2050 compared to 2005.
  - The Act also paved the way for the broader implementation of a carbon-trading system, the final details of which have yet to be worked out.
  - Last October, in a move designed to reboot the process, the legislation was substantially revised and reinvented as the Climate Change Response Act.
- **Philippines accounted for 0.4% of total emissions in 2021, as per BP Statistical Review of World Energy, 2022**
  - By 2030, the country has pledged to reduce GHG emissions by 75%.

FIGURE 3

Carbon dioxide emissions, 2021



*Only includes power sector carbon emissions in Singapore

Source: BP Statistical Review of World Energy, 2022, and Statista
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf ; https://www.statista.com/statistics/1303267/singapore-power-sector-carbon-emissions/#:~:text=In%202021%2C%20power%20sector%20carbon,following%20the%20previous%20year's%20drop

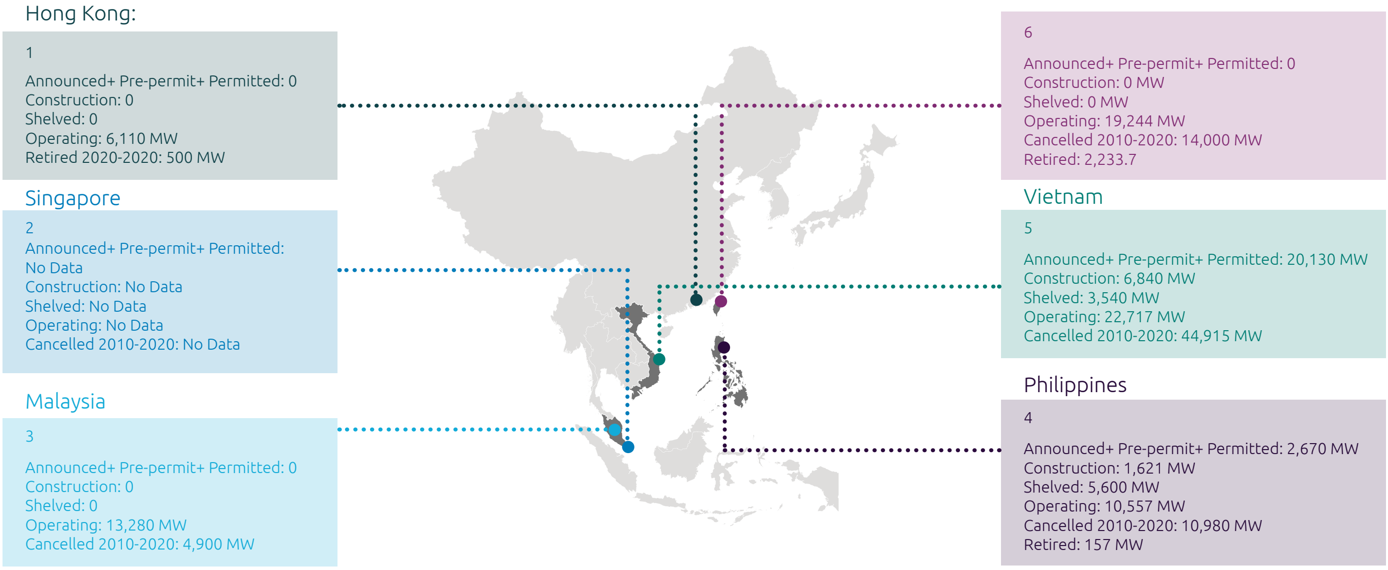
Southeast Asian countries are closing the door on new coal projects with strict government intervention

Southeast Asia's power generation has almost tripled in the past two decades, keeping pace with economic growth; the largest increase in generation is coming from coal-fired power plants

- **The Philippines has 10,557 MW of operating coal-fired capacity**
  - Coal accounts for 57% of the country's power capacity, far more than any other energy source.
  - Years ago, coal was perceived to be a low-cost power option. However, the Philippines has some of the highest-priced electricity in the Association of Southeast Asian Nations.
  - In November 2021, the Asian Development Bank (ABD), Indonesia, and the Philippines launched a partnership to set up an energy transition mechanism, aiming to help accelerate Southeast Asia's clean energy transition.
  - The ABD launched a plan to retire 50% of the Philippines' and Indonesia's coal fleets over the next 10 to 15 years.
- **The coal fleet in Vietnam has grown faster than almost any other country.**
  - In 2021, the country had 22,717 MW of operating coal plants; The country plans to add new coal-fired power plants with an installed generation capacity of 143.8GW, accounting for up to 31.4%, by 2030.

FIGURE 4

Coal Plants in Southeast Asia, January 2022



Note: Includes coal plants of 30 MW or larger, as well as every plant proposed since January 1, 2010.

Source: US EIA Annual Energy Outlook, 2022
Link: https://www.eia.gov/outlooks/aeo/

  - According to Power Development Plan 8 (PDP 8), the country needs to invest $115.96 billion in new power plants and power grid expansions by 2030 and up to $227.4 billion by 2045, when installed capacity may be up to 329.6 GW.
- **The power plants under construction in the Southeast Asia region are expected to double the region's fossil fuel capacity and its committed power sector CO_2 emissions**
- **The coal and gas plants in Indonesia and the Philippines are likely to crowd out renewable deployment**
- **Philippines power supply projections from 2020 to 2030 for fossil fuel plants may exceed projected demand**

Climate Change Performance Index (CCPI) 2022 monitors climate mitigation efforts globally, including SEA countries

The CCPI aims to enhance transparency in international climate politics and enables comparison of climate protection efforts and progress made by individual countries.

- **The climate protection performance includes all the countries, which account for 92% of global GHG emissions, is assessed in four categories:**
    - GHG emissions
    - Renewable energy
    - Energy use
    - Climate policy
- No country performs well enough in all index categories to achieve an overall very high rating in the CCPI. Therefore, once again, the top three places in the overall ranking remain empty.
- Denmark is the highest ranked country in CCPI 2022, but does not perform well enough to achieve an overall very high rating.

Significant SEA level performance insights

- Among the newly included countries in this year's CCPI, **only the Philippines performed high in this category.** Due to a very low rating in the current trend indicator, **Vietnam received a low score.**
- The **Philippines ranks 23rd, with a medium rating** and received a low rating in the National Climate Policy indicator. In 2021, the Department of Energy defined new regulations for reducing GHG emissions. It seeks a renewable energy target with a 35% share by 2030, a higher renewable portfolio standard, and a moratorium on coal power plant development.
- Regarding energy use, the National Economic Development Authority approved the Philippine Urban Mobility P rogram in 2020, which prioritizes multi-modal low-carbon public transport in urban cities.
- In April 2021, the Philippines finally submitted its first Nationally Determined Contribution, with a 75% GHG emissions reduction sought by 2030 compared with 2010 levels.

SEA CCPI Ranking

1. The Philippines: Rank 23
2. Vietnam: Rank 43
3. Malaysia: Rank 57
4. Taiwan: Rank 58

Note: Hong Kong and Singapore aren't covered under the CCPI ranking

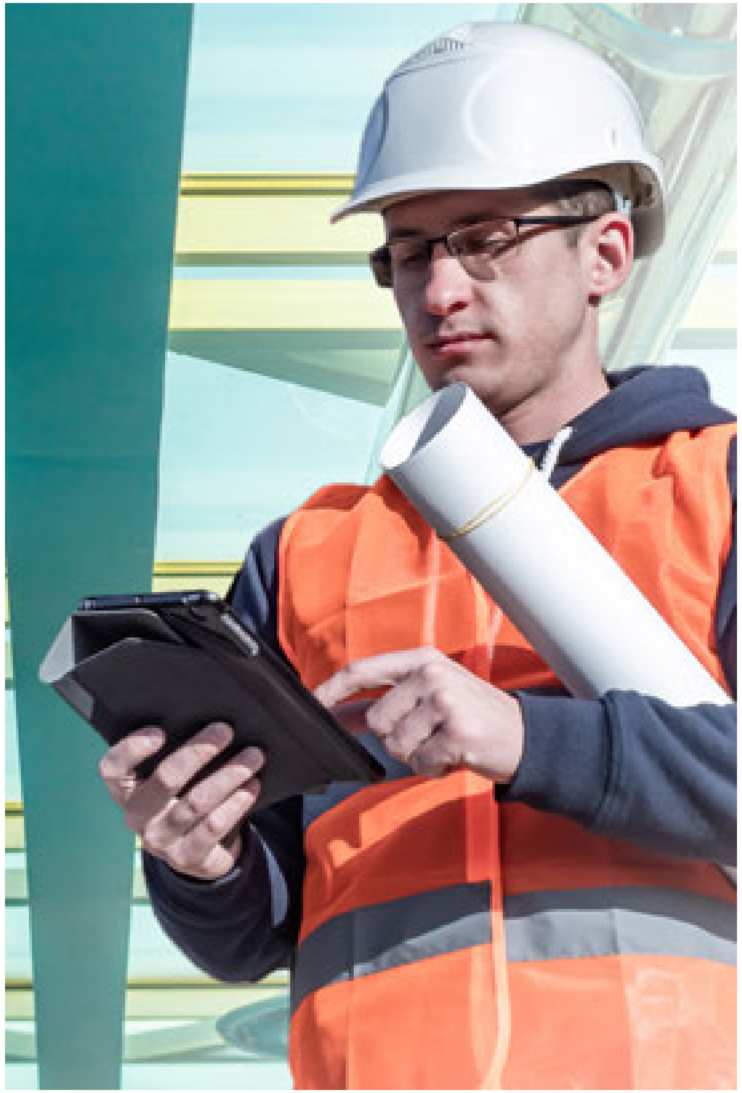
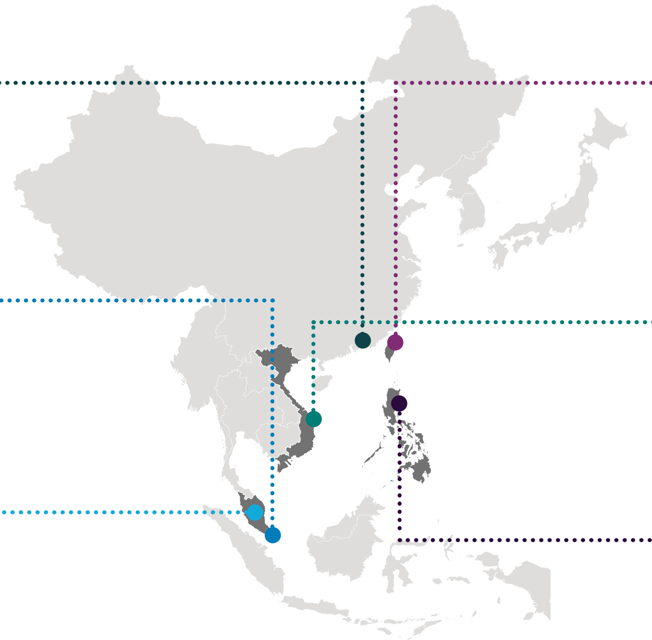


FIGURE 5

Southeast Asian Countries in the Climate Change Performance Index 2022



Climate Change Performance Index 2022

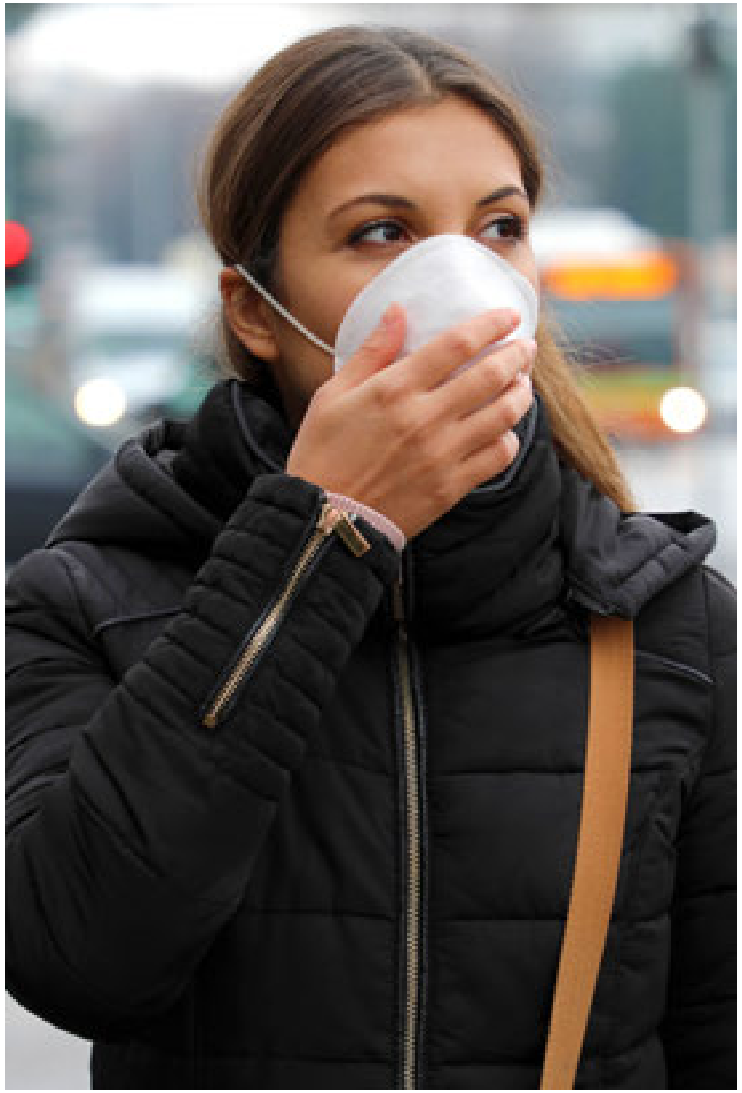
CCPI Rank 2022	Country	CCPI Score
23	Philippines	58.98
43	Vietnam	49.21
57	Malaysia	33.74
58	Taiwan	30.70

Renewable Energy (RE), Ranking 2022

RE Rank 2022	Country	CCPI Score
25	Philippines	9.00
32	Vietnam	7.48
51	Malaysia	4.04
58	Taiwan	2.79

1. The Philippines, as one of three new entrants in this year's CCPI, ranks 23rd, with a medium rating.
   - In the four main CCPI categories, the Philippines rates low in Climate Policy, medium in Renewable Energy, and high in GHG Emissions and Energy Use.
   - It seeks a renewable energy target of a 35% share by 2030, a higher renewable portfolio standard, and a moratorium on coal power plant development. Nevertheless, the moratorium will not affect coal projects over 7 MW that are committed to be built by 2030. Additionally, no policy on coal phase-out is in place.

Source: CCPI-2022-Results
Link: https://ccpi.org/wp-content/uploads/CCPI-2022-Results-1.pdf



Southeast Asia power market: Challenges including Covid-19, Impact of Russian–Ukraine war, and under-investment

Per IEA World Energy Outlook 2022 report, Power generation has almost tripled in the past two decades to keep pace with economic growth, with the largest increase coming from coal-fired power plants. Rising living standards have led to a threefold increase in the number of air conditioning units over the same period.

- Both Covid-19 and the turbulence in global oil and gas markets caused by Russia's invasion of Ukraine have dented Southeast Asia's energy and economic prospects.
- Governments across Southeast Asia have pledged to reduce their dependence on fossil fuels and set targets toward carbon neutrality. However, the International Energy Agency (IEA) says these countries are unlikely to hit their targets with their current policies.
- Energy demand in Southeast Asia has increased by an average of 3% annually since 2000 – a trend that is set to continue as economic growth returns after the pandemic. However, the IEA says three-quarters of this new demand is likely to be met by fossil fuels, increasing CO2 emissions by one-third.
- Although the region imports most of its oil from the Middle East and Africa, market turbulence caused by Russia's war on Ukraine has "shone a spotlight on the energy security vulnerabilities of Southeast Asian countries and their mechanisms in place to weather supply disruptions." – IEA World Energy Outlook 2022 report

Clean energy as a solution

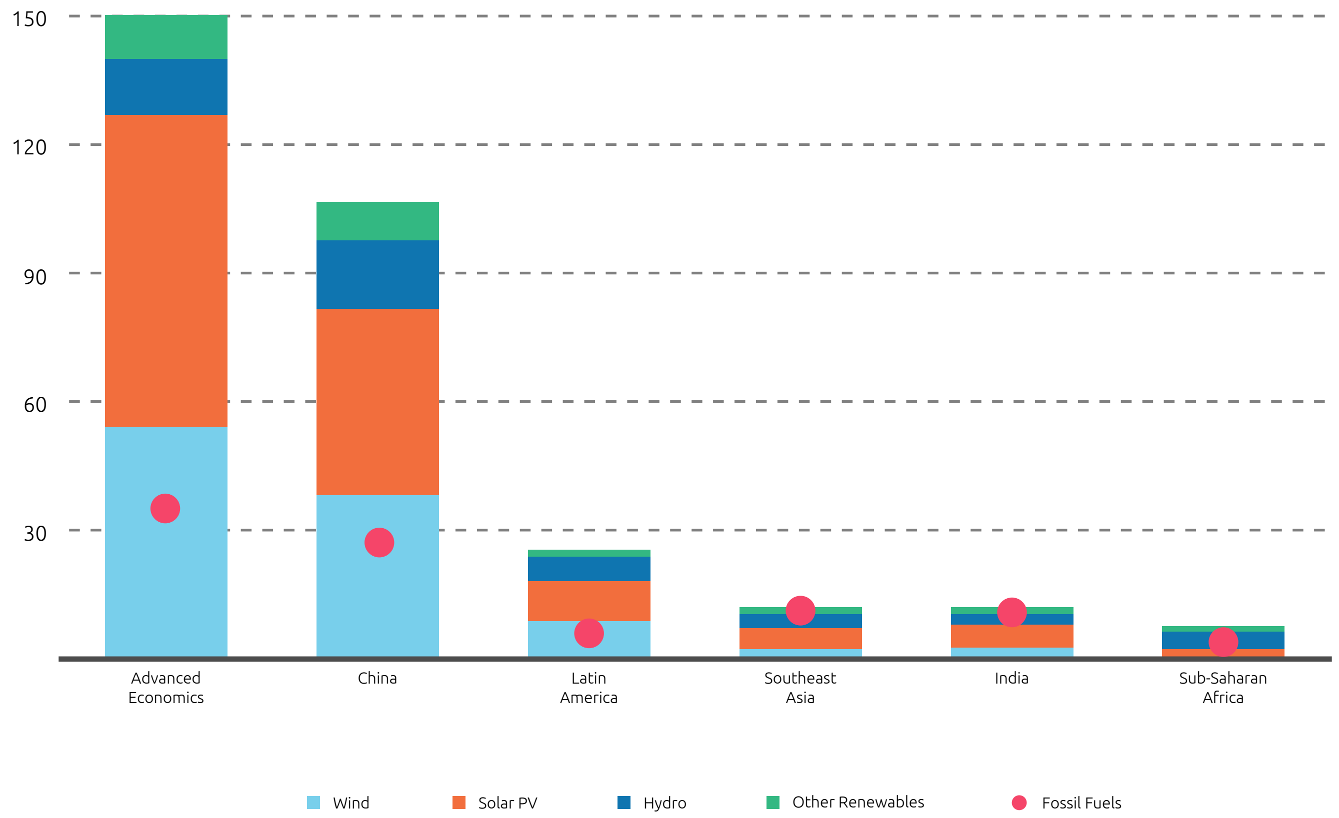
- Per IEA World Energy Outlook 2022 report – the transition to clean energy will provide a long-term solution to soaring oil and gas prices. However, it warns that energy costs will rise in the short term for several Southeast Asian nations, as they increase their fossil fuel stockpiles to guard against supply disruptions.
  - In recent years, only about 40% of the region's energy investment has gone into renewables. That needs to increase sharply to help keep global temperature rises below 1.5°C. These nations will need to spend approximately $190 billion annually on solar and wind capacity and on improving energy grids by 2030 to meet this goal.

Unpredictable regulation and restrictions on foreign direct investment are holding back private-sector investment

- Solar energy in Indonesia would be 40% cheaper if its investment and financing risks were comparable to those of advanced economies.
  - Contracts with power generators also need to become more flexible to reflect the variable nature of renewable generation. Power stations in some countries are currently paid whether their electricity is needed or not.

FIGURE 6

Average annual investment spending, 2016-2020, $ biliion



Source: https://iea.blob.core.windows.net/assets/e5d9b7ff-559b-4dc3-8faa-42381f80ce2e/SoutheastAsiaEnergyOutlook2022.pdf

Clean energy investment levels remain well below the region's potential and its needs

- Clean energy investment in Southeast Asia in power, efficiency and end use, and low-emission fuels was estimated at $27 billion in 2021. The amounts spent on clean energy in 2021 comprised just over 40% of total energy investment, a higher share than in 2015.

For every dollar invested in renewable power in Southeast Asia in recent years, another was invested in unabated fossil fuel generation

- Average annual spending in renewables from 2016-2020 was $12 billion.
- Average annual investment in solar photovoltaic (PV) and wind amounted to $7 billion. This is higher only than the level in sub-Saharan Africa, and the majority was mobilized in just one country (Vietnam).

Wind and solar PV have experienced major cost reductions over the last decade, but costs remain relatively high in Southeast Asia, mainly due to unclear and slow-moving policies, which have hampered long-term predictability for investors.

LCOE: LEVELIZED COST OF ENERGY

DEBARGHYA MUKHERJEE
ALEXANDRA BONANNI
MARIE VERMERSCH

Levelized cost of energy increased due to rising costs of commodity, capital (stagflation) and freight during the energy crisis along with increase in Carbon costs Emissions Trading System (ETS) in Europe

Ongoing macroeconomic and regulatory matters, Europe's energy crisis, supply chain limitations, inflation, growing commodities costs, interconnection challenges, and government auctions majorly affected supply and increased PPA prices.

Nordics, however, have been impacted less compared to other European regions due to the profusion of low-cost hydropower.

- The energy crisis caused Spain's solar market to cool off in the short term as Spanish P25 solar prices rose 11.5% during Q4 2021.
- In Italy, P25 solar prices increased nearly 21% during Q4 2021.
- In Q1 2021, average solar PPA prices were €34/MWh in Denmark and €64/MWh in Austria.
- Sweden and Finland continue to be the cheapest market for wind PPAs, with P25 PPA offer prices of €29.4 and €30.

The price of emissions allowances traded on the **EU ETS has increased from €8 per tonne of CO_2 equivalent at the beginning of 2018 to an average 2021 price of €52 per tonne** (reaching almost €90 per tonne in December 2021).

- Major price drivers are the introduction of the **MSR, the Fit for 55 package, high gas prices, and a perceived shift toward more stringent climate policies.**
- The 2022 average price is expected to be around €75 per tonne. Reduced supply, high gas prices, and reforms will continue to support the European carbon price.

Renewables-linked PPA prices have shot up nearly 28% year over year, especially due to the Russia-Ukraine war. For solar, they range between €0.038/kWh in Spain and €0.074/kWh in Lithuania.

At the end of 2021, **Germany's tender for utility scale solar closed with an average price of €0.05/kWh**; around 512 MW of PV capacity was allocated by the German authorities in the procurement exercise.

According to International Renewable Energy Agency (IRENA), in 2021, almost two-third or 163 GW of newly installed renewable power in 2021 had lower costs than the world's cheapest coal-fired option in the G20. **The cost of electricity from onshore wind fell by 15%, offshore wind by 13%, and solar by 13% compared to 2020.**

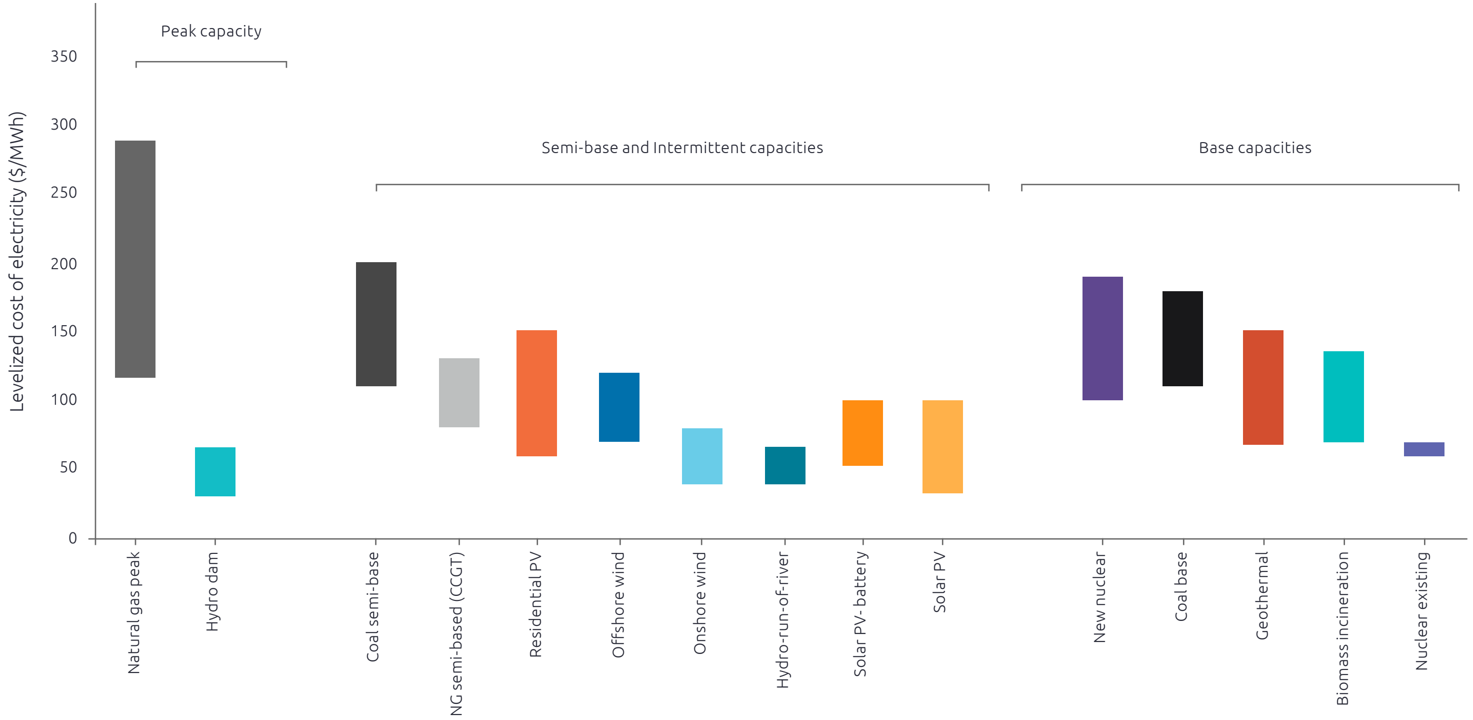
Sources: LevelTen Energy PPA Price Index Europe, Q4 2021
Bloomberg, ECB Europa, PV Magazine ,IRENA

European and U.S. LCOE 2021

- Wind and solar power plants in Germany have notably lower LCOE costs than conventional power plants.
- Due to the rising price of CO_2 certificates, the cost competitiveness of existing coal and gas-fired plants is expected to further decrease in the future.
- LCOE of residential photovoltaics ranges from 60 to 150 $/MWh, depending on the type of plant and solar irradiation.
- LCOE of solar PV-battery systems ranges from 50 to 100 $/MWh. The wide cost range is due to the large price difference between the various battery systems.
- LCOE of onshore wind turbines ranges between 40 and 80 $/MWh, whereas offshore wind turbines are significantly more expensive at 70 to 120 $/MWh

FIGURE 1

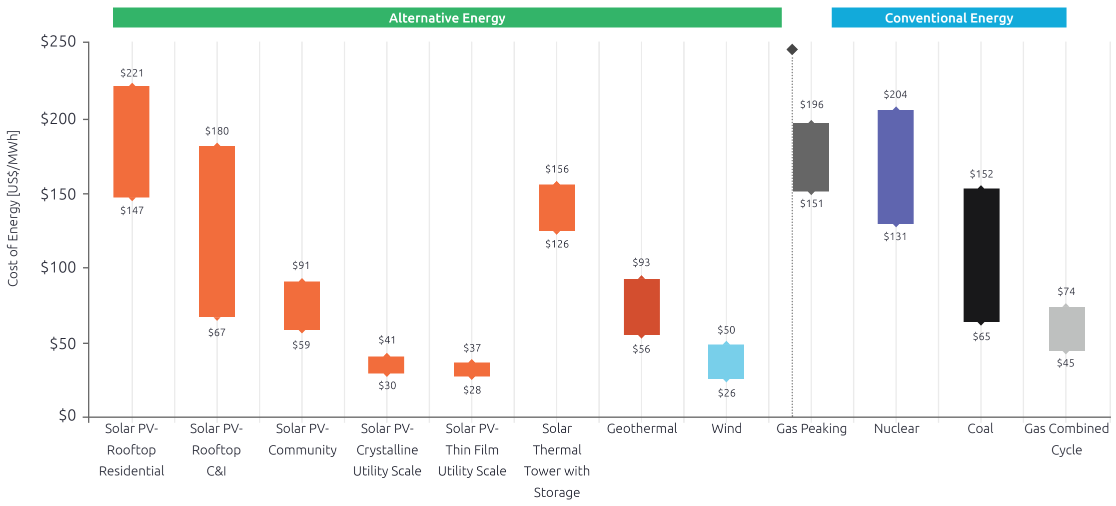
European levelized cost of electricity, 2021 ($/MWh)



Source: Fraunhofer Institute for Solar Energy Systems, IRENA 2021, IEA, Capgemini Analysis
Note: Analysis of the current situation and the future market development of photovoltaic (PV), wind power plants (WPP) and bioenergy plants in Germany in 2021

FIGURE 2

U.S. unsubsidized LCOE, 2021 ($/MWh)

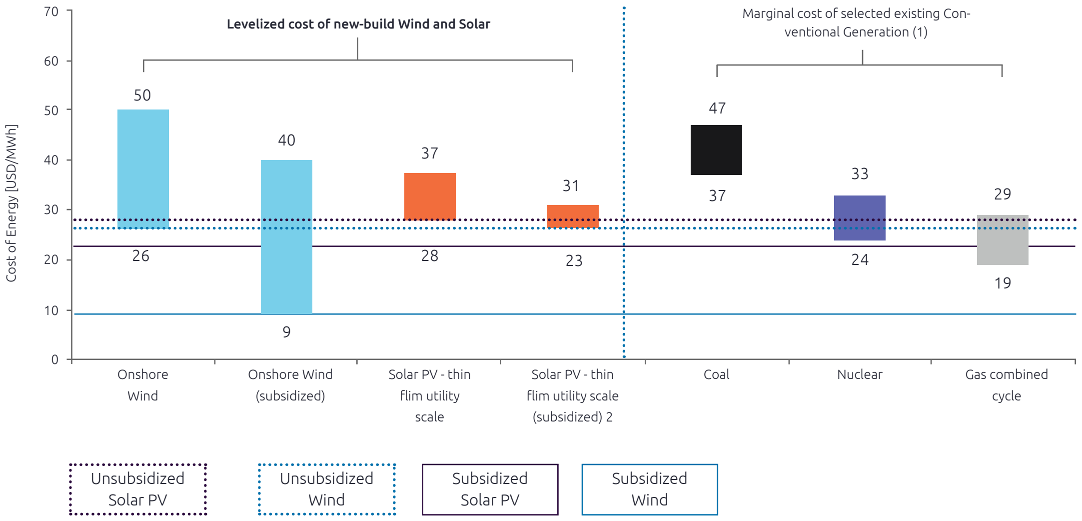


Source: Lazard - Levelized Cost of Energy, Version 15.0 (October 2021)

FIGURE 3

Levelized cost of energy comparison: Renewable energy versus marginal cost of selected existing conventional generation

Certain renewable energy generation technologies have an LCOE that is competitive with the marginal cost of existing conventional generation.



Note: Unless otherwise noted, the assumptions used in this sensitivity correspond to those used in the global, unsubsidized analysis as presented on the page titled "Levelized Cost of Energy Comparison—Unsubsidized Analysis".

1. Represents the marginal cost of operating fully depreciated gas combined cycle, coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned gas combined cycle or coal asset is equivalent to its decommissioning and site restoration costs. Inputs are derived from a benchmark of operating gas combined cycle, coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper and lower quartile estimates derived from Lazard's research.
2. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to U.S. Federal Tax Subsidies" for additional details

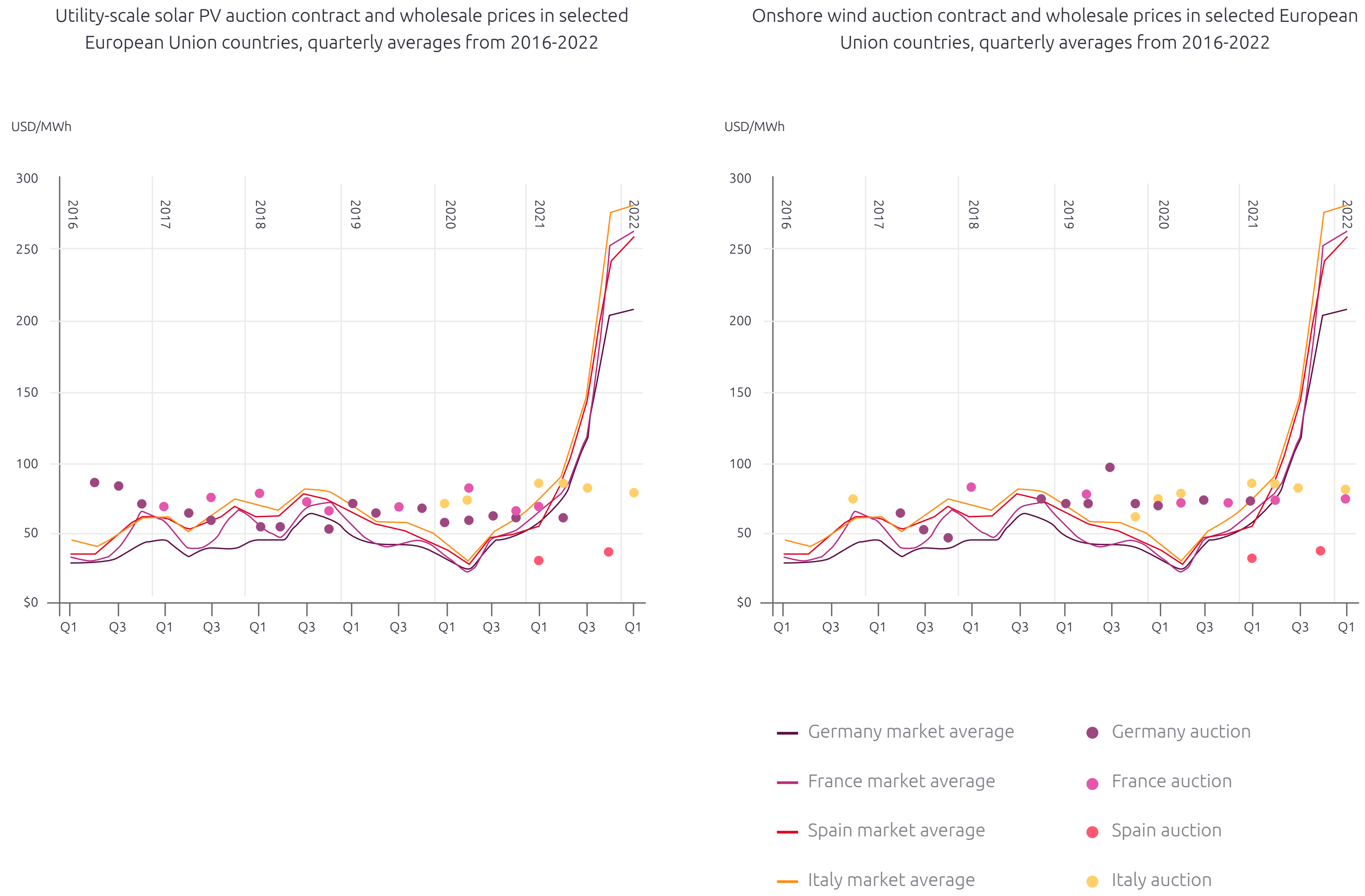
Source: LAZARD 2021

Onshore wind auction contract and wholesale prices in selected European Union countries

- Historically, long-term contract prices from solar PV and wind auctions have been higher than wholesale prices in many large EU markets.
- Highest-priced onshore wind and utility-scale contracts signed over the last five years are half the average wholesale prices seen today in the European Union.
- For newly contracted projects, despite cost increases, onshore wind and solar PV ventures offer long-term contracts significantly lower than wholesale price averages.
- For instance, prices for utility-scale solar PV and onshore wind projects increased 15-25% in the recent Spanish auction held in December 2021, to $37/MWh and $35/MWh, respectively.

FIGURE 4

Onshore wind auction contract and wholesale prices in selected European Union countries



Source: IEA

05

INFRASTRUCTURE & ADEQUACY OF SUPPLY

EUROPE ELECTRICITY (MIX EVOLUTION, CONSUMPTION, SECURITY OF SUPPLY, CAPACITY MECHANISMS)

ANTOINE LALANDE
ARNAUD STRICHER
CHARLES DAGICOUR
DEBARGHYA MUKHERJEE
STEPHANE COUCKE
FABIAN DECOUR
OUSSAMA ZEKKARI EMRANI
LOUIS SOUMOY

A challenging landscape in 2021 brought European power generation to an unexpected outcome

The European Union validated Green Deal ambitions through the European Climate Law

With the adoption of the European Climate Law in June 2021, the European Union validated the targets previously enacted by the European Green Deal :

- 55% reduction of carbon dioxide emissions, compared to 1990 levels
- 40% renewable energy production by 2030
- 36% to 37% of final energy efficiency targets for each Member State by 2030, compared to business-as-usual scenario

In addition to that, the European Climate Law confirmed the European Union's ambition to reach net zero greenhouse gas emissions by 2050.

Production has increased in 2021 as a result of increased demand and consumption growth

In 2021, European electricity production saw an increase of around 4%[1] as compared to the previous year, reaching an almost pre-Covid level, as driven by consumption growth.

However, important discrepancies between the types of production are hidden behind this global rise.

1 Eurostat

- In opposition to the European Union's will to reduce its use of carbon dioxide-emitting sources, fossil-fuel-based generation gained 6% overall between 2020 and 2021:
  - Coal-fired power production has been increasing significantly (+20%[2])
  - Oil-based production increased by more than 6%[2], more than the overall production growth
  - Those raises offset the almost 4% decrease of gas production over 2021
- Along with fossil-fuel-based sources and born by a significant capacity growth (around 25 GW of installed capacity, up 34%[3] compared to 2020), solar production rose by around 9%[2], even though the sunshine duration was lower in 2021 than in 2020 – which was a record year[4] in that aspect.
- While hydroelectric production remained almost constant compared to 2020, wind production slightly decreased by 3% in 2021 compared to the previous year, despite 11 GW being installed in the EU[5].
- Finally, despite the lack of availability of the French nuclear park, and Germany closing three of its six remaining reactors, European nuclear production also increased significantly by more than 7%[2].

2 Fraunhofer institute based ENTSOE's data
3 PV Magazine
4 Copernicus
5 Wind Europe

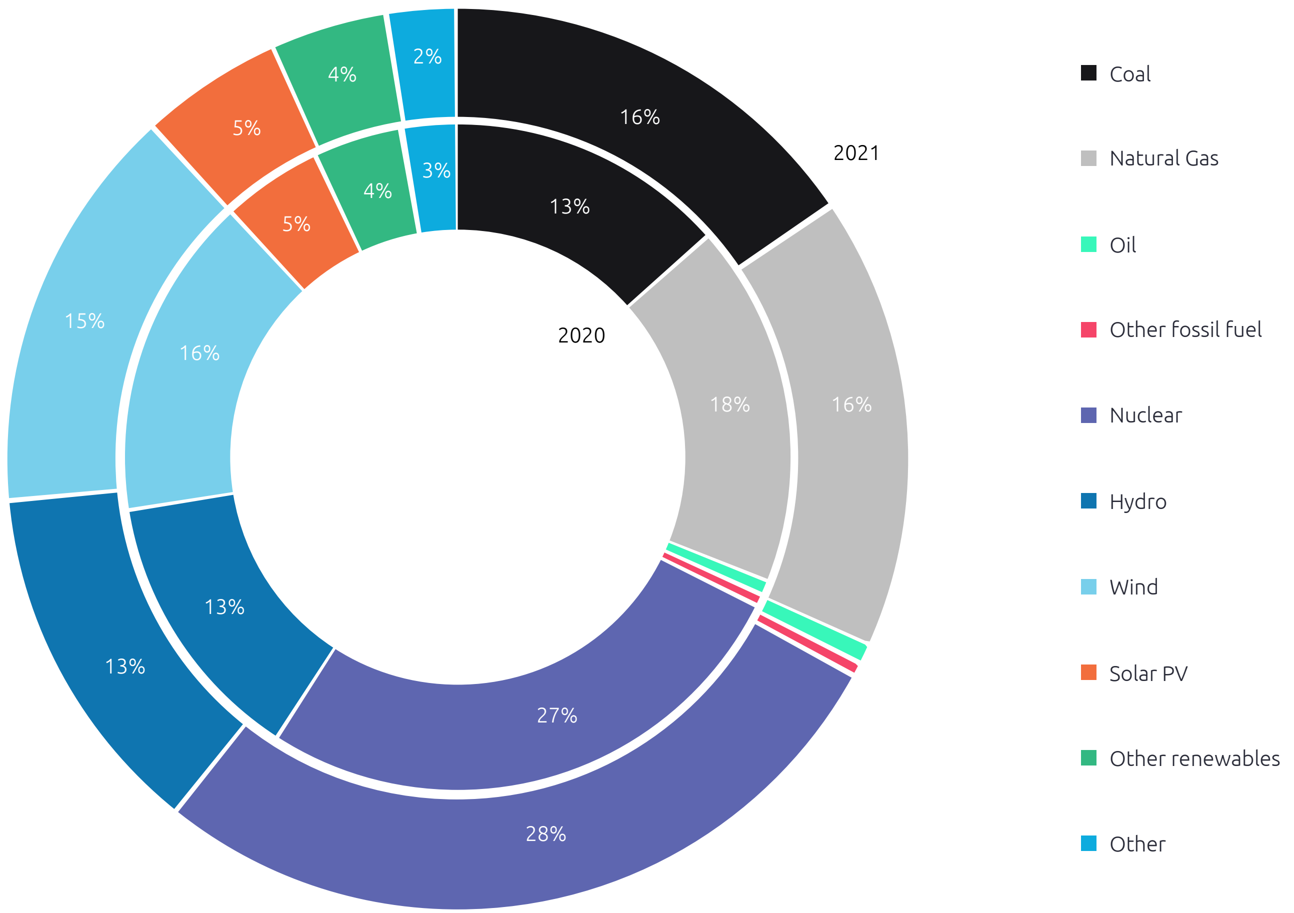
2022 is shaping up to be an even more noteworthy year for European electricity production

Situations observed in the first half of 2022 will also strongly impact the efforts of the European countries to bring down their carbon emissions and dependency towards fossil fuels:

- The war in Ukraine, as well as its consequences on the delivery of gas from Russia, forced several countries to recommission unused fossil-fuel-based production capacity, especially coal.
- Record high temperatures and severe droughts experienced in Europe deeply affected hydroelectric production, which was down 25% in H1 2022 compared to H1 2021.
- Since an important part of the French nuclear park has been under maintenance over corrosion suspicions[6], the associated production dropped by 12.4% over the first semester (-15% in France which had to import energy from neighboring countries this summer[7]).

FIGURE 1

Evolution of European Union's generation by Energy Source



Source: Fraunhofer Institute based on ENTSOE's data

6 ASN
7 La tribune

European coal phase-out challenged by the energy crisis

In 2021, some European countries continued to intensify their efforts to cut their coal production

Through REPowerEU, one of the main goals of the European Union is to reduce greenhouse gas emissions, as well as fossil fuel dependency, and especially its dependency on Russian gas.

- Overall, the European Union* reduced its fossil fuel-based capacity by 5% in 2021[8], reaching a little less than 300 GW[1].
- Beyond countries which have already reached their carbon neutrality (Sweden and Switzerland for instance), some European countries have taken radical decisions towards fossil fuel-based sources:
  - In November 2021, Portugal became "coal-free"[9], by shutting down all their remaining capacity (~1,800 MW).
  - Romania shut down most of its coal production infrastructures (-82% compared to its 2021 capacity with only 176 MW remaining**).
  - Despite still being a significant part of the German energy mix (17% of the installed capacity at the start of the year[1]), the country managed to shut down about 15%[1] of its coal-based infrastructures.

*Note: *EU27, excluding Slovakia, Malta and Cyprus*
***In 2021, coal represented around 5% of Romanian production capacity compared to 1% in 2022*

8 ENTSOE
9 Reuters

Several European countries will slow down their coal phase-out plans in order to secure winter electric supply

Due to the complex context of the beginning of 2022 (the Ukrainian crisis, corrosion issues at the French nuclear park, drought in Europe, etc.), some European power producers had to use coal-fired production in order to match the required power and maintain good economic conditions.

For instance:

- While France planned to close one of its two last remaining coal plants, the government decided to reopen the Saint-Avold[10] plant in order to secure French power supply during the winter.
- Germany also had to disrupt its energy plan. Since the country is particularly dependent on Russian gas (more than 50% of total gas imports before the conflict[2]), it had to rapidly respond to gas price increases and Russian supply disruptions by suspending coal-fired plant dismantling and use reserve coal plants.
- In addition to the decisions taken by two of the EU leaders, several more European countries such as the Netherlands announced their intentions to produce more coal-based power than expected in their climate ambitions.

A trend directly linked to ask questions about long-term European climate ambitions

Consequently, to those decisions, European CO_2 emissions linked to power generation are expected to rise in Europe in 2022 though they are projected to decrease in every other geographic region[1]. However, the European Commission declared that it would keep a close eye on several countries' announcements and be particularly attentive to the breadth and duration of the coal resurgence[2]. Indeed, the European Union provides economic resources to countries and regions that initiate transition towards clean and renewable production sources. In that context, the European Commission stated that any extended usage of coal should be compensated by a reinforcement of energy savings, energy efficiency, and more renewable production toward 2030[2]. In case of strong deficiency towards target achievement, the Commission even stated that funding could be suspended or retrieved.

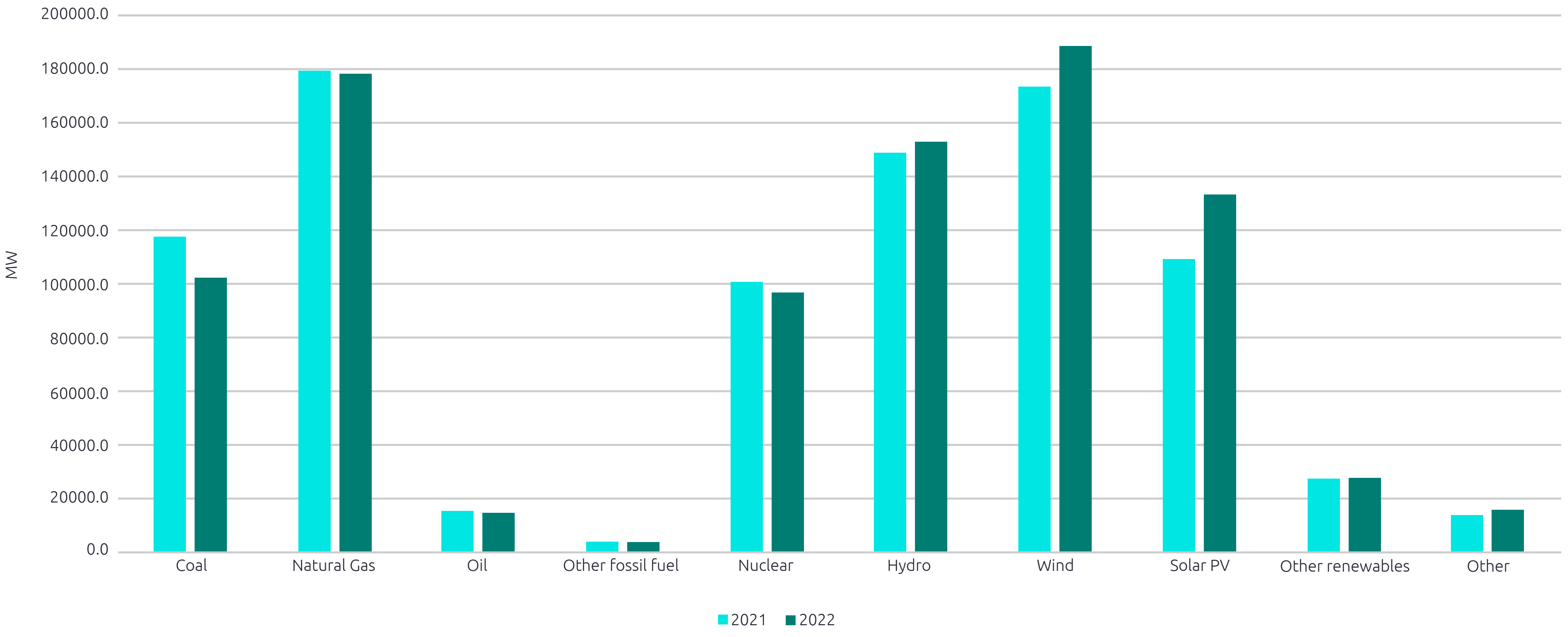
10 La tribune

In addition, this tendency to replace gas-based electricity generation with coal-based generation is motivated by the surge in gas prices following the war in Ukraine. As the coal-based production rises, the cost of compensating the corresponding emissions increases, therefore progressively reducing utilities' attraction to coal, as compared to gas.

- In August 2022, one ton of CO_2 reached an annual high at almost €100/t[3]. The cost then dropped back to around €70/t[3] following a slight decrease in gas demand (and price).
- Forecasts predict that one ton of CO_2 should remain at high levels in 2023 and 2024 averaging around €100/t[2], potentially and progressively making coal less attractive compared to gas (if gas prices reach an acceptable level for utilities again).

FIGURE 2

Evolution of European Union's capacity* by Energy Source



Source: ENTSOE

2022 energy crisis as a ramp-up to boost European renewable capacity installation and reach its 2030 climate target

While Europe is committed to reaching 40% of renewable energy production by 2030, it remains behind schedule to reach this target:

- 2021 constituted a record-breaking year for solar capacity installation (a first since 2011) with around 25 GW of new capacity, though at least 50 GW/year are necessary to reach the target.
- Though they were 11% lower[11] than expected due to permitting bottlenecks and supply disruption, wind farm installations also reached a record high in 2021 with around 14 GW installed in EU-27[12] (more than 17 GW when including the U.K.[1]) However, Europe will need to install 23 GW each year from 2022 to 2026 in order to reach the 2030 target. Once again, European forecasts fall short with an average of only 18 GW of yearly installations over the same period.

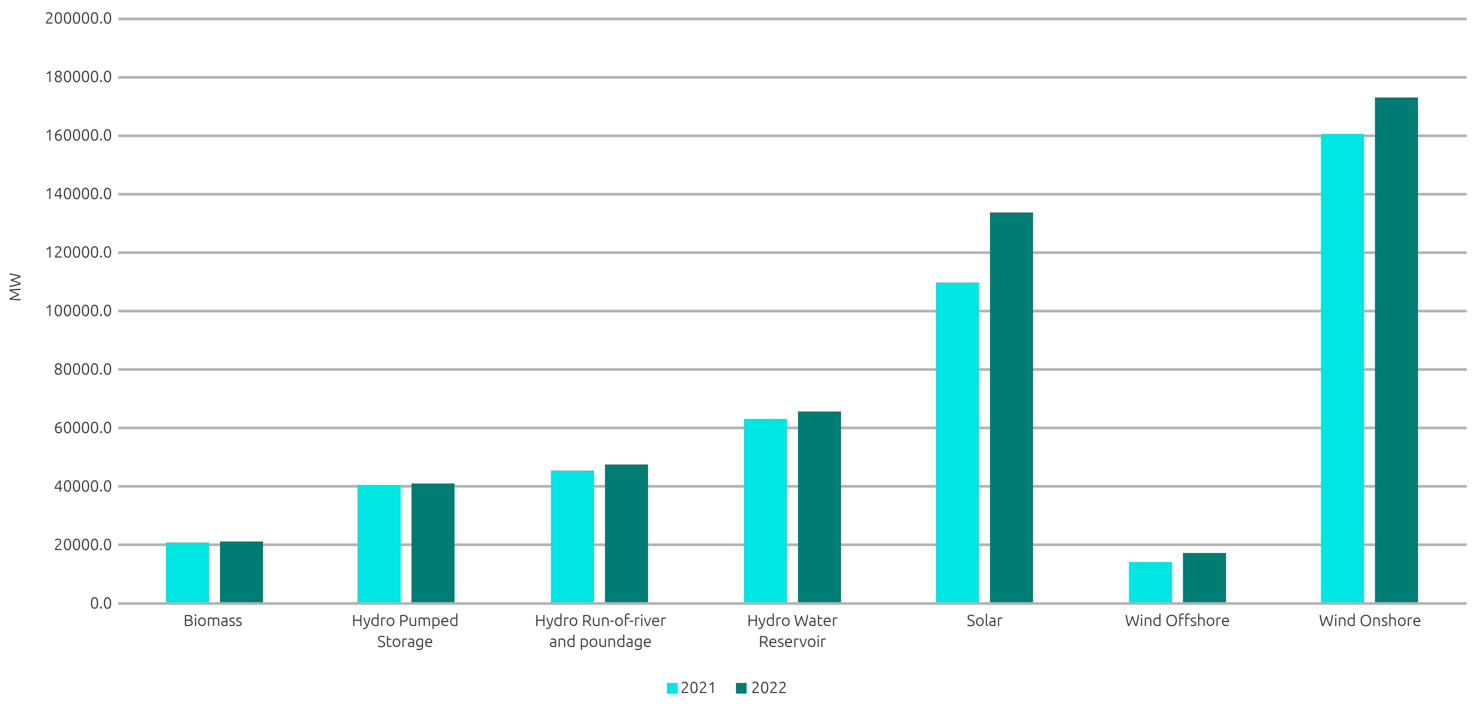
However, following the Russian invasion and the energy crisis that accompanied it, the European Union chose to seize the opportunity to reinforce its commitment to boost energy savings, produce clean energy, and diversify energy sources through the publication of a new plan, REPowerEU:

- It intends to, once again, increase the 2030 target to 45% of renewable energy production, requiring a total of 1.236 GW of renewable capacity (1.067GW to reach 40% target[13])
- Overall, PV plants are supposed to represent 600 GW – more than four times the capacity installed as of 2021[14].
- This is reachable through the systematization of PV installation on public buildings, such as large commercial and new residential buildings, as well as simplification of the permitting process.

As the rising capacities will mostly generate variable and non-"steerable" energy, this new REPowerEU will also represent a strong opportunity for EU countries to develop their flexibility infrastructure (i.e., storage).

FIGURE 3

Evolution of European Union's major renewable capacity*



Note: * EU27, excluding Slovakia, Malta and Cyprus

Source: ENTSOE

11 Wind Europe
12 ENSTOE
13 European Commission
14 Contexte Energie

Electricity consumption

Focus on demand: Almost back to pre-pandemic consumption levels

Despite the Covid-19 restrictions that were applied in 2021 in most EU countries, European demand almost reached 2019 levels.

In last year's edition of The World Energy Markets Observatory, we highlighted the significant drop in the European electricity demand due to the pandemic (-4% in 2020 compared to 2019[15]) with an upturn tendency in Q4 2020. In 2021, boosted by the recovery of the economic activity, the tendency has been confirmed and the European demand grew back to its pre-pandemic level (+4% compared to 2020 and only -0.1% compared to 2019[15]).

Though, the analysis by Member States reveals discrepancies with the overall observation:

- While several countries such as Denmark (+7.0%[15]), Hungary (+6.0%[15]) and Estonia (+5.8%[15]) consumed more electricity in 2021 than in 2019, other countries like Spain (-3.3%), Greece (-2.9%) and even France (-0.3%) and Germany (-1.0%[15]) still have not reached their pre-pandemic levels

The impact of the Ukrainian crisis on European consumption is still contained, but the trend is to be followed over the next months

Despite the surge in electricity prices emphasized by the war in Ukraine and the firm will of the European Union to reduce its dependency towards Russian gas (currently 22.9% of the EU energy import[16]), the impact on European demand is still moderate, with only a 0.7% reduction compared to the 2019 level over the months of February, March and April.

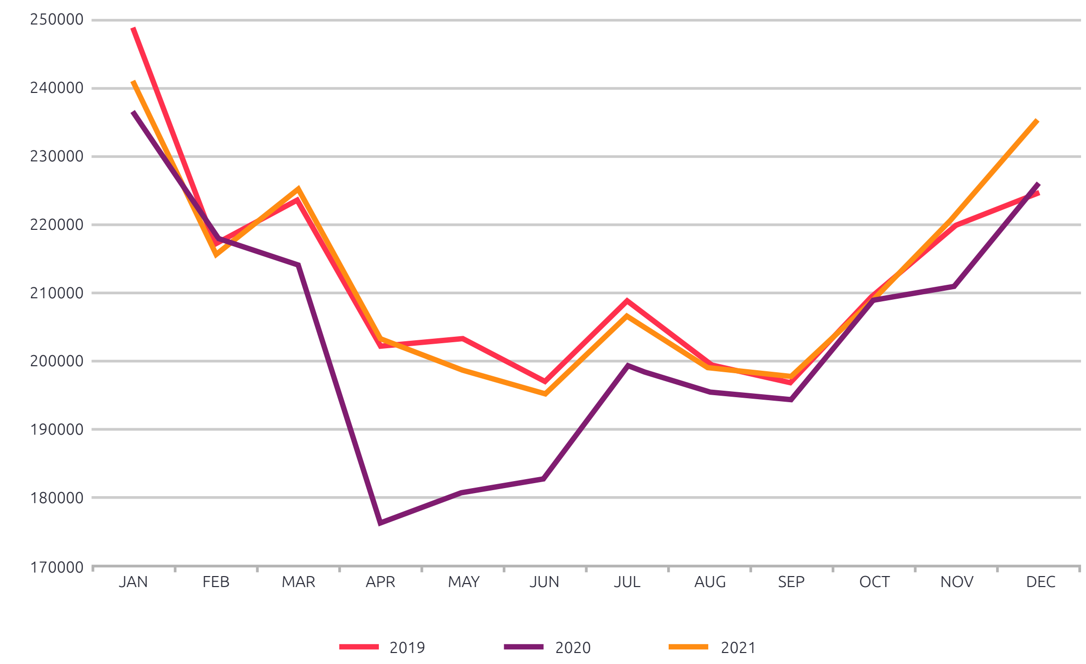
- This tendency may increase over the next few months, as several countries highly dependent on Russian gas, such as Germany (-1.9% from February to May[16] compared to 2019 consumption level) or Finland (-5.6%[16]) see a higher reduction of their consumption.
- Tensions also rose on the consumption of countries less dependent on Russian gas. For instance, the three major electricity suppliers of France (which supply around 90% of end consumers[17]) publicly asked for a reduction of consumption amid corrosion detection in several nuclear units, threatening French energy sovereignty[18].

15 Eurostat
16 European Central Bank

17 Estimate based on data from CRE, TotalEnergies & Engie
18 ASN

FIGURE 4

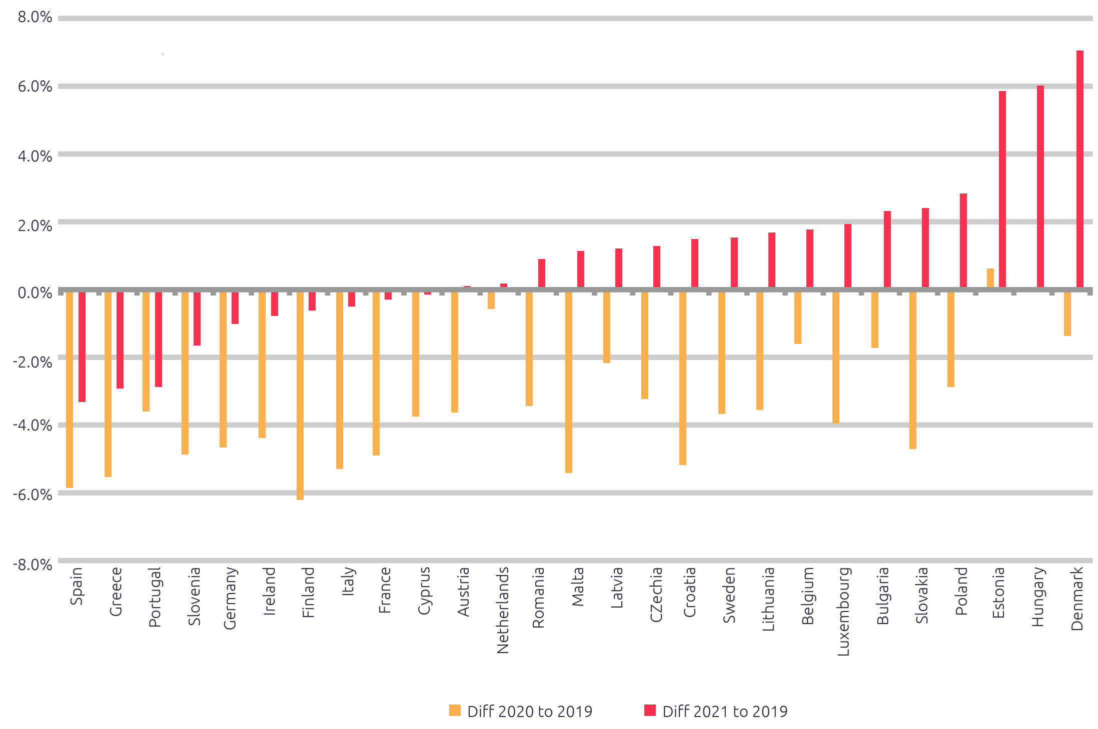
Electricity consumed by end-users in 2019, 2020 and 2021 (GWh)



Source: EUROSTAT

FIGURE 5

Electricity consumed by end-users, by country, 2021 and 2020 compared to 2019 (GWh)



Source: EUROSTAT

Electricity spot prices

In line with conjunctural problems (e.g., gas dependency, French nuclear unavailability) and power demand evolution, European power spot prices have experienced unprecedented volatility with spot prices breaking several records.

2021 power prices skyrocketed, as driven by economic recovery and high gas price levels

While 2021 was a recovery year for the European economy with 5% increase[19] in GDP, power prices have been rising to hit the €50/MWh mark in Q1 2021 with the weakening of governmental Covid-19 measures.

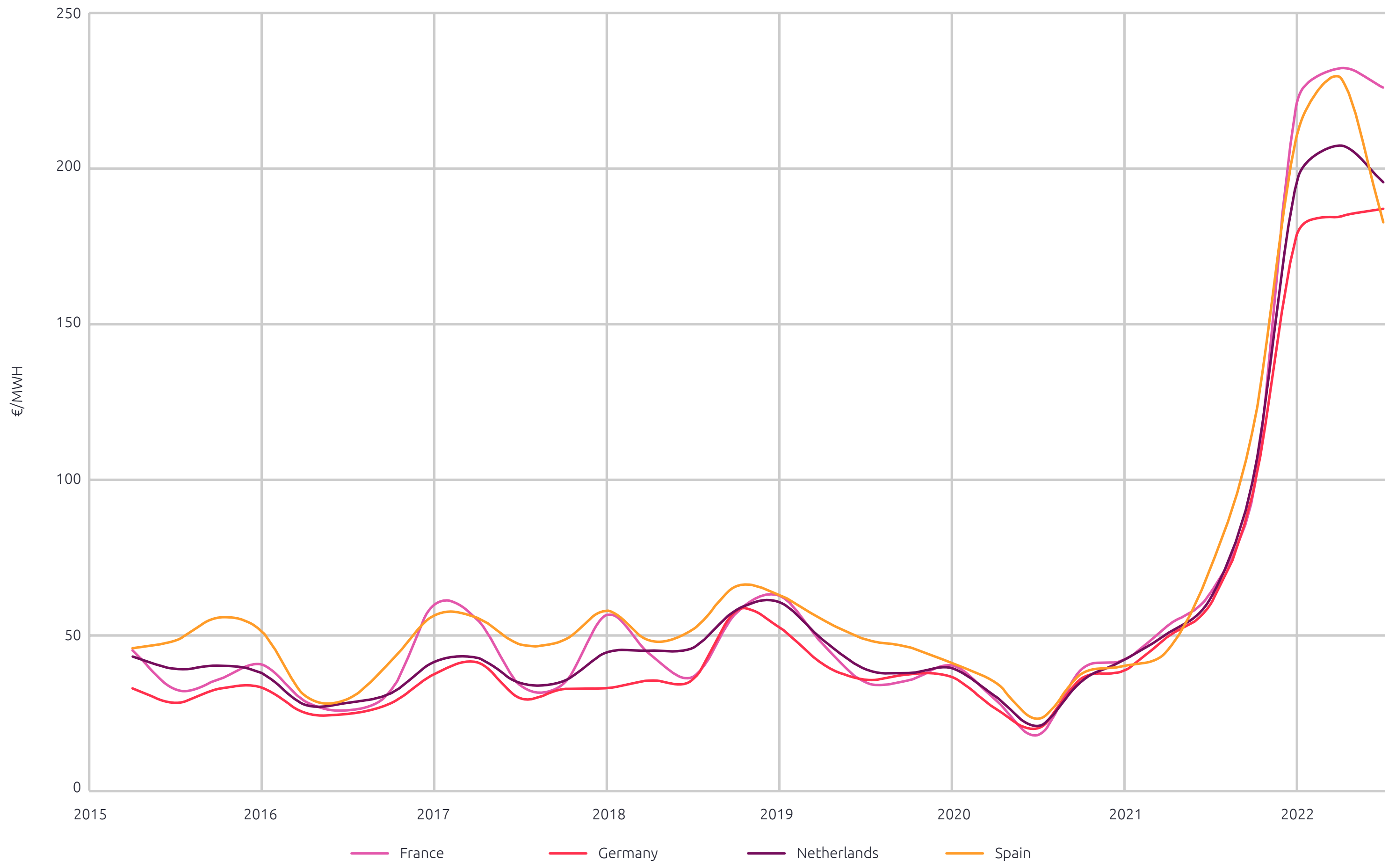
During the year, market, geographic and political factors have contributed to non-stop increasing power prices, but the increase in gas prices has been the major driver; gas prices broke several records in the second half of 2021. For instance, the leading European gas benchmark saw prices rise by around 450% between January and October 2021[20]. Gas price volatility even hit never seen levels in December 2021, with prices doubling from around €90/MWh[21] to €180/MWh3. This year's extreme volatility has been driven by Russia's will to keep gas supply to Europe down in order to keep pressure on European approval for the Nord Stream 2 pipeline.

Even though European countries tried to gradually reduce their dependency on fossil fuels, the shift to renewable power production sources and the structure of the European power market have not contained power prices. Moreover, the phase-out of coal-fired and nuclear power plants increased the power price sensitivity to the evolution of gas prices. Indeed, the never seen increase of gas prices led to power spot prices hitting record high values going from around €50/MWh in Q1 2021 to €200/MWh[22] by the end of the year.

19 Euronews - Europe's COVID recovery: economy bounces back but risks remain
20 Euronews - Why Europe's energy prices are soaring and could get much worse
21 Bloomberg - European Gas, Power Extend Slump as LNG Supplies Promise Relief
22 Fraunhofer Institute – Energy charts

FIGURE 6

Power spot prices evolution in 4 European countries



Source: Fraunhofer Institute – Energy charts

2022 power prices likely to follow the same path as previous year

By the beginning of 2022, European power prices stayed high at an average of €201/MWh in Q1 2022 (European commission's European Power Benchmark). This was 281% higher than the first quarter of 2021[23]. This increase has not been steady across Europe, with Spain and Greece's Q1 2022 power prices being respectively 411% and 343% higher compared to the same period in 2022. Meanwhile countries showing less dependency to gas, such as Sweden or Finland, experienced only a two-digit increase compared to Q1 2021 (respectively +49% and +86%). In fact, even though their dependency to gas is limited (respectively 1 and 2%[1]) those countries saw a rise in electric power prices due to weak hydropower production and high prices on the European mainland.

If the first and second months of the year saw the electricity spot prices plateauing thanks to improved gas supplies, the Russian invasion of Ukraine led to a new rise of spot prices in March 2022 and power prices once again reached a peak across Europe.

This new increase was mainly due to European sanctions against Russia and market fear of gas supply disruption for European countries.

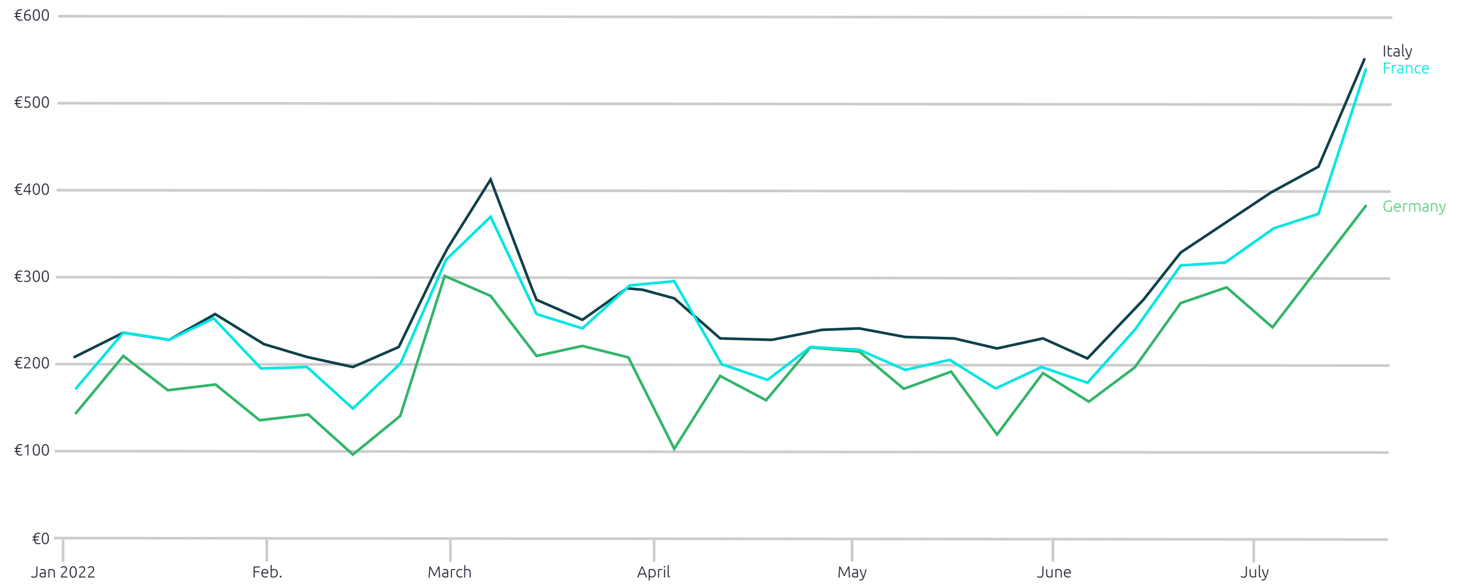
After reaching a peak in March, European power prices saw another two-month plateau before going up again. By the beginning of July, a new record had been broken with the European price benchmark hitting €328/MWh[24].

This new rise has been driven by another reduction of gas supply to Europe by Russia through the shutdown of the Nord Stream 1 pipeline for scheduled maintenance. While Moscow claimed that key compressor parts were stuck in Canada because of the sanctions, European countries saw this as a new pretext to reduce gas supply. In parallel, French nuclear facilities hit an exceptionally low availability rate because of a combination of maintenance, plant closures due to the detection of corrosion problems, and low river flows due to the drought.

More than disturbing French nuclear power plant production, and thus the regional power production system, the major heatwave experienced by Europe during the summer of 2022 weakened structural elements from power networks, such as transmission cables and power stations. Fearing blackouts while the thermometer hit the 40°C mark, the U.K. market reached a new peak at €905/MWh[25] (£774/MWh) by July 19, showing that European countries should also strengthen their transmission networks regarding the future stresses that will be brought by climate change.

FIGURE 7

Average power price in selected European countries (€/MWh)



Source: AXIOS - Europe's surging electricity prices are shattering records

23 European Commission - Quarterly report On European electricity markets (Q2 2022)
24 Financial Times - Europe power prices hit new high in wake of Russian gas supply cuts

25 iNew - 40°C heatwave pushed UK grid to the brink of blackouts with electricity demand close to outstripping supply

As Europe fears gas shortages for the winter, power prices are not likely to decrease[1]. French fixed-term contracts indeed reached the €900/MWh mark for Q1 2023, representing more than 15 times[2] the normal price. Even though France is facing a particularly tense situation with nuclear reactor unavailability, it is not the only country to see such an increase. In Germany, Q1 2023 is expected to be around seven-times higher[2] as normal.

European market system on the verge of being remodeled?

Even though gas-fired plants represent about 20% of European power capacity and generation mix, European spot power prices are mainly driven by gas prices due to the regulation of the European wholesale market. Indeed, the European wholesale market works on a "pay-as-clear" or marginal price mechanism. In this type of market, the commodity price is fixed by the price of the most expensive offer accepted. As renewables and nuclear power are cheaper to produce than fossil-based electricity in the current context, the market price is set on coal- or gas-fired electricity prices. With combustible prices representing an important part of the final power prices with these two fossil-fueled technologies and gas prices reaching new highs, gas-based electricity became the most expensive offers on market and made electricity prices skyrocket.

Seeing the European electricity prices beat record after record, some European leaders pushed for a strong evolution of market regulations. Spanish and French governments are especially keen on this evolution as shown by the statement of the French Minister of Economy: "an energy European market in which decarbonized electricity prices stay dependent on fossil fuel energy prices is absurd."[3] Furthermore, Spain insisted on the fact that high energy prices would remain longer than expected when the European Union presented its toolbox, and that the European Union should remodel the energy market accordingly[4].

Responding to those demands, President of the European Commission - Ursula von den Leyen admitted on June 8 that "the electricity market is not functioning anymore and requires a major reform."[5] During her intervention, the President of the European Commission admitted that the toolbox put in place in fall 2021 was not enough to treat the structural problems shown by market evolution. According to von den Leyen, the actual market is consistent with what was needed 20 years ago but should adapt to reflect new dynamics, notably the development and rentability of renewable sources.

While some drawbacks have been identified within the current market structure, the new regulation should bring answers by:

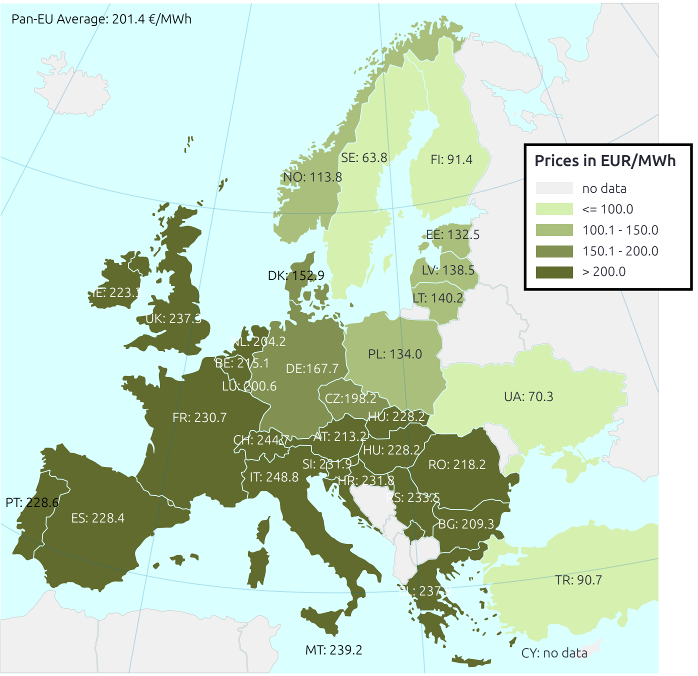
- Enabling less price volatility in order to give long-term vision on prices to investors
- Protecting European households and companies from extended high price situations brought by fossil-fuel price increases

By succeeding in challenging these points, investments in power production systems should not be uniquely driven by government incentives anymore, but by visibility brought on by the market.

Low-carbon production (renewables and nuclear) systems development should also be boosted by this visibility since such highly capitalistic investments have to be amortized on a long-term basis. This would contribute to the European security of supply.

FIGURE 8

Comparison of average wholesale base-load electricity prices (Q1 2022)



Source: European Commission - Quarterly report On European electricity markets (Q2 2022)

1 Bloomberg - Europe Power Prices Set to Climb Even Higher After Record Month
2 Enerpress – 04/08/2022

3 Euractiv - La France, cheffe de file pour réformer un marché de l'énergie devenu « absurde »
4 Euractiv - Ukraine : l'Espagne demande des «solutions structurelles» alors que les prix de l'énergie s'envolen
5 Enerpresse – 06/29/2022

Cross-border interconnections as a requirement to secure European targets

It is crucial for Europe to improve its cross-border electricity connections in order to achieve its energy and climate goals. By connecting Europe's electricity systems, the European Union will be able to better integrate renewables into its energy market, thus strengthening the security of its energy supply. Due to the current tensions between the European Union and Russia, this objective has become a critical focal point of the European Union[6].

For instance,

- In the event of a power plant failure due to extreme weather, it is important for the European Union states to rely on neighboring countries to supply their energy needs.
- By strengthening connections with neighboring countries, the risk of blackouts decreases. Also, the need for the construction of new plants is reduced.
- Finally, there is the added advantage of simplifying the management of solar, wind, and other renewable power sources.

As a result, the European Union has set an interconnection target of at least 15% (15% of net transfer capacity with respect to total production capacity) by 2030 to encourage EU countries to interconnect their installed electricity production capacity. The previous interconnection target was set at 10% by 2020.

In 2021, 16 countries, such as Denmark and the Netherlands, reported being on track to reach that target by 2030, or had already reached the target. However, more interconnections are needed in some regions.

The graph on the right shows the interconnection level of the countries in Europe and their positioning with regard to the 2020 and 2030 targets.

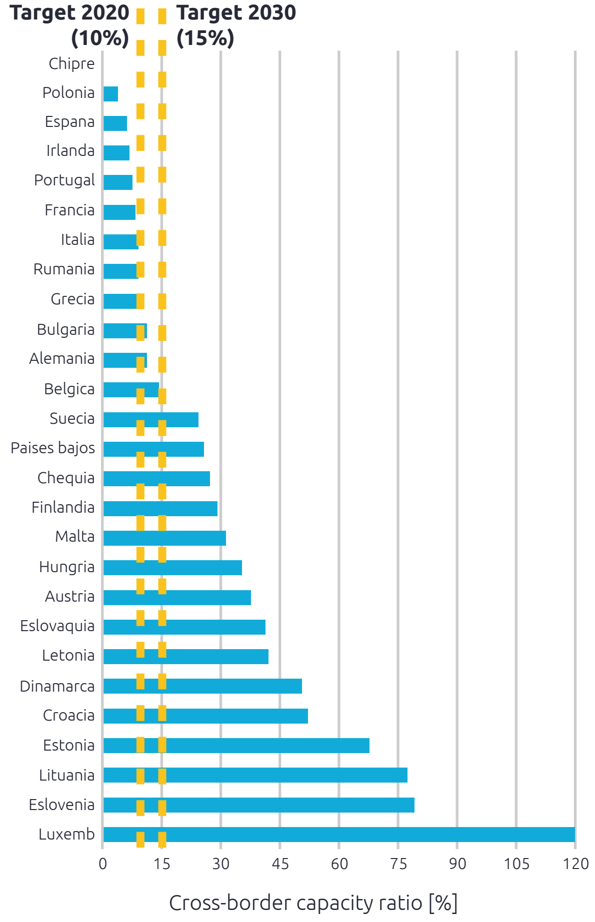
For example, Spain did not meet the 2020 target, but major projects are underway to reach the new 2030 target. On the other hand, most of the Nordic countries have an interconnection capacity that exceeds the European targets.

Major interconnection projects are being developed to ensure European security of supply

- In November 2020, Amprion and the Belgian TSO Elia put into operation the first direct electricity interconnection between Germany and Belgium (to be named ALEGrO)[7].
- Spain-France submarine interconnection: This new submarine electricity interconnection through the Bay of Biscay represents a challenge that will enable the electricity exchange capacity between Spain and France to be increased up to 5 GW, compared to the current 2.8 GW. Currently, this project is still in the consultation phase, and its commissioning is foreseen for the 2026-2027 horizon[8].

FIGURE 9

Level of electricity interconnection (%) between ENTSO-E members



Source: European commission (2020)

6 European Commission – Electricity interconnection targets

7 Elia Group – ALEGrO, the first interconnector between Belgium and Germany
8 Red eléctrica – Spain-France submarine interconnection

Unusual behaviors are happening at the interconnections because of the war in Ukraine

In 2022, the war in Ukraine strongly accentuated rising wholesale gas prices and, as a result, electricity prices. This variability caused a shift in the selection of power plants in operation, which led to a change in the production mix (price and energy vector) for each country.
Hence, a structuring change in the dynamics at the interconnections has been observed. For example, at the France/Italy interconnection, the Italian operator grid TERNA recorded electricity exports behaviors on several occasions, while Italy is usually known to import electricity from France at this interconnection.

The graph on the right shows the ENSTO-E projections in terms of connectivity infrastructure and capacities.

Focus on impacts of the Ukraine-Russia conflict on the development of the interconnection with Ukraine

An acceleration of the interconnection development of the European networks occurred in the beginning of 2022 following the beginning of the war in Ukraine, especially in the Ukrainian area.

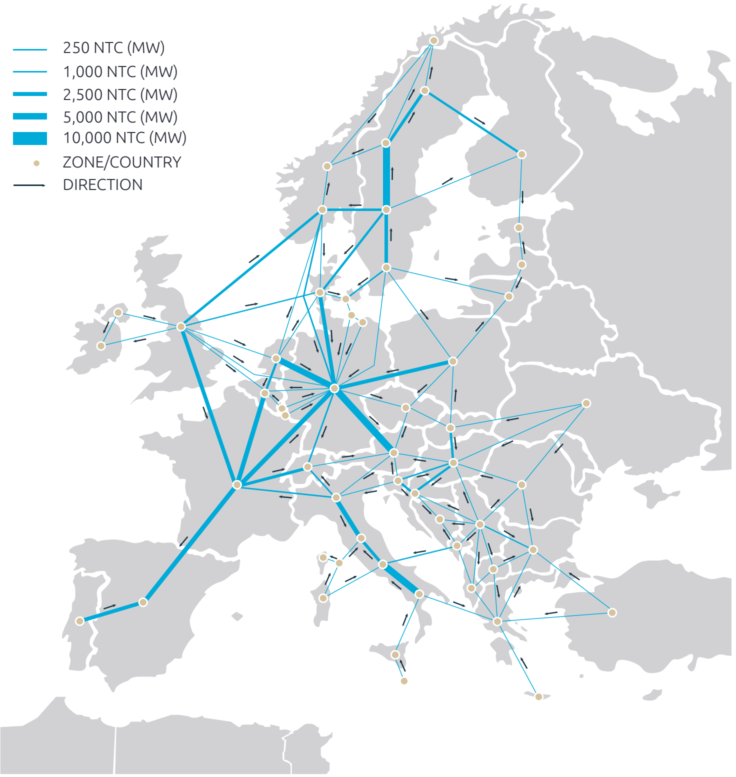
In fact, the Ukrainian and Moldovan electricity networks have been connected to the European grid. The commissioning of the connection was originally planned for 2023 by ENTSO-E but the emergency synchronization allowed for interconnection without every usual prerequisite being completed. Some key points :

- **Energy independent:** Since Ukraine disconnected from Russia, it has been testing its grid in "island mode"
- **Major challenge:** Synchronizing the grids, which involves aligning the frequencies of each power generation facility in the connection systems
- **Synchronization:** The 26 ENTSO-E member countries have set March 16 as the day to jointly adapt their technical specifications to those of the Ukrainian infrastructure

The trade opening between Continental Europe and Ukraine/ Moldova was not possible in March because the technical requirements were not yet fulfilled. In June 2022, the technical requirements for trade were met, starting trade between Ukraine and Romania. The increase of the exchange capacity is under study, as well as the enlargement of the number of countries with which this is done, such as the Ukraine-Hungary trade.

FIGURE 10

Standard Net Transfer Capacity model for 2030



Source: ENTSO-E Completing the map – Power system needs in 2030 and 2040 (2020)

In Europe, the joint capacity mechanisms are progressively going live

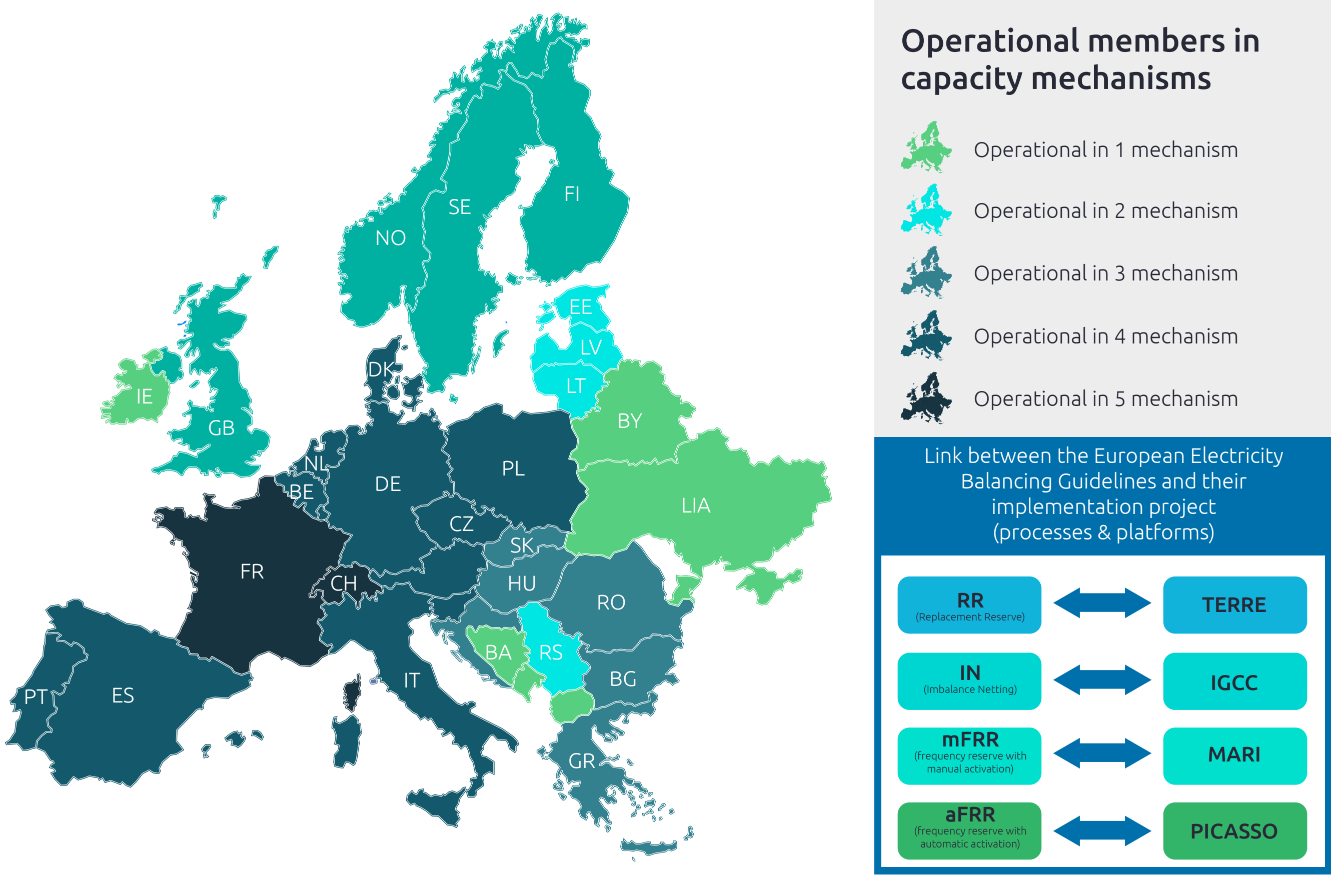
Involvement of European countries in security of supply mechanisms remained despite a complex geopolitical context

Though most European countries joined the capacity mechanism thinking groups and platforms in previous years, only a few changes have been observed in 2021 as these countries maintained their commitment in the more concrete and operational phases[9].

- As in previous years, Switzerland and France are the countries involved in the most mechanisms (5).
- 11 countries are still strongly involved in the European security of supply and take part in four mechanisms.
- More specially:
  - Greece and Romania joined the IGCC Mechanism on June 22, 2021 and December 17, 2021, respectively; they should be followed by Serbia and Bulgaria. This confirms the growing involvement of southeastern Europe in the common capacity mechanisms.
  - As for the United Kingdom, due to Brexit, National Grid ESO is currently preparing its exit from TERRE. It should be replaced by the TSO PSE (Poland) whose go-live is scheduled in 2023.

FIGURE 11

Map of Capacity Mechanisms in Europe



Source: ENTSO-E 2022

9 ENTSOE

By September 2022, four European balancing mechanisms should be operational

Already in place in 2022, the **IGCC Mechanism** allows the saving of more than 2,770 GWh per quarter, improving the security of supply in Europe.

- **PICASSO** went live on June 1, 2022, almost two months before the legal deadline.
  - On June 22, 2022, the German TSOs (50 Hertz, Amprion, Tennet Germany, and TransnetBW) and the Austrian TSO (APG) joined the Czech TSO (CEPS) on the platform[10].
  - The Belgian and Swiss TSOs (Elia and Swissgrid), followed by the French and Romanian TSOs (RTE and Transelectrica), are also expected to go live before the end of 2022.
- After the completion of the platform design and operational tests, **MARI** should go live between mid-August 2022 and mid-September 2022.
- Paving the way for joining the MARI and PICASSO mechanisms (for mFRR and aFRR) in 2024, a **Nordic Balancing Mechanism (NBM)** is being implemented among the Nordic countries.
  - After a go-live in Norway (December 6, 2021) and in Sweden (May 12, 2022) Denmark and Finland should join the aFRR mechanism.
  - The mFRR mechanism should also be launched in 2023.

10 ENTSOE

THE NEED FOR DISTRIBUTED SOFTWARE PLATFORMS IN TRANSMISSION & DISTRIBUTION (T&D)

THIERRY BATUT
DEBARGHYA MUKHERJEE

Trends

#1: Asset type

The diversity of assets to be considered on the grid (mainly in the distribution grid) is increasing in terms of

- Distributed energy:
  - Solar (generation)
  - Wind (generation)
  - Hydrogen (generation and storage)
- Batteries (generation and storage)
- Methane (generation and storage)
- Heat pumps
- Electrical vehicle (chargers and mobile batteries)

#2: Huge increase of asset numbers

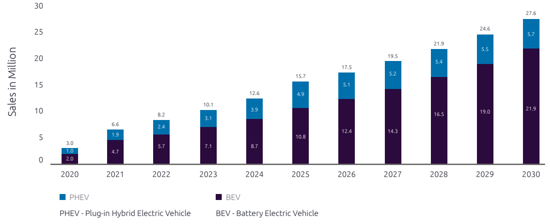
These new types of assets are going to be deployed at a very large scale. In comparison, where utilities have been used to managing tens of thousands of assets from an automation standpoint, we are talking about millions of them in this new era.

#3: Mobility, a new paradigm

Electrical vehicles, in addition to being a new asset type, are also introducing a new pattern on the grid. As a result, utilities must balance the grid more quickly and at a lower level to include a higher number of variable assets and forecast consumption and storage.

FIGURE 1

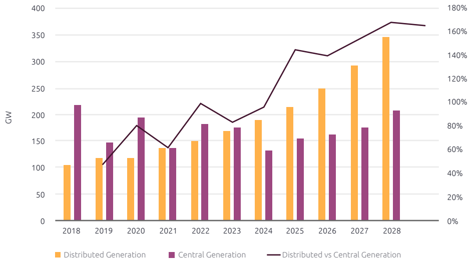
Global EV Car Sales (Mn)



Source: Global EV Outlook 2022 IEA

FIGURE 2

Global annual revenue from distributed energy resources (DER)



Source: Navigant Research

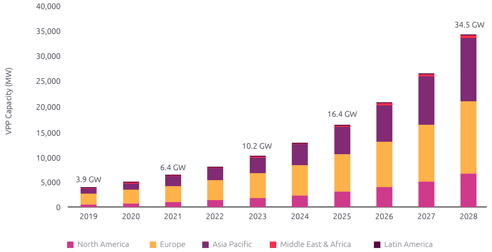
#4: New type of services

T&D operators, with the paradigm shift and the set of new consumption patterns, must deal with various new services:

- Beyond the meter: Manage end customer production/consumption (prosumer)
- Reinforce load/demand real-time balance
- Flexibility, demand-response, storage, capacity management
- Energy-as-a-service, due to mobility paradigm
- Peer-to-peer: Edge mediation between end customers
- Connected microgrid or community that could be operated by utilities

FIGURE 3

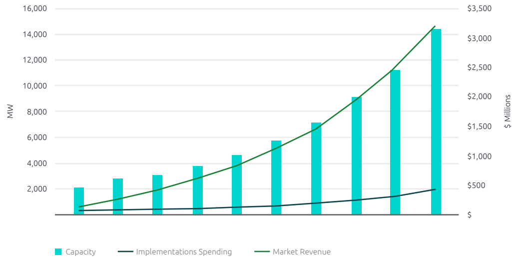
Global VPP Capacity Market Forecasts: 2019-2028



Source: Navigant Research

FIGURE 4

Annual Total VPP Capacity, Implementation Spending and Market Revenues, Europe: 2019-2028



Source: Navigant Research

#5: Increasing number of stakeholders involved in grid management, in addition to regulators, electric system operators, and sometimes asset owners

The number of participants involved in the management of the distribution grid is increasing:

- Renewables operators, prosumers
- Virtual power plant provider (both in terms of flexibility and asset optimization)
- public network microgrids (communities, campus, hospitals) connected to the grid

In addition, there are higher expectations on the delivery of energy:

- Increase network resilience:
  - Against frequent, recurring climatic events (e.g., wildfires, flooding, hurricanes)
  - Secure criticality of energy availability due to the extension of the usage (SAIDI, SAIFI)
- Deliver more efficiently:
  - Optimize network design by limiting the number of connections (copper saving)
  - Increase performance (never-ending requirement)
- Improve flexibility:
  - To manage intermittency of renewables due to their increased proportion in the energy mix
  - Be more agile in implementing new/evolution use cases/services
  - Shortening deployment at scale on the edge
- Secure reliability in a new network architecture:
  - From centralized to decentralized generation
  - From one-way to two-way flow
  - Guarantee the level of service (geopolitical tensions, autonomy)
  - Strengthen cybersecurity

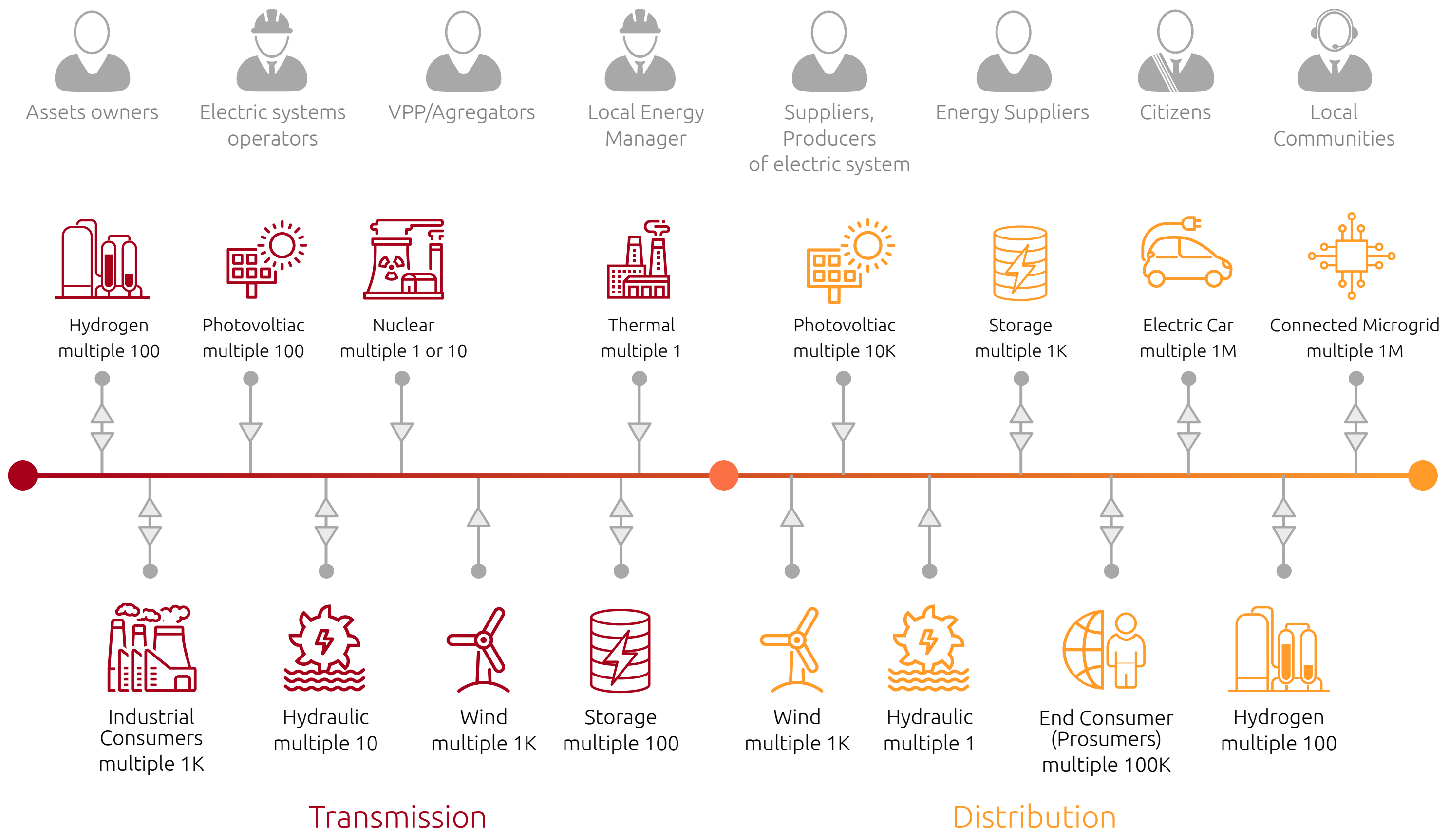
Constraints and challenges

To tackle ongoing trends:

- Each country has its specifics, but regulatory bodies have to change regulation on various domains:
  - Today's DSO on the grid is based on HW assets and does not recognize the value of software enough
  - Modernize the market structure to enhance the aggregator role and create more room to play
  - TSO/DSO boundary to be reviewed, each of them having to take a joint responsibility in demand/response forecasting and supervision
  - Capacity markets and new services to be supported under the responsibility of T&D operators
- Sustainability generates a pressure on resource consumption; both raw material and energy itself (new non "technical losses" corresponding to the management of the grid).
- Intermittent energy generation has to be optimized without degrading service quality, which, as a consequence, needs a near real-time modelling in terms of impact assessment and allocation management (real-time balancing at the end)

FIGURE 5

Utility Transformation: Distributed Energy Resources



- Utilities:
  - Have to shift their mindset to embrace the digital transformation both in terms of technology shift and short project lifecycle
  - Have to take into account its legacy and determine its strategy with high-pressure short-term milestones (energy shortage that increases pressure on DER connection)
  - Need to embrace new services as already stated
  - Have to invest in grid modernization at a moment when auto consumption and microgrids could decrease energy transiting, and, as a result, compensation; more investment and less compensation, causing a financial effect
  - Need to take into account more and more data for managing the grid (e.g., weather patterns, auction outcomes, flexibility connections, DER profiles) and getting value out of data
  - Must consider for the mid-term, network convergence triggered by new energy mix and Power-to-X/X-to-Power services

Due to these trends highly impacting the management of the distribution grid, utilities' transformation is on a radical change path

In the past, utilities managed everything centrally:

- Production was centralized
- Distribution network was one way
- End-users were consumers
- Storage was almost non-existent
- Production was permanently connected to the grid
- Many, if not most, activities were done manually

Today, the distribution network is decentralized which leads to:

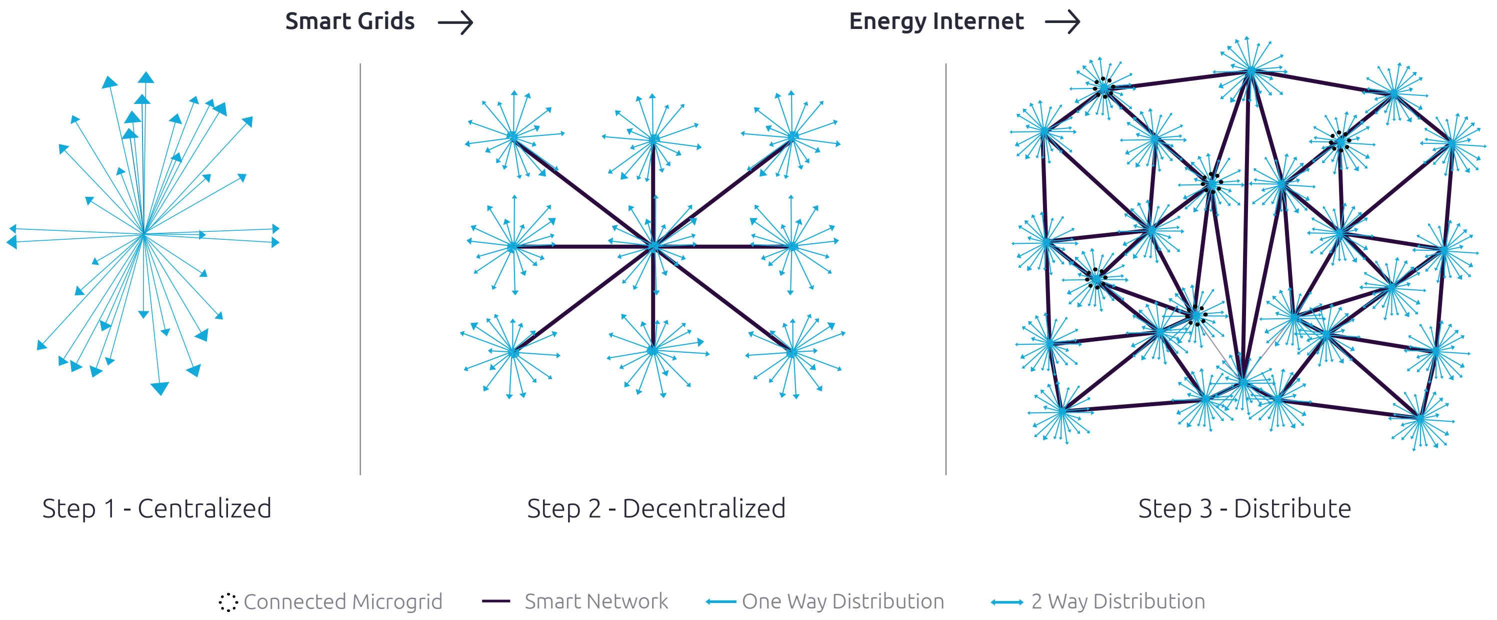
- Production is hybrid and scattered across the territory
- Distribution network works both ways
- End-users are prosumers, using or injecting on the grid energy they produce
- Storage is taking an important room
- Production and storage assets are sometimes disconnected from the grid
- Some assets start to be mobile in their connection to the grid
- Almost all high- and medium-voltage grids will be automated rapidly

Tomorrow, a distributed network will be the norm:

- Huge increase of small size storage (V2G, P2G, and battery)
- Production and storage assets will go on and off the grid
- Off-grid systems can run independently from the grid
- Automation of low-voltage grid will be mandatory
- Near real-time management of the grid will be needed with complex and changing pattern to manage (intermittency and decentralization)
- The complexity of the management of the grid will require a high level of automation (still under the supervision of humans)
- Network convergence (electric, gas, heating, cooling, hydrogen)

FIGURE 6

Decentralization of Distribution Network



As a result, the technology and solutions need to evolve tremendously as the pressure to move to more sustainable and decarbonized energy is becoming higher.

This not only encompasses utilities, but also their entire provider ecosystem. The latter could evolve with this paradigm shift with new entrants.

In addition, this change will have to be deployed at scale. Since it is focusing on a medium/low-voltage networks, it increases the magnitude of the effort to be performed and will require the appropriate strategy and execution. Each utility will have its own based on constraint, regulation, and unique priorities with the software toolset needed to manage such deployment.

As a result, CAPEX are expected to double; and the share of software will grow from 15% of the modernization cost to about 35%, due to the distribution grid

Solutions

In order to address these future needs, DSOs will have to put in place a highly distributed management system based on multiple levels of nodes, each of which will require its own level of automation and self-decision making mechanisms. Introducing here the well-known smart grid concept at a high level:

At the end, each of the nodes will have:

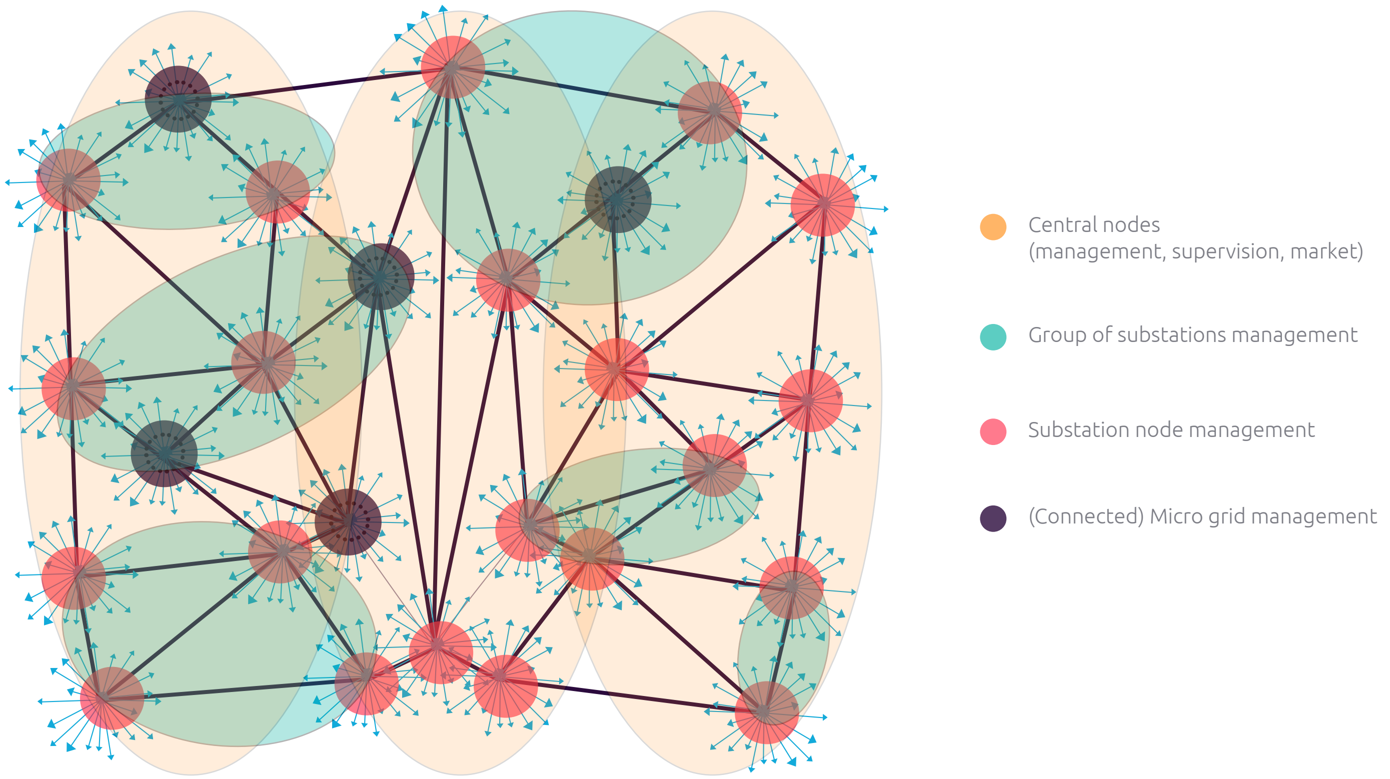
- Its own level of decision making, including part or the majority of smart grid components above
- ML/AI/rule-based type of algorithms in order to be able to manage the complexity of network topology, market, or technical rules
- Will require a high level of OT/IT integration

To make this development easier, a common software platform architecture has to be designed and implemented to develop and connect new functions (two stakeholders exchanging data through an intelligent and automated platform).

The overall node configuration will be subject to changes over time, depending on the state of the distribution grid and its topology evolution.

FIGURE 7

Distributed software platform to manage future distributed energy grid



As a result, in order to manage such infrastructure **at scale:**

- A set of central software platforms will still be required to:
  - Coordinate and supervise all these nodes
  - Provide a mediation layer for aggregators and other market stakeholders to interface them for energy grid management
  - Ensure overall (cyber)security of the system
- A software factory to manage both the development and the administration of all those components
- The development/deployment cycle will need to be heavily shortened compared to existing cycles

This platform approach will strengthen resiliency and efficiency by its flexible distributed management. Overall sustainability due to this additional level overlay will be an attention point.

This will require digitalization of the grid in all its dimensions: planning, forecasting, simulation and management, taking into account the vast variety of devices and its tremendous numbers.

The various resulting components of a smart grid that we can identify will be:

- Smart metering (almost already existing)
- Network instrumentation, IoT and edge compute (down to low voltage)
- Grid operations, including DERs
- Advanced asset management from planning to operations,
- Data-driven grid (transversal to get value out of the data and new services) will be impacted by the solution requirements

Conclusion

Distributed software platform required to manage future distributed energy grid

Software platform:

- Software platforms are becoming utilities' key asset to support the digital transformation like all other markets. This is a radical change in the current value chain and its way to operate

Edge:

- Edge compute capabilities are a must in transmission and distribution transformation as the new grid complexity and associated response time can no longer be managed by a centralized architecture

Smart assets:

- Any asset will have to become connected, smart, and automated with embedded OT/IT integration and will have to be delivered with its digital twin (middle term)

Multi-level management:

- Flexibility of grid node management is needed (moving from one to many control rooms) to optimize compute balancing requirements

Cloud technology:

- Cloud-based technology will best fit the need. Not cloud-first, but cloud-only. Using hyperscalers systems and/or services will raise the need for sovereignty and privacy

We are moving from an energy transportation and distribution grid to a distributed (production and consumption) energy system. The grid becomes the backbone enabler of the (complex) system.

NORTH AMERICA ADEQUACY OF SUPPLY

ALEXANDER RODRIGUEZ
SARA STRITHARAN
ISHANDEEP

U.S. electricity consumption growth: According to the EIA's Annual Energy Outlook 2022, electricity use will moderately increase from 2021 to 2050.

As the economy recovers to pre-pandemic levels of economic activity, according to the U.S. Energy Information Administration (EIA) predictions, the three-year rolling average growth rate of power consumption in the United States will peak in 2023.

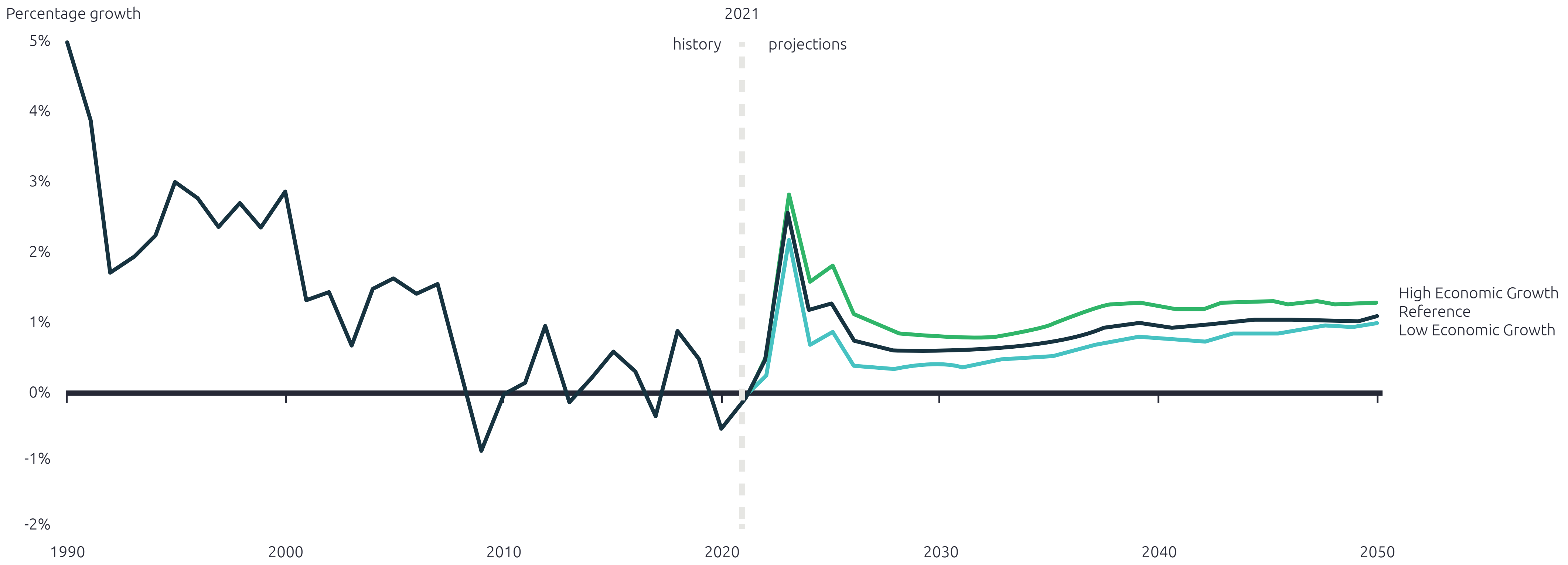
- In the near term, weather variations, economic shocks, or other unforeseen occurrences may cause fluctuations in electricity demand. Although significant electricity demand is not expected, there is an expectation in the electrical generation source to significantly shift from fossil fuels to renewable sources. U.S. could expect to see more than 40% of their electrical generation come from solar, wind and hydro.
- Longer-term trends in electricity consumption are driven by economic expansion, however efficiency gains somewhat balance the growth.
- In the Reference case, the average annual growth rate of electricity consumption surpasses 1% but not until near the end of the projection period (2021 – 2050).
- Electricity demand grows about 0.25% faster in the High Economic Growth case than in the Reference case, and about 0.25% slower in the Low Economic Growth case.

Electric utilities must consider how much electricity electric vehicles (EVs) consume because it will determine if they have enough generation to supply the rising number of EVs.

- From 308,000 in 2020 to 608,000 in 2021, sales of new light-duty plug-in electric vehicles, including all-electric vehicles and plug-in hybrid electric vehicles (PHEVs) doubled. EV sales contributed around 73% of all plug-in electric vehicle sales in 2021. While PHEV sales increased by 138% over the prior year, EV sales increased by 85% between 2020 and 2021.
- According to EIA forecasts, the overall electric vehicle percentage of the on-road light-duty vehicle (LDV) stock, which includes BEVs and PHEVs, rises from less than 3% in 2021 to 13% in 2050. This transition takes place even though the number of LDVs on the road is anticipated to increase from 260 million to 288 million throughout that time.
  - Between 2019 and 2050 in the Reference case, increased electrification of the on-road LDV fleet results in a rise in electricity consumption from less than 0.5% to more than 2% of overall energy consumption in the transportation sector.

FIGURE 1

U.S. electricity use growth rate, three-year rolling average economic growth cases



Source: U.S. Energy Information Administration, Annual Energy Outlook 2022 (AEO2022)
Link: https://www.eia.gov/outlooks/aeo/ppt/AEO2022_narrative_graphs_electricity.pptx

U.S. electricity generation: Electricity generation from coal increased in 2021 while production of natural gas decreased

Although its contribution decreased year over year in 2021 for the first time in ten years, natural gas is still the leading source of electricity in the United States.

- In 2021, gas accounted for 38% of generation, or 1,572 TWh. Despite an increase in overall electricity demand, that represents a roughly 3% decrease in its contribution from 2020.
- Over the past ten years, the combined share of renewable energy and natural gas in overall power generation increased from 38% to 59%.

The energy generation mix varies throughout the U.S. with different power-generating technologies contributing various amounts in different power markets.

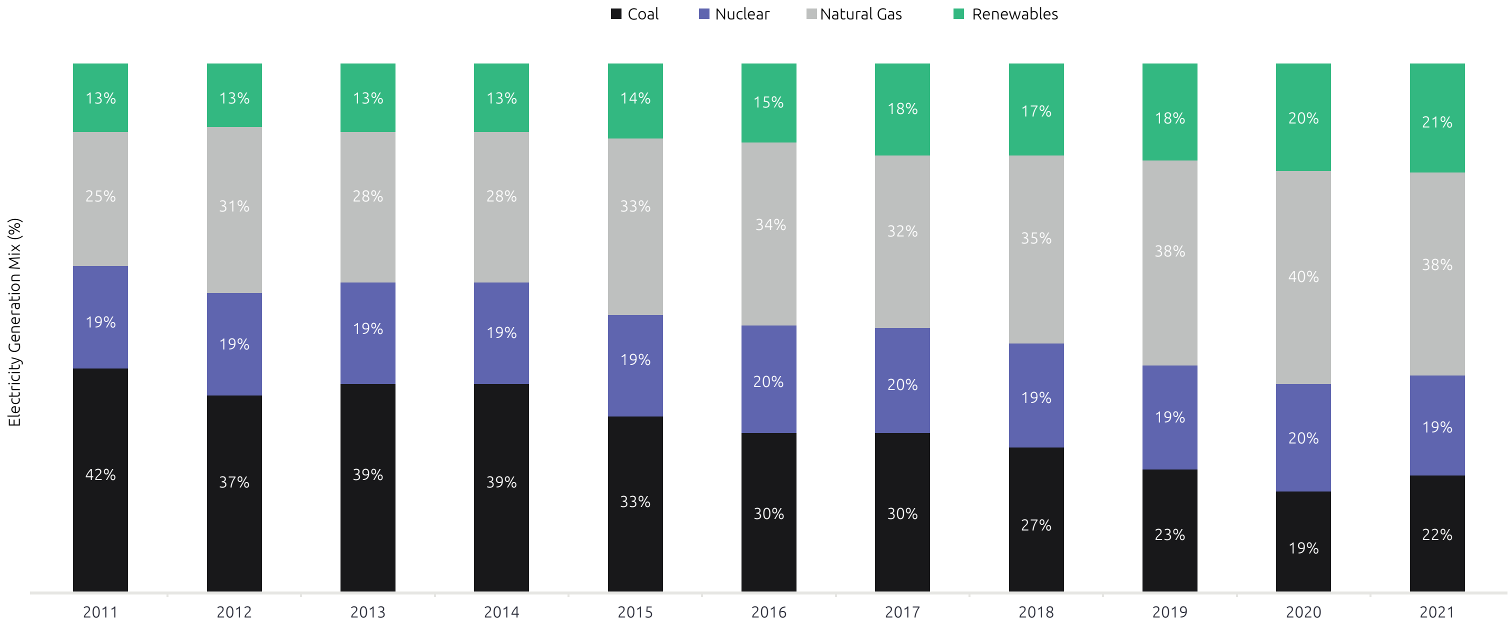
- In 2021, the contribution of renewable electricity generation increased 4.1% year over year. The contribution from wind and solar increased to a remarkable 13%. Renewable energy generation increased 33 TWh in absolute terms to reach 858 TWh, or 21% of the total power supply.
- Due to the severe drought in California and the northwest, hydropower's contribution decreased by 11% in 2021.
- For the first time since 2014, coal-fired generation increased year over year, reaching 22% of the total in 2021.

This resulted from noticeably higher natural gas prices (coal prices also saw a rise in the second half of the year but to a lesser extent). Since 2013, there have been no new coal-fired power plants installed in the United States, and 30% of the fleet have been decommissioned since 2010.

- With only one plant closing in 2021, nuclear power maintained its status as the source of just under one-fifth of American electricity.

FIGURE 2

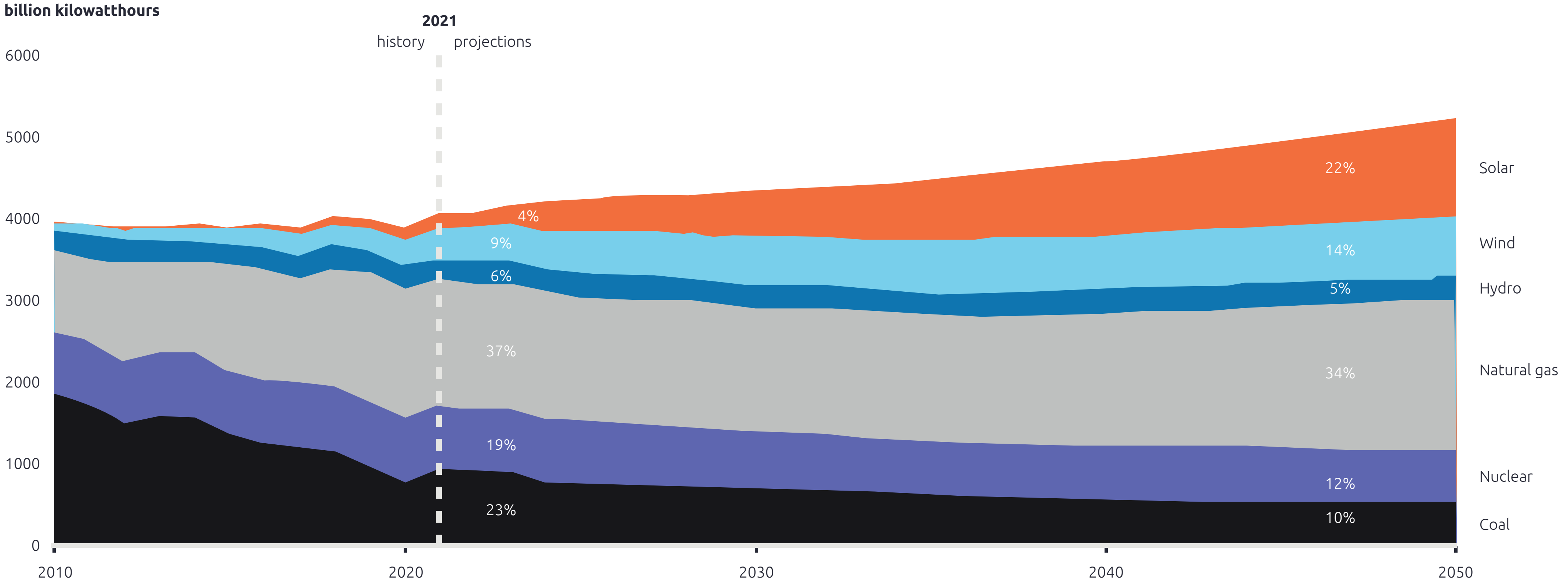
U.S. historical electricity generation mix evolution, 2011-2021



Source: BNEF ~ Sustainable Energy in America Factbook, 2022. Note: Results are rounded to the nearest whole number and so, may not add up to 100%
Link: http://www.bcse.org/factbook/#

FIGURE 3

U.S. electricity generation from selected fuels



Source: U.S. Energy Information Administration, Annual Energy Outlook 2022 (AEO2022) Reference case; Note: Solar includes both utility-scale and end-use photovoltaic electricity generation.
Link: https://www.eia.gov/outlooks/aeo/ppt/AEO2022_narrative_graphs_electricity.pptx

U.S. electricity generation: The share of on-site electricity generation is projected to increase in 2050 across non-transportation sectors

On-site generation of electricity expands significantly in the U.S. residential, commercial, and industrial sectors, reducing growth in electricity purchased from centralized generators.

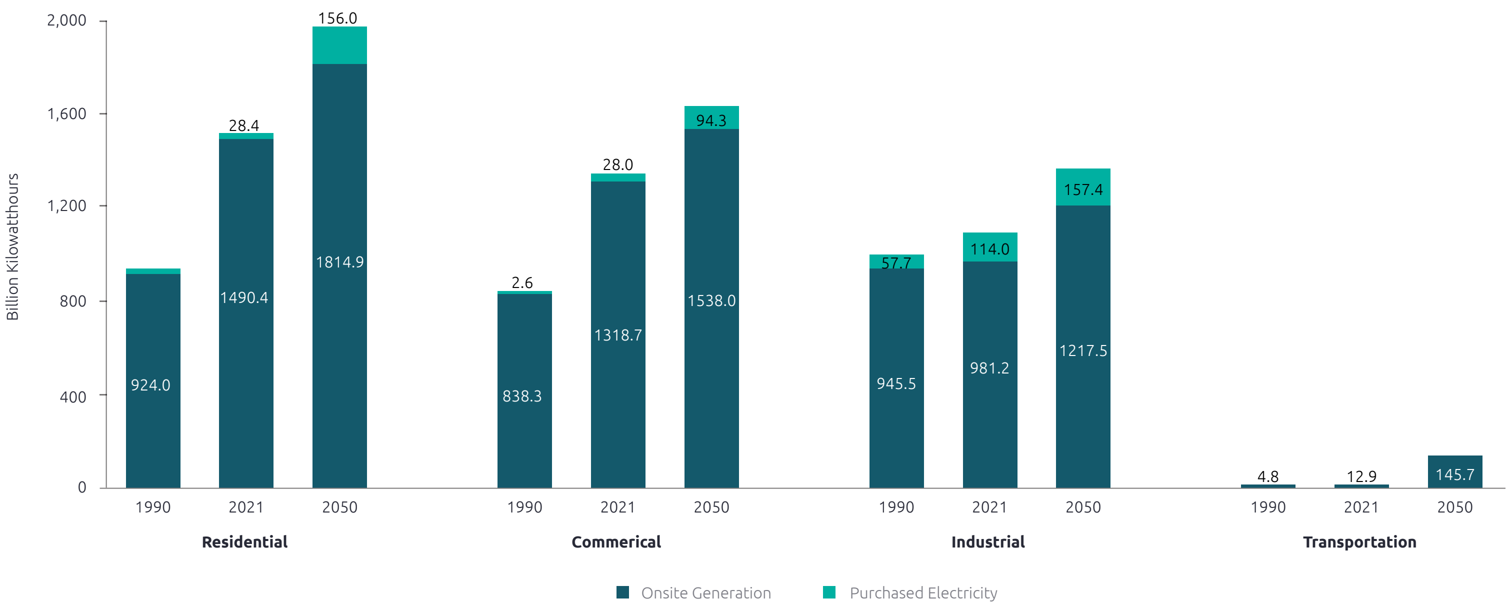
- According to the EIA, on-site solar PV systems in the residential, commercial, and industrial sectors would generate more than 8% of all electricity by 2050, nearly doubling the percentage held by on-site power generators in 2021.
- The increase in residential on-site generation is an indication of a shifting consumer base and increased economical sense of solar generation.

Electricity demand in transportation remains low.

- EIA stated that demand for electricity grows fastest in the transportation sector, even as consumption in that sector remains less than 3% of economy-wide electricity consumption.
- In the Reference case, the percentage of fully electric vehicles in the on-road LDV fleet increases from less than 1% in 2021 to just over 7% in 2050. The progress of EV technology, market changes, and current fuel economy rules are the main causes of the rise in demand.

FIGURE 4

U.S. electricity use by end-use sector, 1990, 2021, 2050E (billion KWh)



Note: Onsite generation is electricity produced onsite for own use.

Source: US EIA Annual Energy Outlook, 2022
https://www.eia.gov/outlooks/aeo/

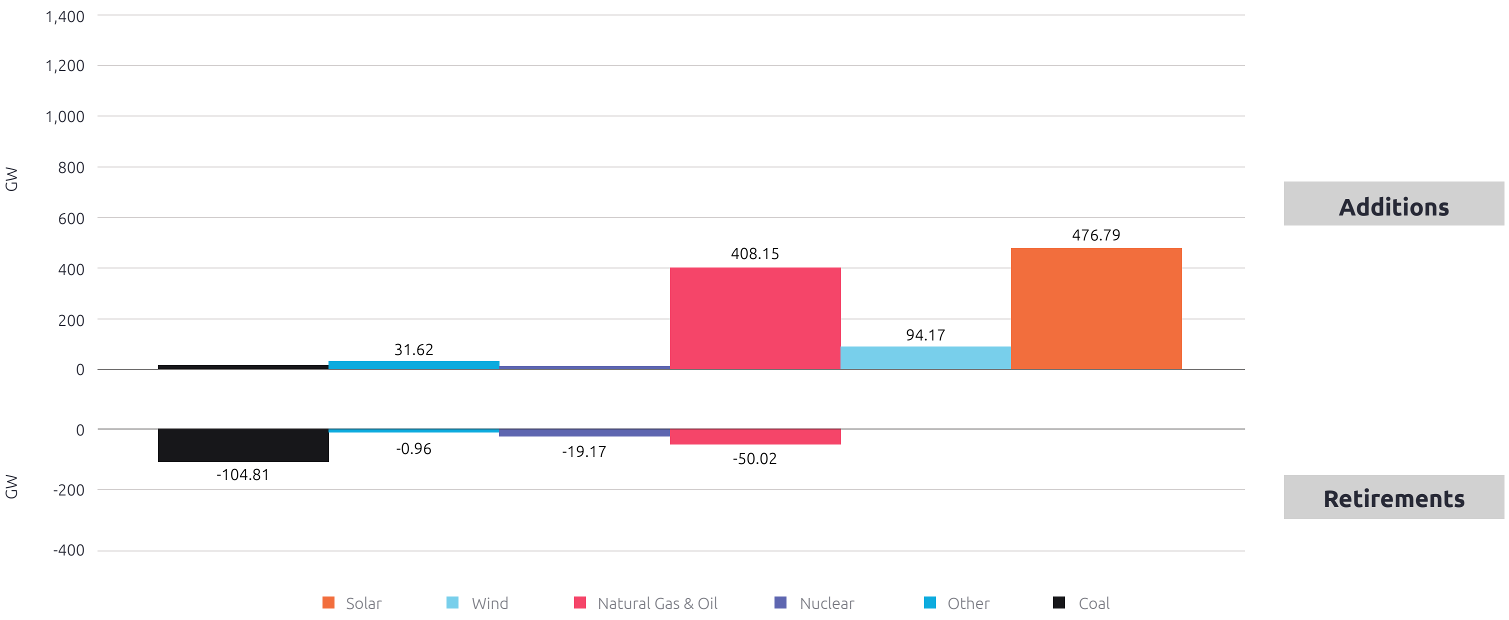
U.S. electricity generating capacity: Renewables account for most of the projected capacity additions from 2021 to 2050.

Solar accounts for the majority of U.S. capacity additions in most regions.

- Over 57% of the roughly 1,000 GW of cumulative capacity additions that EIA projects in the Reference case from 2021 to 2050 come from renewable electric-generating technologies.
- Throughout the forecast period, wind capacity is gradually added, but considerably less than solar capacity. 47% of new electric-producing capacity increases come from solar capacity, while 10% comes from wind energy.
- Natural gas-powered generating technologies account for most of the remaining share of new capacity additions (39%), some of which is used to provide electricity when intermittent wind and solar resources are not available.
- Solar generating capacity grows steadily across all regions of the United States in the Reference case.
- Some regions are building diurnal storage capacity to support larger daily price fluctuations from the solar capacity additions.
- Compared to 8.4 GW of natural gas-fired production capacity, the EIA predicts that California will add roughly 13 GW of diurnal storage power capacity through 2050 in the Reference case.
- PJM interconnection and the west are the only regions that add more natural gas capacity than solar capacity, but these regions also show high growth in solar.
- By 2050, solar will account for 29% of all U.S. capacity, up from 7% in 2020. 30% of solar additions come from end-use PV, such as rooftop solar systems on homes and businesses, and 70% are utility-scale PV power plants.

FIGURE 5

U.S. cumulative electricity generation capacity addition and retirements, 2022-2050E (GW)



Source: US EIA Annual Energy Outlook, 2022
https://www.eia.gov/outlooks/aeo/

Most of the coal and nuclear retirements come from the mid-continent, PJM, and southeast regions.

- Cheaper solar and wind energy, accompanied by natural gas-fired plants, replaces coal and nuclear in the mid-continent, PJM, and southeast regions.

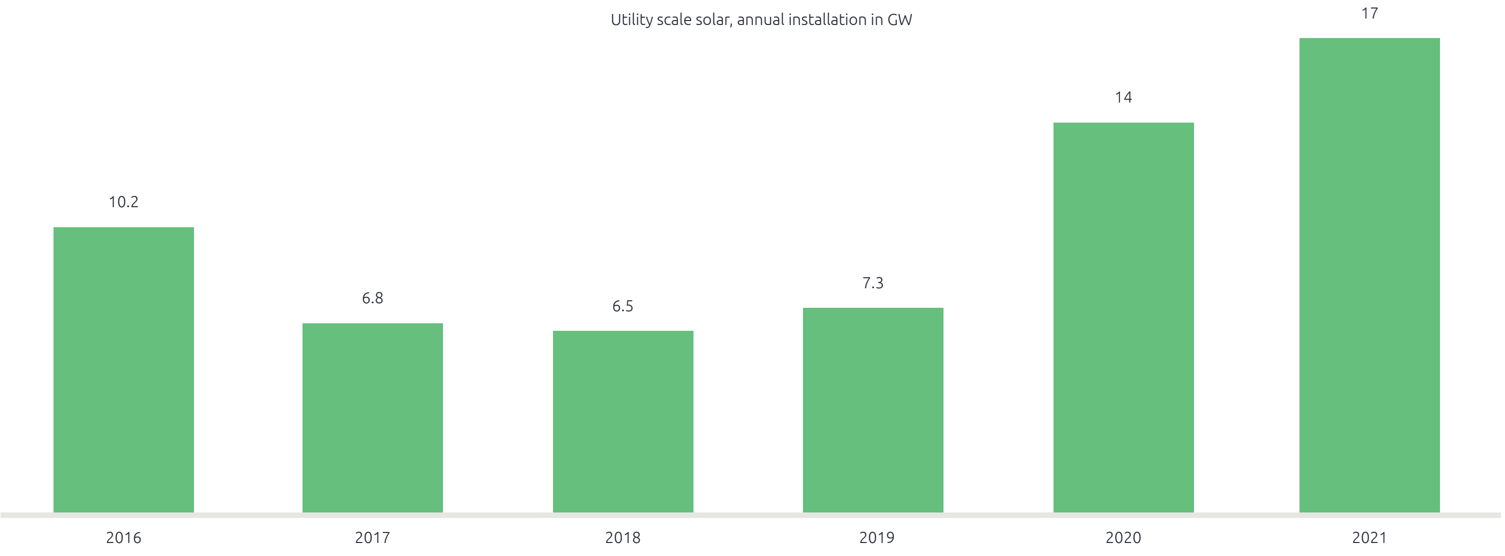
Despite the record growth, solar installations in 2021 were lower than expected due to supply chain constraints, logistics challenges, and trade headwinds.

Utility-scale solar set an annual installation record at nearly 17 GW.

- Due to supply chain issues, logistical difficulties, and trade headwinds, utility-scale installations in 2021 totaled 17 GW, which was about 3 GW less than anticipated. Many projects that were supposed to be finished in the fourth quarter were postponed until 2022.
- For the 2022 pipeline, developers have postponed at least 8% of planned capacity to 2023 or later and canceled at least 5%.
  - In the long run, it's doubtful that these difficulties will overcome the demand for the utility-scale solar component. In 2023, the industry is expected to recover owing to ongoing initiatives to increase federal renewable energy support, rising interest in environmental, social, and governance (ESG) investments, and new procurement techniques.
- In the final quarter, price rises for utility-scale solar reached 18% year-over-year for fixed-tilt projects and 14.2% for single-axis tracking projects.
- Today, at least 91% of electricity generation occurs in a country where either onshore wind or utility-scale PV (or both) is the cheapest new bulk electricity generation.
  - The momentum may slow as a result of net metering restrictions being discussed in California and Florida, according to the Wood Mackenzie and Solar Energy Industries Association (SEIA) report, U.S. Solar Market Insight 2021 Year in Review.
  - **Texas** had a successful year for utility solar and **added more than 6 GW of total solar capacity in 2021. Texas passed California,** which added 3.6 GW, for the **first time as the top state for solar capacity additions.**

FIGURE 6

U.S. large-scale solar build deployment (GW)



Source: US EIA Annual Energy Outlook, 2021; Secondary Search
Link: file:///C:/Users/ISHAND/Downloads/2021-Sustainable-Energy-in-America-Factbook.pdf

U.S. wind energy continued to grow in 2021, providing low-cost clean energy to millions of Americans.

The U.S. wind industry installed 13,413 MW of new wind capacity in 2021.

- The U.S. wind sector added 13.4 GW of new wind capacity in 2021, bringing the total installed capacity to 135,886 MW, according to the U.S. Department of Energy (DOE). In comparison to 2020, when the nation constructed 17.1 GW of wind capacity and invested $20 billion, this is the second-highest amount of wind capacity installed in a single year.
- Increase in wind energy capacity have been sparked by decreases in the cost and performance of wind power technology, the Production Tax Credit, and other factors, resulting in cheap wind energy.

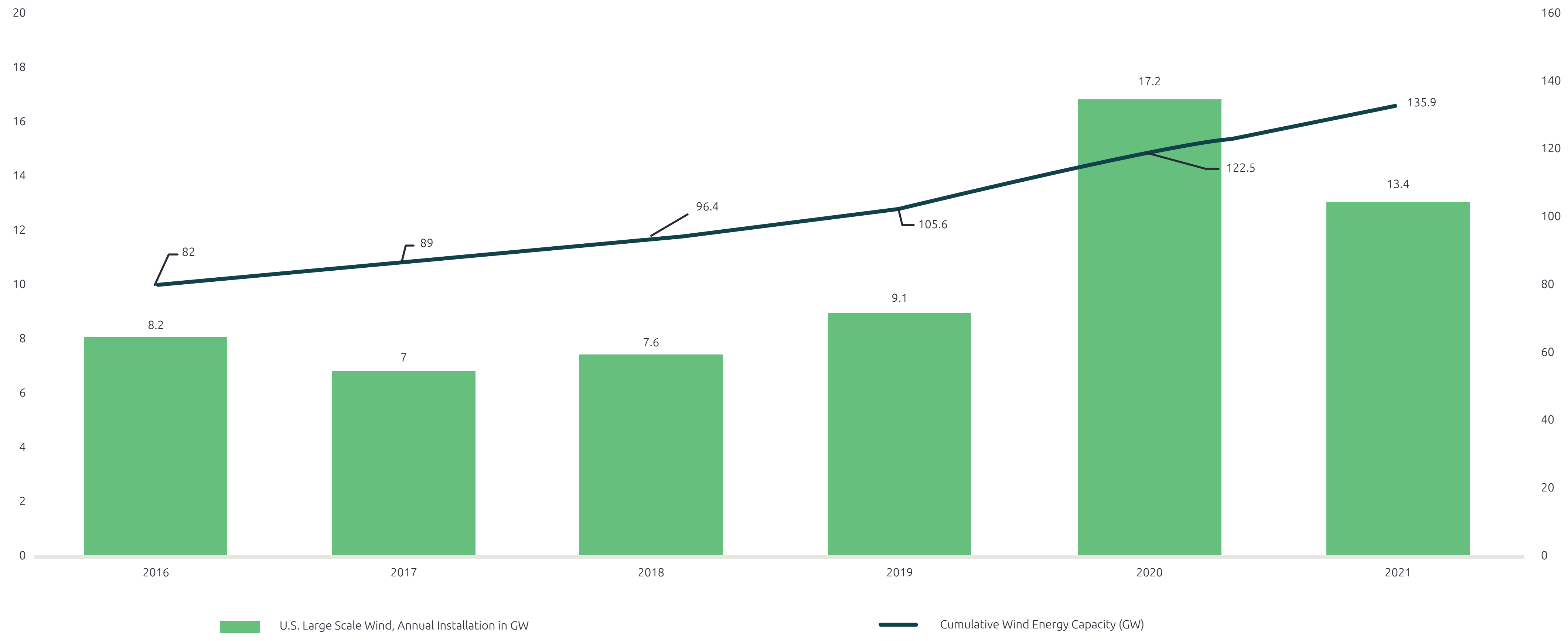
Just four turbine manufacturers, led by GE, supplied all of the U.S. wind power capacity installed in 2021

- Of the 13.4 GW of wind installed in the United States in 2021, GE Wind supplied 47%, with Vestas coming in second (26%), followed by Siemens Gamesa Renewable Energy (SGRE) (13%) and Nordex (13%), essentially tied in third place.
- GE and Vestas have dominated the U.S. market for some time, with SGRE and Nordex vying for third.

Installed Capacity (MW)			
Annual additions (2021)		Cumulative (end of 2021)	
Texas	3,343	Texas	35,969
Oklahoma	1,403	Iowa	12,219
New Mexico	1,368	Oklahoma	10,994
Kansas	1,228	Kansas	8,245
South Dakota	610	Illinois	6,997
Iowa	600	California	6,142
Illinois	580	Colorado	5,035
Michigan	550	Minnesota	4,591
Indiana	500	North Dakota	4,302
Missouri	448	New Mexico	4,001
Nebraska	388	Oregon	3,842
Wyoming	349	Indiana	3,468
Colorado	305	Washington	3,396
North Dakota	299	Wyoming	3,178
California	288	Michigan	3,159
Minnesota	266	Nebraska	2,942
Ohio	247	South Dakota	2,915
Montana	240	Missouri	2,435
New York	205	New York	2,191
West Virginia	169	Pennsylvania	1,459
Rest of U.S.	27	Rest of U.S.	8,405
TOTAL	**13,413**	**TOTAL**	**135,886**

FIGURE 7

U.S. large-scale wind build deployment (GW)



Source: U.S. Department of Energy, Land-Based Wind Market Report: 2022 Edition
Link: https://www.energy.gov/eere/wind/wind-market-reports-2022-edition

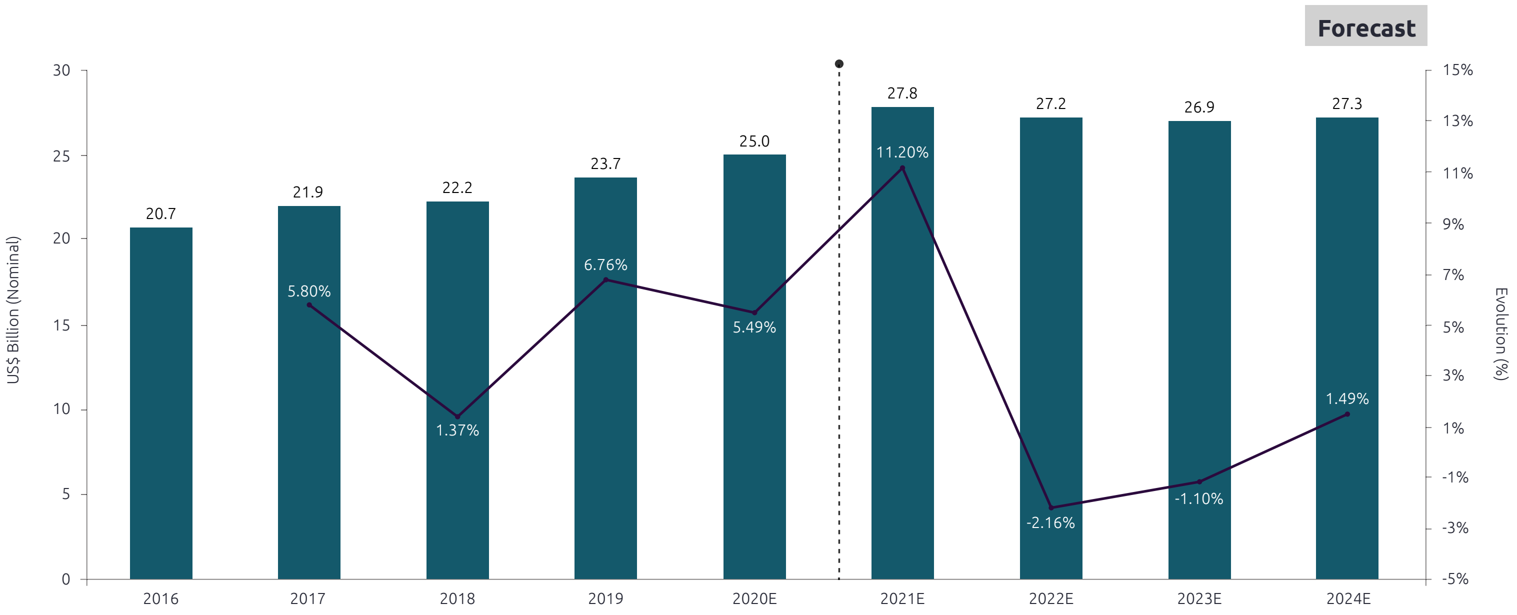
U.S. electric transmission investment

Investor-owned utilities (IOUs) and independent transmission developers spent a record $25 billion on electric transmission in 2020, according to the Edison Electric Institute (EEI).

- An estimated $27.8 billion will have been invested by IOUs and independent transmission developers in 2021. The investment has increased by 21% and 5.5% from 2016 and 2019, respectively.
- 2021 CAPEX plans suggested that investment reached its peak in 2021. However, future-year budgets are not yet finalized, and these numbers may be revised upward.
- The transmission upswing has been driven by the need to replace and upgrade aging power lines, resiliency planning in response to potential threats (both natural and man-made), the integration of renewable resources, and congestion reduction.
- Between 2021 and 2024, investor-owned electric providers expect to spend about $109 billion on transmission infrastructure.
  - Investments in distribution by investor-owned electric firms totaled $40.3 billion in 2020 in contrast to $36.0 billion in 2019.
  - Investor-owned electric businesses made a minimal $164 billion investment in the U.S. distribution system between 2016 and 2020.

FIGURE 8

U.S. electric transmission investment by investor-owned utilities and independent transmission developers, 2016-2024E



Source: BNEF ~ Sustainable Energy in America Factbook, 2022; http://www.bcse.org/factbook/#

U.S. offshore wind energy market potential and project pipeline assessment

The U.S. offshore wind energy pipeline grew by 13.5% between May 31, 2021, and May 31, 2022.

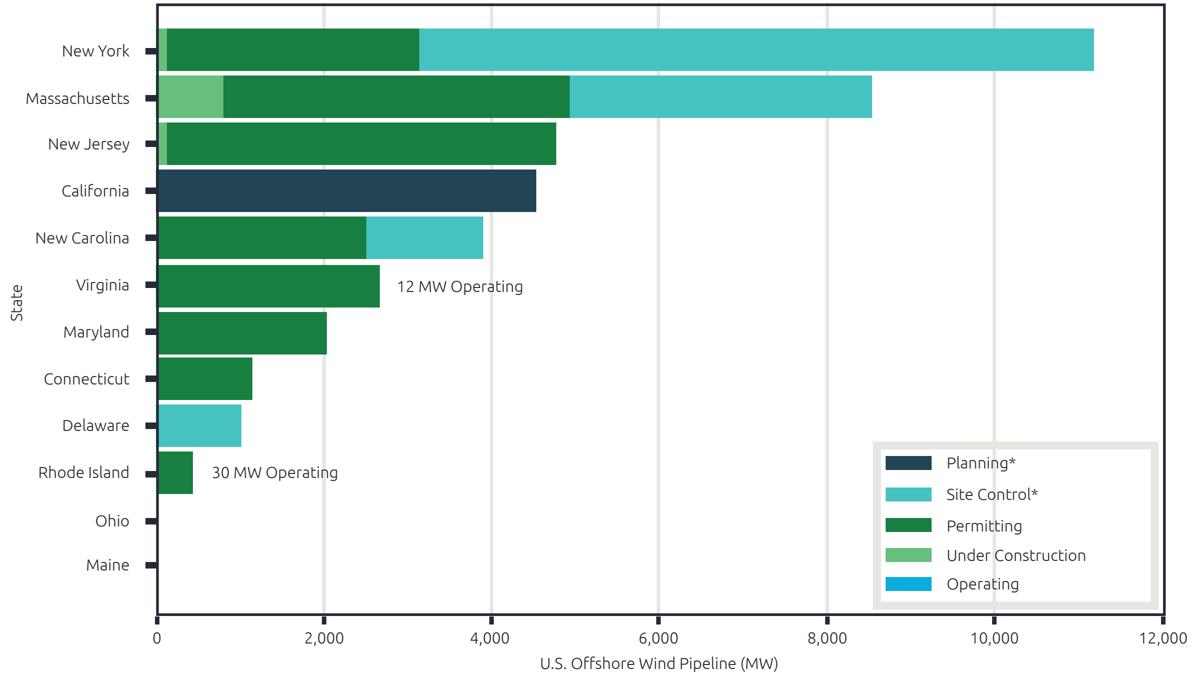
- By May 2022, the U.S. offshore wind energy project development and operational pipeline grew to a potential generating capacity of 40,083 MW. The 40,083 MW in the U.S. offshore wind energy pipeline shows a 13.5% growth over the 35,324 MW reported in the Offshore Wind Market Report: 2021 Edition.
- In addition to this continued global market expansion, in the United States multiple projects advanced within the project development pipeline.
- As of May 31, 2022, National Renewable Energy Laboratory (NREL) estimates the U.S. offshore wind energy pipeline will have 40,083 MW of capacity, which is the sum of current installed projects, approved projects, projects in the permitting process, existing lease areas, and unleased Wind Energy Areas (WEA).
- With the six new lease areas in the New York Bight, New York and New Jersey now have a combined estimated pipeline potential of more than 15,915 MW. Massachusetts has an estimated pipeline capacity of 8,553 MW.
- In total, there are 56 sites in the United States where there is offshore wind energy development activity takes place in North Atlantic, Great Lakes, South Atlantic, Gulf of Mexico, and in Pacific.

State policies aim to procure at least 39,322 MW of offshore wind energy capacity by 2040.

- The U.S. offshore wind energy market continues to be driven by state-level offshore wind energy procurement activities and policies. Collectively, offshore wind energy policies in eight states call for deploying at least 39,322 MW of offshore wind energy capacity by 2040.

FIGURE 9

U.S. offshore wind project pipeline by state



Source: U.S. Department of Energy: Offshore Wind Market Report, 2022
Link: https://www.energy.gov/sites/default/files/2022-08/offshore_wind_market_report_2022.pdf

U.S. natural gas demand

Total demand for U.S. gas increased by 9.4% in 2021, a rebound from the minimal growth in 2020 due to the Covid-19 pandemic.

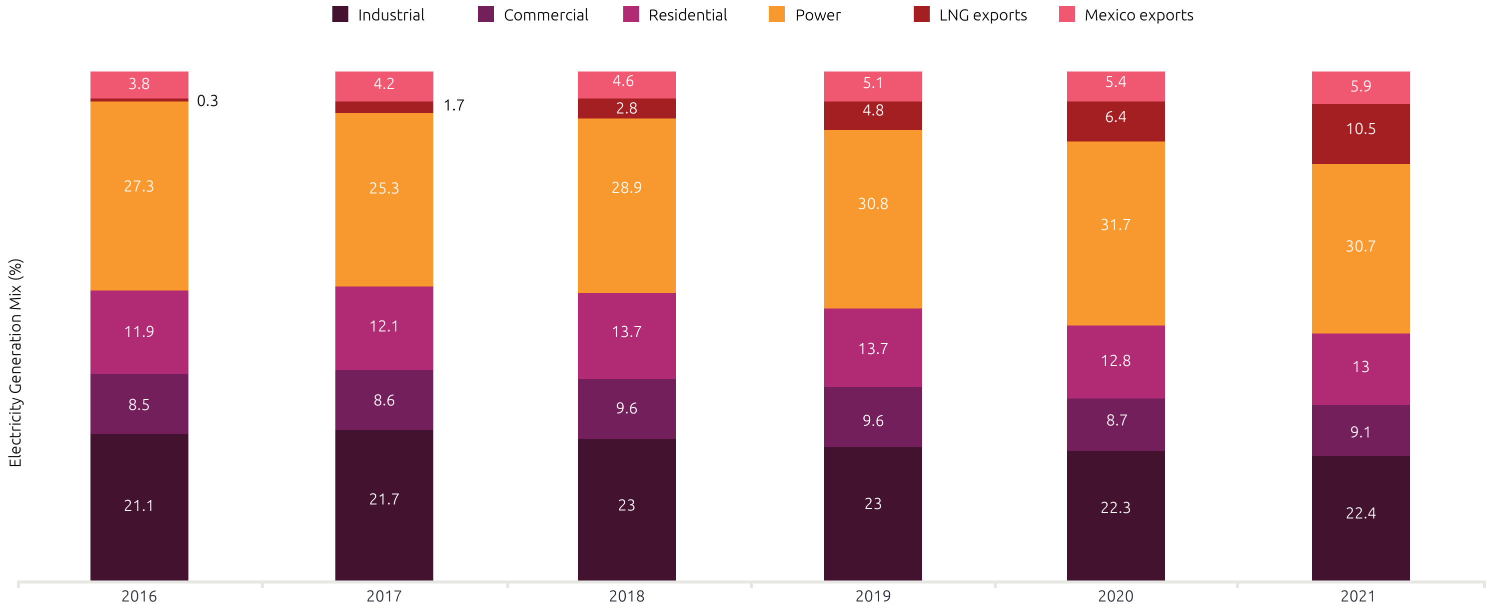
- While overall load grew, gas demand for power generation fuel dropped by 1.0 billion cubic feet per day (BcfD) (-3.3%) as high year-on-year gas prices lead to more coal-fired power plants being online.
- LNG exports rose very significantly (64%) in 2021, driven mainly by a demand surge in Europe and Asia. In Europe, LNG has backfilled depleted domestic production while in Asia LNG meets high demand from economic growth and replaces coal generation.
- Industrial, residential, and commercial heating demand increased 0.4%, 4.7% and 1.9%, respectively. The increase in residential gas customers was the largest since 2006, with 900,000 more customer hook-ups in 2020.
- The average residential customer efficiency continues to improve. Gas utility energy efficiency investments from 2011 to 2019 alone saved an estimated 319 trillion BTU or more, according to the American Gas Association.
- The next market for renewable natural gas (RNG) is set to be utilities who use the molecules for reducing carbon footprints. Utilities are aiming to displace around 20% of existing fossil gas use with RNG by 2040. Approximately $3 billion has been earmarked for RNG investment in 2021.

The economy seeks to decarbonize, demand for decarbonized natural gas is rising.

- With the passage of the new infrastructure law, the U.S. is poised to provide $20.5 billion in federal funding for CCS and hydrogen efforts.
- Demand for RNG rose in 2021, with 33 states taking action to promote the use of the fuel for thermal heating purposes in the residential or commercial sectors, up from 26 in 2020.

FIGURE 10

U.S. natural gas demand by end-use (BcfD)



Source: U.S. Department of Energy: Offshore Wind Market Report, 2022; Note BCFD denoted "Billion cubic feet per day"
Link: https://www.energy.gov/sites/default/files/2022-08/offshore_wind_market_report_2022.pdf

U.S. LNG projected export capacity

U.S. LNG export capacity is set to expand further as new projects begin construction.

- As of July 2022, LNG exports from the U.S. lower 48 states began in February 2016; since then, both LNG export capacity and LNG exports have expanded to become the world's largest.
- As of August 2022, the seventh and latest U.S. LNG export project, Calcasieu Pass LNG, has placed in service all of its liquefaction trains ahead of the originally announced schedule. This additional capacity led to the United States becoming the world's largest LNG exporter, with exports averaging 11.1 Bcf/d in the first half of 2022.
- Golden Pass LNG is constructing standard-size liquefaction trains with peak LNG production capacity of up to 0.8 Bcf/d per train; Plaquemines LNG and Corpus Christi Stage III use a modular technology, which includes mid-scale refrigeration trains allowing for a shorter project construction timeline. Calcasieu Pass LNG, which also uses mid-scale liquefaction technology, started LNG production 30 months after the FID, the shortest construction period of all U.S. LNG export projects to date.

Once completed, the three export projects currently under construction will expand U.S. LNG peak export capacity by a combined 4.9 Bcf/d nominal (5.7 Bcf/d peak) by 2025.

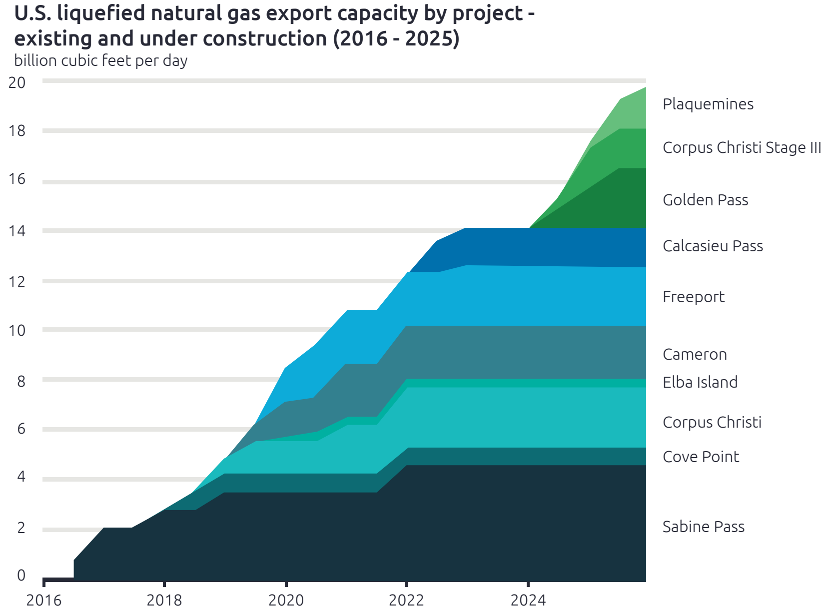
- As of July 2022, EIA estimated that U.S. LNG liquefaction capacity averaged 11.4 Bcf/d, with a shorter-term peak capacity of 13.9 Bcf/d.
- LNG imports in the EU and U.K. increased by 63% during the first half of 2022 to a average of 14.8 Bcf/d.

As per U.S. Department of Energy: In 2021, Mexico holds the top position in importing 2,154,457 Mmcf of natural gas from U.S., followed by Canada (importing around 937,124 Mmcf) and South Korea (importing around 453,483 Mmcf).

- Other countries, including China, Japan, Brazil, India, Netherlands, France, and Chile, imported a significant amount of gas from the U.S. in 2021.

FIGURE 11

U.S. LNG export capacity by project, existing & under construction (2016 – 2025)



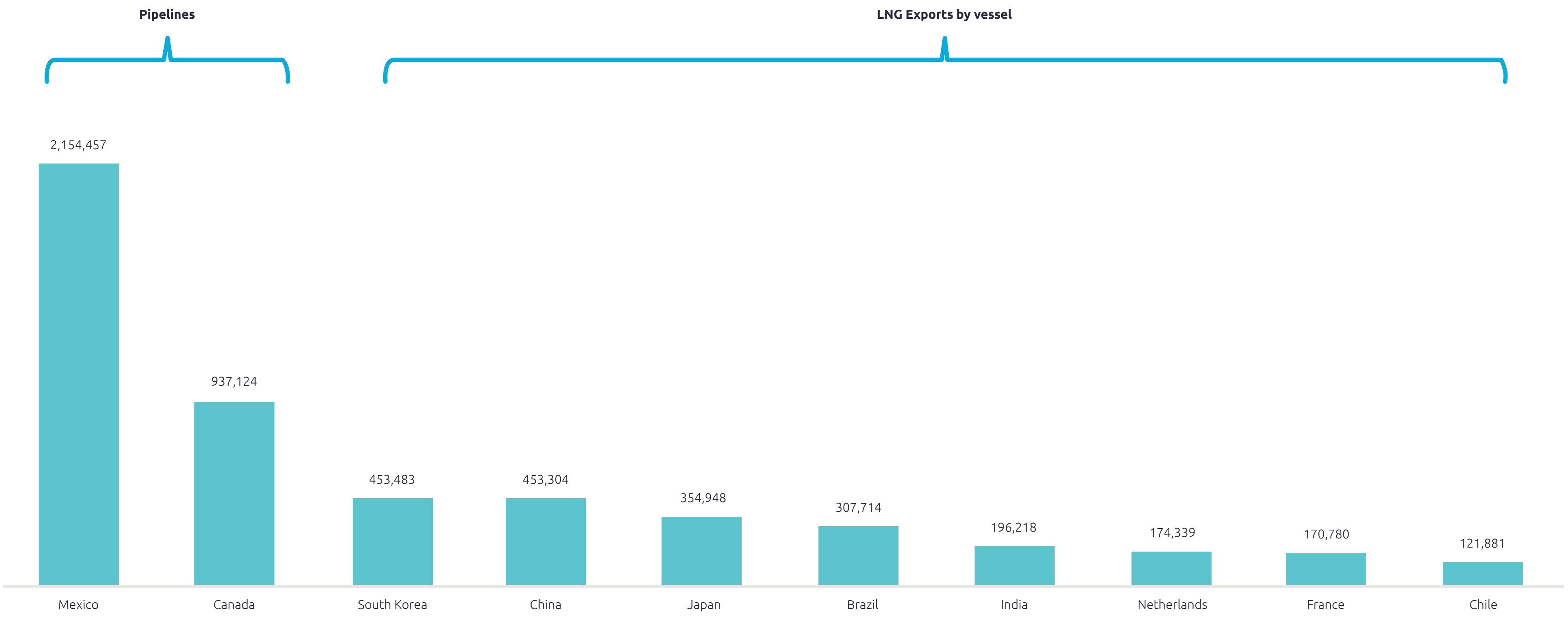
Source: U.S. Department of Energy: Natural Gas Weekly Update, August 24, 2022

Link: https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2022/08_25/#itn-tabs-0

As per GlobalData, a data analytics and consulting company, the U.S. is expected to lead the global LNG liquefaction capacity additions, contributing 57% of the total LNG liquefaction capacity additions between 2022 and 2026.

FIGURE 12

U.S. natural gas exports by top 10 countries, Million Cubic Feet (Mmcf), 2021



Source: U.S. Department of Energy: U.S. imports by country
Link: https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm

Renewable energy is gaining traction in Canada's electricity generation.

In 2021, Canada generated around 641 TWh of electricity as compared to 649.1 TWh in 2020 (down -1.25%).

- Hydro-electricity contributed majorly to overall electricity generation in Canada in 2022 with 380.8 TWh (59.4%), followed by nuclear energy, coal, and gas.
- Nuclear energy was the second largest contributor to the overall electricity generation with 92.0 TWh (14.4%), whereas gas and coal accounted for about 75.9 TWh (11.8%) and 38.7 TWh (6%), respectively.
- On the other hand, renewables accounted for 50 TWh (7.8%) of overall electricity generation in Canada in 2021.
  - Major contributors in the renewable sector were wind energy, which accounted for 35.1 TWh (70.2%), and solar energy with 5.2 TWh (10.4%). Other renewables accounted for the remaining 9.7 TWh (19.4%) of overall renewable electricity generation in Canada in 2021.

In May 2022, Canada Invested in the Clean Energy Hub in Quebec.

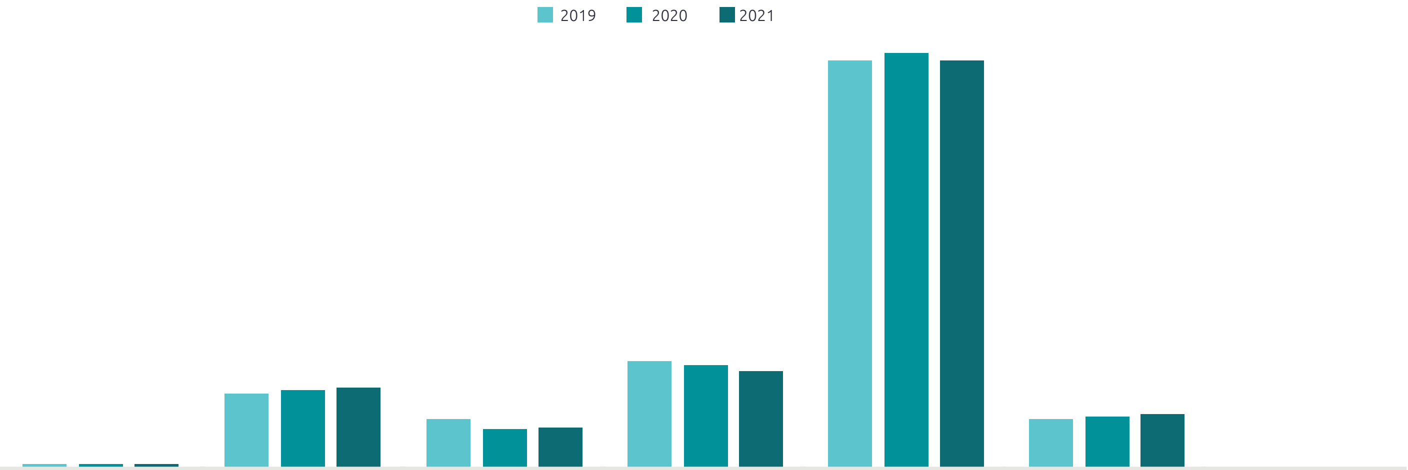
- Federal funding for this project is provided by Natural Resources Canada's Smart Renewables and Electrification Pathways Program (SREPs), a four-year, $964-million program, which provides support for smart renewable energy and electrical grid modernization projects.
- This program will significantly reduce greenhouse gas emissions by enabling increased renewable energy capacity that will provide essential grid services while supporting Canada's ongoing transition to a net zero economy by 2050 and Canada's commitment to achieve a 100% net zero-emitting electricity system by 2035.

Weighing on Clean Energy for Rural and Remote Communities Program

- An additional $300 million is available until 2027 for clean energy projects in indigenous, rural, and remote communities across Canada.

FIGURE 13

Canada: Electricity generation (TWh)



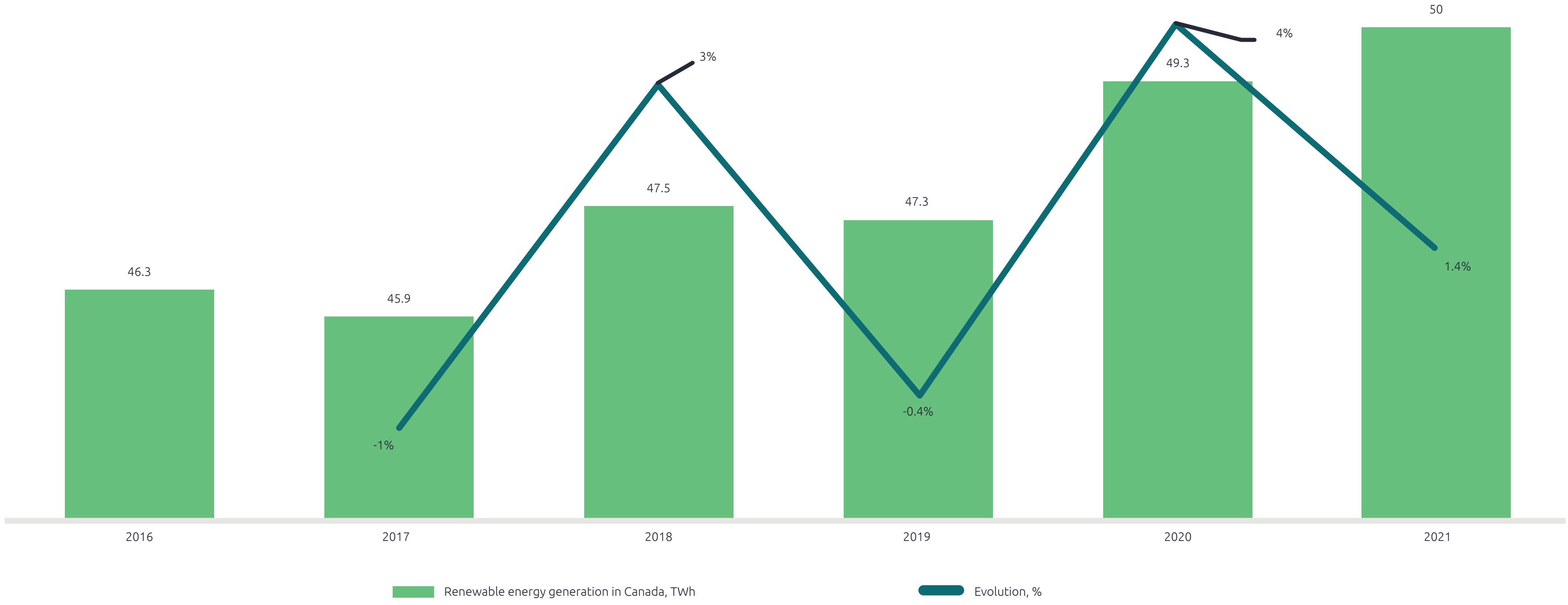
	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renewables	Others
2019	3.2	69.5	47.9	100.5	379.7	47.1	0.7
2020	2.9	73.6	38.6	97.5	386.5	49.3	0.6
2021	2.9	75.9	38.7	92	380.8	50	0.7

Source: BP Statistical Review, 2022

Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

FIGURE 14

Canada: Renewable energy generation (TWh)



Source: BP Statistical Review, 2022

Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

AUSTRALIA
SECURITY OF SUPPLY

VINNIE NAIR
NICOLE ALLEY

Recently, we have seen headlines such as "All resources needed in energy transition"[1] and "No transition without transmission"[2] in the Australian media. This article will focus on the recent energy supply crisis and shortage of electricity in the Australian National Electricity Market (NEM). It will also examine the events preceding this crisis, the years of underinvestment in grid infrastructure, and the energy reform that has followed. Finally, the article will explore the role the Australian Energy Market Operator (AEMO) played in averting further crisis and ensuring security and reliability of supply.

What is energy security?

The International Energy Agency (IEA) defines energy security as the uninterrupted availability of energy sources at an affordable price. Energy security has two main aspects:

1. Long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs; and
2. Short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance.[3]

In the context of the electricity market, energy security primarily focuses on how the electricity grid or "power system" reacts to events that may influence it. It includes the grid's capability to react and recover securely to major events such as faults or generation tripping, often referred to as contingencies.

Australia is currently caught in an energy trilemma. The trilemma consists of three variables: security, sustainability, and affordability. Each of these variables are interconnected and cannot be thought of in isolation. The end game is to find sustainable sources of energy which are secure and affordable for the wider population – a task that is easier said than done. To understand why we have an energy crisis today we must understand the history of energy in Australia.

1 https://www.afr.com/companies/energy/new-tripwire-for-power-politics-20220619-p5auv2
2 https://www.afr.com/companies/energy/no-transition-without-transmission-redman-s-new-motto-20220310-p5a3fn
3 https://www.iea.org/topics/energy-security

A history of the Australian energy market and state of affairs

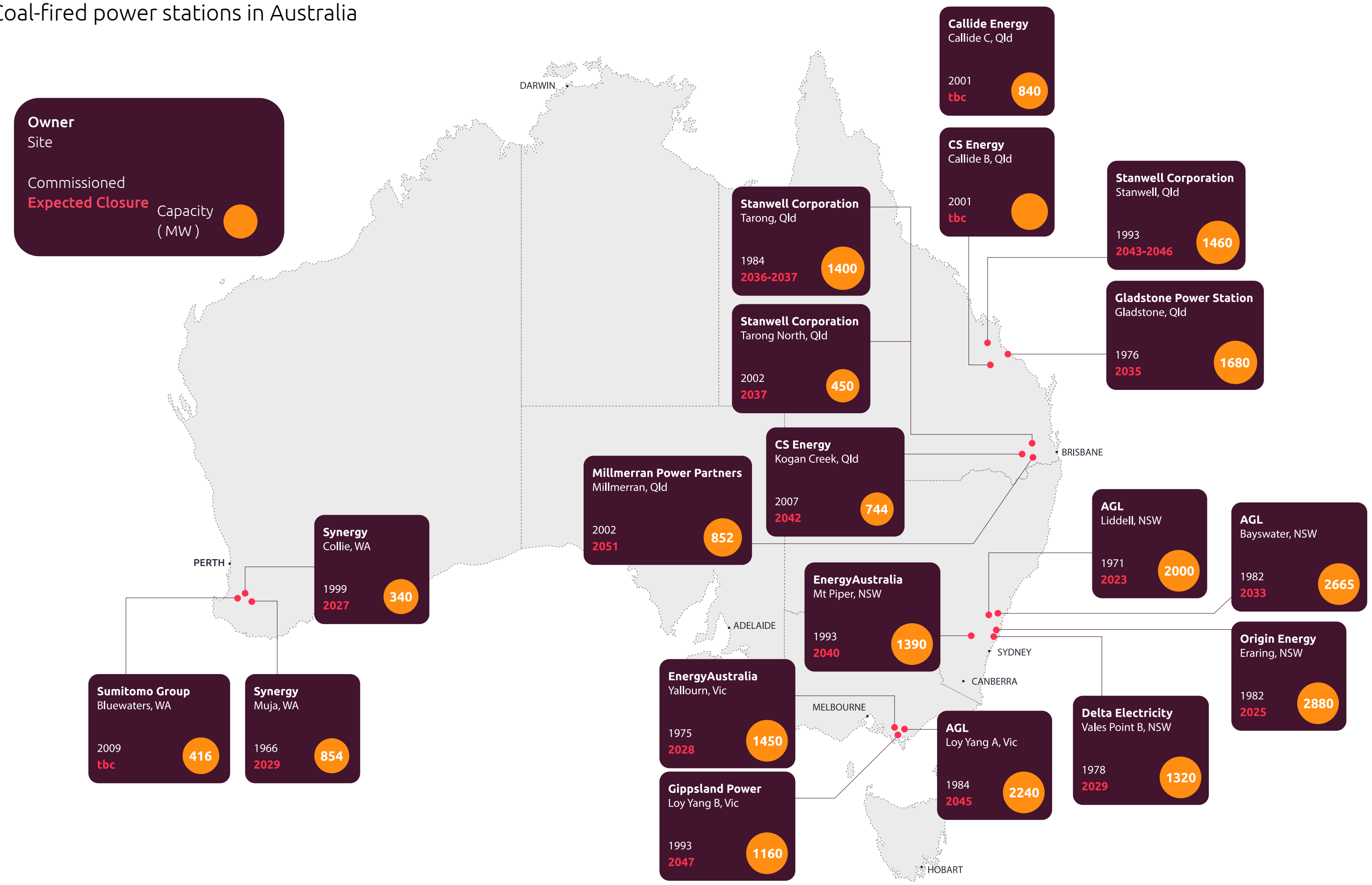
Most of Australia's electricity comes from fossil fuels. Australia is resource rich and has proven coal reserves equivalent to 1,231.3 times its annual consumption. The country has the third largest coal reserves in the world. This naturally has encouraged the proliferation of coal-fired power plants over the last 50 years. Despite a surge in investment in renewable energy projects that use wind and solar power, burning coal remains the key means of electricity generation in Australia.

In 2021, 59.1% of Australia's electricity came from coal and 7.7% came from gas. Many of the country's coal plants are more than 30 years old and well beyond their optimal asset life. This makes them increasingly unreliable and costly to run.

> *A large share of the existing coal-fired power fleet is simply not available when it is absolutely needed, which is a good deal of what's behind the current energy crisis.*
>
> **Frank Jotzo**
> Professor of climate change economics at the ANU Crawford School of Public Policy

FIGURE 1

Coal-fired power stations in Australia

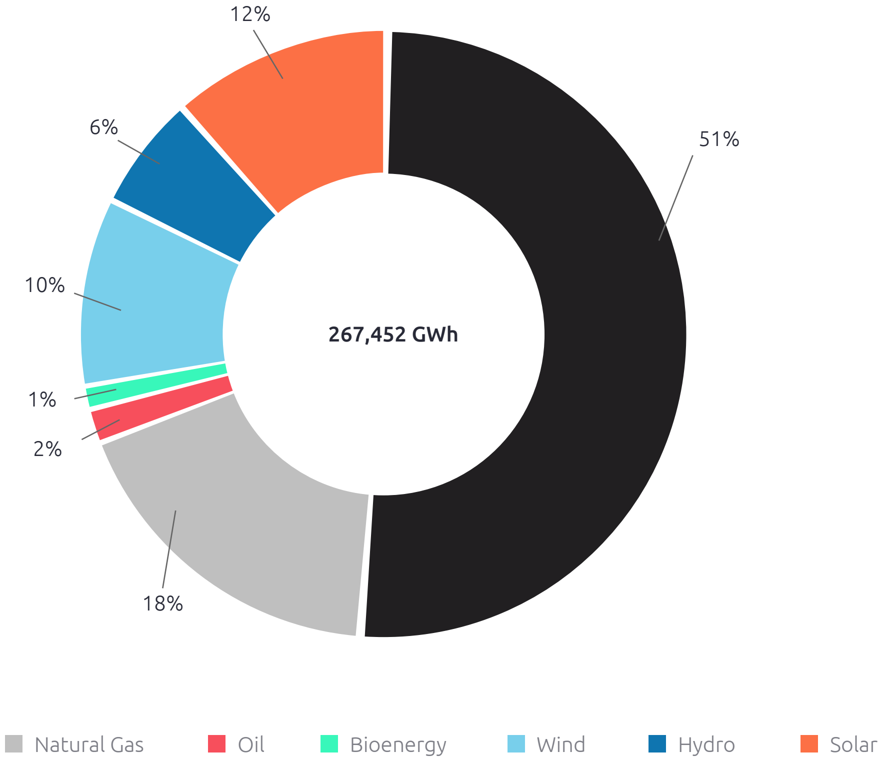


Source: AEMO, The Australian Financial Review
https://www.afr.com/policy/energy-and-climate/why-it-will-cost-320b-to-ditch-coal-in-three-maps-and-a-chart-20220608-p5as3t

In the meantime, renewable energy, such as solar and wind, has grown. In 2001, renewable energy accounted for just 11% of Australia's total electricity generation. Twenty years later, in 2021, it accounted for 29%, up from 24% in 2020.

FIGURE 2

Electricity generation in Australia, 2021



Source: Australia Government, Australian Energy Statistics, Table O
https://www.energy.gov.au/sites/default/files/2022-04/Australian%20Energy%20Statistics%202022%20Table%20O%20-%20Publication%20version.pdf

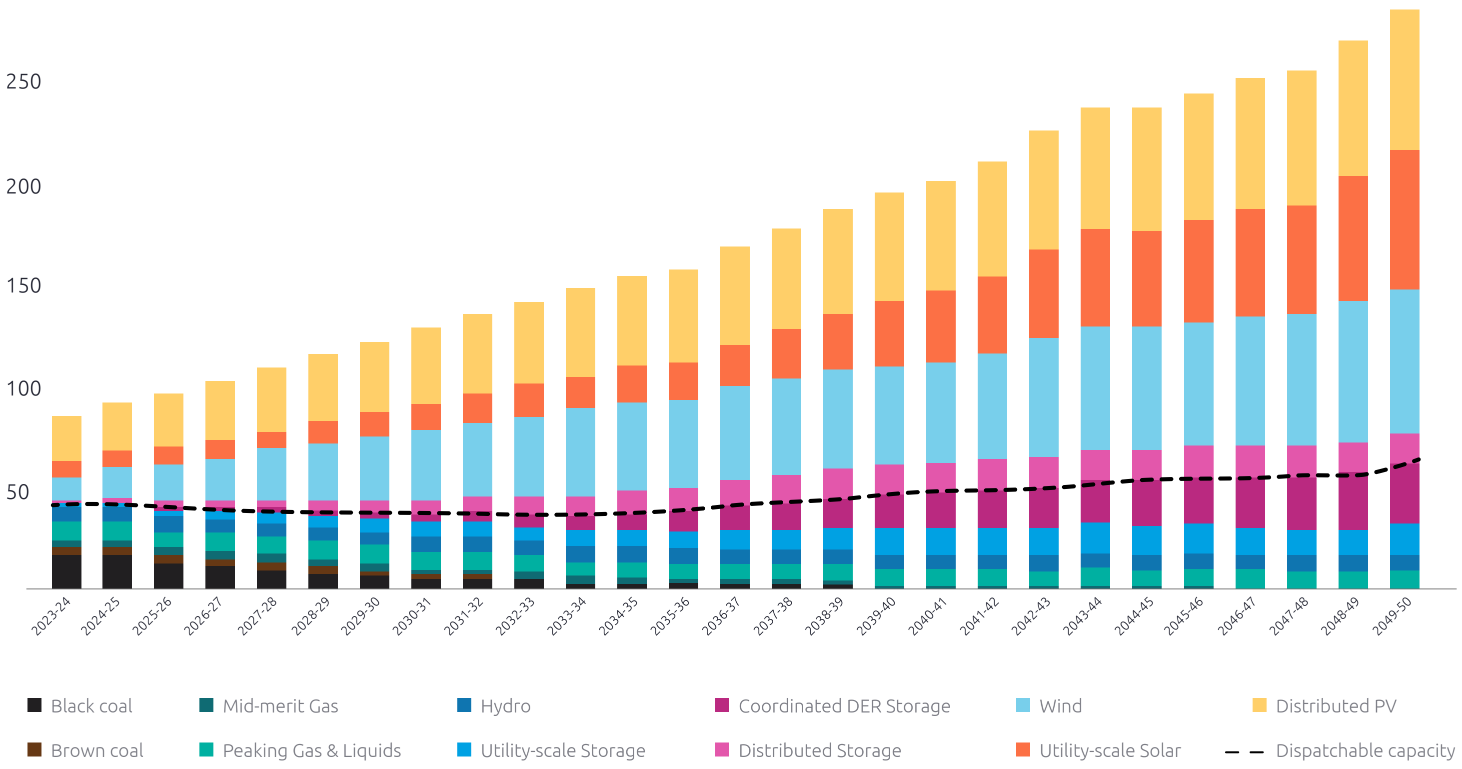
What's next: 2022 – 2050

The AEMO Integrated System Plan[4] was released in June 2022. In its Step Change (i.e. most likely) scenario, AEMO says renewable energy as a share of the total energy generated on the grid will rise to 83% by 2030-2031, to 96% by 2040, and to 98% by 2050.

History has proven that these estimates tend to be conservative. The key driver for the growth of renewable investment has been the increasing flow of capital from large investors and asset managers such as BlackRock and Brookfield, and their ability to allocate capital to such projects. It is more than likely that we could achieve 96% share of renewables on the grid well before the 2040 date. The general public's climate change awareness and concern for the environment could accelerate this even further.

FIGURE 3

Forecast NEM capacity through 2050: Step-Change scenario with transmission

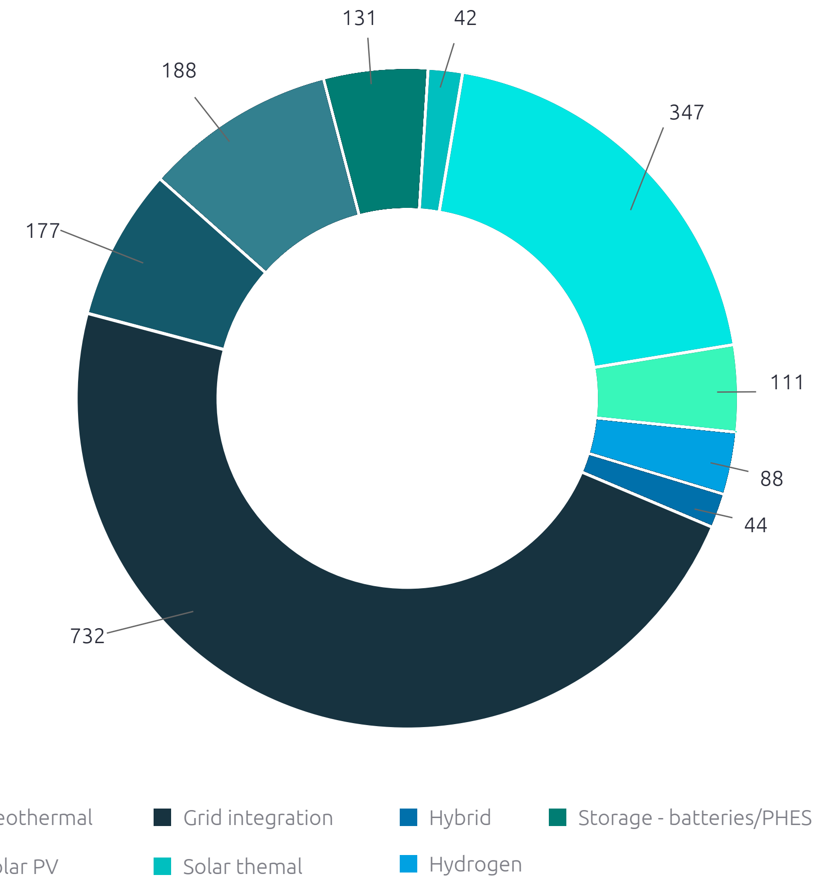


Source: AEMO
https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la

4 https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp

FIGURE 4

Investment by technology in Australia



Source: ARENA at a glace – As of March 31, 2022
https://arena.gov.au/arena-at-a-glance/

How does this affect energy security

In layman's terms the real question is: What happens when the coal-fired power plants are past their "use by" date, the sun is not shining, and the wind is not blowing? The worst-case scenario could be rolling blackouts across the country. There is also an issue with how Australia's population is distributed. Most of the population is along the coastline and along the fringes, concentrated in capital cities.

The largest renewables growth areas, however, are far from populated towns, mostly in rural Australia. AEMO and some of the State Governments have earmarked areas called Renewable Energy Zones (REZs) including Offshore Wind Zones (OWZs), which are high-quality resource areas where clusters of large-scale renewable energy projects can be developed using economies of scale.[5]

5 https://aemo.com.au/-/media/files/major-publications/isp/2022/appendix-3-renewable-energy-zones.pdf?la=en#:~:text=Renewable%20Energy%20Zones%20(REZs)%2C,developed%20using%20economies%20of%20scale.&text=investments%20to%20determine%20an%20optimal,based%20on%20four%20future%20scenarios.

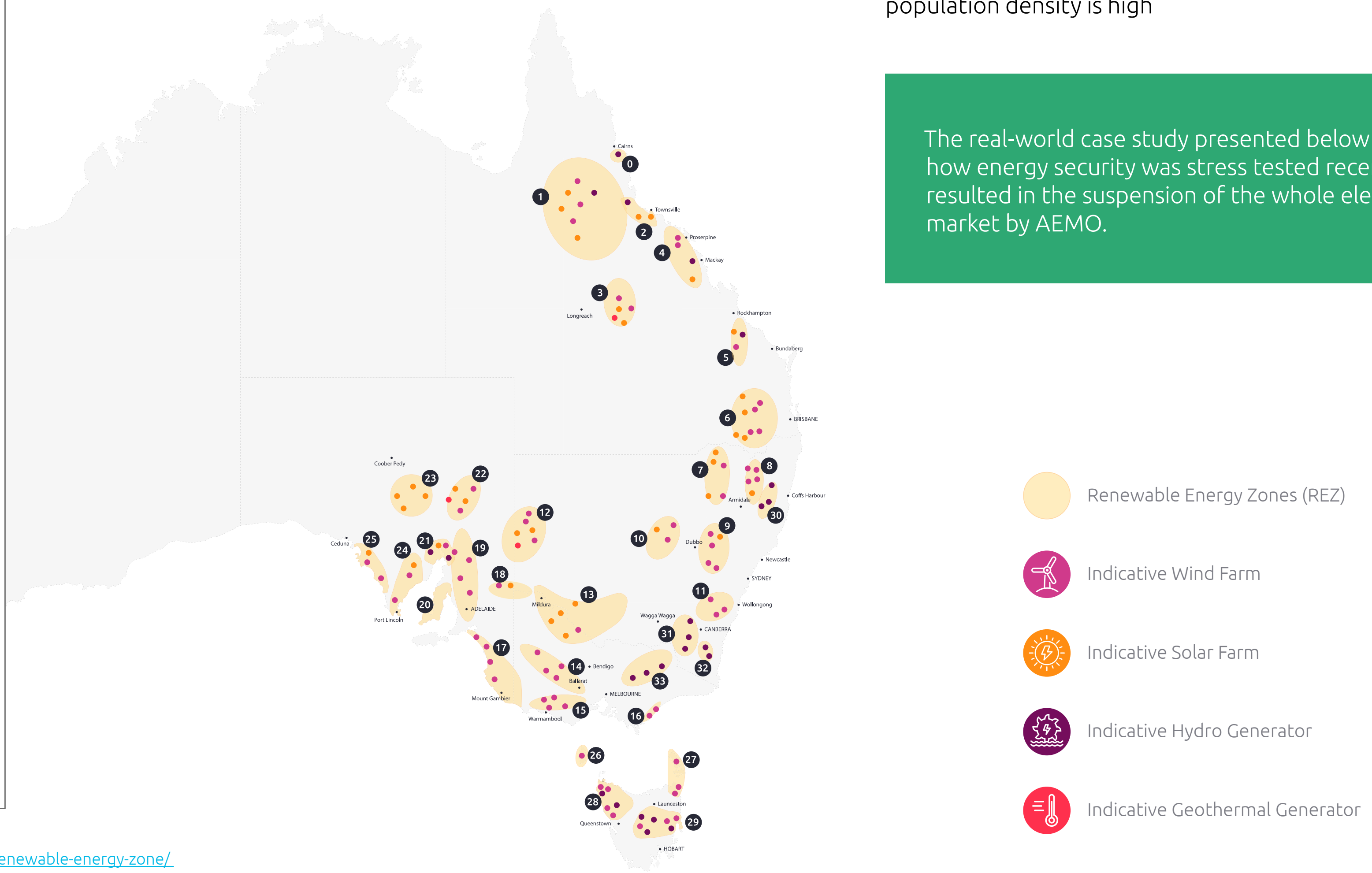
RENEWABLE ENERGY ZONES

0 For North Queensland
1 North Queensland Clean Energy Hub
2 Northern Queensland
3 Barcaldine
4 Isaac
5 Fitzroy
6 Darling Downs
7 North West New South Wales
8 Northern New South Wales Tablelands
9 Central New South Wales Tablelands
10 Central West New South Wales
11 Southern New South Wales Tablelands
12 Broken Hill
13 Murray River (NSW & VIC)
14 Western Victoria
15 Moyne
16 Gippsland
17 South East South Australia
18 Riverland (SA & NSW)
19 Mid North South Australia
20 Yorke Peninsula
21 Northern South Australia
22 Leigh Creek
23 Roxby Downs
24 Eastern Eyre Peninsula
25 Western Eyre Peninsula
26 King Island
27 North East Tasmania
28 North West Tasmania
29 Tasmania Midlands
30 New England
31 Tumut
32 Cooma-Monaro
33 Ovens Murray

Source: ARENA- Australian Renewable Energy Agency
https://arena.gov.au/blog/funding-announced-to-kickstart-nsw-renewable-energy-zone/

FIGURE 5

Renewable Energy Zones



This creates an "electricity transport" problem which requires electricity to be transmitted over large distances from where it is generated at the REZ to the destinations where population density is high

The real-world case study presented below describes how energy security was stress tested recently and resulted in the suspension of the whole electricity spot market by AEMO.

Event: On June 15, 2022, AEMO suspended the spot market for the entire country

What is a "spot market "?

Operating in New South Wales, the Australian Capital Territory, Queensland, South Australia, Victoria and Tasmania, the NEM is both a wholesale electricity market and the physical power system. AEMO also operates the retail electricity markets that underpin the wholesale market. Generators sell electricity and retailers buy the power in the market and then sell it to customers. For the lights to stay on the amount of electricity sold must match the amount of electricity needed by the market. The "spot price" is the cost of wholesale power in the market. It changes throughout the day based on the demand profile in the NEM.

Why did the spot market get suspended?

The spot market was suspended because of a large number of so-called "black swan" events occurred simultaneously in the Australian electricity market. Rising costs of coal exponentially increased the cost of generation in the market. AEMO decided to set a price cap in order to control the price. As a result, the generators decided to curtail the total power in response to the price cap. This led to a shortage of supply in the market and prompted blackout warnings by AEMO.

To keep power flowing and ensure reliable supply to the NEM, AEMO was forced to step in and shut down the spot market.

What did this mean for consumers?

The end consumer was protected from blackouts and AEMO managed to maintain reliability. AEMO set a fair price which was equitable for everyone. That said, eventually, someone will have to pay for the higher price of generation. As a resul, there will some price increases which may impact the larger consumer base in the end.

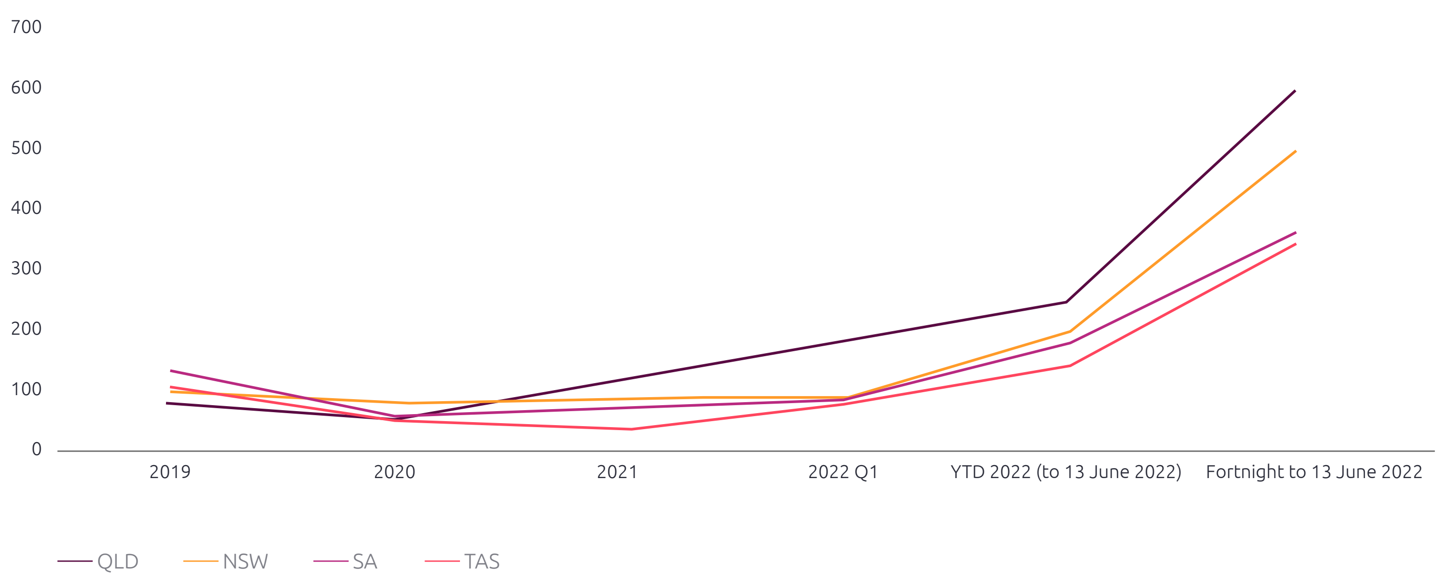
This situation was inevitable and was the best outcome that AEMO could have possibly achieved given the difficult circumstances.

Therefore, a combination of factors such as long distances, line losses, and lack of inertia (solar, wind, and battery) creates a very complex physics problem that involves intermittency of supply, balancing frequency, and the need for power system strength.

It is clear from the above map that the energy future in Australia is focused on renewables and non-fossil fuel generation sources. But the question yet to be answered is how do we get there.

FIGURE 6

NEM volume-weighted average spot prices ($/MWh)



Source: ACCC – Inquiry into the National Electricity Market, June 2022
https://www.accc.gov.au/publications/serial-publications/inquiry-into-the-national-electricity-market-2018-2025/inquiry-into-the-national-electricity-market-may-2022-report

How do we get here? The target and the roadmap

The answer could lie in the phrase "the future is electric"[6] or "electrify everything."[7]

There is a wealth of collateral in the public domain which clearly articulates the journey, and the destination Australia needs to choose as a country. The AEMO Integration System Plan (ISP)[8] provides an integrated roadmap for the efficient development of the NEM over the next 30 years. This journey will be complex and require significant policy change, investment, and coordination across participants. AEMO has identified an optimal development path (ODP) which requires large investments in key growth areas.

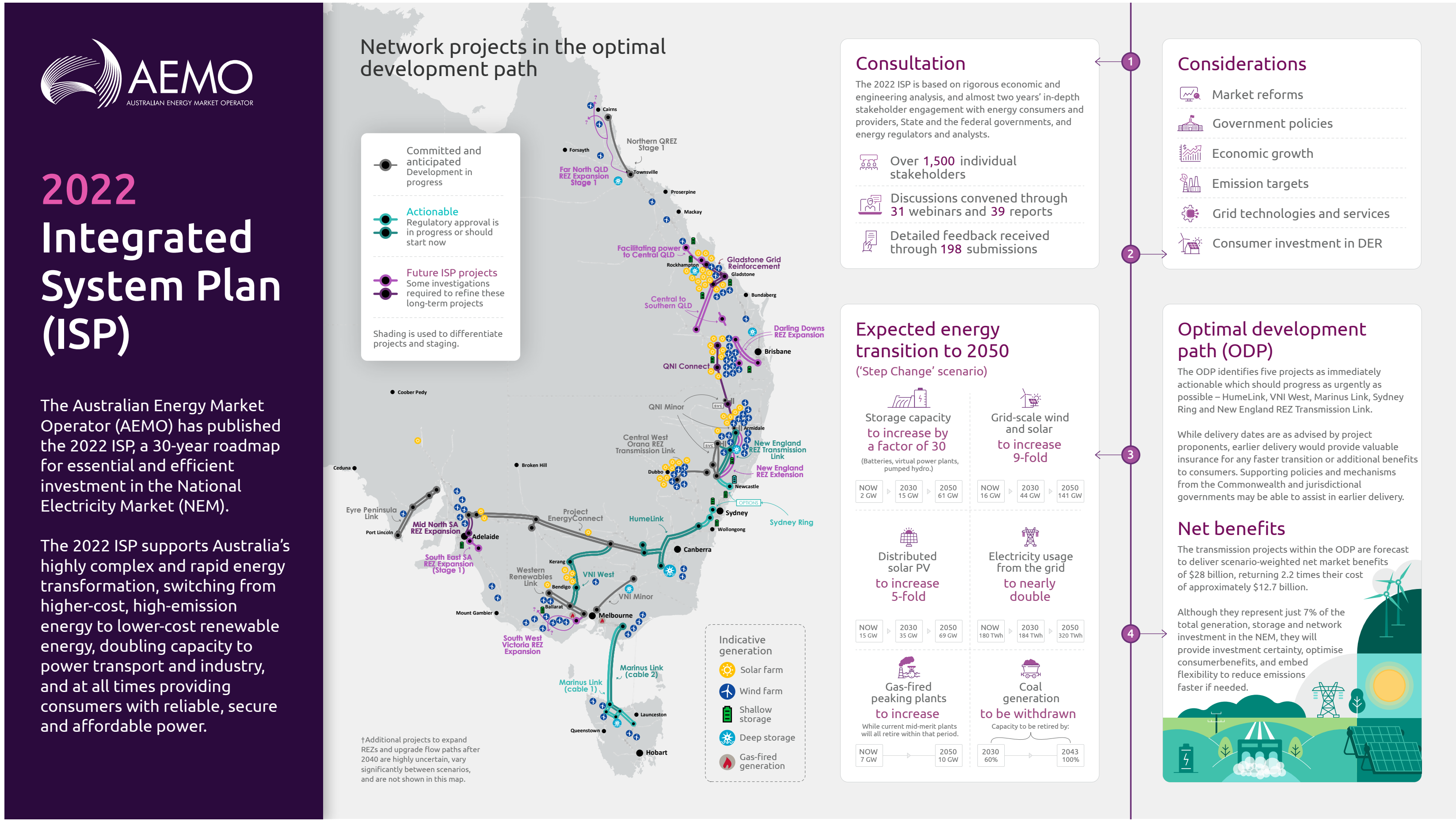
The single biggest investment identified is in the transmission space. The ODP prioritised five projects as immediately actionable which should progress as urgently as possible: HumeLink, VNI West, Marinus Link, Sydney Ring, and New England REZ Transmission Link.

The transmission projects within the ODP are forecast to deliver scenario-weighted net market benefits of AUD$28 billion, returning 2.2 times their cost of approximately AUD$12.7 billion. Although they represent just 7% of the total generation, storage, and network investment in the NEM, they will provide investment certainty, optimize consumer benefits, and embed flexibility to reduce emissions faster if needed.

6 https://thefifthestate.com.au/energy-lead/energy/the-big-switch-saul-griffith-says-the-answer-is-electric/
7 https://www.rewiringaustralia.org/
8 https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp

FIGURE 7

2022 Integrated System Plan (ISP)



In summary, Australia, due to its unique geography and distribution of population around the fringes, needs targeted investments in key areas to achieve 2050 goals. There is significant transmission infrastructure investment needed to carry the DER generation capacity from the REZ zones into densely populated cities such as Sydney, Melbourne, and Brisbane. The ODP will seek to achieve a large proportion of this and help address the problem in the near future.

Balancing the energy trilemma is a delicate juggling act and needs careful coordination between the regulatory bodies, policy makers, market participants, capital providers, and solution providers such as technology companies. This is a "must do" for getting to the destination that AEMO has set out in its plan.

Source: AEMO

AUSTRALIA TRENDS IN ELECTRICITY AND GAS

VINNIE NAIR
NICOLE ALLEY
ALEX LAM
ISHANDEEP

Flexible demand and dispatchable generation in the electricity market

Summary:

The following article will cover how utilities are using flexible demand as an innovative solution to maintain system reliability and security. The article will explore a range of topics, including:

- Investments via government vehicles and The Australian Renewable Energy Agency (ARENA)
- Projects being stood up by network operators so they can assist the Australian Energy Market Operator (AEMO) with system stability
- Key reforms such as the AEMO Integrated System Plan (ISP); and The role of the Distribution System Operator (DSO) in the market..

Introduction: The rise of a renewable generation and associated impediments

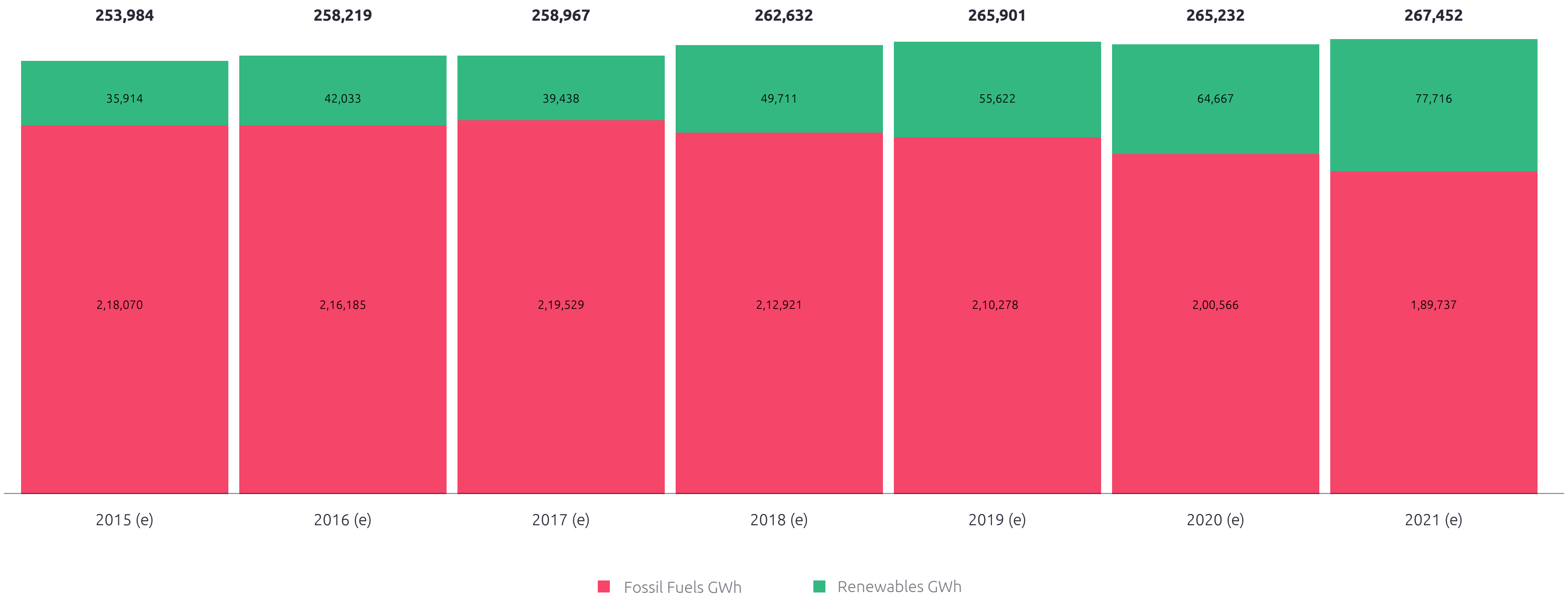
Over the past 10 years, both the federal and state governments have put numerous incentive schemes in place to stimulate the installation of renewable generation for large commercial and industrial customers, as well as consumers in general. In 2021, grid-connected wind generation supplied 26,796 GWh[1], roof-top solar supplied 20,223 GWh, and large-scale solar PV supplied 10,971 GWh[2]. The significant increase in these intermittent generation sources, coupled with the decommissioning of a number of coal-fired generation sites, has resulted in a number of problems for transmission and distribution networks.

1. For example, in the state of Victoria, many of the wind generation sites have been built in clusters around the western part of the state, while the decommissioned Hazelwood Power Station (1,600 MW) was in the eastern part of the state. This resulted in state-wide transmission capacity constraints.
2. Intermittency in both wind and solar can lead to a mismatch in supply and demand. Fast fluctuations in wind and solar energy output not only disrupt the hourly load-following phase of grid planning, but also the second-to-second balance between total electric supply and demand.
3. In the case of roof-top solar, the back-feeding of power can result in power quality issues, and as a result, be constrained by the distribution network service provider enforcing export limits[3].

1 https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2020-21-and-2021
2 https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2020-21-and-2021
3 https://reneweconomy.com.au/flexible-pv-south-australia-trials-new-solar-export-rules-as-it-heads-to-100-pct-solar/

FIGURE 1

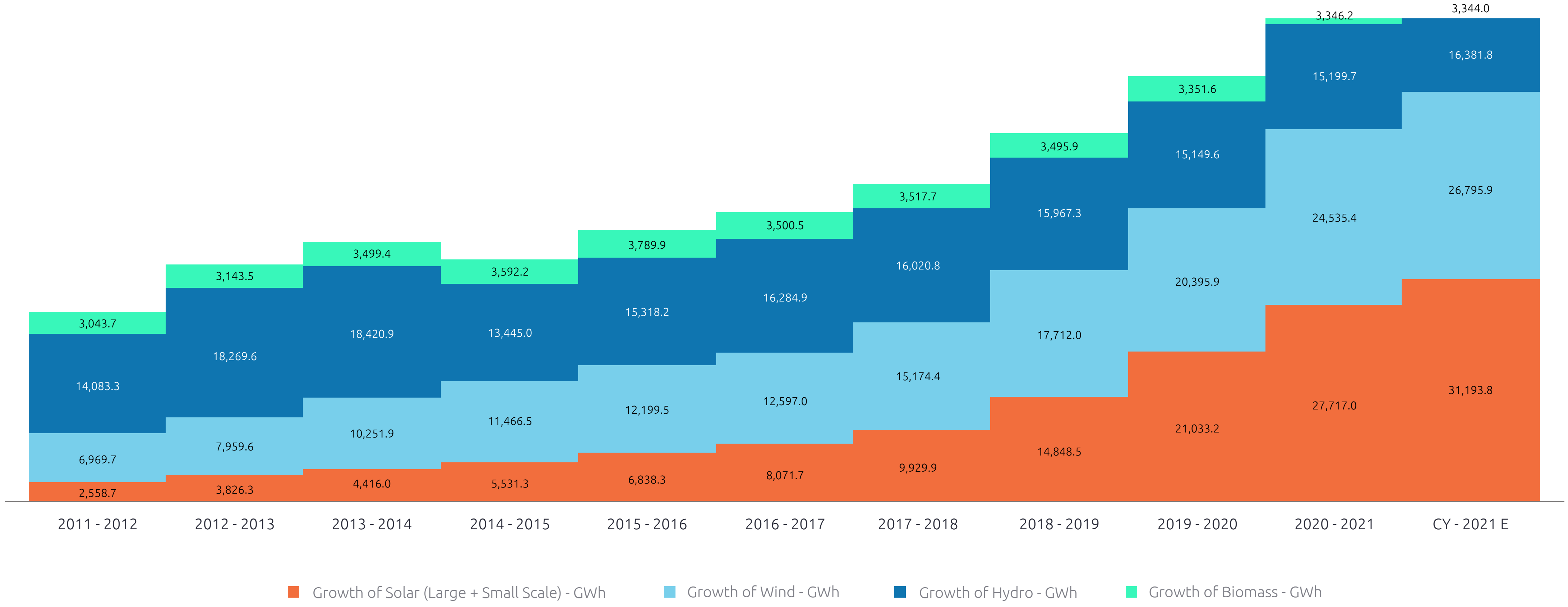
Australia electricity generation (Gigawatt-hours – Calendar Year (2015 -2021)



Source: Australian Energy Statistics, Table O Electricity generation by fuel type 2020-21 and 2021
https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2020-21-and-2021

FIGURE 2

Renewable growth by technology in GWh (2011 – 2021)



Source: Australian Energy Statistics, Table O Electricity generation by fuel type 2020-21 and 2021
https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2020-21-and-2021

The issues illustrated in the graphs above are going to be further exacerbated by the continual proliferation of utility-scale variable renewable energy, distributed photovoltaics (PV), and the adoption of electric vehicles (EVs). Due to a lack of storage capacity on the grid, the balance between electricity supply and demand must be always maintained to avoid a blackout or other cascading problems.

Attempting to solve the Distributed Energy Resources (DER) integration problem: A case study

Clearly, the solutions lie with the use of utility-scale energy storage, the emerging role of the DSO new market mechanisms, and innovative retail products.

There are many players in the utilities market who are currently implementing and trialling these solutions. In the future, participants' roles will very likely change and become more varied.

In September 2021, AEMO announced that it is researching the integration of DER into the grid with a blockchain-based project (Energy Demand and Data Exchange). This project's goal is to develop an understanding of and provide information about the most efficient and sustainable way to integrate DER into the electricity system and associated markets. It will allow all consumers to benefit from a future with high levels of DER[4].

The world's first two-way energy system will enable qualified customers, such as large-scale National Electricity Market (NEM) participants, to trade electricity and grid services via an aggregator or Virtual Power Plant (VPP) operator for DER (for example rooftop solar and batteries). This is currently being designed and tested by AEMO, in collaboration with electricity network provider AusNet Services and the retailer, Mondo. The off-market platform will also be expandable across the NEM.

PXiSE (a developer of market logic software), and Microsoft (a provider of cloud services), will collaborate on the creation of the DER marketplace solution[5].

4 https://www.smart-energy.com/industry-sectors/energy-grid-management/australias-energy-market-operator-to-trial-der-marketplace-on-blockchain/

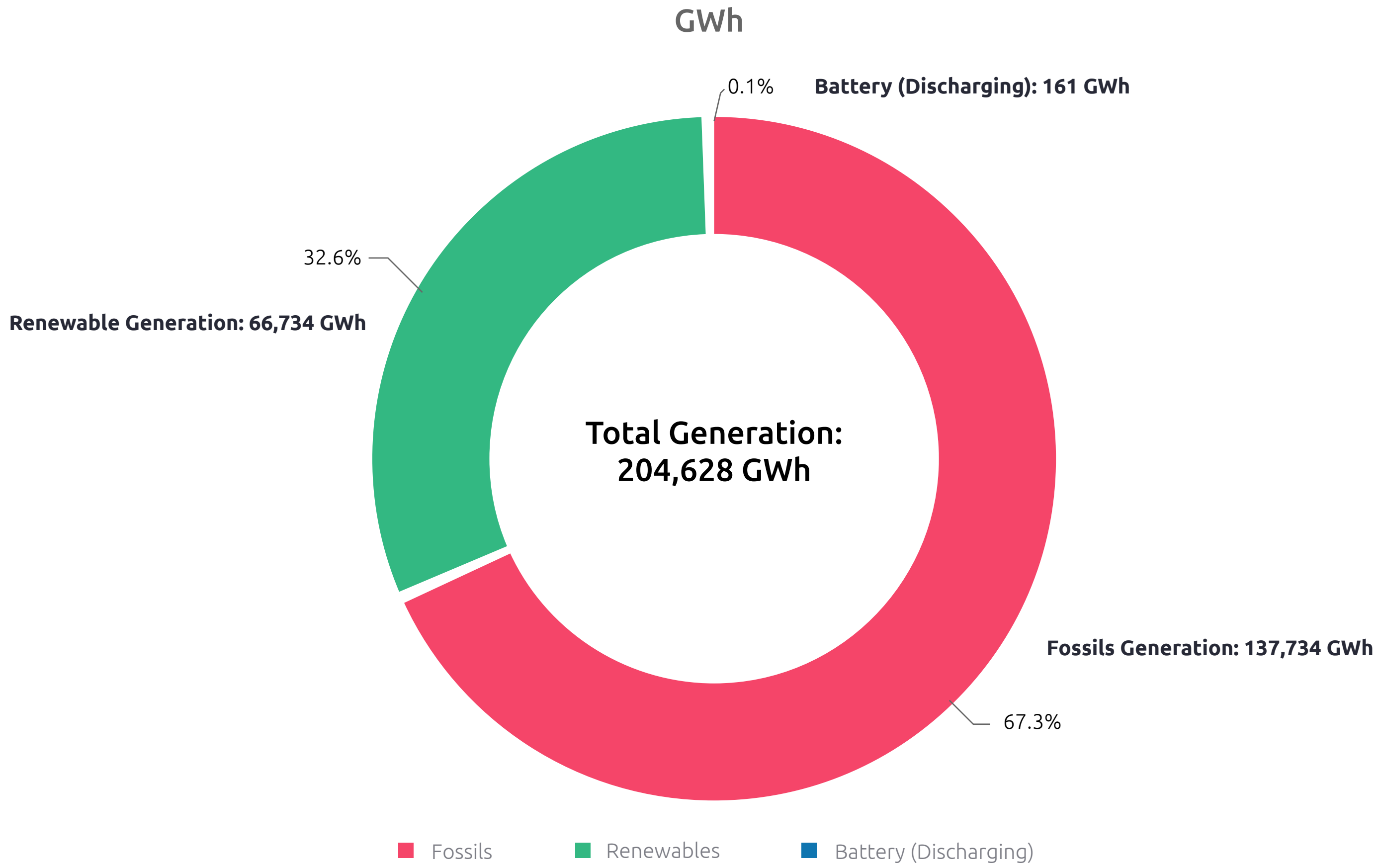
5 https://www.pv-magazine-australia.com/2021/09/03/aemo-pushes-der-market-platform-trial/

Dispatchable generation and firming capacity in the NEM: Solutions and trials

Currently, the NEM relies on 45.5 GW of dispatchable generation and storage for firming capacity, of which 23 GW is from coal-fuelled generation, and 1.5 GW from energy storage. AEMO expects that by 2050 the firming capacity required will be over 60 GW, and dispatchable storage will need to make up 46 GW/640 GWh of that.

FIGURE 3

NEM: Electricity production (May 2021 – May 2022)



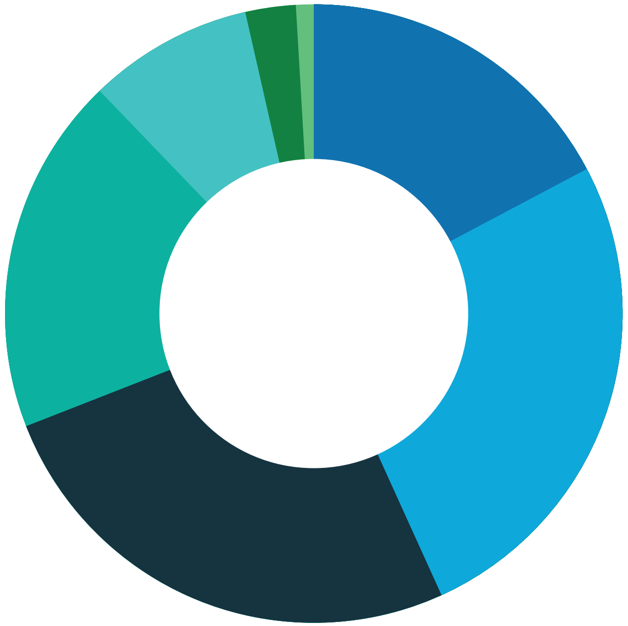
Source: NEM open data (May 2021 – May 2022)
Link: https://opennem.org.au/energy/nem/?range=1y&interval=1M

The source of the firming capacity is expected to comprise utility-scale batteries, hydro storage, gas-fuelled generation, smart behind-the-meter batteries, or VPPs and vehicle-to-grid (V2G) services. However, there are other emerging technologies being trialled, including a 1.5 GWh compressed air storage system supplying Broken Hill in rural New South Wales. This project is being funded by TransGrid to alleviate transmission constraints, and uses a proprietary technology designed by Hydrostor, a Canadian company.

FIGURE 4

Number of small-scale batteries installed in 2021 (estimated)

Number Of Small-scale Batteries Installed In 2021 (Estimated)



State	Systems	Capacity (MWh)
SA	6,000	60
NSW	9,000	90
VIC	9,000	90
QLD	6,500	65
WA	3,000	30
TAS	900	9
NT	331	3
TOTAL	34,731	347

Source: Clean Energy Australia Report 2022
Link: https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2022.pdf

The orchestration of distributed rooftop solar and storage is complex in Australia, as it has the highest PV generation in the world, with solar contributing to over 13% of Australia's electricity generation.

- There are many developments underway in the VPP space in the NEM. Additionally, network operators are working alongside regulators to limit the exports per customer. Currently, more than 19 electricity retailers in Australia provide VPP programs, each with a unique blend of subsidies, tariffs, contract length terms, capacity requirements, technology compatibility, and location eligibility.
- One example is the Australian energy retailer, Simply Energy. Simply Energy is currently expanding their VPP pilot nationally, and they also include a wider selection of compatible batteries and inverters. Simply Energy provide services and engage with customers using a platform created by SwitchDin, which coordinates and orchestrates both rooftop solar and battery storage to respond to peak-period demand, while providing frequency support services[6]. Customers on the Simply Energy network are rewarded by receiving payments or credits for their electricity bills.
- Distribution networks often have capacity and power quality constraints from excess solar generation, which is associated with reverse power flow. To avoid exceeding these technical limits, some authorities have imposed export limits and remote disconnects, often at the disadvantage of newly connected solar customers.
- Several trials are being considered throughout Australia, to optimize the orchestration of power flow. One trial at South Australia Power Networks (SAPN) looks to use smart inverter technology to enable customers' inverters to automatically adjust their export limits every five minutes. This is based on a locational, dynamic limit signal provided by the distribution network service provider[7].

Market mechanisms and demand-side participation (DSP): The role of the customer

- To maintain system reliability and security, dispatchable generation is being utilized as a solution. However, there needs to be more of a partnership approach with customers, where the value of DER can be shared beyond automated transactions in energy flows.
- New market mechanisms need to be designed to enable two-sided markets to maximize the value of DER. DSP can be considered as part of a two-sided market but is currently being used in the context of "demand peak shaving" and not "demand valley filling".
- Dispatchable resources are needed to firm renewable energy intermittency despite all weather conditions across the NEM. As renewables become the dominant source of generation, diversity in those firming resources will be more valuable. That diversity may be both geographical and technological, such as gas-fired generation and energy storage of varying depths.

The figure below shows how the different generation sources interact, to deliver electricity to consumers across New South

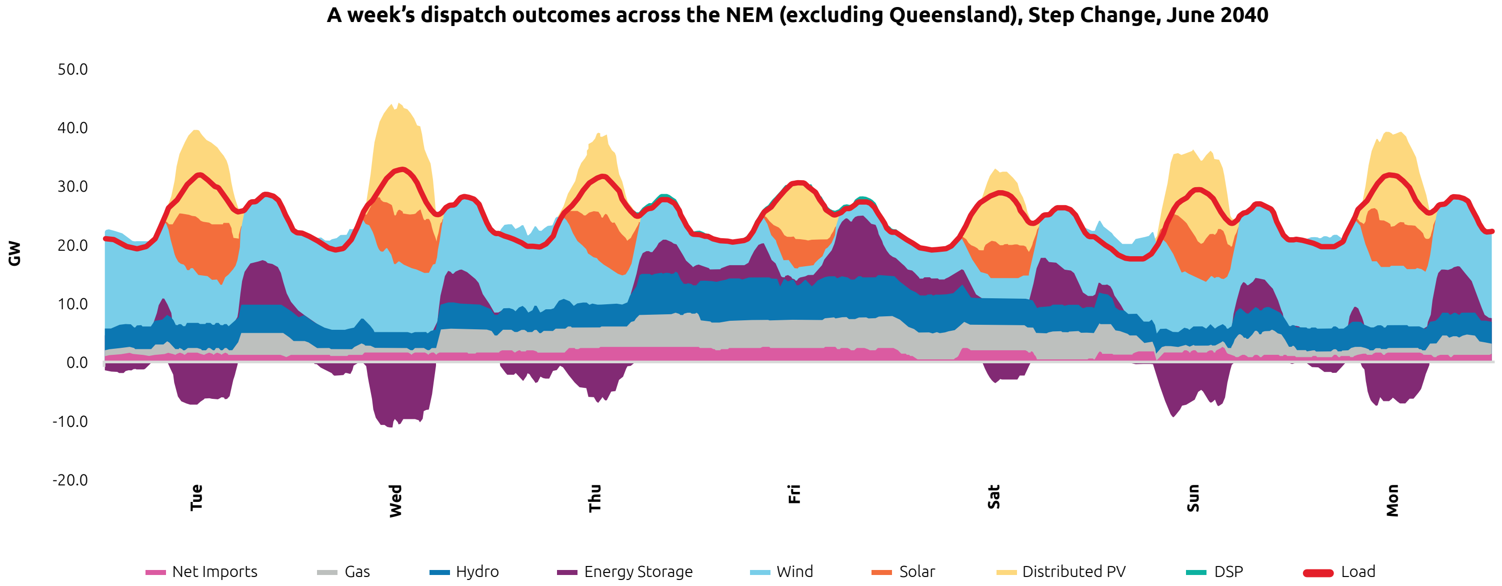
6 https://www.switchdin.com/blog/2021/12/1/switchdin-simply-energy-vpp

7 https://www.sapowernetworks.com.au/public/download.jsp?id=320260

Wales, Victoria, South Australia, and Tasmania. The graph illustrates a forecasted winter week in July 2040, using a historically observed set of weather conditions. Traditional demand management is geared towards major energy consumers, such as industrial plants. AEMO has

FIGURE 5

A week's dispatch outcomes across the NEM (excluding Queensland), Step Change, June 2040



Source: AEMO: 2022 Integrated System Plan (ISP), Chart Data
Link: https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/chart-data.xlsb?la=en

several mechanisms through which it pays big energy users to power down when the system is struggling. However, there are now mechanisms in place to allow residential customers to participate through programs run by retailers, network service providers, and DSP aggregators.

DSP is being used as a tool for both market-driven events and reliability-driven events

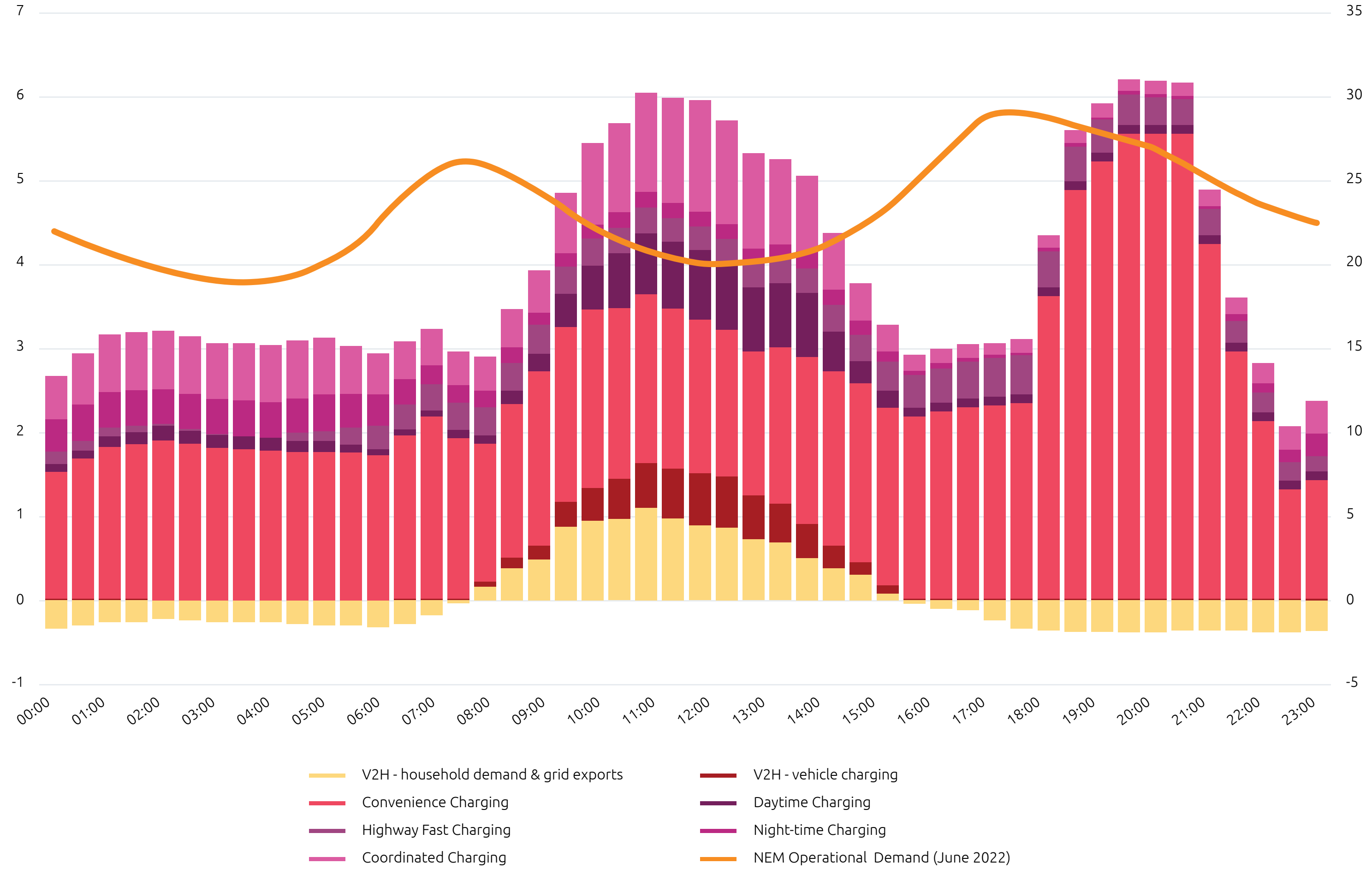
- We are starting to see an uptake of retailers offering programs for customers which notify them of "peak events" and give them the opportunity to opt-in to reducing their consumption.
- For example, AGL's Peak Energy Rewards program enable customers to be rewarded with credits if energy reduction targets are met.

The use of DSP is becoming more topical as the demand of EVs is expected to create significant "peaks" during afterwork charging. V2G solutions are still in their infancy, with only two models of vehicles available on the market that are capable of V2G. There is only one significant V2G trial in Australia, consisting of 51 Nissan LEAF EVs. This trial is still in its early stages, with charger installations and software implementation taking place[8].

In summary, a crucial element in the successful integration of variable renewable energy (VRE) or intermittent renewable

FIGURE 6

Forecast daily EV charging demand in June 2040



Source: AEMO: Cornwall Insights Australia Analysis
Link: https://www.cornwall-insight.com/our-thinking/chart-of-the-week/do-network-operators-dream-of-electric-vehicles/

8 https://cleantechnica.com/2022/01/23/the-unknown-unknowns-of-vehicle-to-grid-tech/

energy generation into the NEM, is forecasting accuracy. As renewable generation continues to account for a larger portion of the generation mix, forecasting systems and forecasting improvements (along with appropriate market structures and operational tools) will be increasingly important for promoting efficiency in NEM dispatch, pricing, system reliability, and security[9].

9 https://www.aemc.gov.au/sites/default/files/2022-04/%5BREL0083%5D%202021%20Annual%20Market%20Performance%20Review.pdf

SOUTH EAST ASIA ADEQUACY OF SUPPLY

ISHANDEEP
NUPUR SINHA
ALEXANDRA BONANNI

Improved performance in energy access and the security of Southeast Asia is driving the region in energy transition

According to the 2021 World Economic Forum's Energy Transition Index (ETI), Asia has improved at the fastest rate, boosting its ETI index score by 6% in the past decade. This is driven by significant improvement in the region's performance in energy access and security.

- Singapore has a high ETI ranking of 21, as driven by stable guidelines, establishments, governance framework, and transparency, along with a culture of innovation and contemporary infrastructure.
  - The aggregate score for Singapore has remained consistent over the past six years, demonstrating the strength of its energy system.
  - As a major refining hub and emerging center of the global liquefied natural gas (LNG) trade, Singapore plays a significant role in the global energy system. The fossil fuel industry is a major economic driver in Singapore.
- Malaysia also has an ETI ranking of 39 due to its high electrification rate, low usage of solid fuels, diversity of its fuel mix, and high quality of electricity supply.
- The Philippines has a low ETI rank of 67, which declined from the previous year. The country is piloting the Energy Transition Mechanism (ETM) project where the Agus-Pulangi hydropower plants will be rehabilitated and expanded to enable the early retirement of coal-fired power plants.
  - The country has plans to work with the Asian Development Bank (ADB) and some private sector partners in developing the ETM, which could become the largest carbon reduction program in the world.
- Vietnam has a low ETI rank of 65 due to weaker institutions, a low level of investment freedom, and a low quality of transportation infrastructure.
  - The government plans to increase LNG imports and non-hydro renewable energy generation capacity.

Note: The 2022 World Economic Forum's Energy Transition Index (ETI) benchmarks the progress of a country's energy transition (over a decade) on the dimensions of the energy triangle: economic development and growth, energy security and access, and environmental sustainability, as well as enabling the environment for transition

FIGURE 1

Energy Transition Ranking in Southeast Asia, 2021

The Energy Transition Index, 2022

Association of Southeast Asian Nations (ASEAN) Rank benchmarks the six Asian countries: Thailand, Singapore, Malaysia, Indonesia, Vietnam and the Philippines on the performance of their energy system, as well as their readiness for transition to a secure and sustainable energy future

Hong Kong:

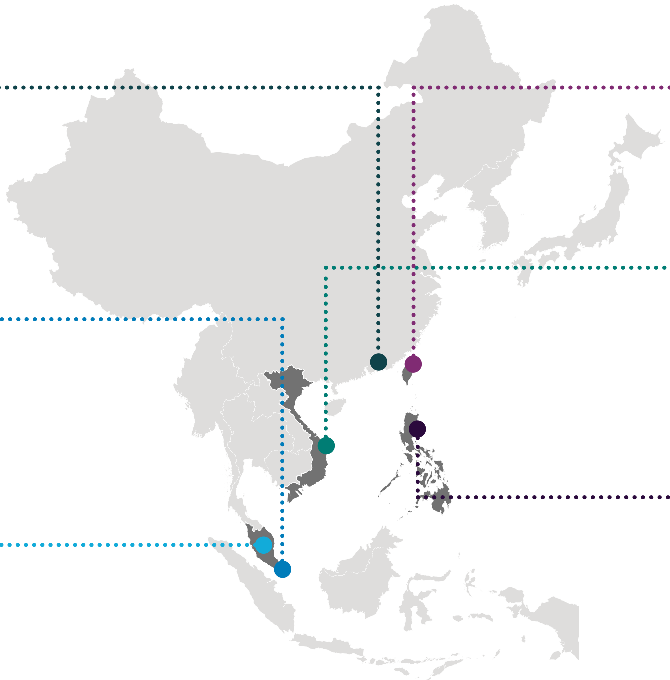
No Data Available

Singapore:

Global Rank	21
ASEAN Rank	01
ETI 2021 Score	67%
System Performance	67.1%
Transition Readiness	66.9%

Malaysia:

Global Rank	39
ASEAN Rank	02
ETI 2021 Score	64%
System Performance	68.5%
Transition Readiness	59.5%



Taiwan:

No Data Available

Vietnam:

Global Rank	65
ASEAN Rank	04
ETI 2021 Score	57%
System Performance	61.0%
Transition Readiness	54.0%

Philippines:

Global Rank	67
ASEAN Rank	05
ETI 2021 Score	57%
System Performance	66.5%
Transition Readiness	47%

System performance provides an assessment of countries' energy system related to their delivery in three key priorities: the ability to support economic development and growth, universal access to a secure and reliable energy supply, and environmental sustainability across the energy value chain

Energy transition readiness is captured by the stability of the policy environment and the level of political commitment, the investment climate and access to capital, the level of consumer engagement, the development and adoption of new technologies, etc

Source: Information available till April 2021, World Economic Forum, 2021 & 2022
http://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_2021.pdf
https://www3.weforum.org/docs/WEF_Energy_Transition_Index_2022.pdf

Southeast Asian countries have improved in the 2021 Energy Trilemma Index despite the economic toll from the Covid-19 pandemic

Southeast Asia is one of the most dynamic and diverse regions in the world in terms of energy transition. In the 2021 World Energy Council's Energy Trilemma Index, Southeast Asian countries are among the top and bottom ranks.

- Energy equity scores have generally increased, primarily due to successful deployment of modern and affordable energy across the region.
- Despite the Covid-19 pandemic, Singapore, Hong Kong, and Malaysia maintained high standards with a consistently high overall score exceeding 90.
- Southeast Asia remains the largest energy importer in the world and its energy security is expected to become even more challenging.
- Government policies focusing on decarbonization and key pressures such as increasing transparency and accountability in balancing social, environmental and security aspects are emerging.

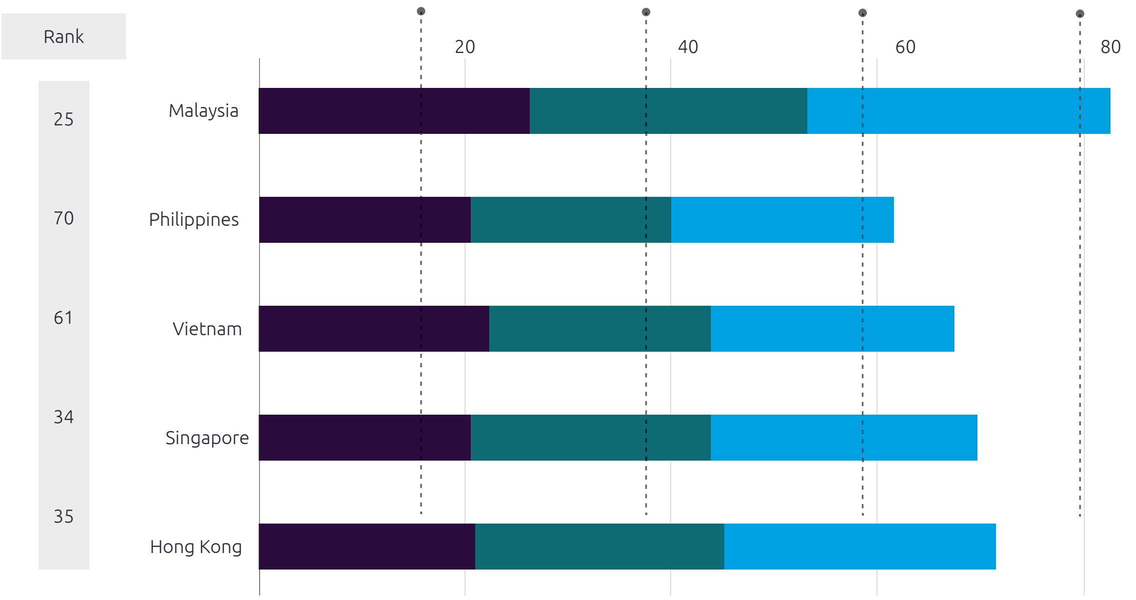
Improvement trajectory for each country varies in Southeast Asia:

Country	2021 Rank	2022 Rank	Rank Changes
Malaysia	25	33	▼
Philippines	70	76	▼
Vietnam	61	65	▼
Singapore	34	40	▼
Hong Kong	35	34	▲

FIGURE 2

Southeast Asia Trilemma Index, 2021

World Energy Trilemma Index, 2021
World Energy Trilemma Index, provides an objective rating of national energy system performance across three Trilemma dimensions which involves three core dimensions: Energy Security, Energy Equity and the Environmental Sustainability of Energy Systems throughout the transition process



Energy Security: Measures a nation's capacity to meet current and future energy demand reliably, withstand and bounce back swiftly from system shocks with minimal disruption to supplies. Also, overs the effectiveness of management of domestic and external energy sources, as well as the reliability and resilience of energy infrastructure.

Energy Equity: Assesses a country's ability to provide universal access to reliable, affordable, and abundant energy for domestic and commercial use. The dimension captures basic access to electricity and clean cooking fuels and technologies, access to prosperity-enabling levels of energy consumption, and affordability of electricity, gas, and fuel.

Environmental Sustainability of Energy Systems: The dimension focuses on productivity and efficiency of generation, transmission and distribution, decarbonisation, and air quality.

Country Context: Focuses on elements that enable countries to effectively develop and implement energy policy and achieve energy goals.

Note: The World Energy Council's Energy Trilemma Index tool, produced in partnership with Oliver Wyman, ranks countries on their ability to provide sustainable energy through 3 dimensions: Energy security, energy equity (accessibility and affordability), and environmental sustainability

Source: World Energy.org, 2021
https://www.worldenergy.org/assets/downloads/WE_Trilemma_Index_2021.pdf?v=1634811254

Southeast Asia represents a key growth region for renewables over the next few years

Oil, coal, and natural gas continue to be the dominant sources of energy in the primary energy consumption mix in 2021.

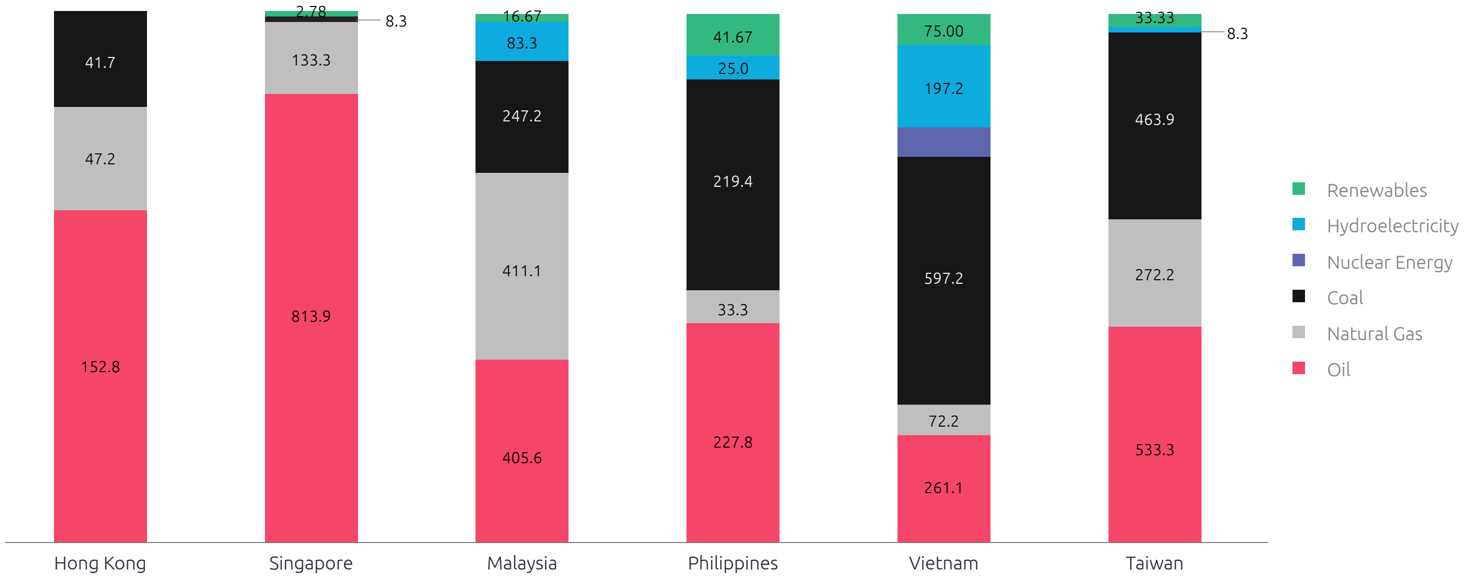
- SEA countries consumed 5,494 TWh of energy in 2021 wherein fossil fuels including oil, natural gas, coal contributed around 4,941 TWh (90%) of total energy consumption collectively.
- Oil continues to hold the largest share of the energy mix (43.6%) with 2,394.4 TWh, Coal is the second largest fuel in 2021, accounting for 1,578 TWh (29%) of total primary energy consumption.
- Nuclear energy and hydro-electricity contributed 69.4 TWh and 313.9 TWh representing 1.3% and 5.7% of total energy consumption in SEA in 2021 respectively.
- Renewables have overtaken nuclear with 169.44 TWh of contribution in overall electricity consumption in SEA.

Southeast Asia is expected to experience strong gas demand growth through 2030, mostly driven by increased power generation, but also through increased demand in the industrial sector and petrochemical feedstock

- The Philippines plans for a 35% share of renewable energy by 2030 and around 50% by 2040. This includes a moratorium on new coal power investments resulting in gigawatts of variable wind and solar power generation with energy storage for smooth grid integration.
- Vietnam inaugurated a $2 billion coal power plant, which will generate approximately 7.3 billion kWh/year to meet the power demand. Also, in the Power Development Plan VIII (PDP8), Vietnam aims to lower coal power to 9.6% and increase renewables to more than 50% by 2045.

FIGURE 3

SEA Energy consumption by fuel (terawatt hours), 2021



Source: BP Statistical Review of World Energy, 2022
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

Energy efficiency, demand management, and response in Southeast Asia

Southeast Asia can be shielded from the effects of unpredictable international markets by well-managed energy transitions, but energy security during transitions is not free.

- The invasion of Ukraine by Russia has had a significant impact on the energy markets, resulting in high and unstable prices for fossil fuels and increased competition for non-Russian supplies. The market turmoil has highlighted Southeast Asia's vulnerability in energy security, and its resilience to supply disruptions.
- Since the middle of the 1990s, the region has largely imported oil; high oil prices have had a negative impact on consumers and the economy in general.
- By 2050, it is predicted that the region will import more than 130 billion cubic meters (bcm) yearly and turn into a net importer of natural gas by 2025. However, the price increase in 2021, which is further highlighted by the invasion of Ukraine, may have a long-term impact on the role of natural gas in the SEA region.
- Throughout energy transitions, targeted investments in energy security are still essential. In all scenarios outlined in the International Energy Agency Stated Policies Scenario (STEPS), the demand for electricity rises rapidly, as does the output from variable renewable sources (wind and solar PV).
  - Under these conditions, ensuring the security of energy demands significant investments in networks, side control, digitization, improved cyber resilience, and interregional planning.
  - Oil reserves remain a key defense against supply interruptions even as the region adopts policies to shift away from oil. There are several obligatory operational oil stockpile regimes for companies operating in Southeast Asia. These typically correspond to less than 40 days of oil use (and in some cases, as few as six days).

Governments can implement laws and regulations to increase energy availability for all people, make it more affordable and secure, and reduce emissions.

- In STEPS, the current policy settings will keep Southeast Asia's energy consumption growing by about 3% annually through 2030, as has been the pattern over the past two decades. Although the economies of the nations in Southeast Asia are at various levels of development, they have nearly all grown by more than a factor of two since 2000.
- In recent years, Southeast Asia's energy accessibility has increased; currently, about 95% of families have access to electricity; 70% have better cook stoves and use liquefied petroleum gas for clean cooking.
- Southeast Asian governments have outlined long-term objectives for a more stable and sustainable future. For instance, carbon neutrality and net zero emissions goals have already been set by six Southeast Asian nations.
- In the Sustainable Development Scenario (SDS), an average of 21 GW of renewable capacity will be installed annually until 2030 (tripling the level of recent years).
- By 2030, over 25% of the automobiles sold in the area will be electric. The cost of importing fossil fuels into the area is reduced as a result of these efforts. All customers will have access to power and clean cooking by 2030 with an annual investment of $2.8 billion (about 2% of the average annual energy sector investment in the region to 2030).

The two crucial levers to drive Southeast Asia toward a sustainable energy future are improvements in energy efficiency and the deployment of renewables.

As per International Energy Agency Stated Policies Scenario (STEPS):

- By 2030, energy demand is expected to grow by just over 3% annually, which is a little less than the 3.3% annual average growth experienced in the decade before Covid-19. Growth slows after 2030, but it will not plateau even by 2050.
- According to the Sustainable Development Scenario (SDS), the region's overall energy supply will grow slowly until 2030, by around 2.2% per year before reaching a plateau in the 2040s. In 2050, the difference in energy demand between the two scenarios will be greater than 10 exajoule (EJ), which is currently equal to Indonesia's total energy supply.
- Southeast Asia's population will still be able to access the same level of energy services despite the differences in results.
- In contrast to the STEPS, everyone will have access to energy more rapidly and easily in the SDS plan. Less demand reflects significantly higher efficiency, which includes the increases in proficiency that come with energy transitions since less energy is lost during the production of thermal electricity and electric motors take the place of combustion-powered ones.
    - Improvements in end-use equipment, such as air-conditioners and other appliances, that are driven by policy are also included.
- In the SDS, more aggressive measures are taken to encourage energy end-use efficiency, which caps total final energy consumption at 24 EJ in 2030 and 25 EJ in 2050.
- The cap on energy use for transportation is set at 7 EJ in 2030. Due to the increased popularity of electric vehicles (EVs) and their improved efficiency, the total amount of energy used for transportation in 2050 will be slightly less than it was in 2030.

SEA countries taking initiatives to improve energy efficiency

Country	Policies and targets
Malaysia	• Promote energy efficiency in the industry and buildings sectors with methods of standard setting, labeling, energy audits, and building design.
Philippines	• By 2030, reduce energy intensity by 40% vs. the 2010 level. • Decrease energy consumption by 1.6% per year by 2030 from baseline forecasts. • Reduce energy intensity and total energy consumption by 24% relative to the BAU level by 2040.
Singapore	• Improve energy intensity by 35% by 2030 vs. the 2005 levels.
Vietnam	• The nation is attempting to address the issue of energy efficiency by working on Vietnam National Energy Efficiency Program (VNEEP3). • The initial objective of the VNEEP3 is to conserve up to 10% of the energy required for the nation to develop under the usual development scenario. The plan is for the entire nation to save at least 5-7% of its total energy up until 2025; by 2030, this percentage should increase to 8-10%.
Taiwan	• Improve energy efficiency by more than 2% per annum, so that when compared with the level in 2005, energy intensity will decrease 20% from 2015 vs. the 2008 baseline.

Source: IEA – SEA Energy Outlook 2022, Secondary Search

Grid optimization in Southeast Asia

Demand response will account for almost a quarter of the flexibility in peak demand hours by 2050, with smart electrification of end-use sectors and the adoption of hydrogen in the Sustainable Development Scenario presenting new opportunities to contribute to the stability and reliability of the electricity system.

- In order to lessen and prepare for the worst effects of climate change, Southeast Asian countries are quickly assessing their current power generation capacity and grid systems.
- By 2030, it is anticipated that Southeast Asian countries like Malaysia, the Philippines, and Vietnam will add more than 50 GW of new generation capacity and spend upwards of $100 billion on grid improvements and new power transmission and distribution networks.
- In recent years, SEA has emerged as a major regional market for smart grid solutions.
  - By 2026, Malaysia expects all homes to have smart meters. If this goal is accomplished, an estimated 9.1 million residences nationwide would have smart meters installed.
  - A significant initiative is being carried out by Taiwan Power Company to install smart meters in all Taiwanese homes. The initial roll-out includes 1.2 million residences.
- Smart meters installation started in Singapore in 2017. Over a seven-year period, 1.5 million meters were to be installed. However, only 500,000 were completed by March 2021.
- From November 2018 to 2025, CLP Power customers in Hong Kong will gradually have their conventional meters converted to smart meters. Over 1.2 million smart meters were linked by the end of 2021, despite a shortage in the supply of new meters brought on by the disruption of the global supply chain. In Hong Kong, this accounts for more than 40% of all client accounts. The objective of CLP Power to swap out all conventional electric meters by 2025 is still in place.
- By proposing to deploy 3.3 million smart meters by 2024 and a smart grid roadmap by 2027, the Philippines has prioritized investments in technology to digitally enhance utility operations. One of the first companies to implement smart meters was Meralco, which started its program in 2015. In the first half of 2021, 102,000 smart meters were installed.
- Another notable ASEAN country that has used smart meters is Vietnam. It uses the Meter Data Management System (MDMS) as a central database to hold meter data, enabling speedy data collection and analysis for accurate billing and effective management of power outages.

Energy readiness across Southeast Asia

Country	Electrification rate, 2020 (%)	SP Smart Grid Index, 2021
Taiwan	100	
Singapore	100	
Hong Kong	100	
Vietnam	100	
Philippines	96.8	
Malaysia	100	

Source: SP Group, World bank, Capgemini Internal Analysis

06 RETAIL MARKETS

EUROPE RESIDENTIAL MARKETS

GUIDO WENDT
ROBERT REHNER
MARISSA PAPAS
JON NELMES
RAPHAEL HEIMEL
FRANZISKA HOOCK

One of the biggest challenges in the European retail energy market is the scissors effect of rising wholesale prices and volatile energy prices.

- This results in reduced margins and puts enormous pressure on the energy market and its players. This is intensified by new competitors, as well as new business models that are reshaping the energy market.
- Also, markets which are not deregulated today are shifting, opening the doors for more competition. Thus, cost competitiveness becomes an ever-growing topic in those increasingly competitive markets.
- Rising pressure is also seen in the development of current electricity and gas prices.

Data from the current residential energy market supports these trends. Compared with the previous year, electricity prices rose by an average of 18% and gas prices by 36% across Europe.

Residential electricity prices in the EU27 have become even more volatile – the prices vary around a value of +/- €260/MWh, even more in 2022 in some countries like France.

The same applies for the residential gas prices – the prices vary around a value of +/- €200/MWh.

Annual prices have become even more uncertain and expensive compared to 2020

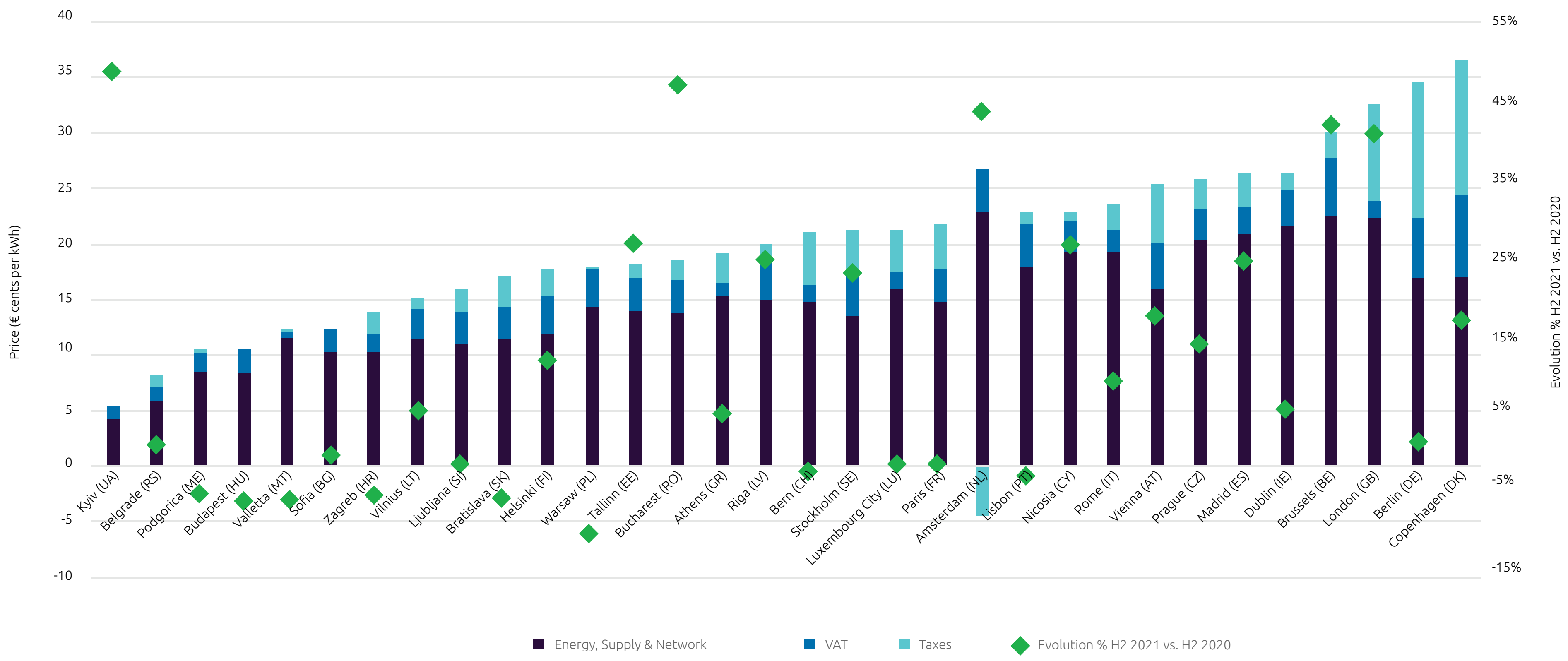
- In 25 out of 27 countries, residential electricity prices rose between 2020 and 2021. For 17 of these countries the increase was more than 10%. This includes Italy (15%), Czech Republic (20%), Spain (30%), and Netherlands (48%). There has been an increase in residential gas prices in 25 of the 28 countries with the average increase reaching just over 36% between 2020 and 2021. As a result, some governments have introduced price caps to protect end consumers. France, for example, has introduced the “bouclier tarifaire” to freeze the gas tariff and set a cap on electricity price increases of 4% in 2021.

Major challenges exist for retailers and the price structure within the EU.

- The market is also becoming more difficult for retailers who do not have competitive plants and purchase power to be sold on the wholesale market. These retailers will face major economic challenges and most of them could fail in the near future.
- There are also major disparities in electricity prices within the EU. Prices in Germany (€350/MWh), France (€210/MWh), and Belgium (€298/MWh) are in some cases more than twice as high as household electricity prices in Poland (€180/MWh), Greece (€134/MWh), Finland (€176/MWh), and Hungary (€106/MWh). A similar picture is found in gas prices, where countries like the Netherlands (€138/MWh) or Sweden (€233/MWh) have prices almost twice as high as in Latvia (€49/MWh) or Lithuania (€57/MWh).

FIGURE 1

Residential Electricity prices in Europe – all taxes included (H2 2021 compared H2 2020, € cents per kWh)

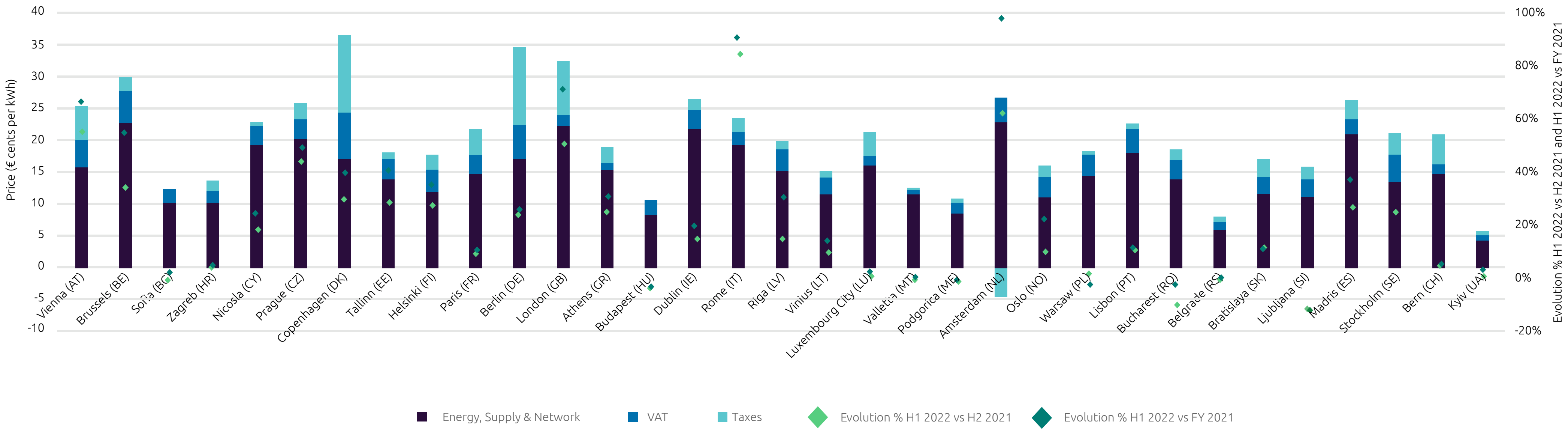


Source: EUROSTAT

I. EUROPE RESIDENTIAL MARKET

FIGURE 2

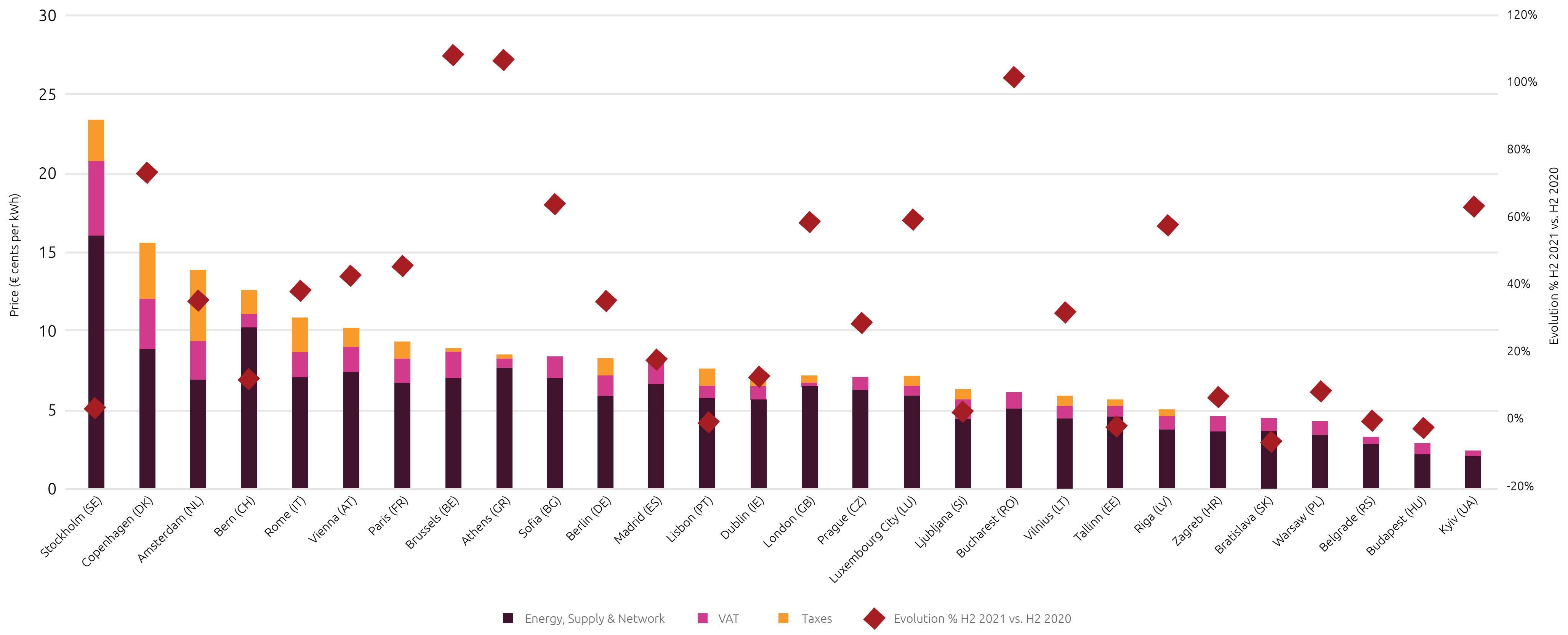
Residential Electricity prices in Europe – all taxes included (H1 2022 compared to H2 2021 and FY 2021, € cents per kWh)



Source: EUROSTAT

FIGURE 3

Residential Gas prices in Europe – all taxes included (H2 2021 compared H2 2020, € cents per kWh)

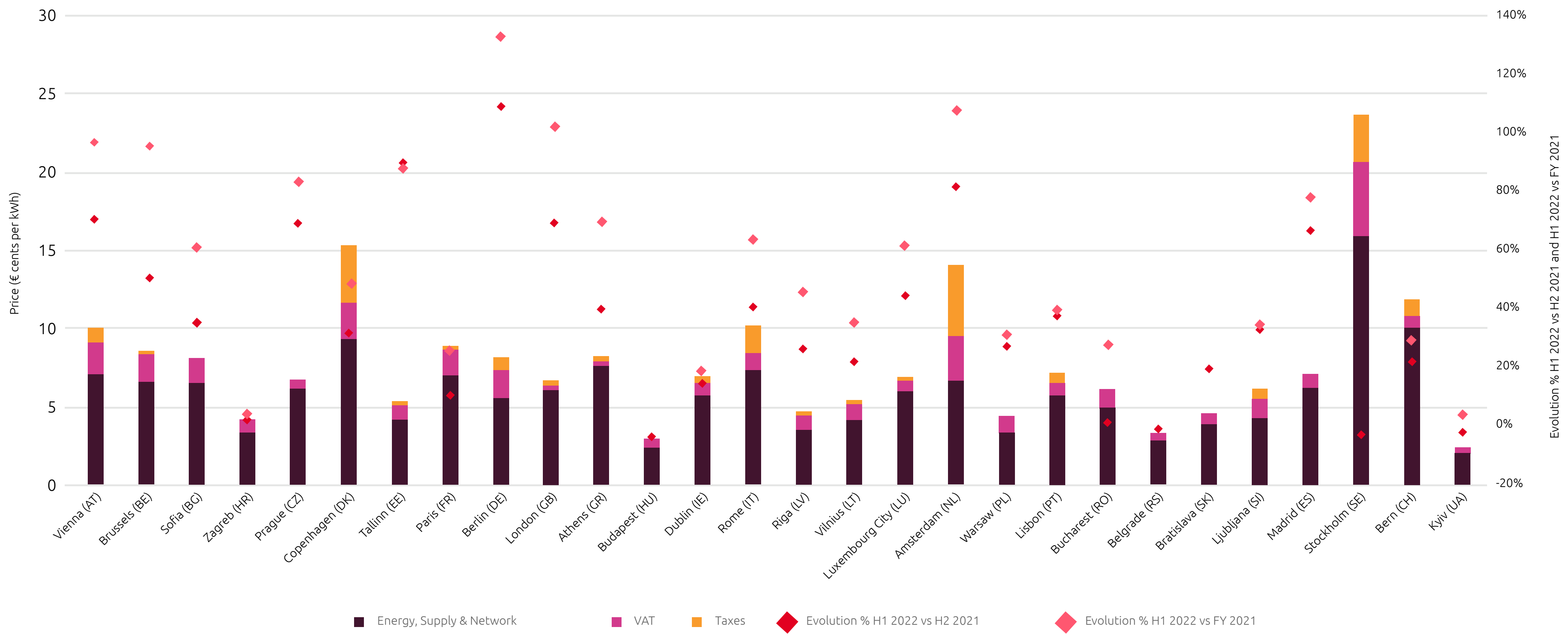


Source: EUROSTAT

I. EUROPE RESIDENTIAL MARKET

FIGURE 4

Residential Gas prices in Europe – all taxes included (H1 2022 compared to H2 2021 and FY 2021, € cents per kWh)



Source: EUROSTAT

I. EUROPE RESIDENTIAL MARKET

Overall comparison of residential energy costs in the EU.

Household energy bills #1 – In 2021, the average consumer in major European cities paid an annual energy bill of €1644, or 3.9% of their disposable income. Furthermore, the annual bill for the average household consumer was over €2000 in five countries: Sweden (€3495), Germany (€2616), Italy (€2088), Denmark (€2520), and Belgium (€2230).

Disposable income #2 – Based on the purchasing power standard (PPS) in countries where competition is higher, consumers are paying a smaller share of their disposable income, as seen in the U.K. (2.7%) or the Netherlands (2.9%). In countries where competition is lower or average revenues per household are lower, consumers are paying a higher share, as can be seen in Portugal (5.1%), Greece (5.4%), or Bulgaria (8.8%).

Switching behavior #3 – These differences can also be reflected in the behavior of customers who change their utility provider. Switching rates are particularly high in countries with a very active market where energy prices and market supply are higher, such as the Netherlands (29%), Czech Republic (17%), or France (14%), on average. In less active markets with lower on average household energy bills, the switching rates are lower, as seen in Slovenia (4%) or Austria (5%), or even less in dormant markets like Poland (0.22%).

Ukraine-Russia war #4 – The challenges in 2021 have been significantly tightened by the Ukraine-Russia war. This has led to a strong increase in energy prices for end consumers / retailers. This particularly affects those countries that are more dependent on external (specifically Russian) gas or commodity supplies.

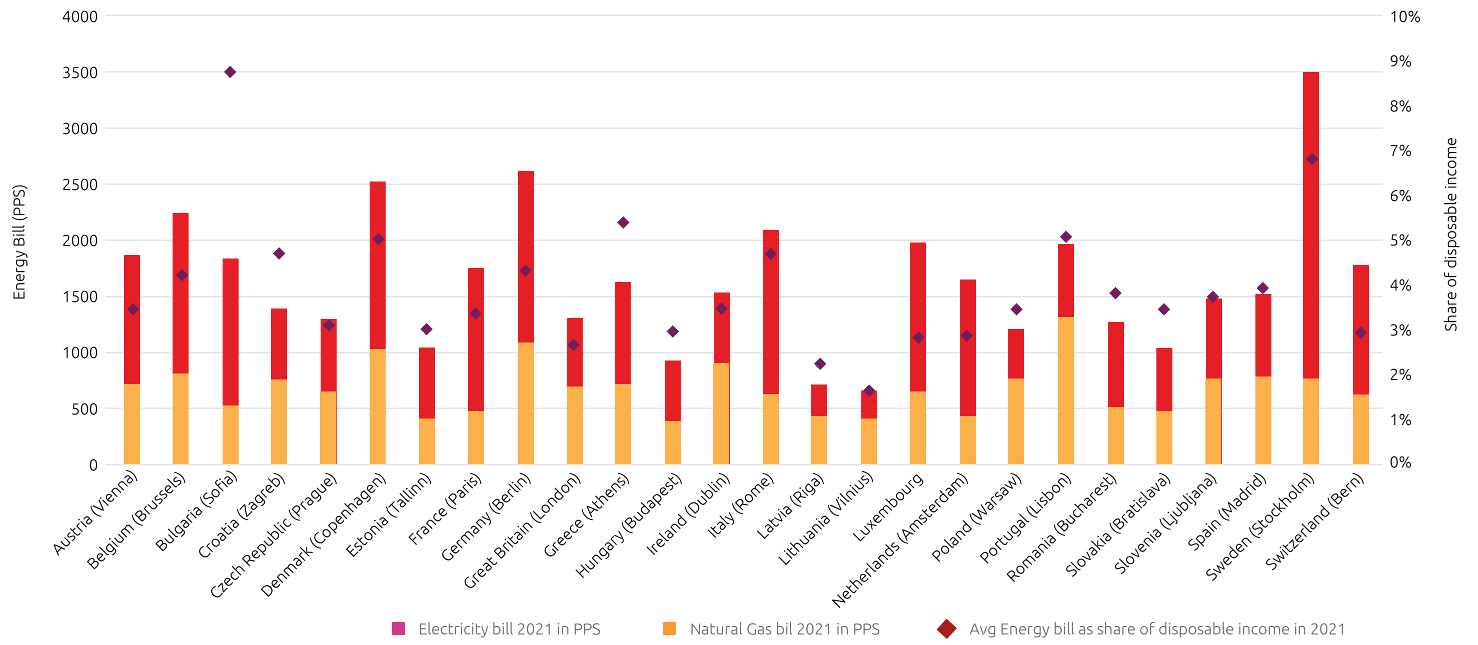
Influence on 2022 prices #5 – This can be seen in the gas price increases in H2 2022 compared to the year 2021 (Figure 4), especially in Germany (+151%), Netherlands (+119%) or other countries such as Austria (+110%) or Italy (+93%). Gas prices have risen sharply by 58% on average and electricity prices have also increased by 25%.

Price capping #6 – Price capping is currently a political response to protect consumers. For example, the German government protects its gas importers from high purchase prices from Russia to avoid collapse of industrial and consumer prices.

The energy market is very dynamic and highly volatile; events will shape the market for the next several years.

FIGURE 5

Residential Electricity prices in Europe – all taxes included (H2 2021 compared H2 2020, € cents per kWh)



Source: EUROSTAT, HEPI, VaasaETT

The rise of customer self-service and its link to sales

FRANZISKA HOOCK

The rise of customer self-service and its link to sales

Customer self-service (CSS) has established an increasing form of support to help customers carry out actions autonomously. This results in lower cost-to-serve and higher customer satisfaction. While this development can be found in all industries, over 90% of larger utilities provide a customer portal with self-service attributes. Nevertheless, there is still a gap regarding functionalities, particularly in the use of the sales potential.

Part 1: What are the challenges of traditional customer service?

Customer self-service has become popular in part because it levels out the main challenges of classic customer services:

Challenge #1: **Customers want their problem to be solved – instantly.** Modern customers want results, not sympathy. They want to solve their request as soon as possible and not spend time in telephone loops or told to call again during business hours. According to recent studies, 85% of all customers prefer to proactively serve themselves before reaching out to a contact center representative. In addition, the vast majority, fully 94% in Germany, uses the internet (2021).

Challenge #2: **Traditional customer service is expensive.** Customer service is a big share (over 40%) of the so-called cost-to-serve (CTS) especially due to personnel costs. (E.g., average CTS is €22 in 2022 in Germany). A single customer interaction costs around €6, considering six minutes process time and a standard hourly cost rate. Furthermore, there can be frustration on both the customer and employee side when there is no direct outcome. This results in higher churn rates

on the customer side and higher turnover rate of customer service staff.

Challenge #3: **Optimization in telephone service is limited.** About 40-50% of customer service units implemented smart routing to increase first-time resolution rates. This also reduces the process time by approximately one minute per call and therefor saves a small share of CTS. Intelligent knowledge management and automatic call routing to the best service agent are a means to an end but eventually only a drop in the ocean.

Customers want to try to solve their problem by themselves first. Companies can not only save money but also increase customer satisfaction by fostering self-service.

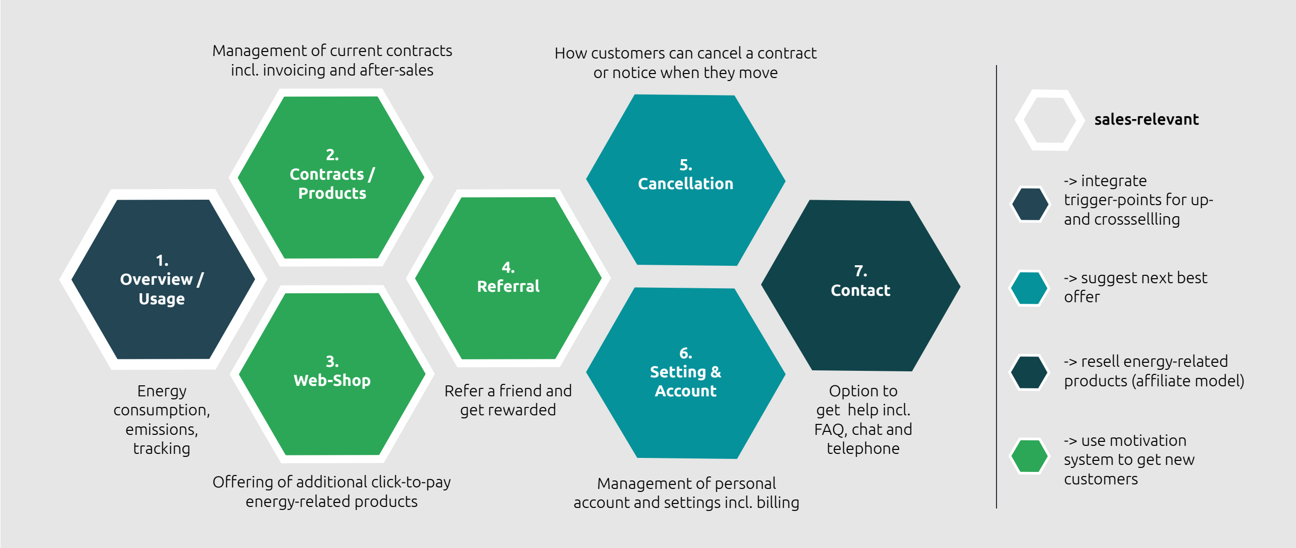
Part 2: What are key characteristics of a state-of-the-art CSS?

- **Clear and easily accessible content.** It must be regarded as very easy for the customers to find and use self-services. In terms of channels, CSS needs to be seamlessly integrated so that customers find services via web search, on the website, and the web and/or mobile customer portal. To log into the personal profile, customers prefer single sign-on and dislike two-factor authentication. One of the most common information pools is a frequently asked questions (FAQ) page where customers can find answers to their queries in a quick and easy way. This section should be clearly structured and adapted dynamically. It can also be linked to a chatbot. Once customers log into their personal account, they want to find a clear menu with relevant topics. These can be emphasized by illustrations, pictures or icons to make it more understandable. Eventually, it also helps to use customer-friendly terminology to streamline customer journeys.
- **Valuable functionalities.** Making information and content easily accessible is only one important self-service attribute. CSS portals also allow customers to carry out some real actions by themselves. Across energy providers, customer journey functionalities like management of contracts, consumption analysis, or meter data entry (i.e., via the customer's smartphone camera) can be found. Other common features include more general actions like adjustment of payment settings, invoice correction, personal data adaption and cancellation of contracts. To make a customer portal attractive, a great variety of functionalities tailored to customers' needs is recommended, which should also include sales features.
- **Integrated sales.** As a next step, customers also ask for sales-related functionalities as self-service. However, Capgemini estimates that less than 30% of utilities have this integrated by 2022. One popular sales-related feature exists in the referral of new customers. This is motivated with a bonus which lies significantly below the cost-to-acquire of up to €180 per contract. Upselling possibilities lie in the management of existing contracts and products if higher-priced or additional products and services are displayed. As an obvious example, a green energy tariff should be offered to customers who currently have a budget tariff. Since data is the new gold, all up-selling and cross-selling possibilities work best when backed up with relevant customer data and the right timing. Successful analytics include next best actions/ offers (NBA/NBO), customer lifetime value forecast and sales behavior analysis. Additionally, customer portals can also sell energy-related products, like smart home devices or plug-and-play solar panels.

The interplay of CSS functionalities can be displayed in the following structure, which also highlights the integration of sales (see figure 1):

FIGURE 6

Interplay of 7 key CSS areas and integration of sales



Source: Capgemini Internal Analysis

Part 3: What is the value of customer self-service?

Let´s look at the great benefits for utilities who make full use of the potential of self-services.

- **Decrease cost-to-serve.** CSS leads to personnel costs savings by every customer interaction which is (partly) solved on the customer portal. Furthermore, integrated, data-based sales generates additional revenues. The potential conversion rate regarding up- and cross-selling is around 10% in the energy sector. This is even surpassed by other industries like telecommunications with conversion rates of 15-20%.
- **Increase customer retention.** Customers will revisit the portal to continue to access additional services and receive added-value. Digital sales, like product-service-bundles and after-sales-services like PV services beyond installation, can boost customer retention.
- **Improve customer satisfaction.** Because of better digital experiences (think of values like faster, always available, results-driven, etc.), the satisfaction of customers is higher through CSS. Additionally, extended features like integrated feedback options, idea management, complaint handling, community voices/ testimonials, guided shopping or tutorials to products and services are to be considered, as they are easy to implement and may add value for the customer. On the contrary, telephone customer service can be insufficient for the customer and lead to churn rates (average of 12% in 2022 in Germany).

Customer self-service is a must to meet customers' needs, though getting it right is critical.

Part 4: What are tips to provide a great CSS portal?

Even though CSS offers strong benefits, there are also some challenges and therefore best practices to bear in mind:

Tip #1: Make the platform flexible and adaptable. As is well known, customer requirements grow and change over time. Therefore, utilities need to be able to adapt existing features for the customers, develop new features, and eventually make these changes in a cost-efficient way.

Tip #2: Connect IT systems. A customer portal with self-services cannot function as a stand-alone tool. The corresponding processes need to be automated as workflows and connected with systems like ERP, CRM, and other relevant tools. On top of that, providers need to measure if their self-service options are working by capturing the resulting data.

Tip #3: Integrate adequate billing solutions. When it comes to more complex products and product bundles, a simple billing solution will not be sufficient. Utilities need to make sure to include this as a requirement for the appropriate software solution and interface when they want to offer individual and flexible products in their portal.

Tip #4: Manage the switch. Generally, people are resistant to change. Thus, utilities who introduce a self-service customer portal need to motivate their customers to change to a new platform or do it the hard way, such as by cutting off telephone service. Utilities need to manage use cases where customers will go to the platform and keep users engaged by relevant or new functionalities.

Tip #5: How to cope with complex customer requests. Since CSS is no panacea, utilities need to consider when it does not make sense to use self-service. There are always customer requests which cannot be solved automatically and require human interaction. In the end, it's up to the customer, and thus recommended to provide a bail-out-option on customer portals. Customers can connect via live chat or telephone with customer service representatives. Obviously, they will expect a seamless journey and omni-channel experience to resolve their request as quickly as possible.

The relevance of platforms in successful B2C energy retail business

LUKAS WACKWITZ

The relevance of platforms in successful B2C energy retail business

Despite the current gas market shocks in Europe due to the conflict between Russia and Ukraine and the resulting financial difficulties faced by energy retailers, the electricity and gas markets remain highly competitive on the supply side. In addition, new market roles such as heat providers and Charge Point operators (CPOs) are entering the market, which is consequently changing the demand market for platform software solutions in the energy sector as well[1].

The market-leading meter-to-cash (m2c) platform providers in Germany, for instance, are designing solutions which cover new service and business models. Simply billing for commodities of grid-based energy is no longer enough to keep pace with the competition, which is growing at persistent rates. Powercloud, kVASy and msu are just a few of the m2c solutions that have significantly increased their market shares in Germany over the past years thanks to a diverse range of services offered[2]. Kraken, Salesforce (+ vlocity), Microsoft Dynamics Verticals, and newer versions of established platforms like SAP and Oracle also play a significant role on the European market.

In the following pages, a closer look is taken at some services outside the standard energy commodity business that are enjoying increasing relevance in the B2C platform business.

E-Mobility and charge billing

Charge Point Operators (CPOs) are companies responsible for the installation, service and maintenance of charging stations for electrically powered vehicles. The functional range of charge (billing) solutions offered by corresponding platform providers to such CPOs is versatile. Charging point management, load and charge management, CRM functions, billing and payment, contract and tariff management are just some of the functionalities offered in this field.

The provision of mobile access to charging stations via white label apps that also offer direct payment functions for spontaneous customers or access to charging stations from different providers via e-roaming are further functionalities that can be covered by platform solutions. Supplementing these functionalities with the possibility of accessing the platforms via cloud services (software-as-a-service) makes them maximally flexible in use.

The exponential growth in the number of charging stations in Europe emphasizes the growing importance of efficient charging point management and service billing.

1 Baubkus Jahresreport Energiemarktdienstleister 2021, page 7
2 Baubkus Jahresreport Energiemarktdienstleister 2021, page 10

Product bundling and tariff optimization

The combination of different commodity and non-commodity products into product bundles is one important way for energy providers to distinguish themselves from others when trading commodities. Thus, converting bundles in modern platform solutions is an essential functionality required from energy suppliers. For example, an electricity or gas tariff can be assigned an individual premium or a non-product-related service, depending on customer consumption; optionally this would include a monthly surcharge or additional payment. This makes it possible to create more individual products according to respective target groups and thus diversify a utility's product portfolio.

In order to optimize an energy provider's electricity and gas tariffs with regard to one's own competitiveness, platforms can be linked to internet databases for regular price comparisons. Optimized electricity and gas tariffs may also be calculated and simulated on the basis of individual margin specifications, as well as taking into account current taxes, levies, charges, and other fees.

In combination with credit scoring functionalities, it is also possible to ensure that certain products are only made available to specific customer groups.

Meter data management

Meter data management allows for obtaining metered values from energy consumption from various sources (meter reading service, customer self-reading, electronically available data, etc.). Some platform solutions allow for assigning priorities to different reference channels so that higher-value measurements are given priority in case of doubt. Modern platform solutions also offer new features such as

the plausibility check of measured values through the use of artificial intelligence (AI). Machine Learning (ML) can help reduce the use of working time, but also to increase data quality so that invoice corrections can be avoided. This can reduce the number of customer complaints.

Using billing platforms is a viable way to significantly reduce Cost to Servce (CtS) of energy suppliers

Billing platforms in the energy industry can have a positive effect on Cost to Serve (CtS) and Cost to Acquire (CtA) through high standardization and automation. Until now, systems had to be strongly adapted to individual preferences (for example, with development costs / IT operation), or special products had to be handled manually (ongoing costs for employees). Modern platforms now allow costs to serve that are below €10 per customer per year.

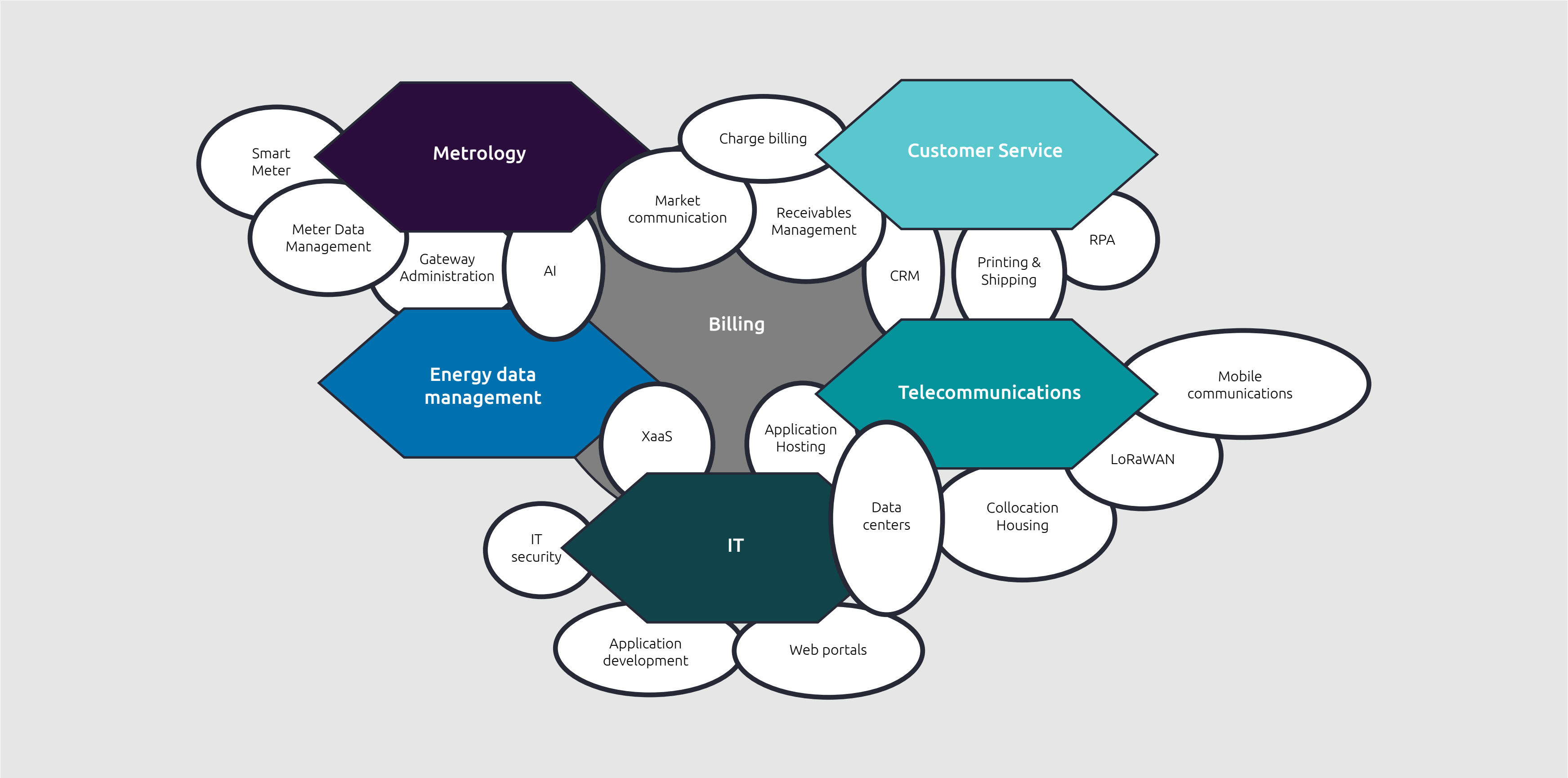
Conclusion:

In a world of heavy competition, new services offered to the customer can be a differentiator. Software platforms in the energy industry must provide a comprehensive view of customers and all associated CRM and m2c-processes in order to be competitive. In the B2C energy retail business, bundling products should be offered in combination with smart tariffs, differing from classic procurement contracts and offering flexibility. E-mobility and smart metering services are also becoming more attractive, but that is not all. Intelligently regulating energy and water use in buildings via smart building/smart home or energy-as-a-service (EaaS) is gaining popularity as well.

Establishing self-consumption models for prosumers and offering flexible services to regulate supply and demand in electricity networks can be delivered by platforms today. Platforms that enable the billing of innovative energy products and services will be the ones succeeding on the European market. A clear trend towards platforms that offer the possibility of being used via cloud services (SaaS) are emerging – cloud platforms may help lower costs and increase process efficiency via automation and standardization. Also, they facilitate the use of sophisticated services, such as analytics and AI and accelerate innovation processes without costly commitments for the IT infrastructure.

FIGURE 7

Current market developments: Related business segments in the meter-to-cash market



Source: Baubkus Jahresreport Energiemarktdienstleister 2021

Energy retailers: Business-wide transformation is fundamental to survival - SaaS implementation is only the tip of the iceberg

CAROLINE MILNER
BEN TOMLINSON-MEN
CONNOR O'GORMAN
MARISSA PAPAS
ALAIN BOLLACK

Leveraging the SaaS revolution: How energy retailers in the U.K. are transforming their customer experience, improving their cash position and shifting their employee culture

SaaS technology is the springboard to revolutionize a business. It presents an opportunity to upgrade business-critical systems, as well as an opportunity to transform their business as it relates to cash, culture, and customers.

Energy retailers in the U.K. are leading the way with SaaS-led transformation. Five out of the six largest U.K. retailers have embarked on this transformation, not just by choice but necessity. Two of the largest global SaaS vendors (ENSEK and Kraken) are based in the U.K., with this technology leading the way across the globe.

The three focus areas that are enabled by a SaaS-led business wide transformation include:

- **TRANSFORMING THE CUSTOMER EXPERIENCE:** More than ever, customer service is a key differentiator for energy retailers in the U.K. and across the world. Enabling customer centricity and being able to go above and beyond for customers is vital to ensure customer loyalty.
- **IMPROVING THE CASH POSITION:** Reducing cost to serve is paramount to energy retailers' survival when the market conditions are so harsh. Bad debt management, particularly in the face of unprecedented price increases, is also critical.
- **SHIFTING CULTURE:** Employees who are empowered will succeed more in their roles and be loyal to the brand. In order to do this, they need the right tools and culture in the business.

CUSTOMERS:

Energy retailers - and consequently their customers - are facing unprecedented levels of change in the face of volatile market conditions and large-scale industry transformations. In the U.K., recent industry changes such as Faster More Reliable Switching (FMRS) and Market-wide Half Hourly Settlement (MMHS) are just two examples, both of which are aimed at increasing transparency and giving customers more control over their energy usage. Switching to a SaaS provider in the face of such change is providing energy retailers with the opportunity to go one step further by building technology solutions which achieve improved customer service levels – a vital contributor to success in an increasingly competitive and complex market landscape.

Enabling customer-centricity

Legacy energy retailers in the U.K. have recently struggled to keep up with increasing customer service demands, with archaic technology systems playing a substantial role in their inability to outperform newer, more agile energy retailers in a range of customer satisfaction surveys like Net Promoter Score (NPS) and Trust Pilot.

One of the main advantages of a transition to a cloud-based SaaS platform is increased agility and the ability to react rapidly to market changes and shifting customer demands. This leads to a reduction in both the time and cost taken to implement changes and improvements to customer service. Retailers using a SaaS platform can respond quickly to changes in energy wholesale prices, re-configuring their propositions and prices to remain ahead of their competitors.

Single view of the customer

In order to manage increasing amounts of industry and customer data, energy retailers in the U.K. have developed robust systems and automated processes which collect and analyze this data in real-time.

Increasingly, energy retailers are turning to SaaS platforms to make data collection and analysis simpler and more effective. SaaS platforms provide easy, real-time access to customer data and insights, which allow energy retailers to understand key metrics. In turn, this enables them to provide more personalized, persuasive service offerings to customers. Retailers like Octopus Energy in the U.K., for example, offer agile tariffs which enable customers to shift their energy use to periods when the price is lower. This is particularly useful for customers who charge Electric Vehicles (EVs) at certain times of day. It is through SaaS platforms that such retailers are able to collect and process raw data into actionable insights and turn them into scaled, personalized products.

Innovative consumer products and propositions

In an increasingly competitive landscape, some energy retailers are no longer focusing solely on energy supply as their main value proposition; instead they are diversifying the range of products and services they offer customers. Some retailers, like British Gas, are focusing their efforts on the installation of energy appliances like EV chargers, storage batteries or heat pumps. Others, like Utility Warehouse, are creating bundled service offerings, combining energy tariffs with broadband.

SaaS platforms are particularly helpful in such cases, providing retailers with a simple way to deliver new products and propositions into the market and to attribute a range of products and services to a single customer account.

CASH:

Energy retailers must maintain a focus on cash flow, continually evolving the business model to reduce cost-to-serve to mitigate the rising price of energy across the U.K. In the U.K., the regulator continues to implement cost-focused regulation at short notice. This means suppliers need to adapt to survive. SaaS platforms are a key enabler for this.

Reducing cost-to-serve

The balance between cost-to-serve and the quality of the customer experience is more important than ever. Energy retailers look to find that perfect balance between delivering high-quality service to customers and having a low cost-to-serve. By having an agile technology platform, the cost-to-serve can be reduced. Energy poverty (due to unprecedented price increases) will also make bad debt management a critical topic.

Having the right CRM system means having data available instantly, moving to new methods of customer service (i.e. chat bot or web chat), enabling advisors to talk to multiple customers at once, and becoming more efficient.

Regulatory challenges

In the U.K., energy retail is heavily regulated; continual additions to regulation are made as Ofgem looks to modernize the energy industry, restrict prices, and tackle the problem of an unstable market. In the U.K., this includes price restrictions and various green schemes (i.e. schemes aimed at supporting green technology and making homes more efficient). These regulations challenge the traditional cost models for energy retailers.

It is more important than ever for retailers to have the right systems in place to allow businesses to be agile when meeting new compliance measures. Updates to SaaS platforms are easier to implement and more cost effective, helping to reduce the risk of regulatory non-compliance.

Connected infrastructure

SaaS platforms enable IT infrastructure to be connected through the cloud, providing reduced costs through elimination of hardware and infrastructure maintenance.

Connecting all systems using a SaaS platform means data will be shared across platforms, giving a single view of the customer; improving the visibility across the business will vastly improve both efficiency and levels of customer service.

CULTURE:

A satisfied and empowered workforce is key to a company's success. At a time when employee turnover is rising, it is vital that energy retailers can attract and retain the best talent. Research shows that the top three reasons people are resigning in the U.K. are money, remote working opportunities, and overall role satisfaction.[1] SaaS platforms are a key enabler for energy retailers to win in each of these spaces, providing retailers with the opportunity to redesign the employee experience and widen the skillsets of their workforce.

Aligning employee incentives

There is a direct correlation between salary and employee satisfaction. In fact, research shows that 35% of people in the U.K. consider leaving their current employer after receiving better offers from competitors.[2]

Generally, there is an increasing trend for energy retailers to increase agent salaries when they transition to a SaaS platform. This tends to be a response to retailers giving agents more responsibility and autonomy, leading to an upskilling of employees.

Remote working as the future of contact centers

Like many companies, energy retailers in the U.K. have transitioned into more modern, hybrid working practices. Some, like British Gas, have given their agents the opportunity to work from home 100% of the time. Others, including So Energy, have adopted a more hybrid approach, giving employees the opportunity to work from home two days during a typical working week.

This increases reliance on technology solutions which retailers rely upon to maintain standards, monitor customer resolutions and service, and provide accurate, real-time reporting on agent performance. Many SaaS platforms provide this functionality, providing a simple, consistent and remote view of the customer which agents can access from anywhere. Energy retailers that leverage SaaS platform solutions have, therefore, been able to mitigate these risks and challenges. As such, they have been able to offer hybrid, remote working opportunities to attract and retain their talent.

Empowering agents

SaaS platforms are a key enabler to employee satisfaction, often putting agents closer to the customer, increasing their levels of responsibility and accountability for achieving the right customer outcome. POD models are an increasingly popular method for energy retailers to empower their agents, by assigning agents to a smaller subset of customers of which they are responsible. PODs are also given more autonomy to provide suitable outcomes to customers which are not constrained by processes or bureaucratic ways of working.

By empowering teams through more agile ways of working, energy retailers can leverage SaaS platforms to create an efficient workforce which are free to make better, more rounded customer decisions. Teams are self-healing and able to resolve customer queries in a more agile and efficient manner. By removing the shackles of red tape and bureaucracy, agents are empowered to truly find the best solution for their customer's needs.

1 Capgemini Thought Leadership: 'The Great Resignation
2 https://www.achievers.com/wp-content/uploads/2021/03/Achievers-Workforce-Institute-2021-Engagement-and-Retention-Report.pdf

NORTH AMERICA CONSUMPTION EVOLUTION, AVERAGE PRICES AND RETAIL PRICES/ RESIDENTIAL MARKET/ B2B MARKET

HARIHARAN KRISHNAMURTHY
ALEXANDER RODRIGUEZ
SARA STRITHARAN
SWETANTA LAHIRI
PARIKSHIT VYAS

U.S. sources of electric generation: Renewable energy growth to accelerate in 2022 due to concern for climate change and support for environmental, social, and governance needs

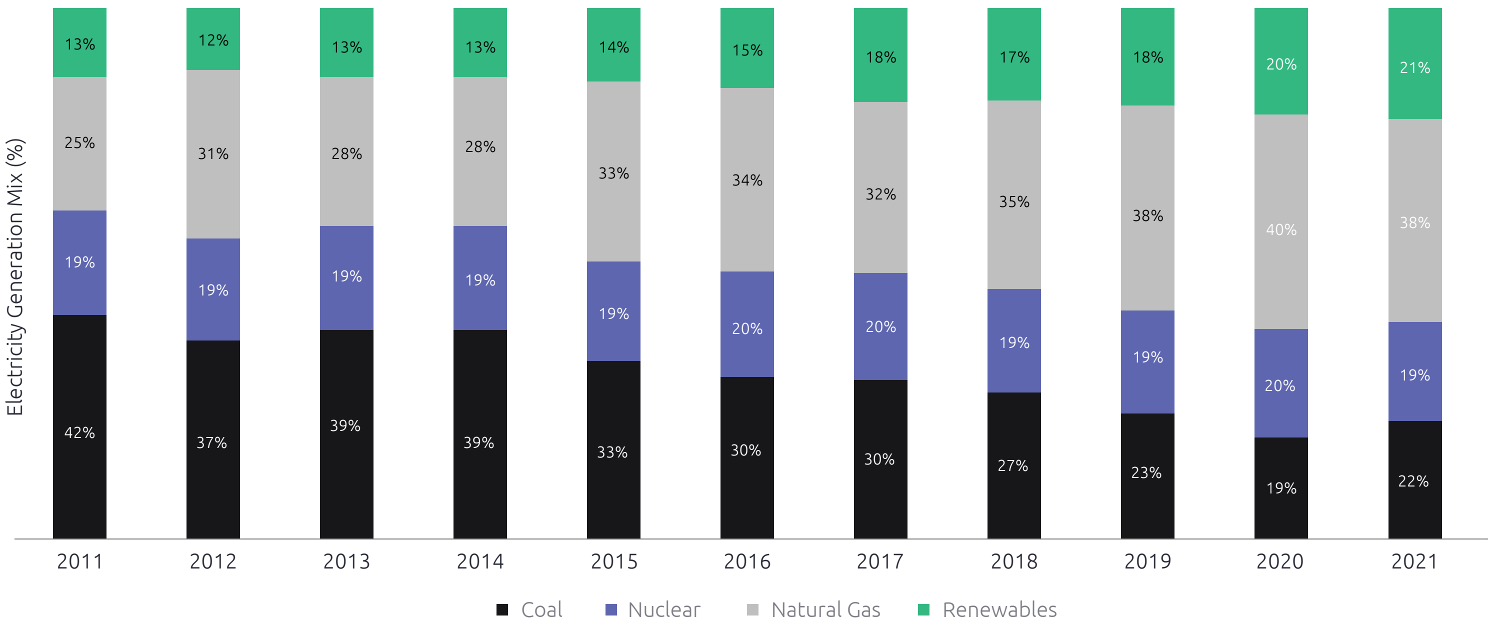
Renewable energy production is growing very fast in the U.S. Solar, wind, and other renewable energy sources contributed 20% to electricity generation in the U.S. in 2021; according to the EIA, the share is expected to double by 2050.

- Around 61% of U.S. utility-scale electricity generation was produced from fossil fuels (coal, natural gas, and petroleum) in 2021; around 19% was from nuclear energy; and about 20% was generated from renewable energy sources.
- The electric power sector in the U.S. successfully added 13 GW of utility-scale solar photovoltaic (PV) capacity in 2021.
- In April 2021, $8.25 billion in loans were released by the Department of Energy (DOE) for developers to enhance the grid's capacity so that it can carry renewable energy.

- The bipartisan infrastructure law was put forward by U.S. government. It includes $65 billion for grid modernization, along with new transmission lines, smart grid and clean energy technologies, and cybersecurity.
- In 2022, the Biden-Harris Administration, through the DOE, released a Request for Information seeking public input on the structure of an approximately $2.3 billion formula grant program to strengthen and modernize America's power grid against disasters such as wildfires and extreme weather.
- In 2022, 46.1 GW of new utility-scale electric generating capacity are expected to be added to the U.S. power grid, according to U.S. Preliminary Monthly Electric Generator Inventory.
- Almost half of the planned 2022 capacity additions are solar, followed by natural gas at 21% and wind at 17%.

FIGURE 1

U.S. historical electricity generation mix evolution, 2011-2021



Source: BNEF ~ Sustainable Energy in America Factbook, 2022. Note: Results are rounded to the nearest whole number and so, may not add up to 100%
http://www.bcse.org/factbook/#

U.S. electricity prices: The U.S. annual average retail price of electricity continues to rise

In 2021, the U.S. annual average retail price of electricity was about 11.18¢ per kWh.

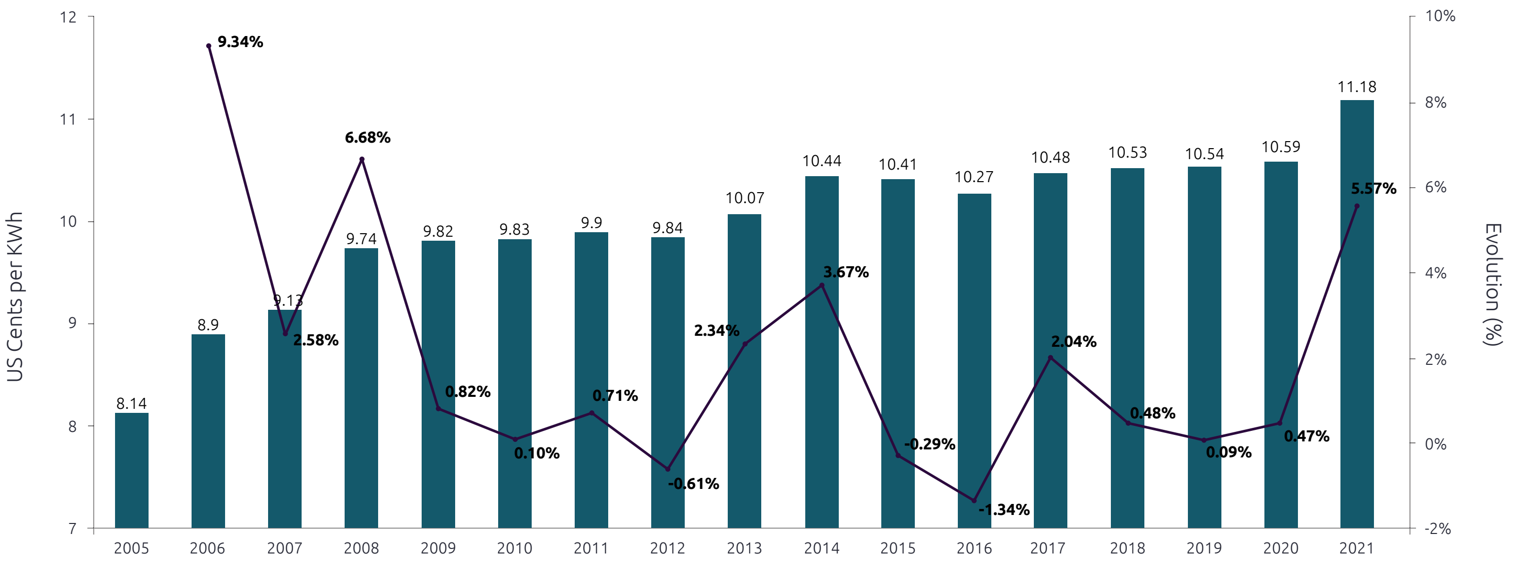
The annual average price by major types of utility customers in 2021 were:

- Residential: 13.72¢ per kWh
- Commercial: 11.27¢ per kWh
- Industrial: 7.26¢ per kWh
- Transportation: 10.21¢ per kWh
- Electricity prices vary by type of customer and locality.
    - Electricity prices for retail customers (residential and commercial) are highest due to a higher cost of distribution.
    - Electricity prices differ by locality based on factors including the availability of power plants and fuels, cost of local fuel, and pricing regulations.
    - The annual average retail electricity price for all types of electric utility customers in 2021 ranged from 30.35¢ per kWh in Hawaii to 8.17¢ per kWh in Idaho.
- Prices for most types of energy commodities increased significantly in 2021, including the cost of power generation fuels, especially natural gas, which helped push electricity prices higher in 2021.

- In 2021, EIA highlighted that the average nominal retail electricity price paid by U.S. residential electric customers rose at the fastest rate since 2008, increasing 4.3% from 2020 to 13.72¢ per kWh, according to data from Electric Power Monthly.
- The constraints on electricity supply pushed prices upwards in the wholesale electricity market in Texas and throughout the United States, raising electricity retail prices for some customers.
- The U.S. residential electricity price will average 14.6¢ per kWh in 2022, up 6.1% from 2021. This is primarily due to higher retail electricity prices and largely reflect an increase in wholesale power prices driven by rising natural gas prices.

FIGURE 2

U.S. average electricity price, (2005-2021) (¢ per KWh)



Source: US EIA 2022
https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g&endsec=vg&linechart=ELEC.PRICE.US-ALL.A~ELEC.PRICE.US-RES.A~ELEC.PRICE.US-COM.A~ELEC.PRICE.US-IND.A&columnchart=ELEC.PRICE.US-ALL.A~ELEC.PRICE.US-RES.A~ELEC.PRICE.US-COM.A~ELEC.PRICE.US-IND.A&map=ELEC.PRICE.US-ALL.A&freq=A&start=2005&end=2018&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=

Canadian electricity prices

The price of electricity is $0.113 per kWh for households and $0.097 for businesses. This includes all components of the electricity bill such as the cost of power, distribution, and taxes.

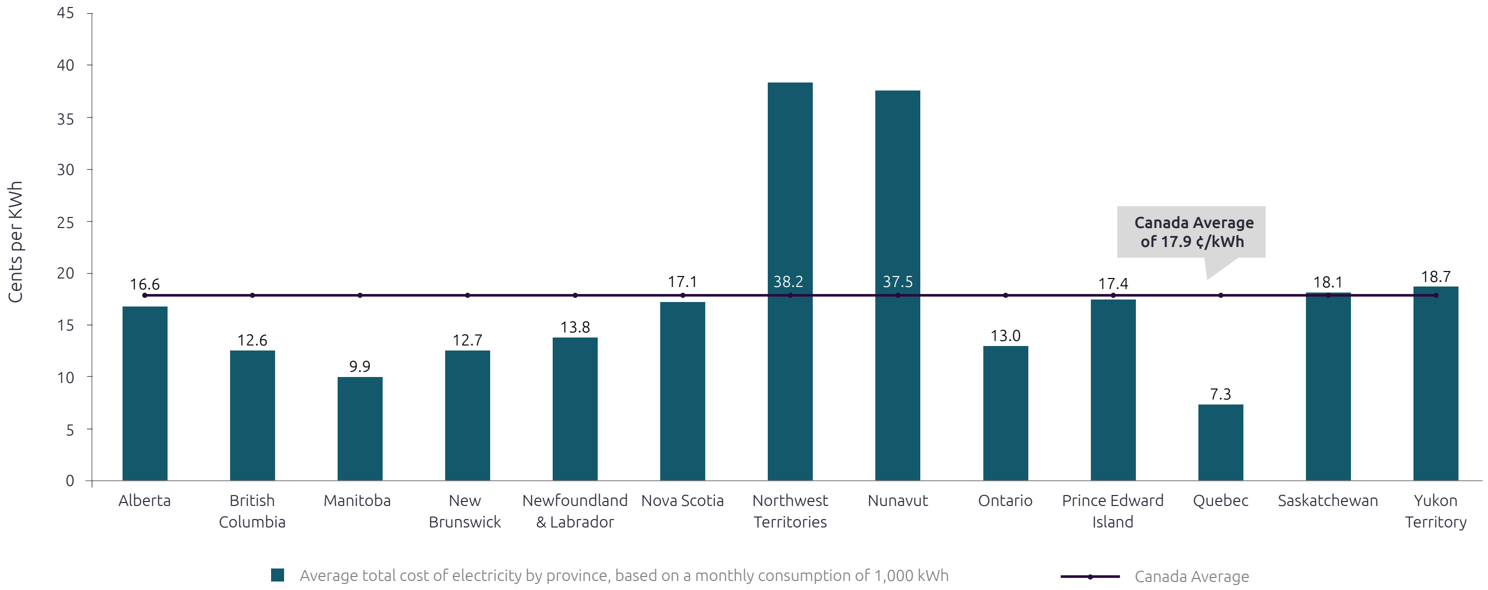
- Higher demand for electricity continued to put upward pressure on prices in January 2022.
- The Electric Power Selling Price Index for industrial and commercial users rose 6.5% month over month in January 2022, after increasing 0.4% in December 2021.
  - Electricity generation in Canada rose 5.4% to 65.1 MWh in January 2022, following a 1.3% decrease in December 2021.
  - The rise was primarily due to the increased electricity generation from non-renewable combustibles (+15.7%) and wind (+31.2%).
  - Most of the increase was attributable to Quebec and Ontario.
  - The electricity generation in Manitoba continued to decline because of low water levels in the province's reservoirs.
  - According to the Consumer Price Index, Canadian consumers paid around 21.2% more YOY for natural gas in January 2022.

According to a Hydro-Québec 2021 press release, electricity rates will increase by 2.6% from April 2020 onwards.

- Impact on residential customers' monthly bills:
  - For residential customers heating their homes with electricity, the 2.6% increase from April 1, 2022 will amount to an extra $1.93/month for a three-bedroom apartment, $3.60/month for a smaller house, $4.77/month for a midsize house, and $5.89/month for a large house.

FIGURE 3

Canadian average total cost of electricity by province, based on monthly consumption of 1,000 kWh (2021)



Source: Energy Hub.org, March 2021
https://www.energyhub.org/electricity-prices/

U.S. corporate procurement of clean energy: U.S. government's objective is to scale power purchase agreements to drive clean energy operations

Corporate power purchase agreements (PPAs) for clean energy totaled a record 17 GW in 2021, a rise from 13.5 GW in 2020 and the previous highest record of 14.1 GW in 2019.

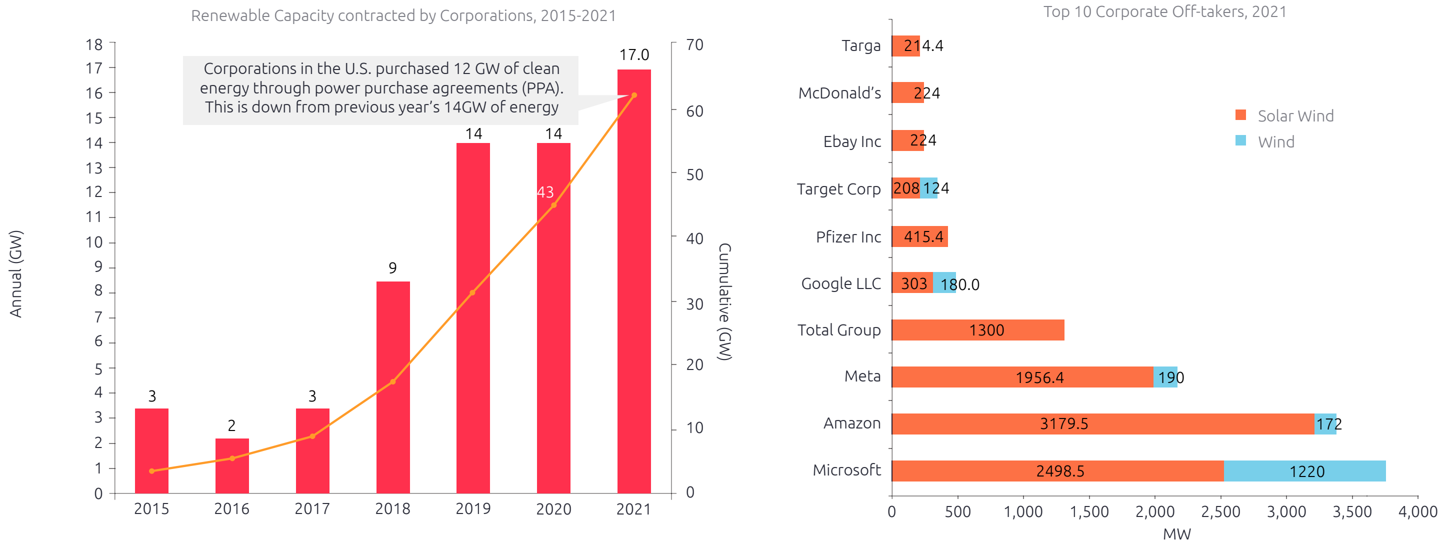
- Major utility companies in the U.S. are following the PPA model, which allows them to sign large deals.
  - Although the PPA model is being followed, only 40 large companies announced large deals, down from 67 in 2020.
- Companies buying clean energy in the U.S. mostly prefer solar with contracted capacity standing at around 13.4 GW.
  - Solar's generation profile is aligned more with peak demand in the middle hours of the day, which means it captures higher realized prices.
  - Furthermore, a rising number of companies are using green tariff initiatives with utilities in regulated markets, such as the southeast and southwest parts of the U.S.
  - The southeast and southwest parts of the U.S. tend to have stronger solar resources.

Big tech companies lead the pack in procuring clean energy across the U.S.

- Microsoft leads the pack with 3.7 GW, followed by Amazon (3.4 GW), Meta (2.2 GW) and Google (0.5 GW).

FIGURE 4

Corporate procurement of clean energy, 2021 (GW)



Source: BNEF ~ Sustainable Energy in America Factbook, 2022
http://www.bcse.org/factbook/#

- Other companies in the top 10 includes: Total Group, Pfizer, Target Corp., Ebay, McDonald's and Targa Resources.
- It is quite conspicuous that solar is dominating when it comes to buying clean energy.

PPAs

- In 2021, Dow in U.S had signed eight new renewable power purchase agreements (RPAs) spanning Europe and the Americas.
- The new RPAs provide cost competitive access to an additional 132 MW of clean power capacity from wind and solar with zero capital investment from the company; this brings Dow's total access to more than 850 MW of clean energy.

U.S. corporate procurement of clean energy: The U.S. announced approximately 8 GW hydrogen-compatible power turbines, primarily at brownfield sites

Out of 10 planned projects in the field of nuclear energy in the U.S., around two-thirds have hydrogen-natural gas blend targets.

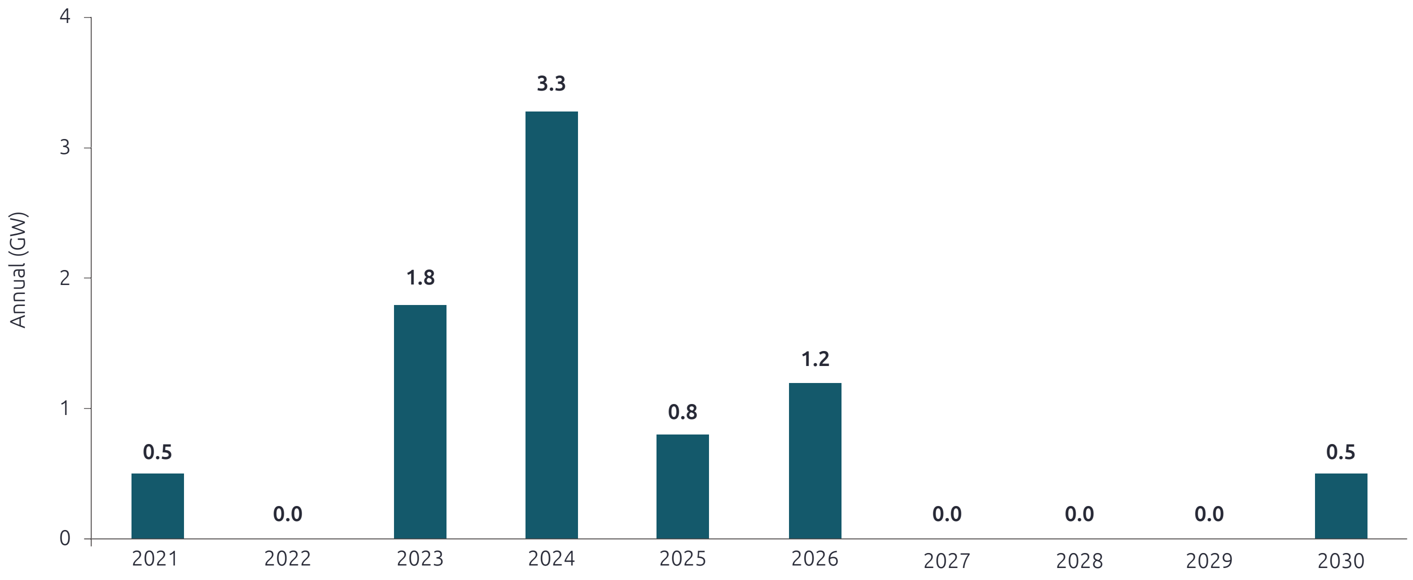
- Half of the projects on clean energy is set to run on hydrogen by 2045.
- 15-16 million metric tons of hydrogen is currently produced by the U.S., of which around 65% is through plants dedicated for hydrogen production. Most of this produced hydrogen is "gray", meaning it is produced from unchanged natural gas.
- There has been an announcement by Air Products for building the largest "blue" hydrogen facility with natural gas and carbon capture and storage (CCS) in Louisiana.
- According to the Department of Energy, approximately 120 MW of electrolyzers were installed as of June 2021; it is expected that 262-336MW of electrolyzers for green hydrogen production would be installed during 2022.
- A majority of the electrolyzers will be from Plug Power, a fully cohesive hydrogen company which opened a gigafactory in New York in 2021.

Funding for accelerating hydrogen technologies.

- The DOE pledged $40 million in funding for the advancement, development, and deployment of hydrogen technologies which are clean.
- The DOE is also interested in projects related to "Nuclear Coupled Hydrogen Production and Use."

FIGURE 5

Planned and projected capacity of hydrogen-fired power plants in U.S. - 2021 to 2030



Source: BNEF ~ Sustainable Energy in America Factbook, 2022
http://www.bcse.org/factbook/#

SOUTH EAST ASIA CONSUMPTION AND RETAIL PRICES/ RESIDENTIAL MARKET/ B2B MARKET

SWETANTA LAHIRI
ISHANDEEP
PRATIK RAJMANE

Electricity generation in most Southeast Asian countries has increased with a focus on renewable power generation

Southeast Asia is one of the fastest-growing regions in the world in terms of electricity demand. Governments have been introducing policies and measure to boost power generation.

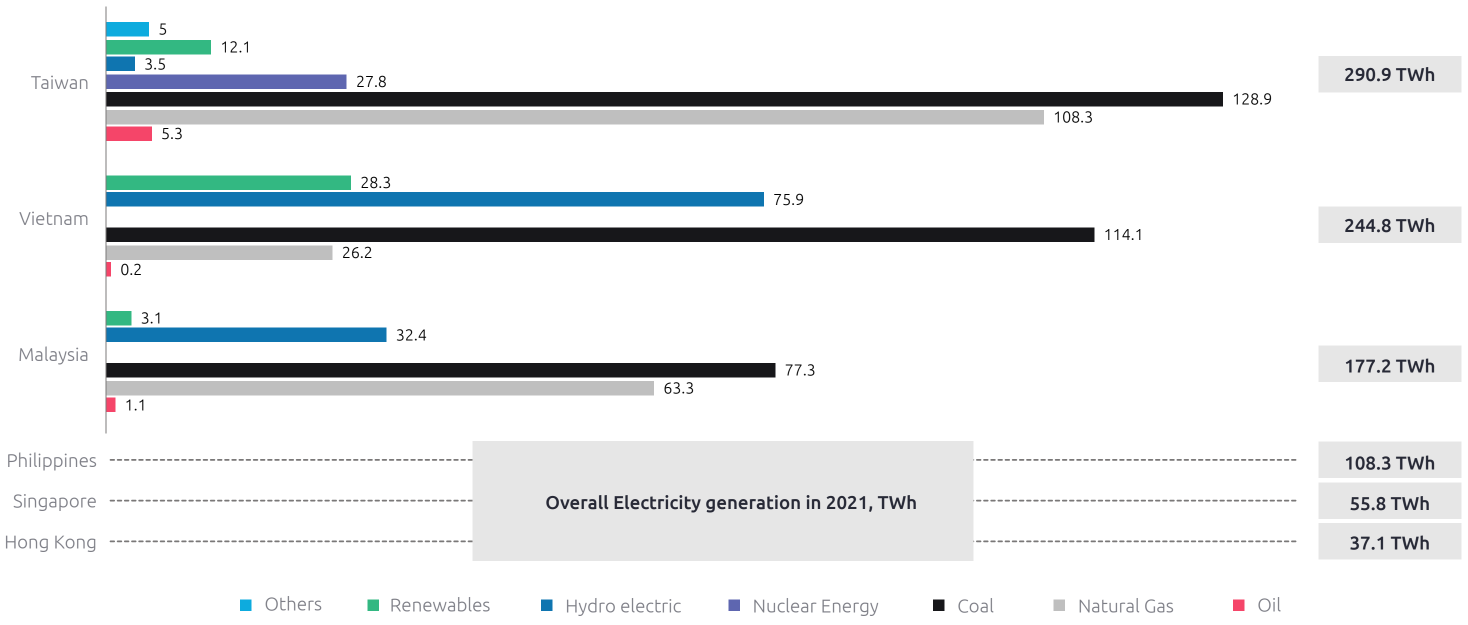
- Southeast Asian countries have put forward ambitious regional development projects to support economic growth and the integration of higher shares of renewable energy in their electricity generation mix.
- Vietnam and Taiwan increased their electricity generation in 2020.
- **Vietnam's electricity generation increased by 4% in 2021 vs 2021**
  - Per Reuters article dated April 26, 2022, Vietnam announced that it wants to nearly double the total installed power generation capacity to 146,000 megawatts (MW) by 2030 and prioritize development of renewable sources and reducing its coal dependency.
- **Electricity generation in Taiwan increased by 4.2% in 2021**
  - Coal power production is the main source for electricity production in Taiwan, followed by natural gas power plants and fossil fuel.

The governments of Hong Kong, Taiwan, Singapore, Vietnam, Malaysia, and the Philippines have long term plans and policies for developing low-carbon technology and increasing carbon reduction capacity.

- **Hong Kong:** According to Hong Kong's Climate Action Plan 2050, published in October 2021, it plans to expedite transformation to low-carbon energy with an increase in the share of renewable energy in the fuel mix for electricity generation from 7.5% to 10% by 2035.
    - Hong Kong aims to become carbon neutral by 2050. The city's two power utilities, CLP Power and HK Electric are overhauling operations to meet the goal.
- **Taiwan:** Taiwan is dependent on fossil fuels to meet around 98% of its energy consumption. Thus, for the reduction of importing fossil fuels, the Taiwanese government plans to develop low-carbon technology and increase carbon reduction capacity.
    - It plans to generate 20% of its energy from renewables by 2025 by adding 14.2 GW for solar energy and 5.7 GW of already allocated offshore wind power to the grid.

FIGURE 1

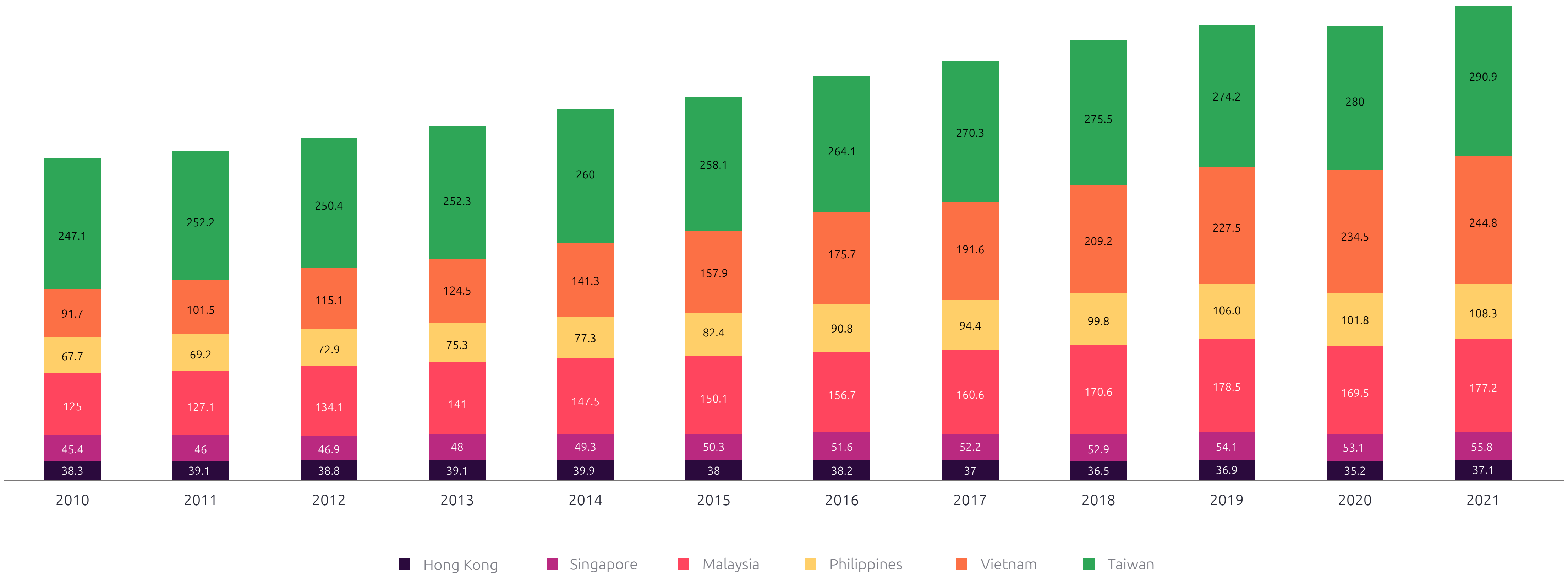
SEA Electricity generation by Fuel (terawatt hours), 2021



Source: BP Statistical Review of World Energy, 2022
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

FIGURE 2

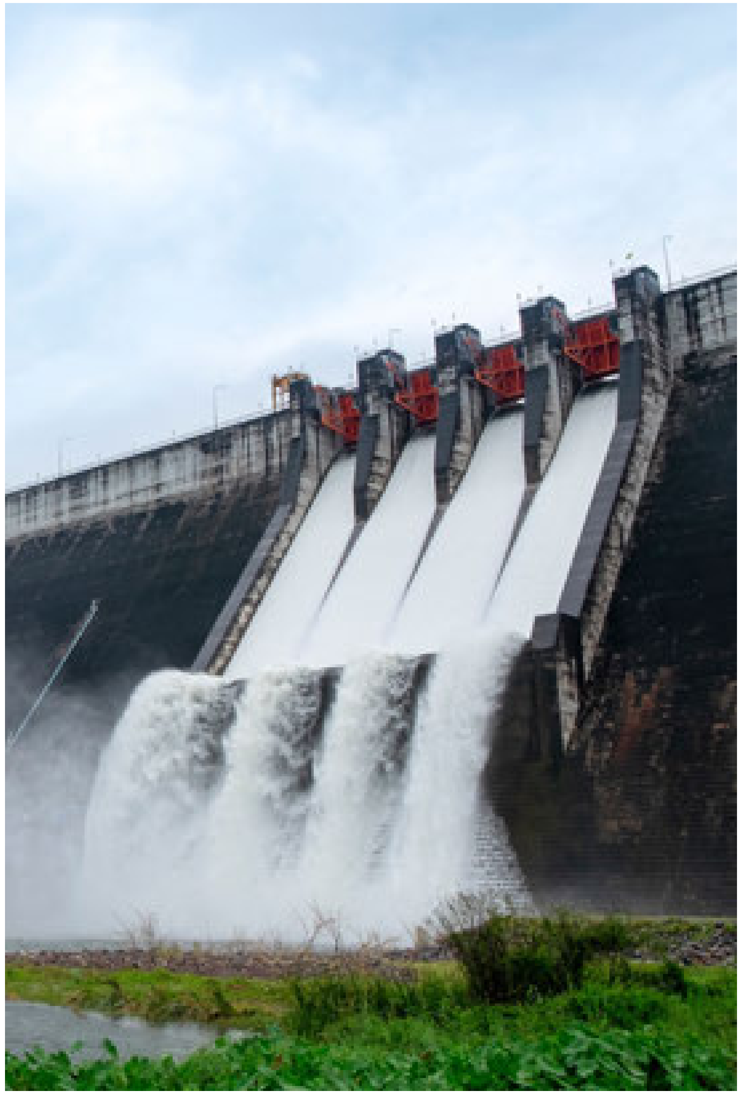
SEA – Electricity generation by country (terawatt hours), 2010-2021



Source: BP Statistical Review of World Energy, 2022
https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf

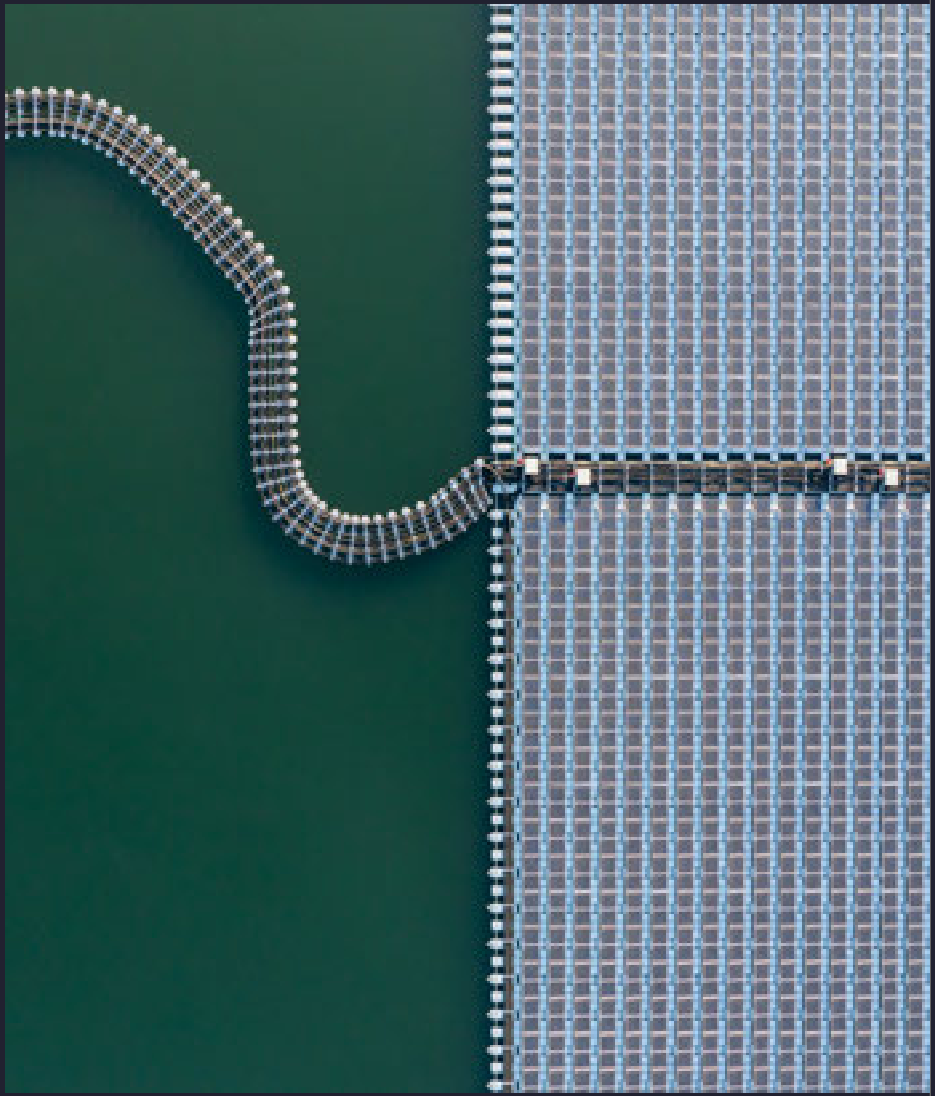
Most of the Southeast Asian countries are focusing on renewable power generation to reduce carbon emissions

- **Singapore:** The country plans to focus on solar, regional power grids, emerging low-carbon alternatives, and natural gas.
  - Solar is a promising source of energy for Singapore, and it is accelerating solar deployment across the country. In 2021, it generated 0.4 terawatt hours of energy from solar. Also, the energy storage systems (ESS) counters the intermittency of renewable energy sources such as solar.
  - The country has plans to focus on regional power grids to access low- carbon electricity and plans to add 4 GW of low-carbon electricity imports by 2035.
  - Emerging low-carbon alternatives: Singapore plans to use emerging low-carbon solutions such as carbon capture, utilization and storage technologies (CCUS), and hydrogen, which will help reduce the country's carbon footprint.
  - Singapore generates around 95% of its electricity from natural gas. From 2000, the country has increased natural gas power generation from 19% to 95%. Additionally, it plans to work with the industry to improve the energy and carbon efficiency of natural gas generation units.
- **Vietnam:** The country plans for total power generation capacity of 146,000 MW by 2030, prioritizing development of renewable sources and reducing coal power generation.
  - According to Vietnam Electricity (EVN), a state-owned enterprise, Vietnam is the largest power generator in Southeast Asia, with total installed generation capacity of 76,620 MW at the end of 2021.
- **Malaysia:** The Malaysian government has implemented a number of renewable energy programmes such as Feed in Tariff (FiT), Net Energy Metering (NEM), Large Scale Solar (LSS), and Self Consumption for Solar Installations with an aim of increasing its renewable energy share in capacity mix to 20% by 2025.
  - The 12th Malaysia Plan, a medium-term plan with the objective of "A Prosperous, Inclusive, Sustainable Malaysia," highlights carbon tax credits, which will levy a tax on companies burning fossil fuels by volume or weight of emissions. These implementations will drive businesses to leverage sustainable practices.
- **Philippines:** The government plans to increase solar PV deployment with the target capacity of 15.3 GW by 2030, as per National Renewable Energy Program (NREP) 2018-2030.
  - Additionally, under the Philippine Energy Plan (PEP) 2018-2040, the government has announced its NREP 2020-2040 (draft), where it plans to add 11,070 MW of new solar capacity.



07

FINANCE



EUROPE PLAYERS, REVENUES, MARGINS, DEBTS, DIVIDENDS

FLORIAN SCHALL
CHARLES DAGICOUR
IBTIHAL KARFIA
DEBARGHYA MUKHERJEE

Dashboard of the main Energy & Utility companies in Europe

Seven indicators are going to be analyzed to give an accurate view of the operational and financial performance of the companies within this panel, including:

1. Revenues
2. EBITDA margin
3. Net debt and leverage ration
4. Stock performance
5. Dividend yield
6. Credit rating
7. CO_2 intensity

Based on the above indicators, utilities are divided into three groups: Leading (those well ahead of average on a given indicator), Average, and Lagging (those below the average on a given indicator).

A dynamic comparison is done for each of the utilities (group of utilities) to determine whether its performance has been ahead of the previous year or not. This analysis also takes into consideration how well the utilities of the studied panel overcame challenges related to the Covid-19 crisis.

FIGURE 1

Companies' panel key financial indicators at a glance

	EUR Bn		%	EUR Bn	X EBITDA	EUR	
Companies	**2021 Revenues**	**2021 EBITDA**	**2021 EBITDA Margin %**	**2021 Net Debt**	**2021 Net debt/EBITDA**	**2021 Stock price**	**2021 DPS (Dividend Per Share)**
EDF	84.5	18.0	21.3%	43.0	2.39	8.0	0.58
ENGIE	57.9	10.6	18.3%	38.3	3.61	12.2	0.85
ENEL	88.0	17.6	20.0%	52.0	2.96	6.7	0.38
Iberdrola	39.1	12	30.7%	39.3	3.28	10.4	0.4
E.ON	77.3	7.8	10.1%	38.7	4.96	9.5	0.5
EnBW	32.1	2.8	8.7%	8.7	3.11	76	1.1
RWE	24.5	3.65	14.9%	-0.4	0.0	35.7	0.9
EDP	15.1	3.7	24.5%	11.6	3.14	4.3	0.19
SSE	7.9	2.6	32.4%	8.6	3.36	18.4	0.9
Vattenfall	16.9	7.0	41.4%	4.2	0.60	Not listed	NA
Centrica	17.1	2.15	12.6%	-0.8	0.0	0.78	To restart/announce
Orsted	10.4	3.26	31.3%	3.2	0.98	112.2	1.7
Uniper	163.9	1.85	1.1%	0.32	0.17	29.2	0.07
CEZ	9.2	2.55	27.7%	4.47	1.75	33.4	2.1
Fortum	112.4	3.81	3.4%	0.78	0.20	26.9	1.14
Naturgy	22.1	3.52	15.9%	12.83	3.64	28.6	0.3
Average	**48.7**	**6.4**	**19.6%**	**16.5**	**2.1**		**0.8**

I. EUROPE PLAYERS, REVENUES, MARGINS, DEBTS, DIVIDENDS

European utilities: Revenue

Main European utilities have shown strong revenue recovery. Most of them reached higher revenues, even compared to pre-pandemic levels. A combination of rare circumstances is behind the extraordinary results.

- 2021 was completely different from 2020, since the main trigger for utilities' revenue increase comes from **high gas prices,** and consequently, **high power prices.** On the one hand, the energy demand increased due to the rapid recovery of the global economy and colder weather in Europe. On the other hand, the energy supply was low due to reduced wind availability and hydro activities combined with low gas storage levels. This **imbalance between energy supply and demand** created high volatility in the gas market, leading to a sharp increase in the electricity market. It is worth mentioning that **higher carbon allowances** – driven by strong European climate policies and higher use of coal – was one of the triggers of the electricity price increase.
- Consequently, the global evolution for our sample shows an **average increase of 47% in revenue in 2021 compared with 2020.**

Uniper and Fortum not only topped the revenue ranking with outstanding sales results but also registered the highest year-to-year increase in revenue, all due to record power and gas prices.

- **Uniper** more than tripled its revenues, mainly due to the difference between spot prices and hedged prices of its contracts, although no effect on EBIT is to be noted. It should be noted that Uniper revenues from energy trading activities account for 86% of sales.
- Almost all business units at **Fortum** achieved great sales results, mainly due to Uniper's gas business including its trading business, and higher nuclear and hydro volumes.

Almost all utilities raised their revenues by 15-40%, reflecting the rise of energy prices. SSE, Centrica, and Engie had a minor revenue increase (less than 4%).

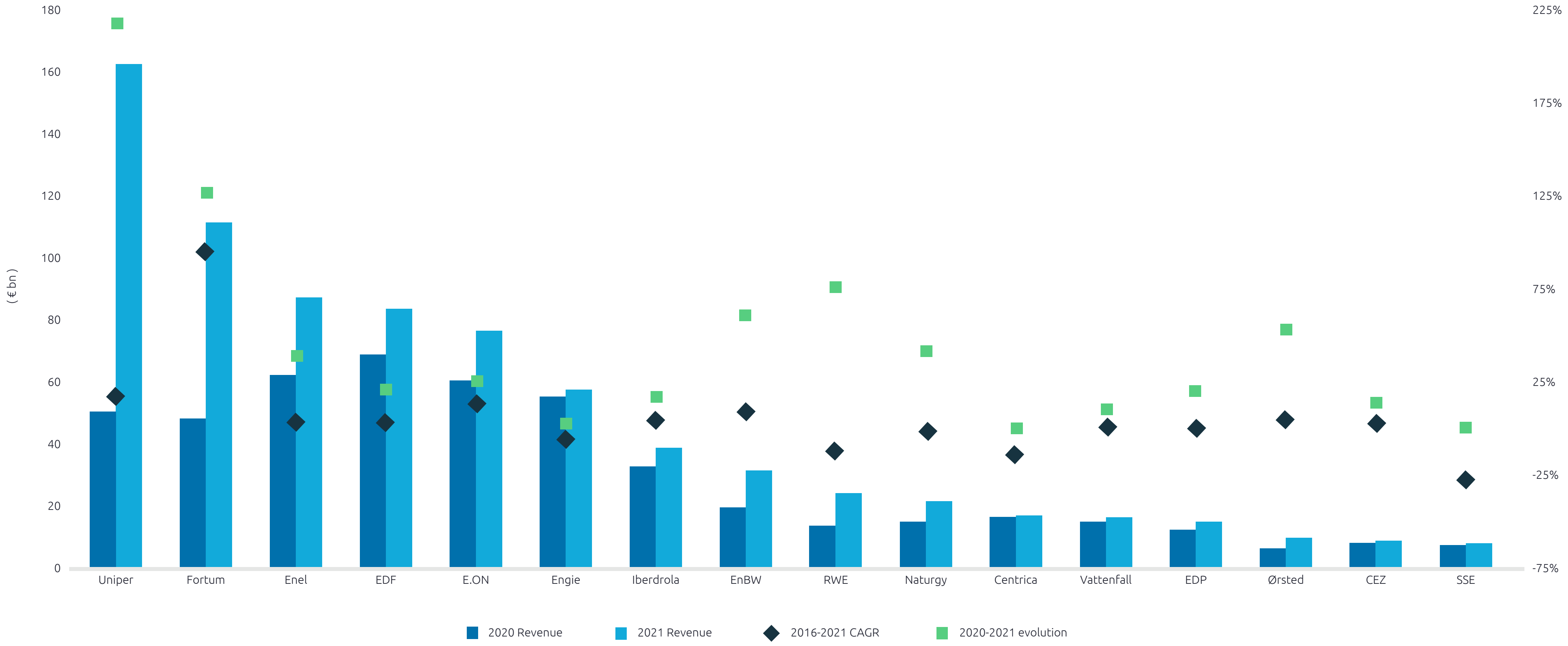
In addition to the rise of gas and electricity prices, some additional factors are worth mentioning:

- **E.ON** established E.ON Energy Markets, a new procurement unit, which contributed to a €14.5 billion increase in revenues.
- **EnBW** benefitted from its trading activities, as well as from the acquisition of Gas-Union Transport.

I. EUROPE PLAYERS, REVENUES, MARGINS, DEBTS, DIVIDENDS

FIGURE 2

2020 & 2021 revenues in € billion and CAGR 2016-2021



Source: Thomson Reuters EIKON data 2021, Annual Reports

European utilities: EBITDA margin

European utilities faced a decrease in weighted EBITDA margin from 20.2% in 2020 to 19.6% in 2021, with most recovering to their pre-pandemic levels. While almost all utilities increased their EBITDA, the rise was not as fast as their revenue levels.

Companies' performance benefitted from higher electricity and gas prices and increasing renewables capacities, while lower wind performance and higher costs for grid businesses had adverse effects on EBITDA.

The studied sample of utilities in Europe can be divided into three main groups based on their EBITDA margin:

1. **The overperforming companies, Vattenfall and SSE, succeeded in significantly improving their EBITDA margin (+33% and +39%, respectively). Orsted and Iberdrola continue to overperform year after year.**

- **Vattenfall** experienced very good performances of nuclear and hydropower generation, as well as wind generation, due to higher electricity prices and newly built capacity.
- **SSE's** strategic move to leverage renewable power generation is paying off, as the company continues to increase its profitability for the third consecutive year, supported by a renewables business and successful disposal programs.
- While **Orsted** was expecting lower EBITDA in 2021, it turned out differently due to combined heat and power (CHP) plants and strong performance of the gas business. This was offset by a lower offshore wind performance due to low wind speeds.

2. **The companies that slightly increased or reached their pre-pandemic profitability**

These companies presented more than average EBITDA margins compared to the selected sample.

- Enel's EBITDA margin (20%) decreased to recover a pre-pandemic level. This is mainly due to cost increases as a result of rising gas and electricity prices. Yet, EBITDA increased as new commercial initiatives were developed by Enel X, new renewable energy plants started, and Open Fiber was sold.
- After years of stable EBITDA margins, Engie succeeded in increasing its profitability by 17%, mainly driven by strong operational performance, price environment, Covid-19 recovery, and colder temperatures.

3. **Companies with decreasing EBITDA margins compared to 2020 and 2019**

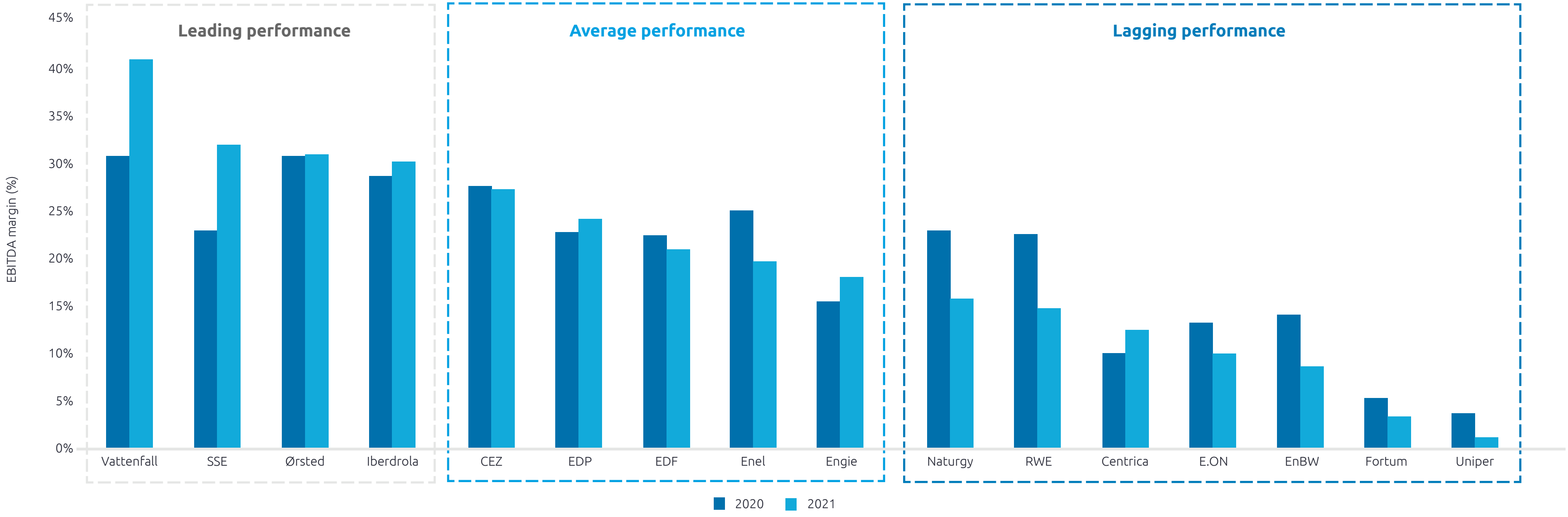
With the exception of Centrica, all companies in the panel reached lower profitability compared to 2020 and didn't recover to their pre-pandemic performances. However, EBITDA reached exceptional levels for some of these companies, even if it did not grow at the same pace as revenue levels. This can mainly be explained by higher energy costs and company-specific factors:

- Even though overall EBITDA increased following a better business performance, adverse factors had a negative impact on **E.ON's** performance due to the higher costs of energy networks. **EnBW** faced the same difficulties, as customers were provided the basic supply of energy at higher procurement costs. Also, the company faced higher expenses for the grid infrastructure and lower performance from renewables.

- **Uniper** and **Fortum** faced a significant decrease in EBITDA margins. Their EBITDA increased significantly, but not as rapidly as their revenue, which topped at exceptional levels. The companies gained significantly from the gas and power price increase.
- **Centrica** hits its best performance since 2014. However, this result does not reflect business performance. It is mainly due to exceptional items and certain remeasurements.

FIGURE 3

2020 & 2021 revenues in € billion and CAGR 2016-2021



	Vattenfall	SSE	Ørsted	Iberdrola	CEZ	EDP	EDF	Enel	Engie	Naturgy	RWE	Centrica	E.ON	EnBW	Fortum	Uniper
2020 – 2021 evolution	+32.8%	+39.1%	+0.1%	+5.5%	-1.0%	+6.5%	-6.6%	-21.4%	+16.6%	-31.6%	-34.7%	+23.3%	-24.1%	-39.0%	-37.2%	-70.3%
2016 – 2021 CAGR	+7.2%	+34.4%	+1.0%	+1.6%	-0.9%	-0.2%	-2.2%	-0.8%	+5.1%	-5.9%	-4.5%	+8.4%	+19.2%	+14.7%	-34.4%	-11.7%

Source: Thomson Reuters EIKON data 2021, Annual Reports

European utilities: Net debt

Net debt level keeps slowing in accordance with last year's trend.
Net debt decreased globally for European utilities dropping from an average of €19.6 million to €16.7 million (a decrease of 26%).

As per last year, uncertain times and important foreseen investments lead utilities toward better debt management and reshaping.
Globally, European utilities are decreasing their leverage ratio from an average of 3.41X (2020) to 2.13X (2021). This is the second time in a row that utilities are globally reducing their indebtment level. Two main factors might explain this:

- European utilities are confronting harsh times and facing ever-increasing competition from new (renewables) actors and a complex economic and geopolitical conjuncture. Energy prices are increasing, but utilities cannot rebill it to customers, therefore, they need to better manage their running costs, including cost of debt.
- Energy players are refocusing on their core business activities (i.e., energy production, sale, and distribution), selling some entities accordingly (e.g., Engie sold their parts in Suez, Equans) to limit use of debt and enhance liquidity to face huge investments in renewables or networks.

Focus on leaders for debt reduction: RWE, Centrica, and Fortum are decreasing their indebtment level by more than 80%.

- **Fortum** decreased its debt level by 93% in 2020. This tremendous decrease is mainly due to changes in short-term liability as well as stronger EBITDA and higher liquidity volume (divestments and non-cash items).
- **RWE** reached a positive net asset position leveraging an excellent free cash flow (activities from trading and supply). Plus, market-driven increases in the discount rates used to determine the present value of obligations also played a role, resulting in a decline in provisions for pensions.
- **Centrica** also reached a positive net cash position leveraging the sale of Direct Energy ($3.6 billion) and Spirit Energy Norway. Moreover, the company is also finalizing its restructuring by performing divestments in non-core business activities.

FIGURE 4

Net Debt and Leverage Ratios for 2020 and 2021

	2021 Net Debt [€ Mn]	2020 Net Debt [€ Mn]	(2021-2020 evolution)	Leverage Ratio 2021	Leverage Ratio 2020
EDF	43,000	48,484	-11%	2.39x	3.08x
Engie	38,300	27,354	40%	3.61x	3.13x
ENEL	51,950	62,045	-16%	2.96x	3.9x
Iberdrola	39,300	47,961	-18%	3.28x	4.97x
E.ON	38,700	33,192	17%	4.96x	4.09x
EnBW	8,700	12,360	-30%	3.11x	4.39x
RWE	-360	4,432	NA	0.0x	1.42x
EDP	11,600	19,553	-41%	3.14x	6.84x
SSE	8,600	11,268	-24%	3.36x	6.21x
Vattenfall	4,170	6,182	-33%	0.6x	1.31x
Centrica	-800	4,530	NA	0.0x	2.64x
Orsted	3,200	1,972	62%	0.98x	0.93x
Uniper	320	763	-58%	0.17x	0.39x
CEZ	4,470	5,507	-19%	1.75x	2.48x
Fortum	780	11,309	-93%	0.2x	4.24x
Naturgy	12,830	16,111	-20%	3.64x	4.51x
Average				**2.13x**	**3.41x**

Source: Thomson Reuters EIKON data 2021, Annual Reports

European utilities: Stock prices

European utilities stock prices shaken by the European energy crisis1

Average decrease of stock prices due to challenging landscape

While the 2021 analysis showed a 6% increase in stock price evolution, 2022 is marked by a diminution of European utilities' market value. Stock price comparisons from July 1, 2021, and July 1, 2022, indeed show a 13% reduction in European stock prices, with only four out of 15 companies from our panel seeing positive evolution. At the same time, Euro Stoxx 50 showed a slight 5% increase.

Few companies played their cards right and came out stronger from the European energy crisis.

Four of our company's panels saw their stock prices increase between mid-2021 and mid-2022. RWE basically remained steady over the year. CEZ saw the biggest growth, with stock prices rising by more than 40%. It benefitted from its long-term strategy toward emission-free generating facilities. Naturgy also benefited from decarbonization targets on a lesser level, with a 7% increase year-on-year.

Centrica benefited from its top position as a first energy retailer to British households and from strong performances from nuclear assets it partly owns, as well as from its upstream of oil and gas activities. As earnings were projected favorably for Centrica, the stock price grew by almost 30%.

Most companies have been affected by the unfavorable context of 2021 and 2022.

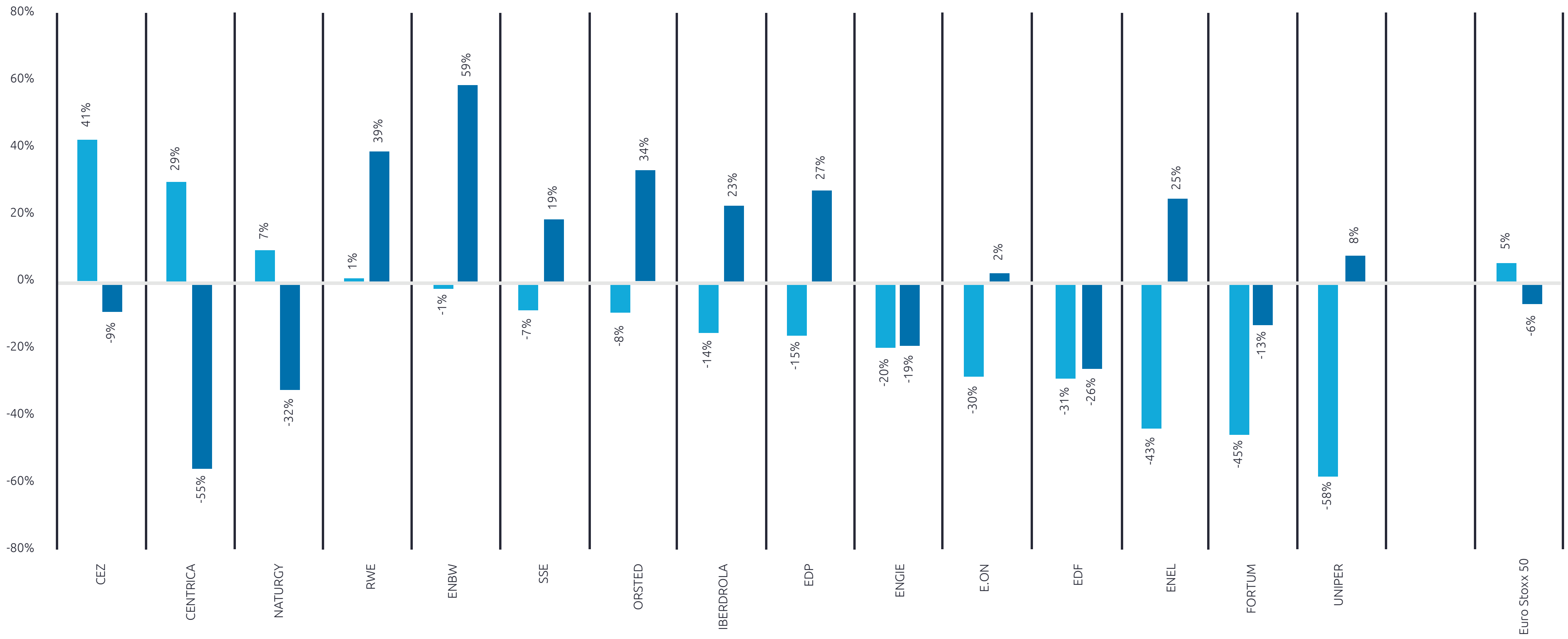
While gas prices started sky-rocketing in the second half of 2021 – due to a fast economic recovery – and surged again following the Russian-Ukrainian conflict, most European utilities are having trouble as European power markets present very strong price volatility . Because of this yet unknown volatility and pessimistic European economic forecasts, most stock prices have decreased during the past year.

French government about to renationalize EDF

At the beginning of July 2022, the French government announced it would buy back the 16% of EDF's stocks, which were not under its control in order to own 100% of the company. As announced, every share should be bought back for €12, explaining the share price to stabilize just under the €12 mark since the announcement. If the price is considered low compared to its €32 introduction price in 2005, the French government considered the offer generous as it was 53% above the stock price at the time of the announcement. Total operation will cost the French government €9.7 billion and will especially enable them to more efficiently manage the new nuclear plant construction projects in the coming years.

FIGURE 5

Utilities' Stock Performance



Source: Thomson Reuters EIKON data 2021, Annual Reports

European utilities: Dividend yield

European utilities back to dividend distribution after Covid-19 crisis

General dividend increased in 2021.

Dividends per share significantly increased in 2021, compared to 2020, with more than a 12% increase. While the Covid-19 crisis caused several companies to limit their dividends per share (DPS), 2021 saw companies going back to generalizing DPS as power demand rose alongside with economic recovery.

Companies that saw their stock prices going up in 2021 decreased DPS for shareholders.

CEZ, RWE, Naturgy, EnBW, and SSE saw their capitalization going up in 2021 and reduced their dividend yield. While Naturgy, SSE, and CEZ decided to reduce dividends per share (DPS), EnBW and RWE chose to increase DPS payments (compared to 2020) to shareholders without having it increase, reaching stock value augmentation. As stock prices were already going up, companies estimated that shareholders had been earning value directly from capital increases and, therefore, considered it possible to reduce earnings through DPS payments.

Other companies increased both DPS and dividend yield to compensate for share price devaluation.

Except for Uniper, all companies that saw their share price go down in 2021 increased both dividend per share and dividend yield. Eight companies out of 15 saw their dividend yield go up in 2021, allowing the average dividend yield evolution to be significantly positive at +26%.

Out of those eight, three had truly significant dividend yield increases (EDF, Engie and Enel), with increases almost doubling (or more) in 2021 compared to 2020. Those three companies are the leading trio with dividend yields higher than 7%.

While Enel's dividend yield went up because of important decreases in stock prices, French utilities, EDF and Engie had increasing dividend yields thanks to the significant rise of DPS at +175% and +60%, respectively.

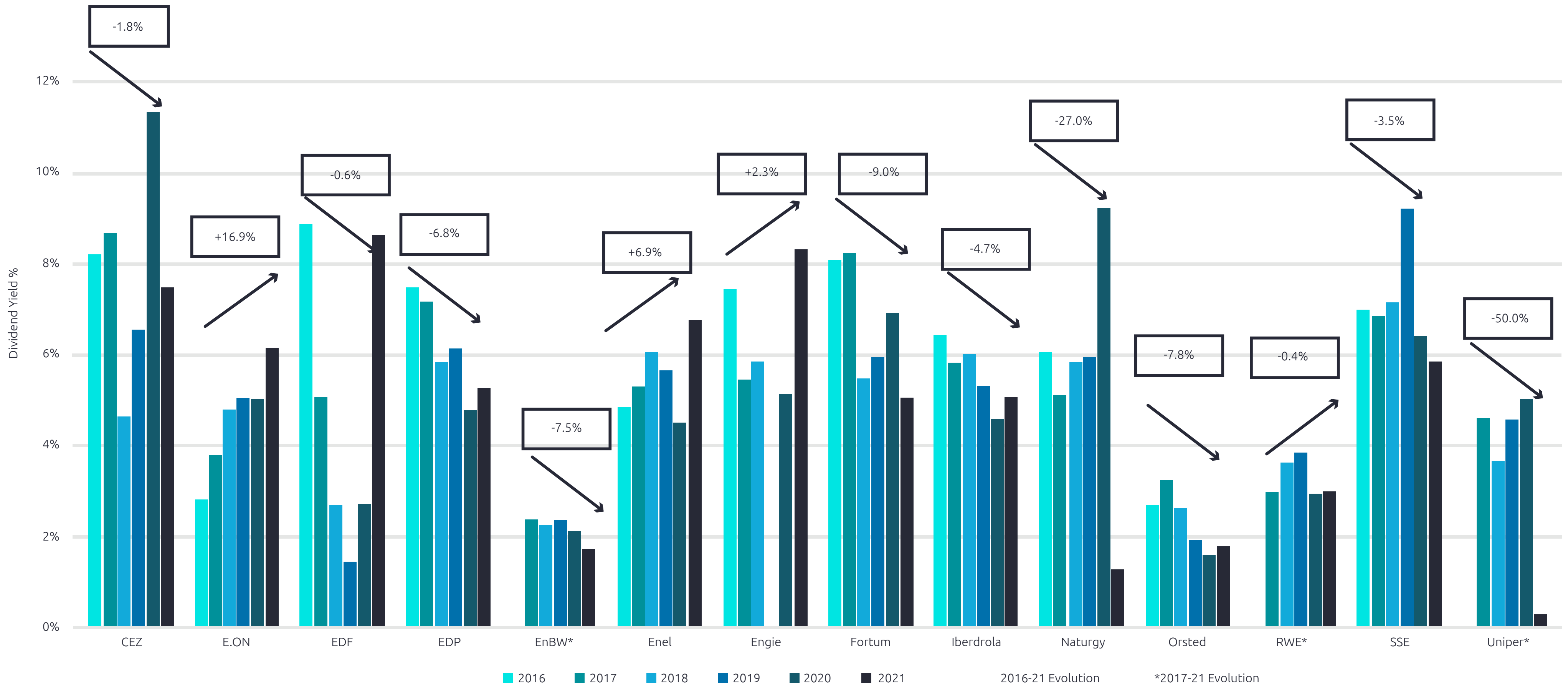
Uniper is the only panel company which saw dividend yields and stock prices go down.

As Uniper is one of the companies suffering most from the skyrocketing prices of the European gas supply, DPS was voluntarily reduced to €0.07. Uniper's board decided to put a break on its previous dividend policy to give priority on liquidity disposal regarding the energy market and political uncertainties.

Being espacially exposed to fossil fuel supply disruption with less than 20% of its power generated from low carbon units, Uniper chose to secure its financial stability for the coming years.

FIGURE 6

Dividend yield in % and 2016-2021 evolution



Source: Thomson Reuters EIKON data 2021, Annual Reports

FIGURE 7

Dividend yield, DPS, Stock Price and 2020-2021 evolution

	Stock Price			△ 2019-20 %	△ 2020-21 %	DPS		△ 2020-21 %	Dividend Yield		△ 2020-21 %
	2019	2020	2021			2020	2021		2020	2021	
Uniper	30.02	30.38	24.14	1%	-21%	1.37	0.07	-95%	4.5%	0.3%	-94%
EnBW	35.33	81.30	95.65	130%	18%	1	1.1	10%	1.2%	1.2%	-7%
Ørsted	86.51	133.91	115.07	55%	-14%	1.54	1.68	9%	1.2%	1.5%	27%
RWE	24.85	32.95	40.36	33%	23%	0.85	0.9	6%	2.6%	2.2%	-14%
EDP	3.71	4.94	4.68	33%	-5%	0.19	0.19	0%	3.9%	4.1%	5%
Iberdrola	8.93	10.97	9.91	23%	-10%	0.42	0.45	7%	3.8%	4.5%	19%
Naturgy	27.47	20.72	24.64	-25%	19%	1.44	1.2	-17%	7.0%	4.9%	-30%
SSE	14.37	17.07	18.37	19%	8%	0.92	0.9	-2%	5.4%	4.9%	-9%
E.ON	10.91	10.49	9.94	-4%	-5%	0.47	0.49	4%	4.5%	4.9%	10%
CEZ	23.29	24.91	37.87	7%	52%	2.03	1.92	-5%	8.2%	5.1%	-38%
Fortum	22.13	23.00	16.94	4%	-26%	1.12	1.14	2%	4.9%	6.7%	38%
EDF	12.46	11.48	8.25	-8%	-28%	0.21	0.58	176%	1.8%	7.0%	284%
Engie	15.22	13.15	12.07	-14%	-8%	0.53	0.85	60%	4.0%	7.0%	75%
Enel	6.94	8.66	4.81	25%	-44%	0.33	0.38	15%	3.8%	7.9%	107%
Average				19.9%	-3.1%				4.0%	4.4%	

Source: Thomson Reuters EIKON data 2021, Annual Reports

European utilities: Credit rating

For most of the actors, the credit rating remains stable.

Overview:

- 12 out of the 16 actors in the panel have the same credit rating as last year
- One out of 16 actors improved credit rating since last year
- Two out of 16 actors lowered their credit rating
- One out of 16 actors has not been rated by the S&P since 2018

Credit rating is decreasing for some actors:

- **EDF** saw its credit rate go from BBB+ to BBB. This is mainly due to high investments expected by S&P to maintain its nuclear plants in operational condition (corrosion issue on 12 out 58 reactors, “Grand carénage”). CreditWatch should be disabled as soon as the group shares more clarity on the expected cash flow.
- **Uniper** saw its rating decrease from BBB to BBB-. This is mainly due to pressure on gas supply – especially from Nord Stream 1, which is delivering 40% of its capacity. Uniper is then to procure the missing volume directly on the market, facing significantly higher prices and significant losses.

EDP is outperforming:

- **EDP** saw its credit rating go from BBB- to BBB, leveraging robust EBITDA generation (split between network activities, 36%) and long-term contracted activities (wind and solar, 48%). Plus, EDP is performing regulated activities in several countries and is not facing strong competition in its local market, ensuring cash creation over the long run. EDP will define a robust plan (including asset rotation) to address the huge **capital expenditure** (CAPEX) amount to come in the next couple of years.

FIGURE 8

Standard & Poor (S&P) credit ratings

Company	2016	2017	2018	2019	2020	2021/22
EnBW	A-	A-	A-	A-	A-	A-
CEZ	A-	A-	A-	A-	A-	A-
EDF	A-	A-	A-	A-	BBB+	BBB*
Engie	A-	A-	A-	A-	BBB+	BBB+
SSE	A-	A-	A-	BBB+	BBB+	BBB+
Vattenfall	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Ørsted	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Iberdrola	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Enel	BBB+	BBB	BBB+	BBB+	BBB+	BBB+
Centrica	BBB+	BBB+	BBB+	BBB	BBB	BBB
Fortum	BBB+	BBB+	BBB	BBB	BBB	BBB
E.ON	BBB+	BBB	BBB	BBB	BBB	BBB
Naturgy	BBB	BBB	BBB	BBB	BBB	BBB
Uniper	BBB-	BBB-	BBB	BBB	BBB	BBB-*
EDP	BB+	BB+	BBB-	BBB-	BBB-	BBB*
RWE[1]	BBB-	BBB-				

Note1: Following RWE decision to end rated by S&P in 2018, this is the last time the company appears in this table
Note2: 2022 H1 updated ratings for some companies are marked as *

Source: Company websites, Annual Reports

European utilities: Carbon intensity

European utilities keep focus on decarbonization target, despite troubled year

The 2021 landscape has shaken decarbonation plans

2021 has been a year of economic growth thanks to the reduction of shutdowns in Europe. Power demand grew significantly, almost reaching the pre-Covid-19 level. As a result, European gas prices skyrocketed until breaking record highs during the second half of the year.

Depending on their capacity mixes, European utilities had to adapt rapidly while maintaining the security of supply across the continent.

As a result, the ones depending most on combustible gas had to put aside decarbonization targets and relied on coal-based production plants more than anticipated.

Lagging performers' decarbonization path slowed down by high gas prices and nuclear dismantling.

RWE, Uniper, EnBW, and Fortum are still lagging performers on our panel in terms of carbon intensity. While RWE managed to decrease its carbon intensity slightly, the three other utility companies saw their carbon intensity rise in 2021 compared to the past year. While Uniper's CO2 intensity suffered from nuclear plant decommissioning, EnBW and Fortum, in particular, suffered from high gas prices during the second half of 2021 and, as a result, had to rely more than expected on coal-fired units. Therefore, their carbon intensity rose compared to 2020.

Mixed results for average performing companies in 2021 that were caught between the success of renewables development and a higher-than-expected use of thermal plants.

In 2021, Enel and EDP both declared suffering from low renewable power production while power demand was increasing. As both utilities mention a low hydroelectric generation, they had to compensate this shortage with thermal power plants. As a result, both companies broke their carbon intensity decreasing trend and saw a slight increase in this indicator.

In contrast, Naturgy and CEZ both succeeded in pursuing their ongoing reduction trend in 2021. Both companies' reports stipulate that those results will reinforce their efforts toward decarbonization. Both mentioned that they would invest strongly in low carbon-production while phasing out highly emitting plants.

Leading performers did not seem to suffer from last year's landscape and kept pushing toward carbon intensity reduction.

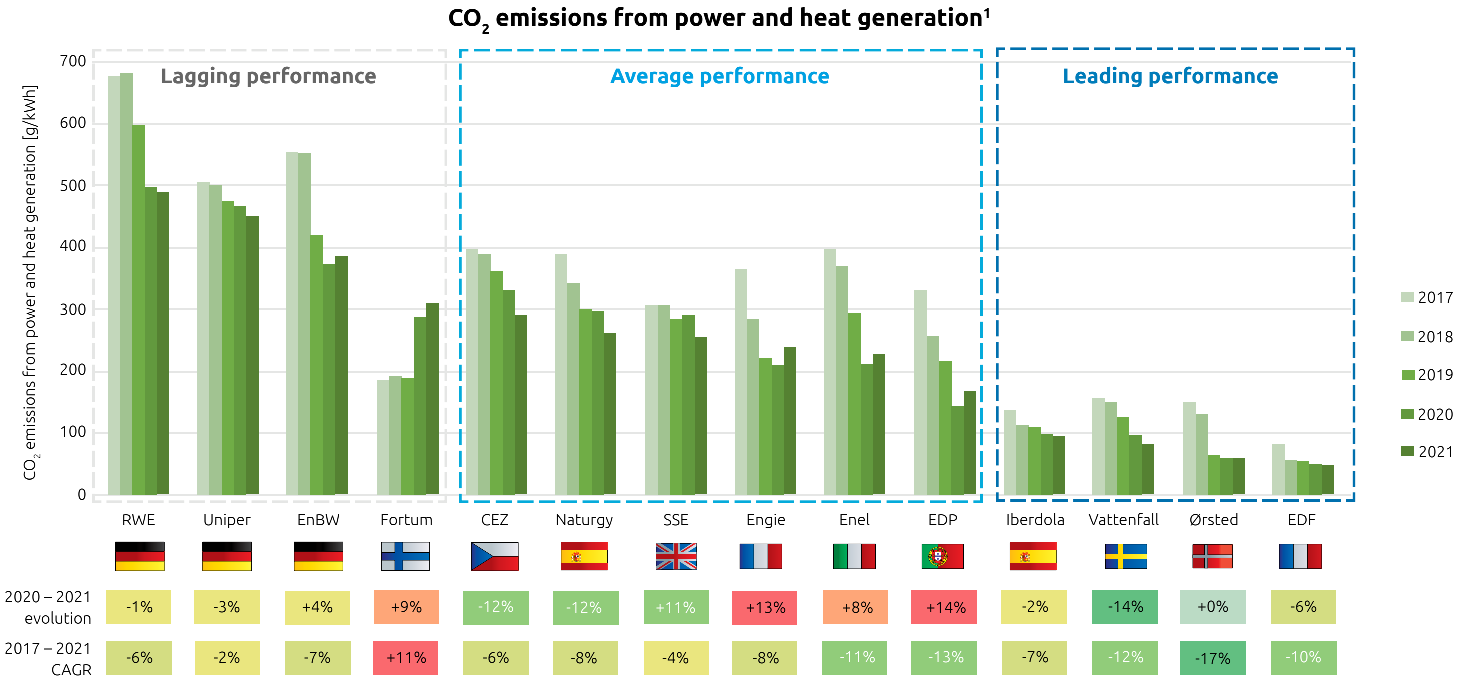
Iberdrola, Vattenfall, Ørsted, and EDF all went through 2021 without seeing their carbon intensity increase. Three of them (Iberdrola, Vattenfall, and EDF) kept reducing it by phasing-out remaining thermal units.

Regarding the mixed results, European utilities insist on their commitment to long-term climate targets.

In 2021, several European utilities saw their carbon intensity going up for the first time in several years. However, all companies insist on the importance of continuing efforts toward carbon emission reduction in the future. Phasing out highly emitting plants is still a priority for them while they intend to develop renewable and nuclear capacities for their future. As some of them intend to develop gas-fired capacity to back-up their renewables, the impact of the European energy crisis on their strategy will have to be followed. However, leading performers are already showing the way, as none of their carbon intensity suffered from the highly tense context of 2021.

FIGURE 9

CO_2 intensity from heat and power generation



1 The chart displays CO2 intensity resulting from scope 1 emissions

N.B. : E.ON and Centrica have not been included in this analysis since power generation does not constitute a part of their core-business.

Source: Thomson Reuters EIKON data 2021

European utilities are facing harsh conditions H1 2022

European utilities are impacted in a heterogeneous way by Russian-Ukrainian crisis

Russia drastically reduced its gas deliveries as a response to the measures taken by European actors following the beginning of the war in Ukraine. This had a huge impact on some actors, especially the ones being exposed to gas import. On H1 2022:

- **Uniper** saw its EBIT decrease to -564M€ and its net result to -359M€. Indeed, to be able to provide its customers and to respect their contractual engagements, Uniper has been forced to buy gas on the market at far higher prices than expected. The impacts on Uniper will be terrible in the second half of the year, German government, granting an exceptional capitalization of €15bn to the company to prevent a failure, endangering German gas security of supply.
- **EDF** suffers from low availability of actual nuclear fleet (up to 31 reactors stopping deliveries for maintenance or corrosion issue fixing. EDF is also impacted by the French government electricity price capping decision. Combined, these two elements have conducted EDF to post a profit warning, forecasting €29bn losses for the full fiscal 2022 year.

On the other hand, companies not being exposed to a surge in Gas prices realized an astonishing H1 2022:

- **EON** increased by 60% its revenues regarding H1 2021 because of robust performance in "customer solution" (from 16 to 42 billion) and "corporate functions" (from 4,8 to 18,6 billion). EBITDA is still decreasing because of the non-recurrence of one-off effect in 2021. Moreover, the shutdown of Brokdorf and Grohnde nuclear power plants at the end of December 2021 also impacted it.
- **Enel** revenues increased significantly (+85,3%) regarding H1 2021 because of an important increase in electricity and gas sold at an important average price, in all geographies. EBITDA slightly increased (+5%) leveraging on the revenue's growth
- **Engie** achieved to substantially decrease its exposure to Russian gas import (from 15 TWh in March 2022 to 4 TWh in June) while taking advantage of current electricity prices. On the other hand, the switch being operated by the company to renewables also decreased its exposure and enhanced its capacity to face current market conditions. Engie finally shows an outstanding +73% EBIT regarding H1 2022.

Some utilities are being restructured to face upcoming (industrial) challenges

- **EDF:** and The French state (already owner of 84% of the company) plans to buy the remaining shares for an amount close to 10 billion to become the sole shareholder of the company. This should secure the multiple challenges - industrial and financial - that EDF will have to face in the coming years:
  - Maintenance in operational condition of the existing nuclear fleet (56 reactors)
  - Launch of 6 new EPRs (+8 as an option)
- **Fortum -** Uniper's majority shareholder - is also facing a complicated situation, inherited from the war in Ukraine (and the impact of retaliatory measures taken by Russia against Europe have strongly impacted Uniper, forcing Fortum to review its plans. Fortum, Uniper and the German government agreed that the latter would provide 15 billion in equity and liquidity to Uniper (in order to stabilize its financial situation) in exchange for 30% of Uniper (reducing Fortum's ownership from 80% to 56%).

NORTH AMERICA
PLAYERS, REVENUES, MARGINS, DEBTS, DIVIDENDS

ALEXANDER RODRIGUEZ
SARA STRITHARAN
SWETANTA LAHIRI
NUPUR SINHA

U.S. tax credits and clean energy investment: The bipartisan infrastructure law brought into action in November 2021 is targeted at mitigating the risk of climate change by spending approximately $80 billion on enhancing decarbonization measures

The bill contains more than $37 billion in support of developing grid infrastructure and nuclear energy, as well as almost $20 billion for developing technologies such as carbon capture, usage, and storage (CCUS) and hydrogen.

- Tax credits like the investment tax credit (ITC) and production tax credit (PTC) have a significant influence on renewable energy project economics.
- In certain regions, these incentives push the economic balance in favor of renewables.
- The impact of the investment tax credit on solar economics is even between regions, whereas the PTC influences wind more in those regions where it is already cheap.
- The ITC and PTC will be phased down over the next few years.
- Extending both is presently under deliberation in Congress.
- Some wind projects that were previously planned to be completed in 2020 were pushed into 2021 due to Covid-19 related delays or tight supply chains.
- But for developers, the Internal Revenue Service (IRS) showed some compassion in allowing projects to receive tax credits even if they did not achieve commissioning until 2021.
- 2021 was the third-biggest year ever for wind build in the U.S.

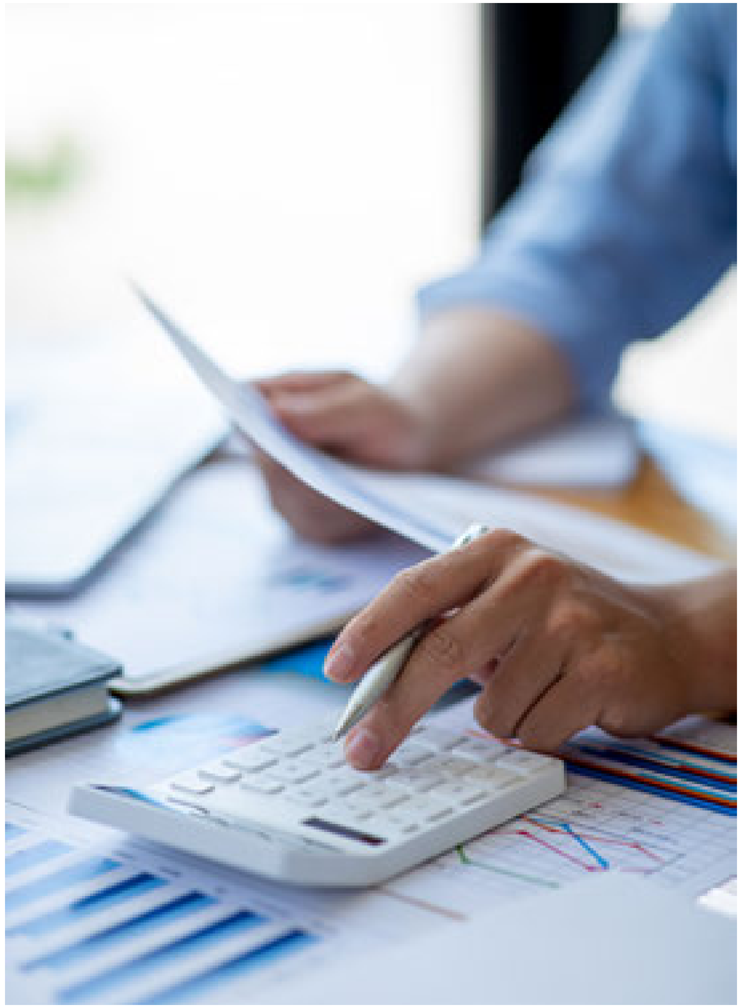
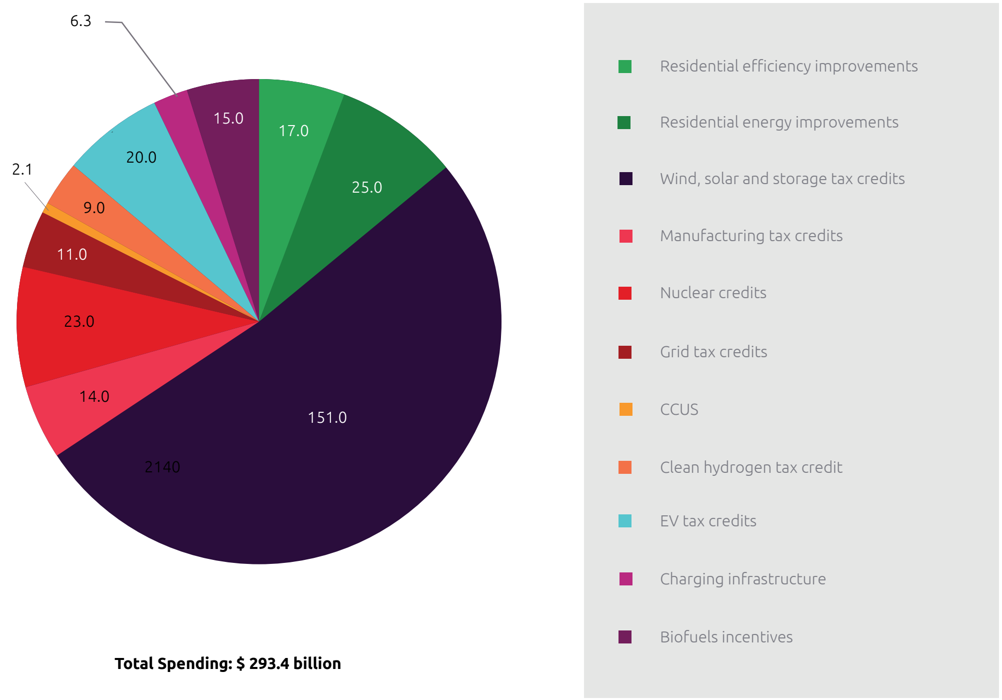


FIGURE 1

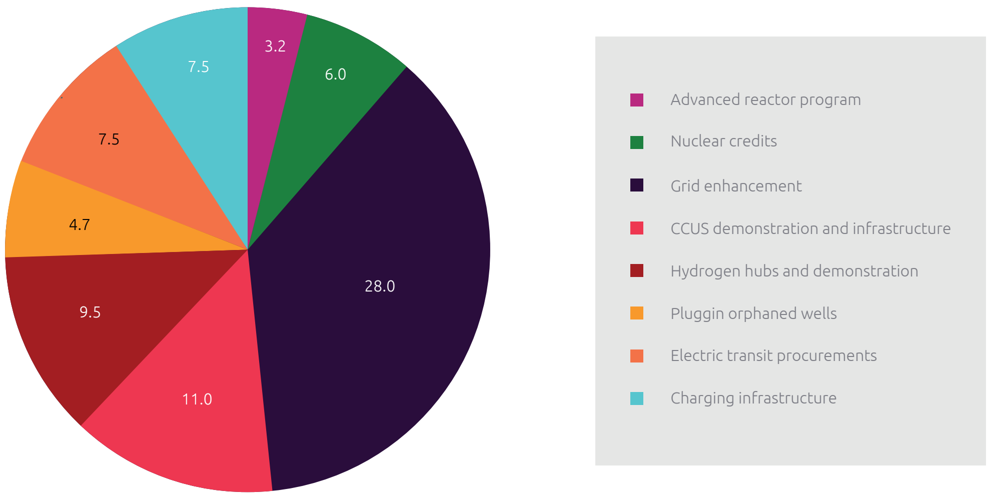
U.S.: Tax credits and clean energy investment (2021)

Energy RD&D spending in U.S. stimulus bill (Build back better bill) - pending



Total Spending: $ 293.4 billion

Energy RD&D spending in U.S. stimulus bill (Bipartisan infrastructure bill) - passed



Total Spending: $77.4 billion

Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

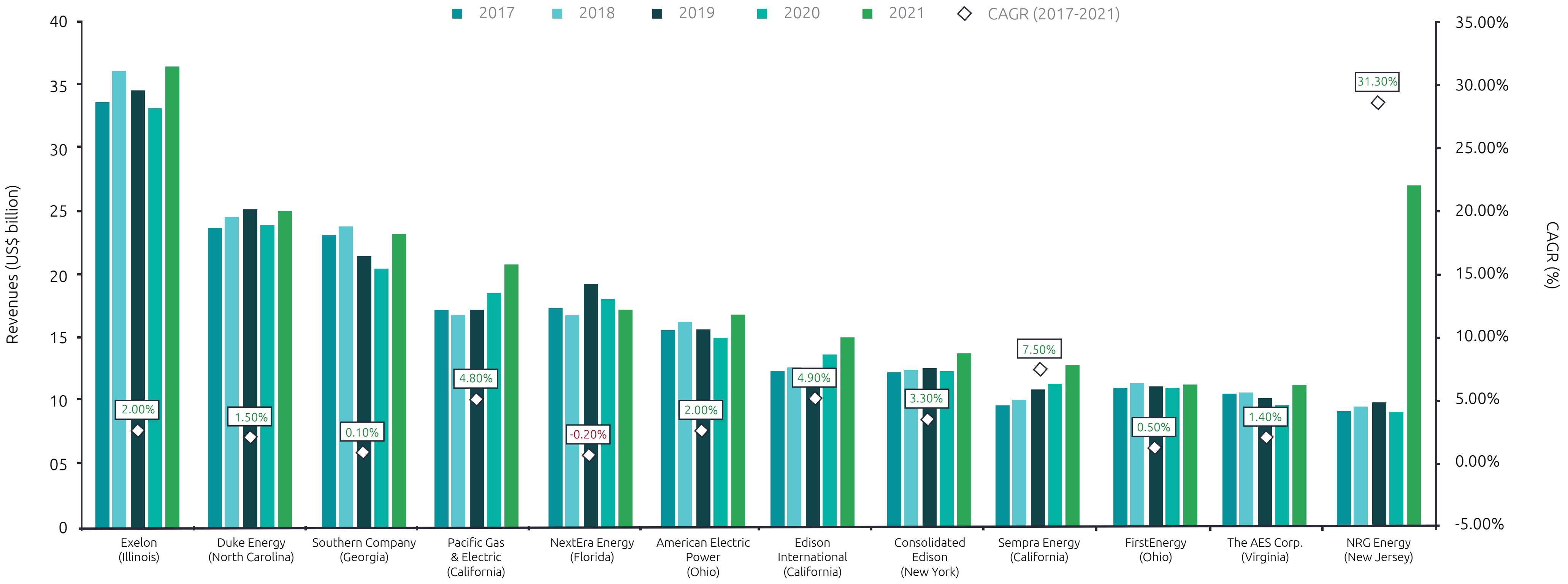
U.S. utilities revenue: In 2021, utility companies were successful in overcoming the Covid-19 challenges which was reflected in revenue increases

As the U.S. economy started to emerge from its pandemic-related problems, electricity sales rose by 3.8% through August 2021 as compared to 2020.

- According to the President and CEO of Exelon, their objective at Exelon is to stay as a major transmission and distribution utility company by providing reliable, clean, safe, affordable services to approximately 10 million customers.
  - Exelon would want to make an investment of around $29 billion as a capital expenditure for enhancing transmission and distribution (T&D) through 2025.
- The increase in revenue for Duke Energy in 2021, as compared to 2020, can be attributed to higher sales in the electric utility's infrastructure segment, supplemented by growth in the gas utilities segment.
  - According to the company, they are one of the major players in the industry's biggest clean energy transformation; approximately 80% of their $63 billion capital plan funding investments is in the area of grid modernization or zero- or low-carbon emitting generation.
- The major capital investments for American Electric Power for 2023, 2024, 2025, and 2026 would be in the areas of vertically-integrated utilities, transmission & distribution utilities, and generation & marketing.
- According to Jeffrey W. Martin, Chairman and CEO of Sempra, 2021 was a very important year for the company as they focused on investments in U.S. utilities; the company has also been successful in providing enhanced reliability and safety, which has contributed to their revenue growth.
- According to Steven E. Strah, FirstEnergy's President and CEO, the board, leadership, and employees worked together in 2021 to deliver a high-quality customer experience, which has strengthened their financial position in 2021.
- NRG Energy's revenue almost tripled in 2021 due to the company's acquisition of Direct Energy from the British energy company Centrica; the move nearly doubled the size of its retail portfolio.
  - According to estimates, NRG Energy's CAPEX from 2022 to 2026 would be around $56 million.
  - The expenditure would be mainly incurred to comply with environmental laws; the principal component is the cost of complying with Effluent Limitations Guidelines (ELG) at their coal units in Texas.
  - The company aims to procure mid to long-term renewable generation through power purchase agreements (PPAs).

FIGURE 2

U.S.: Revenues and associated CAGR (2017-2021)



Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis

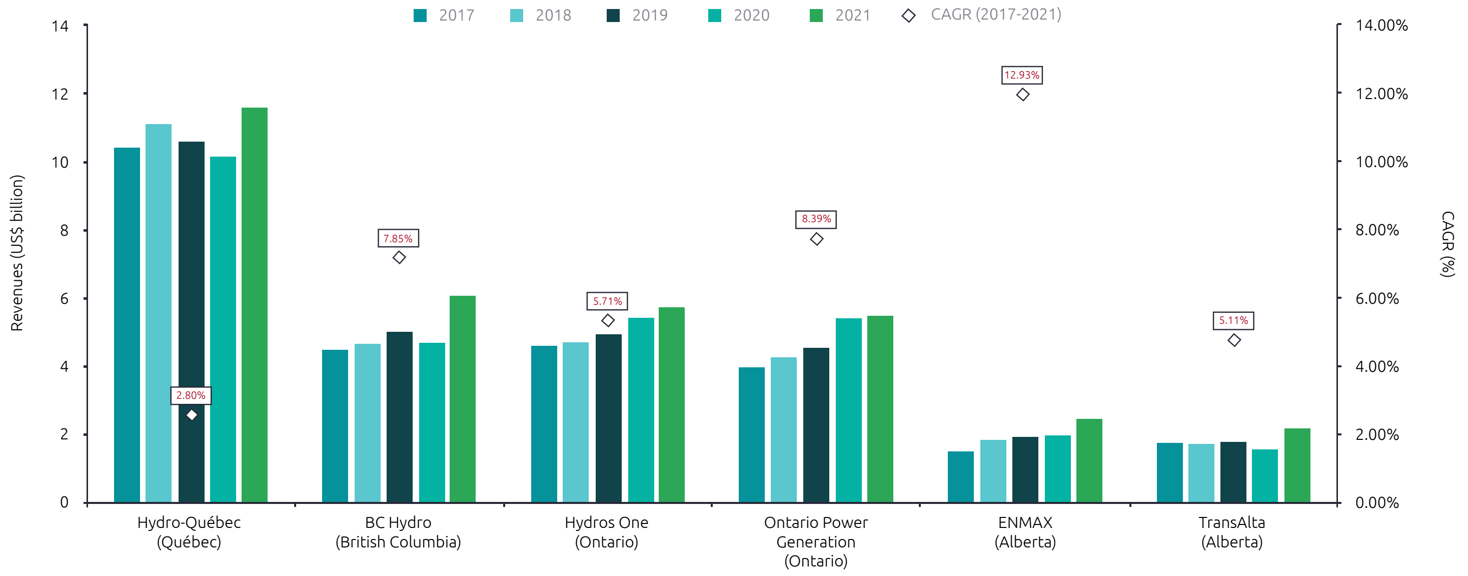
Canadian utilities revenue: Hydro-Québec recorded the highest revenue in 2021 amongst Canadian utilities

All major utility companies were not only able to increase their revenues in 2021, but also were able to continue to allocate significant amounts of funds for capital expenditure.

- The increase in revenue for Hydro-Québec can be attributed to increase in sales in the Québec region as well as outside.
  - In 2021, Hydro-Québec devoted approximately CAD 4,223 million in capital assets such as property, plant and equipment, and intangible assets; this was 25% more than the company invested in 2020.
  - The investments were aimed at major development projects in the generation and transmission sector.
- The increase in revenue for British Columbia Hydro and Power Authority (BC Hydro) in 2021 was mainly due to an increase in sales volumes.
  - BC Hydro would continue to invest meaningfully in capital projects/programs to improve its existing assets and build new infrastructure, which would include distribution wood poles replacements, transmission wood structure, and framing replacements, among others.
- Hydro One's major capital investments would be in transmission and distribution services that are efficient, reliable, and provide value for customers, consistent with the Ontario Energy Board (OEB's) Renewed Regulatory Framework.
- In 2021, the capital expenditure of Ontario Power Generation in the Regulated – Hydroelectric Generation business segment increased by CAD 97 million, mainly for the redevelopment of the Calabogie GS, asset refurbishment programs, as well as capital investments at hydroelectric stations in the eastern region.
- The increase in revenue for TransAlta Corporation can be attributed to the robust performance in the energy marketing segment, as well as the gas segment in 2021.
  - Sustaining capital expenditures for 2021 were higher by CAD 41 million. This is majorly due to maintenance costs associated with converting to natural gas outages of Keephills Units 2 and 3 and Sheerness Unit 1, strategic maintenance at the Australian gas facilities, and the purchase of an additional engine at the South Hedland facility.
  - In November 2021, the company started the commercial operation of 206 MW Windrise wind facility under its program on renewable electricity.

FIGURE 3

Canada: Revenues and associated CAGR (2017-2021)



Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis

U.S. EBITDA margin: NextEra Energy and Duke Energy have maintained high EBITDA margins in the last few years

NextEra Energy's earnings before interest, taxes, depreciation and amortization (EBITDA) for 2021 was 41.4%, as compared to 50.4% in 2020.

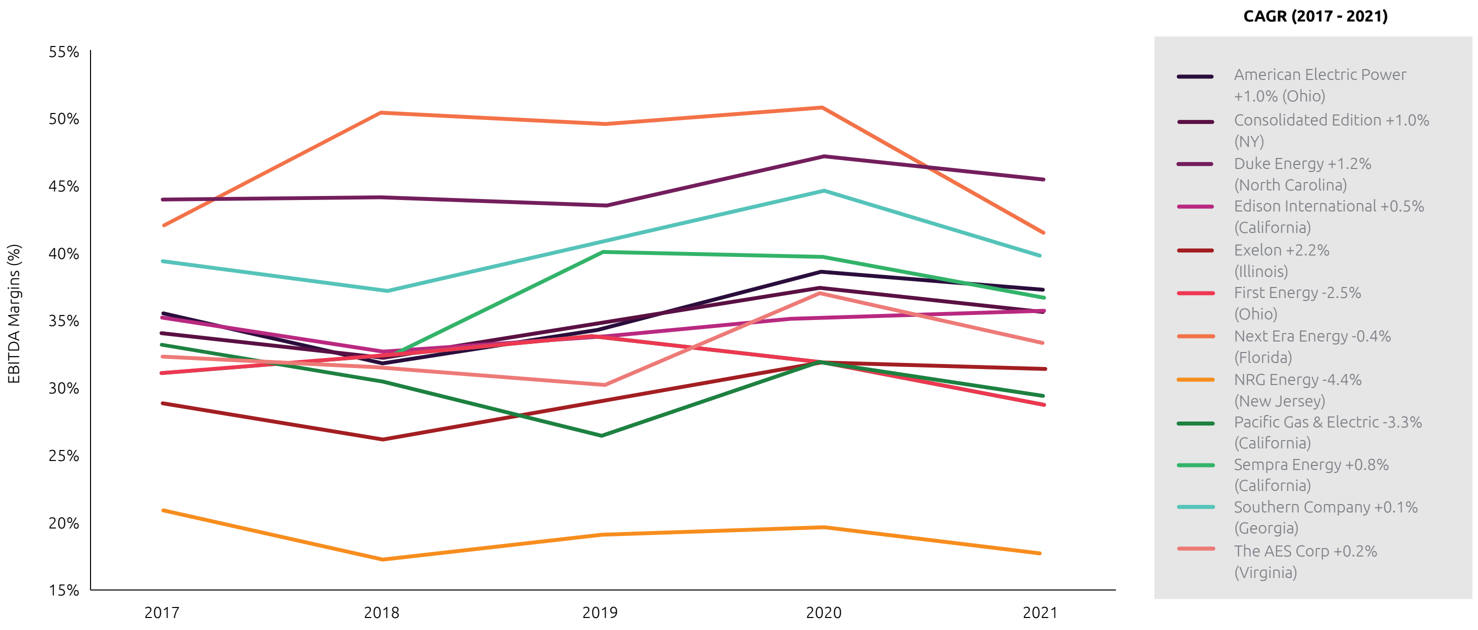
- Despite a decrease in EBITDA margins in 2021, the NextEra Energy Partners portfolio in 2021 delivered run-rate adjusted EBITDA and cash available for distribution (CAFD) in excess of their previously announced expectations ranges.
- NextEra Energy Partners' expectations for, run rate for adjusted EBITDA is expected to be in a range of $1.775 billion to $1.975 billion; CAFD is expected to be in the range of $675 million to $765 million. These figures reflect calendar year 2023 expectations for the forecasted portfolio at year-end 2022.

There has been a marginal decrease in EBITDA for Duke Energy in 2021 (45.3%) as compared to 46.9% in 2020.

- Duke Energy has maintained EBITDA of more than 45% for two consecutive years (2020 and 2021).
- The good performance can be attributed to maintaining their growth in renewables and storage, as well as a diverse energy mix to balance reliability and affordability.
  - Duke Energy proposed a plan to achieve 70% CO_2 emissions reduction by the end of 2030 and carbon neutrality by 2050.
  - This will be done while providing regulators several options that balance affordability and reliability for customers.
- According to Stephen De May, Duke Energy's North Carolina President, the company is committed to bringing their customers and communities affordable, reliable, carbon-free energy as soon as possible.

FIGURE 4

U.S.: EBITDA margins and associated CAGR (2017-2021)



Source: Thomson Reuters EIKON Data ("Normalized EBITDA"), Capgemini Analysis

Canadian EBITDA margin: Hydro-Québec reported the highest EBITDA margin in 2021 amongst Canadian utilities

Hydro-Québec's net income was CAD 3,564 million, compared to CAD 2,303 million in 2020.

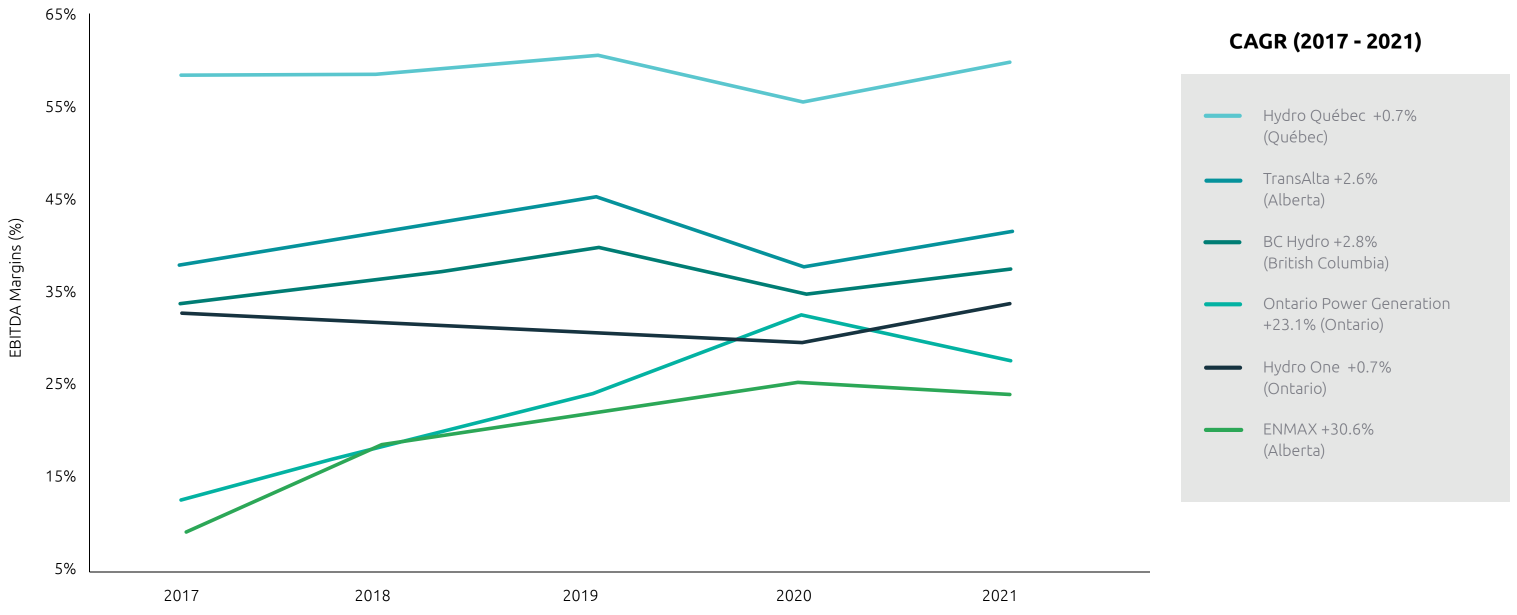
- The increase in net income contributed to a strong EBITDA margin in 2022.
  - The increase can be attributed to: a rise in overall sales; a positive variance in the amounts recognized as other components of employee future benefit cost for the pension plan; and a reduction in financial expenses.
  - Hydro-Québec also performed very well in the export markets (net electricity exports increased by 4.3 TWh).
  - In 2021, net exports accounted for 17% of sales volume and generated 24% of the company's net income.
  - Another reason for the rise in net income can be attributed to the rise in sales to the distributor.
  - Under the Champlain Hudson Power Express project (CHPE), the 1,250-MW CHPE line would bring 10.4 TWh of renewable energy.

The EBITDA margin of BC Hydro increased to 39% in 2021, as compared to 36.3% in 2020.

- The increase in EBITDA can be attributed to an increase in trade revenues.
  - The increase in trade revenues was due to higher sale volumes, partially due to sales of BC Hydro's surplus energy as driven by higher inflows and lower load.
  - The higher sales was due to higher Customer Satisfaction Index, which increased by 2% in 2021, as compared to 2020.
  - The improvements were seen across all three customer segments including residential, commercial and key accounts. The major increase was for residential customers, with customer satisfaction in 2021 being 4.5% higher as compared to 2020.
  - BC Hydro continued to exceed their clean energy performance target of 93%, with a result of 98% of electricity in the province generated from clean or renewable resources.

FIGURE 5

Canada: EBITDA margins and associated CAGR (2017-2021)



Source: Thomson Reuters EIKON Data ("Normalized EBITDA"), Capgemini Analysis

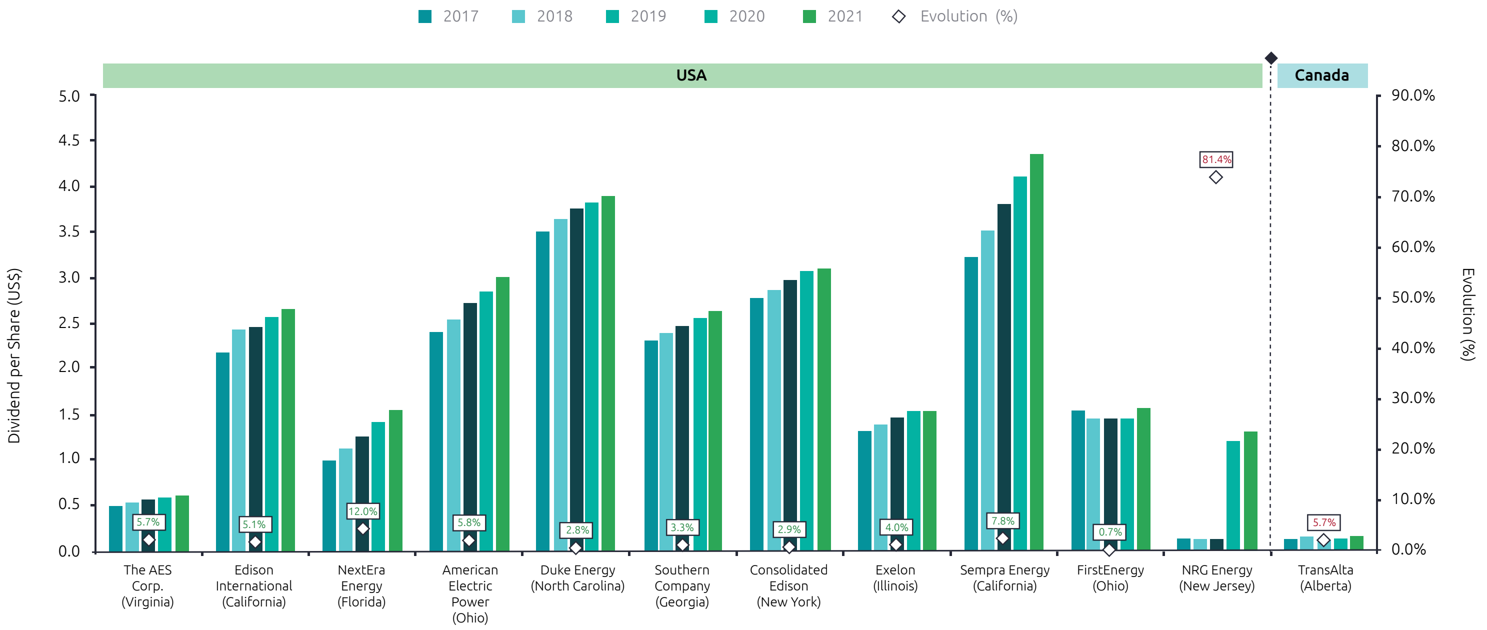
U.S. and Canadian dividend per share (DPS): Utility dividend growth in 2021 can be attributed to strong earnings by the utility companies

Revenues for major U.S. and Canadian utility companies have grown over the last few years, which means that more sales are being generated by these companies overall; subsequently, their profits are increasing too.

- Edison International declared a dividend of $2.65 per share in 2021.
  - Combined with the current dividend yield, the company can see a strong possibility for a double-digit total return for the shares
- NextEra Energy declared a dividend of $1.54 per share in 2021, an approximate increase of 10% as compared to 2020.
  - This increase is aligned with the plan announced in 2020, targeting roughly 10% annual growth in dividends per share through at least 2022, off a 2020 base.
- Duke Energy declared a dividend of $3.90 per share in 2021, an approximate increase of 2% as compared to 2020.
  - The company is focused on clean energy transformation and a business portfolio that has delivered a reliable and growing dividend, with 2021 representing the 95th consecutive year Duke Energy paid a cash dividend on its common stock.
- TransAlta declared a dividend of $0.15 per share in 2021, an approximate increase of 15% as compared to 2020.
  - The increase in dividend can be attributed to a strong performance and their confidence in TransAlta's capacity to execute their growth plan and optimize returns from their existing assets.

FIGURE 6

U.S. and Canada: Dividend per share in USD (2017-2021)



Source: Thomson Reuters EIKON Data ("Dividend per Share DPS"), Company Annual Reports, Capgemini Analysis

U.S. utilities leverage: In 2021, most U.S. utilities showed high leverages of more than 1, indicating high debt levels

According to the National Energy Assistance Directors' Association (NEADA), utility debt increased from around $12 billion before the pandemic to an estimated $32 billion by the end of 2020.

- AES Corporation had a leverage (debt/equity) ratio of 9.48 in 2021, as compared to 7.55 in 2020.
  - Though the company has been using a portion of the company's cash flow to reduce the outstanding debt, it still has a high debt load.
  - One reason for this high debt load can be due to the company's continued focus on renewables and its intention to replace its coal-fired plants by 2025; this requires a lot of new capacity, thus triggering the need for money.
- Southern Company had a leverage ratio of 1.93 in 2021, as compared to 1.76 in 2020.
  - Southern Company has witnessed negative free cash flows since the year 2016, as it has been investing heavily in properties, plants, and equipment.
- American Electric Power had a leverage ratio of 1.63 in 2021, as compared to 1.64 in 2020.
  - This can be attributed to a large spending on CAPEX from 2021-2023 (18% higher than the previous three-year plan; it will result in a 7.4% average annual rate base growth from 2019).
- The leverage ratio for Sepmra Energy has gone below 1 (0.98) in 2021, as compared to 1.20 in 2020.
  - This can be attributed to the decrease in short-term debt.
  - The company is using relatively lower debts to manage the business compared with competitors.
  - Efficient management of debt and nonstop progress in liquefied natural gas (LNG) projects will drive its performance in the long run.

FIGURE 7

U.S.: Leverage (debt/equity) (2020-2021)

Utilities	2020	2021	Evolution
American Electric Power (Ohio)	1.64	1.63	↓
Consolidated Edition	1.29	1.22	↓
Duke Energy (North Carolina)	1.36	1.42	↑
Edison International (California)	1.64	1.98	↑
Exelon (Illinois)	1.21	1.23	↑
First Energy (Ohio)	3.38	2.75	↓
Next Era Energy (Florida)	1.32	1.47	↑
Pacific Gas & Electric (California)	1.44	1.59	↑
Sempra Energy (California)	1.20	0.98	↓
Southern Company (Georgia)	1.76	1.93	↑
The AES Corp (Virginia)	7.55	9.48	↑

Source: Thomson Reuters EIKON Data ("Debt/Equity"), Company Annual Reports, Capgemini Analysis

AUSTRALIA PLAYERS, REVENUES, MARGINS, DEBTS, DIVIDENDS

VINNIE NAIR
NICOLE ALLEY
NICK MCFARLANE

Macroeconomic trends impacting the revenues, margins, debts, and dividends in various Australian networks: 2021-2022 and beyond

The introduction of cheap capital around the world has had a significant influence on the state of finances of major utilities in Australia. This article will cover how excess capital in financial markets, combined with various other socio-economic trends, has impacted the Australian utility market.

The energy market is witnessing the collision of three megatrends – the increasing speed of energy transition, the rise of private capital, and the emergence of the activist investor – all of which will continue to shape the market well into the next decade.

Large global investors have been, and always will be, on the search for high-quality, low-risk, income-producing assets. Traditionally, Australia, with its stable political and social climate, has been a hotbed of activity for yield-hungry investors.

Against a backdrop of ultra-low interest rates and benign inflation, investors sought exposure to regulated utilities, which protected interest rates and inflation in the so-called "building blocks" revenue model. With deepened fear and understandable uncertainty, the global pandemic exacerbated investor demand for safe haven assets, such as those found in Australian utilities.

A somewhat unexpected and largely unconsidered aspect of utility assets throughout the pandemic has been the resilience of network businesses as compared to their peer group. Other like-for-like infrastructure assets, such as toll roads, airports, and ports, were extremely impacted during the pandemic and experienced lower revenues, ongoing uncertainty, and higher operational costs due to increased health and safety obligations. Network businesses have not been burdened by the same external factors, with revenues holding steady and underlying financials remaining sound[1].

Refer to Appendix for Regulatory Asset Base, Revenue and Operating Expenditure for operators in the National Electricity Market (NEM)

The 2021 pandemic market, combined with exceptionally low interest rates (and the view from most investors that rates could not go lower), spurred a very active M&A market across regulated utilities.

1 https://www.ubs.com/global/en/assetmanagement/insights/asset-class-perspectives/real-estate/articles/impact-covid-19-on-infrastructure.html

Highlights:

- Brookfield acquired AusNet Services in a mammoth AUD$18 billion transaction[2].
- AustralianSuper sold 16.7% of Ausgrid to Dutch pension fund APG[3].
- Ontario Teachers' Pension Plan and KKR jointly acquired Spark Infrastructure in a AUD$3.7 billion deal[4].
- Kim Jackson and Scot Farquhar's most recent bid (which involves their Skip Capital vehicle teaming up with U.S.-based private equity firm Stonepeak) for Genex Power is a little over AUD$500 million.
- Atlassian co-founder and billionaire, Mike Cannon-Brookes won a major battle against Australia's biggest energy company, AGL Energy Ltd., by acquiring an 11.3% stake through his investment company Grok Ventures, for about AUD$650 million.

The gloss may have worn off some of these acquisitions. However, a normalization in interest rates will only put upward pressure on debt financing in the coming years, which is probably the most critical aspect underpinning financial security. EBITDA projections remain insulated from inflation, though higher interest rates and the availability of high yields elsewhere will mean downward pressure on underlying asset values.

2 https://www.afr.com/companies/energy/ausnet-takeover-leaves-void-in-energy-sector-20220128-p59rww
3 https://www.reuters.com/markets/deals/australiansuper-offloads-168-ausgrid-stake-dutch-pension-fund-apg-2021-12-09/
4 https://www.afr.com/street-talk/kkr-ontario-teachers-chase-spark-infrastructure-20210714-p589so

Australian network businesses will always be in high demand by global investors, especially given their critical infrastructure status (enabling geopolitical allies to somewhat easily and aggressively lob takeover bids). But the perfect storm environment seen in 2021 has indeed dissipated. We foresee far lower M&A activity in the coming years, with a renewed focus on balance sheet security and prudent capital expenditure.

Extreme volatility in the National Electricity Market (NEM)

The first half of 2022 has seen record volatility in the NEM and sustained high prices for both energy and capacity. This has been driven by:

1. Global disruption impacting energy supply chains
2. Unseasonably high demand due to colder than average temperatures
3. Generation plant outages and higher than forecast maintenance, somewhat due to maintenance schedule changes during Covid-19 lockdowns[5]
4. Physical fuel scarcity[6]

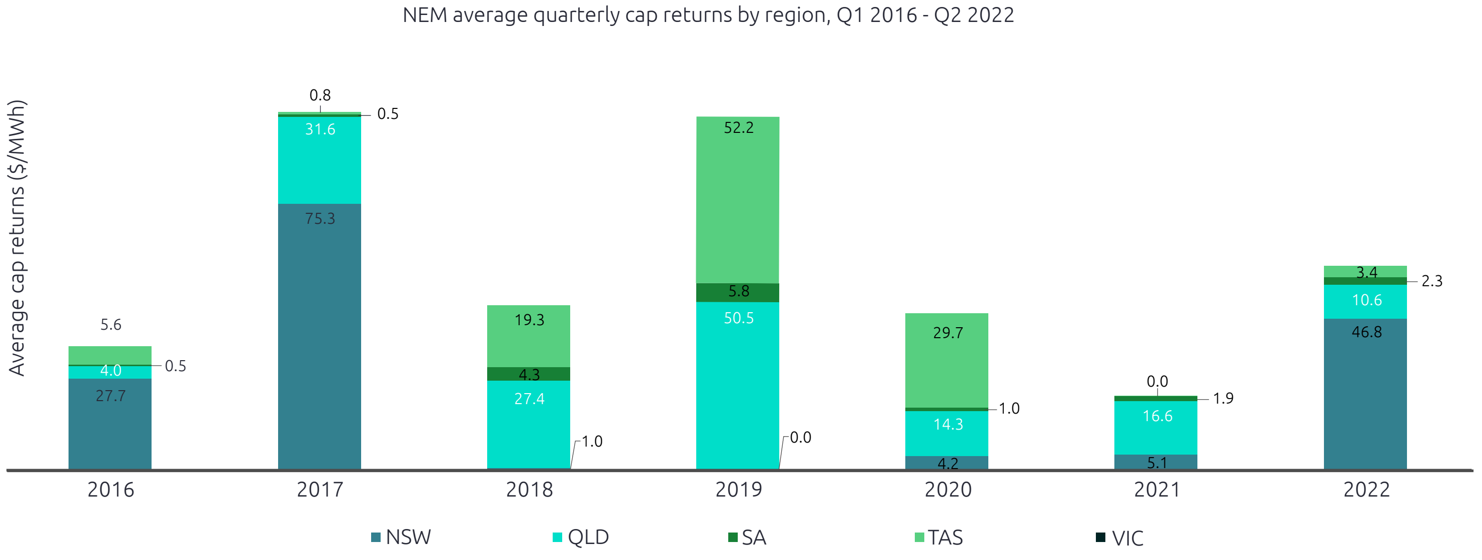
5 https://www.abc.net.au/news/2022-06-14/queensland-blackouts-power-supply-concerns-australia-aemo/101151286
6 https://wattclarity.com.au/articles/2022/08/18aug-aemo-releases-report-on-market-suspension-during-june-2022/

Wholesale electricity price volatility:

Spot price volatility in Q1 2022, as measured by aggregate cap returns across all NEM regions, was significantly higher than in Q1 2021 and fell in the mid-range of historical Q1 outcomes.

FIGURE 1

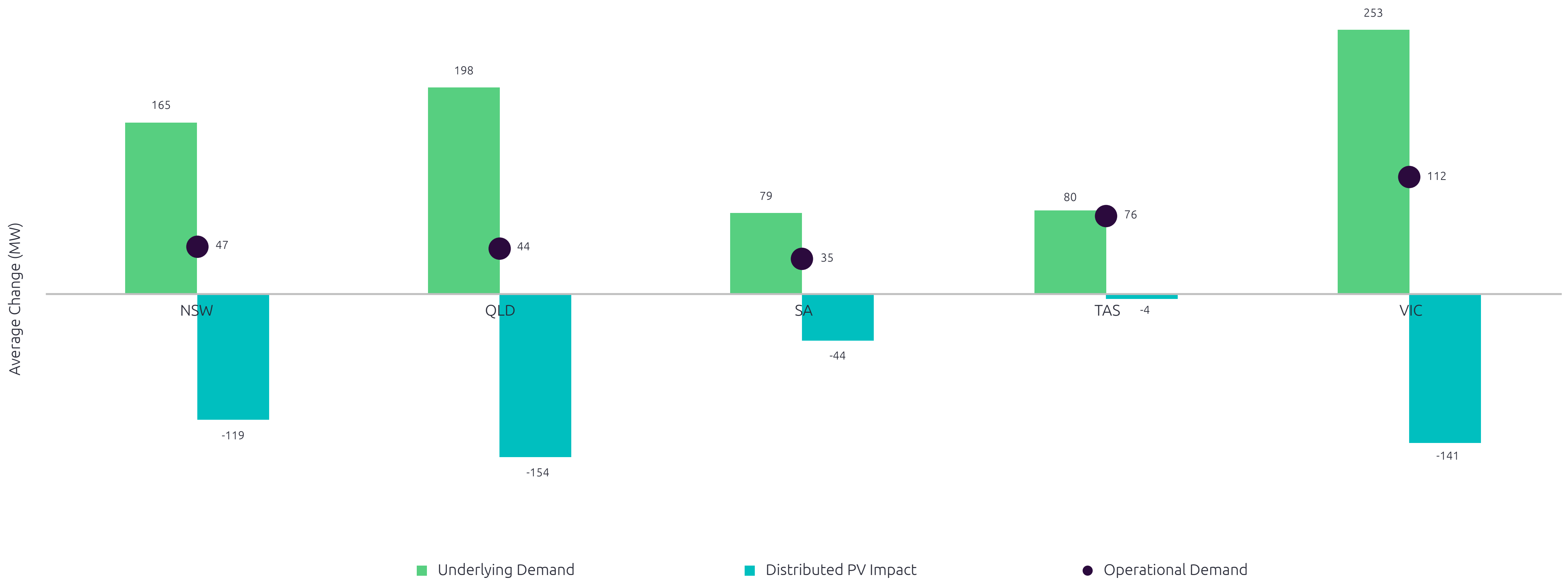
Queensland volatility drives Q1 2022 cap returns, NEM average quarterly cap returns by region



AEMO: Quarterly Energy Dynamics (QED), Q1, 2022
https://aemo.com.au/energy-systems/major-publications/quarterly-energy-dynamics-qed

FIGURE 2

NEM average demands increase across all regions
Change in demand components – Q1 22 vs Q1 21



Source: AEMO: Quarterly Energy Dynamics (QED), Q1, 2022
https://aemo.com.au/energy-systems/major-publications/quarterly-energy-dynamics-qed

As of March 2022, expectations of future wholesale prices have increased in Queensland, New South Wales, South Australia, and Victoria by at least $140/MWh. Future wholesale prices are expected to remain higher across most regions over the next four years. As of June 2022, expected prices over the next four years in comparison to March 2022 were:

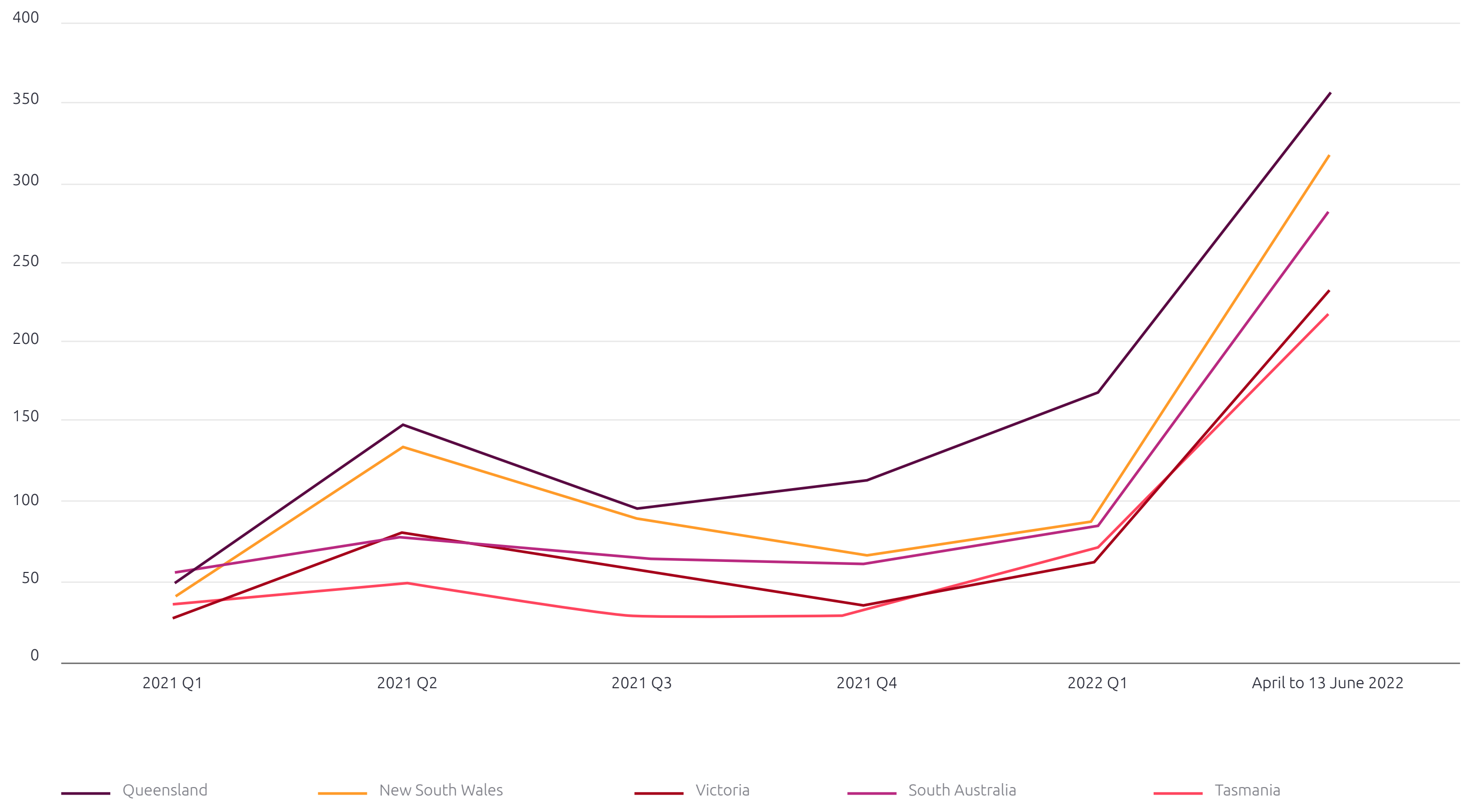
- 16-121% higher in Queensland
- 24-178% higher in Victoria
- 31-167% higher in South Australia

In New South Wales, prices are expected to be 13-58% higher for 2023, but also projected to return to the levels seen in March 2022. That said, these figures are still well above prices seen in September 2021. Recently, very high spot prices may also have reduced the volume of contracts traded. Access to appropriate hedge contracts is important for retailers to be able to manage spot price risk.

This has led to an unprecedented level of market intervention by the Australian Energy Market Operator (AEMO). Cumulative price caps have been imposed for extended periods, and a temporary suspension of the spot market in all regions of the NEM was ultimately required to ensure dispatch coordination in June 2022.

FIGURE 3

Quarterly wholesale spot prices across National Electricity Market regions, Q1 2021 to Q3 2022



Source: ACCC - Inquiry into the National Electricity Market - https://www.accc.gov.au/system/files/May%202022%20report%20-%20Addendum.pdf

Summary:

For generators, this market volatility produced different results:

- For those poorly positioned via low reliability of generation fuel or supply issues, there were large reductions in underlying profit due to spot market buying.
- For those well-positioned, there were super-profits due to cheap, available fuel supply. Most notably, generation via pumped hydro or hydroelectric generation faced little impact.

For retailers, this market volatility resulted in:

- Significant, negative financial impacts for those forced to buy in the spot market (see above chart for spot prices).
- Customers of insolvent retailers have been transferred to large incumbents under the Retailer of Last Resort (ROLR) provisions. This introduced an incremental drag on performance given that no genuine energy position is transferred with the customer.
- Some retailers were forced to lift pricing above the Default Market Offer (DMO) or Victorian Default Offer (VDO) in Victoria reference prices. For example, in NSW alone, the approved increases were anywhere from 9.6 to 18.3%[1].
- Some retailers were forced to withdraw from the market. This includes ASX-listed retailer Local Planning Energy (LPE) and Kiwi-owned ReAmped.

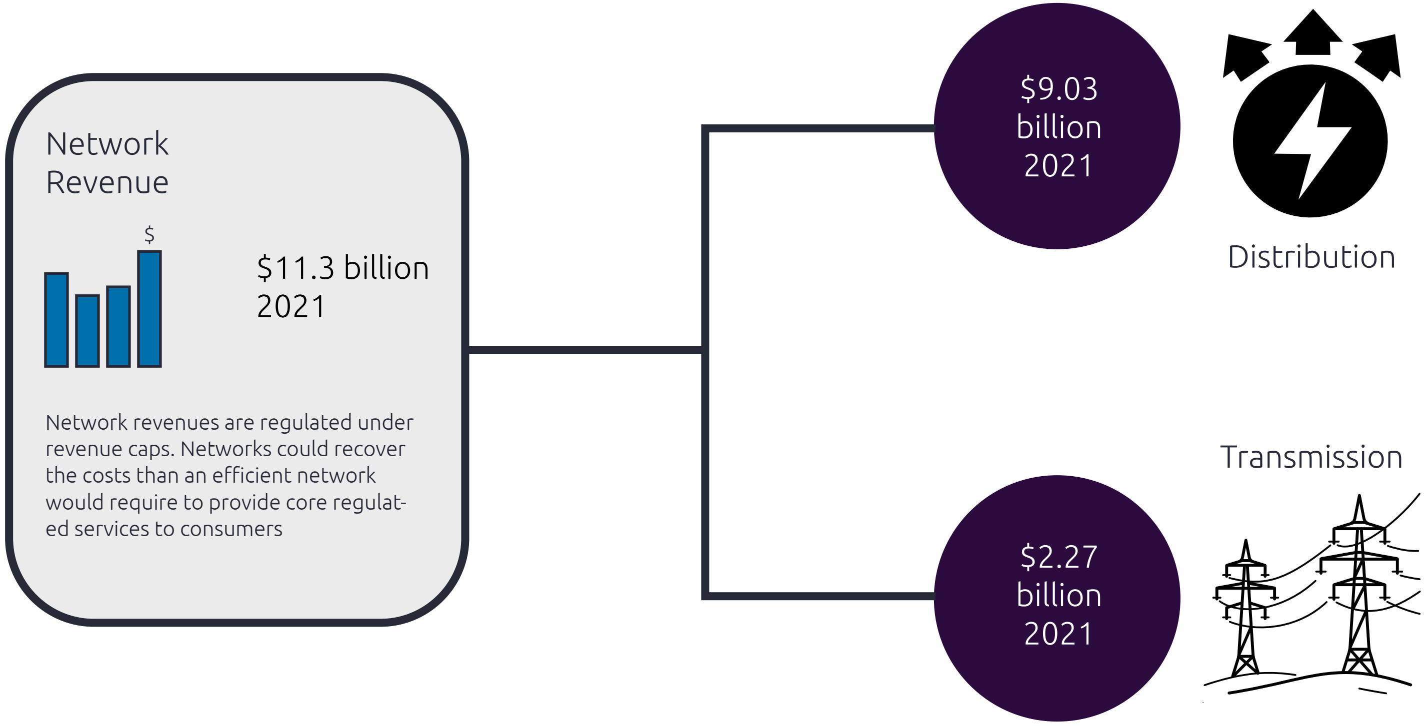
1 https://www.finder.com.au/1-july-energy-price-increase-2022

We believe that ultimately, such conditions will result in further consolidation of retailers so they can survive tough market conditions over the short term.

There is a high probability of further market intervention from AEMO, with the possibility of necessary policy reforms to make a more equitable, sustainable playing field for retailers.

FIGURE 4

Electricity networks performance in 2021



Source: AER - Infographic - Electricity network performance report
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022
https://www.aer.gov.au/system/files/Infographic%20-%202022%20electricity%20network%20performance%20report.pdf

APPENDIX

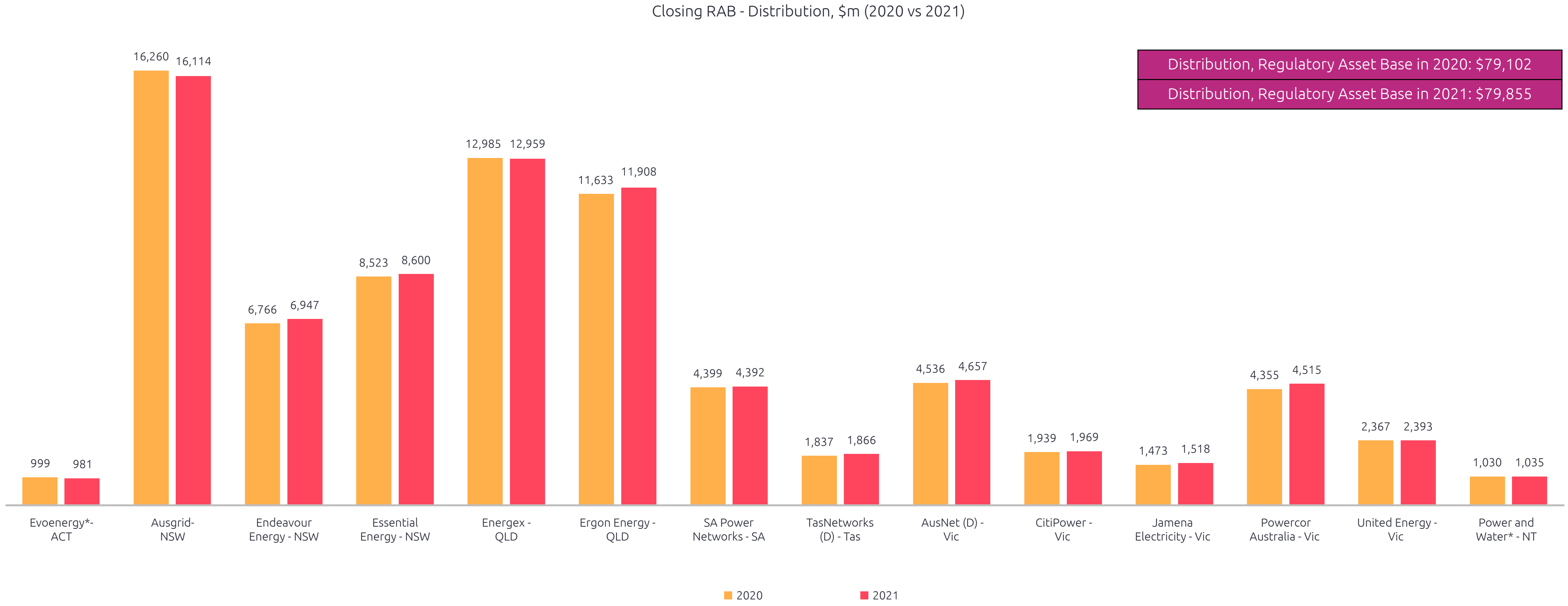
FIGURE 5

Distribution, annual revenue, $ million, (2020 vs 2021)

Source: AER - Electricity network performance report 2022
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022

FIGURE 6

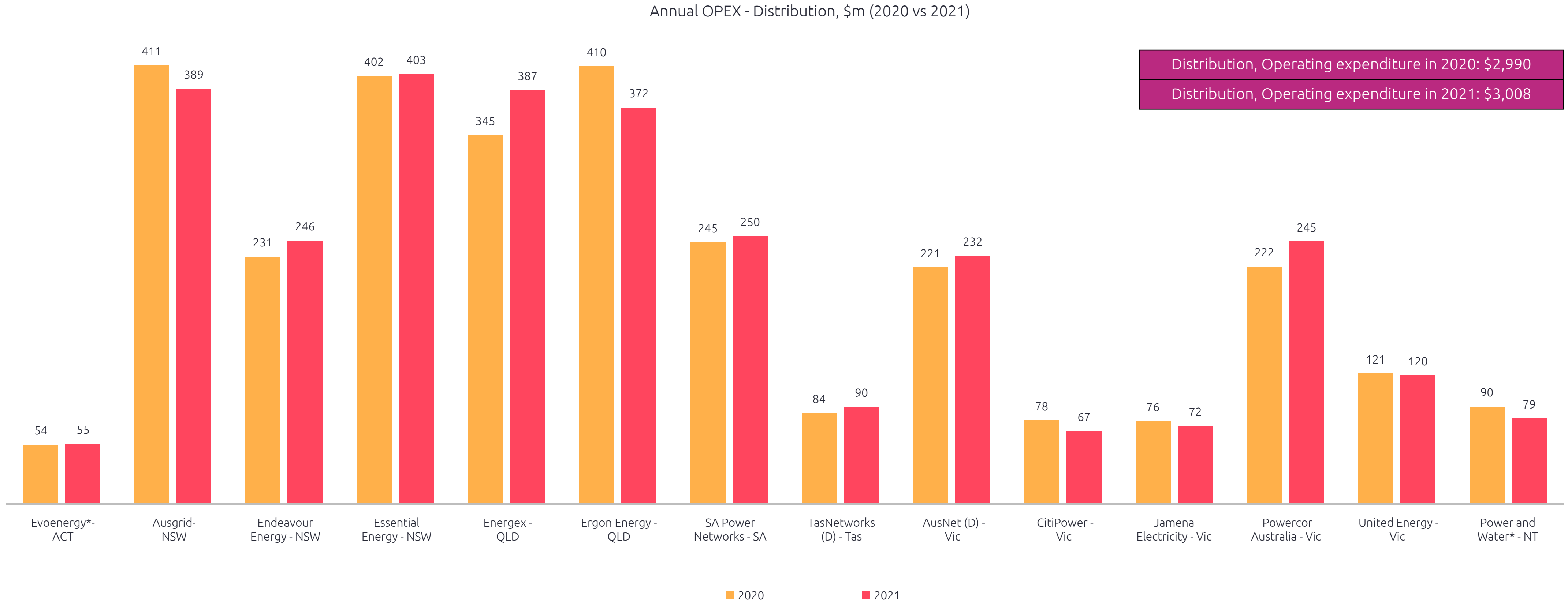
Distribution, regulatory asset base, $ million, (2020 vs 2021)



Source: AER - Electricity network performance report 2022
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022

FIGURE 7

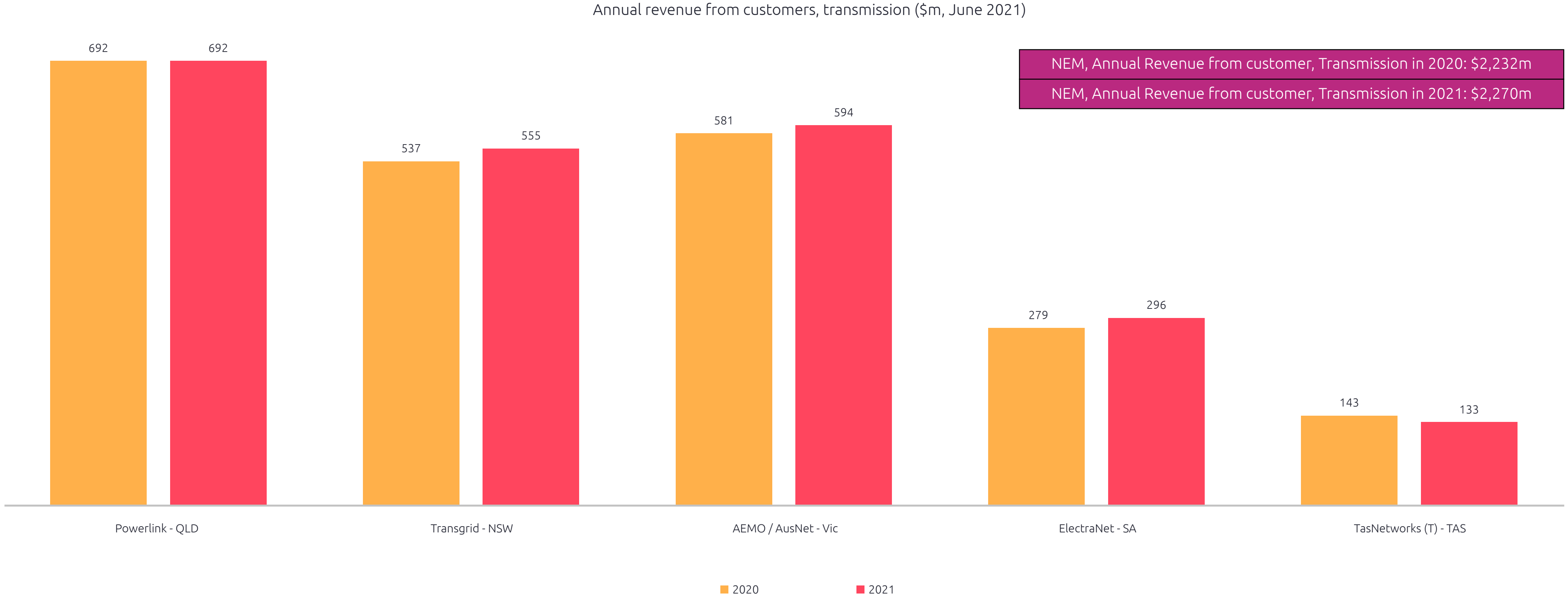
Distribution, operating expenditure, $ million, (2020 vs 2021)



Source: AER - Electricity network performance report 2022
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022

FIGURE 8

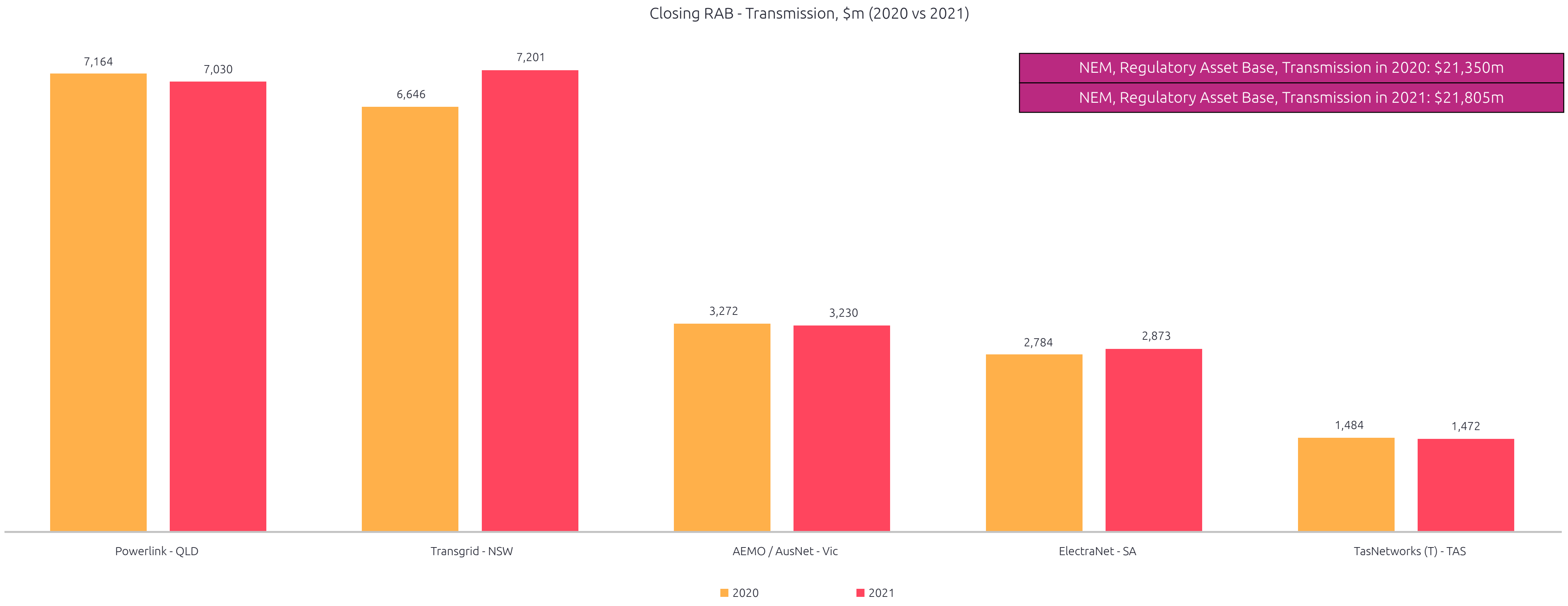
Transmission, annual revenue, $ million, (2020 vs 2021)



Source: AER - Electricity network performance report 2022
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022

FIGURE 9

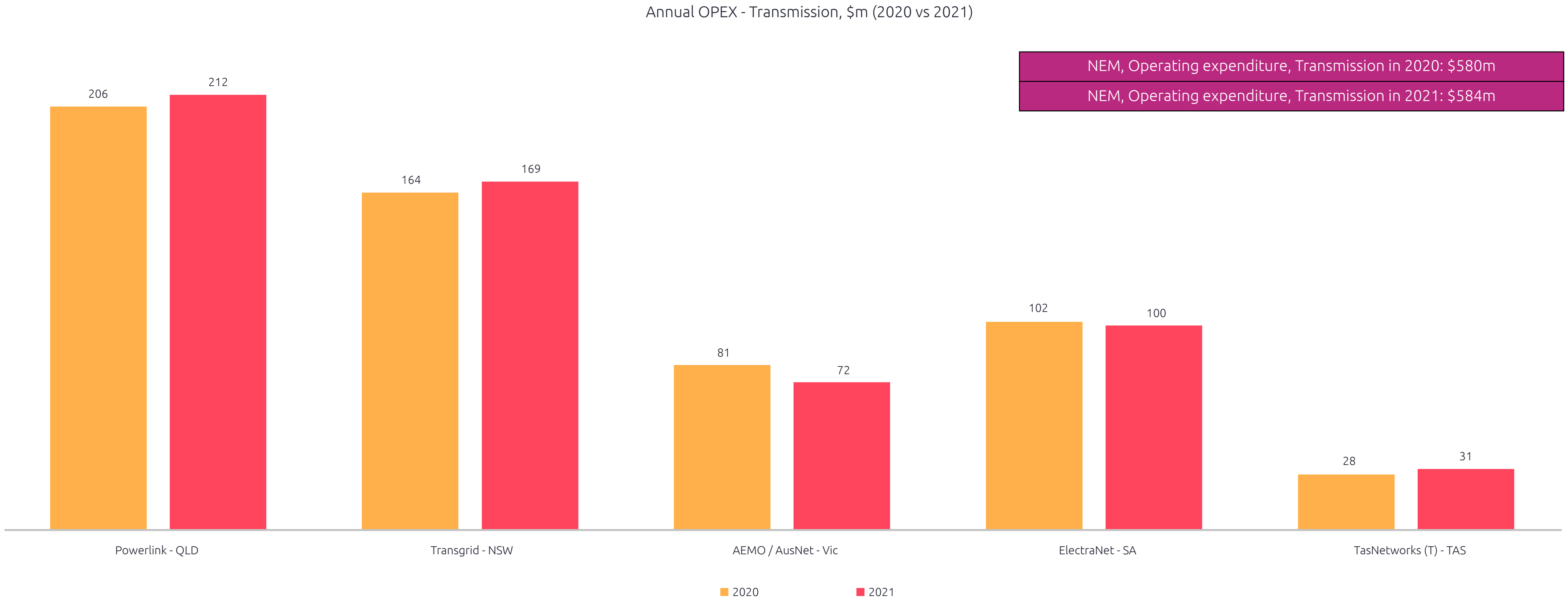
Transmission, regulatory asset base, $ million, (2020 vs 2021)



Source: AER - Electricity network performance report 2022
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022

FIGURE 10

Transmission, operating expenditure, $ million, (2020 vs 2021)



Source: AER - Electricity network performance report 2022
https://www.aer.gov.au/networks-pipelines/electricity-network-performance-report-2022

AUSTRALIA PLAYERS, PRIORITIES, MARKET M&A

VINNIE NAIR
NICOLE ALLEY
ISHANDEEP

In the following article, we identify key players in the Australian electricity market and their market share performance, taking into account the segment within the energy market in which they operate. We outline current challenges being faced by electricity and gas retail and distribution businesses, and describe how fossil fuel generators such as Ampol, Shell, and bp are making efforts to transition their core businesses into the renewable energy market – including within the energy retail segment. Furthermore, we discuss how these players are positioning themselves as key players in the utilities market, and highlight how large telco players (such as Telstra) are diversifying their portfolio through investments in the energy sector.

Key players in the Australian electricity market

The Australian energy market across electricity and gas generation, transmission, distribution, and retail is highly deregulated and unlike many other markets around the world, is not vertically integrated.[1]

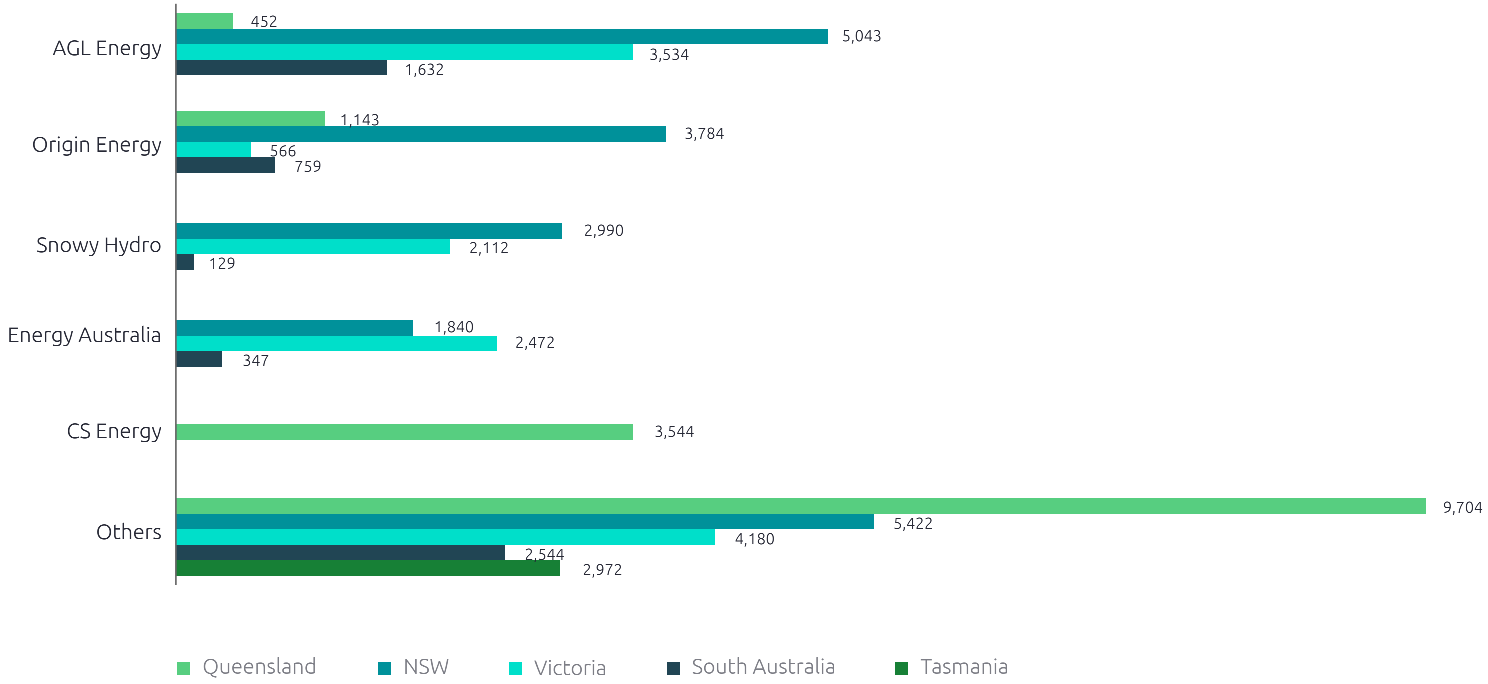
Per the latest "State of the energy market" report, released by the Australian Energy Regulator (AER), July 2021[2]:

- AGL Ltd. and Origin Energy were the largest participants, accounting for over 40% of total generation capacity in all regions, except South Australia.
- Over the past five years, Powerlink (Queensland) and AusNet Services (Victoria) have consistently experienced the fewest loss of supply events amongst all the transmission networks in the National Energy Market (NEM).
- Energex (ENX), Ergon (ERG), and Ausgrid (AGD) are the largest Distribution Network Service Providers (DNSPs). In 2021, the DNSP Annual Benchmarking Report[3] stated that in 2020, ENX delivered 21,141 GWh to 1.52 million customers (over 55,190 circuit kilometers (CKm) of lines and cables). In the same year, ERG delivered 13,567 GWh to 762,303 customers (over 152,896 CKm of lines and cables), and AGD delivered 24,934 GWh to 1.76 million customers (over 42,295 CKm of lines and cables), all within the regions they serve.
- In the retail market, AGL Energy, Origin Energy, and EnergyAustralia are the top three retailers in Australia, based on market share. AGL Energy, Origin Energy, and EnergyAustralia supply 64% of small electricity customers and 73% of small gas customers.

1 https://www.aer.gov.au/industry-information
2 https://www.aer.gov.au/system/files/State%20of%20the%20energy%20market%202021%20-%20Full%20report_1.pdf
3 https://www.aer.gov.au/system/files/Distribution%20-%20Report%20-%20Economic%20Insights.pdf

FIGURE 1

Market shares in generation capacity, GW, 2021



Source: AER – State of the Energy Market Report, 2021
https://www.aer.gov.au/system/files/State%20of%20the%20energy%20market%202021%20-%20Full%20report_1.pdf

Private entities own most generation capacity in NSW, Victoria, and South Australia:

In NSW, AGL Energy (26%) and Origin Energy (20%) are the largest power producers. Snowy Hydro (16%) and EnergyAustralia (10%) are other major players. In Victoria, AGL Energy (27%) and EnergyAustralia (19%) control a majority of the capacity. The government-owned Snowy Hydro (16%) is the next largest participant. In South Australia, AGL Energy is the largest power plant owner, with 30% of capacity. Other significant entities are Engie (18%), Origin Energy (14%), and EnergyAustralia (6%).

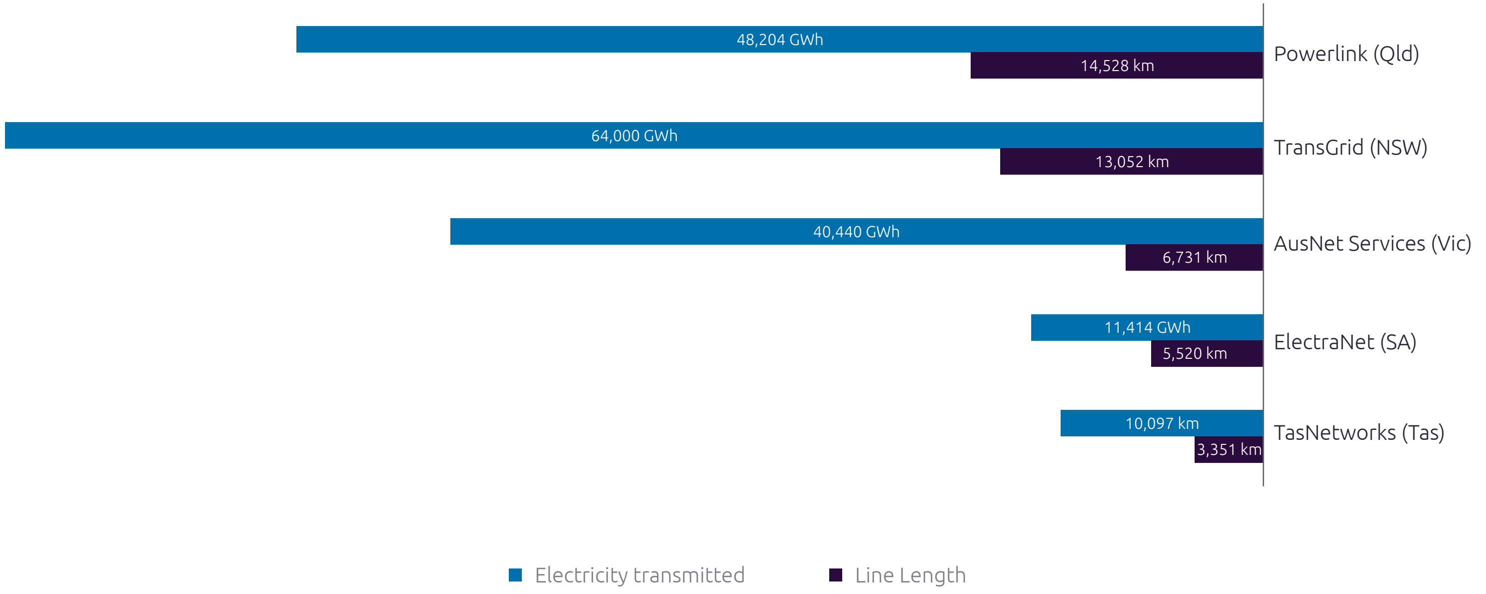
The transmission grid connects with 13 distribution networks:

Consumers in Queensland, NSW, and Victoria are serviced by multiple distribution networks, each of which owns and operates its network within a defined geographic region. South Australia, Tasmania and the ACT are serviced by single distribution networks operating within each jurisdiction. The Northern Territory has three separate networks – the Darwin-Katherine, Alice Springs, and Tennant Creek systems – that are all owned by Power and Water Corporation (Power and Water). The networks are classified as a single distribution network for regulatory purposes but do not connect to each other or the NEM. The AER regulates all major networks in the NEM, other than the Basslink interconnector linking Victoria with Tasmania. It also regulates the Northern Territory's distribution network.

- The AER does not regulate electricity networks in Western Australia, where the Economic Regulation Authority (ERA) administers state-based arrangements.

FIGURE 2

Transmission networks regulated by the AER



Source: AER – State of the Energy Market Report, 2021
https://www.aer.gov.au/system/files/State%20of%20the%20energy%20market%202021%20-%20Full%20report_1.pdf

Energex:

In 2020, ENX delivered 21,141 GWh to 1.52 million customers via 55,190 circuit kilometers of lines and cables. ENX distributes electricity in Southeast Queensland, including the major urban areas of Brisbane, Gold Coast, Sunshine Coast, Logan, Ipswich, Redlands, and Moreton Bay. ENX's electricity distribution area runs from the NSW border north to Gympie and west to the base of the Great Dividing Range. **It is the second largest DNSP in the NEM in terms of customer numbers and energy throughput.**

Ergon Energy:

In 2020, ERG delivered 13,567 GWh to 762,303 customers over 152,896 circuit kilometers of lines and cables. ERG distributes electricity throughout regional Queensland, excluding Southeast Queensland. **ERG is around the seventh largest DNSP in the NEM in terms of customers, but is the second largest in terms of network length.**

Ausgrid:

In 2020, AGD delivered 24,934 GWh to 1.76 million customers over 42,295 circuit kilometers of lines and cables. AGD distributes electricity to the eastern half of Sydney (including the Sydney CBD), the NSW Central Coast, and the Hunter region across an area of 22,275 square kilometers. **It is the largest of the three NSW DNSPs in terms of customer numbers and energy throughput.**

Endeavour Energy:

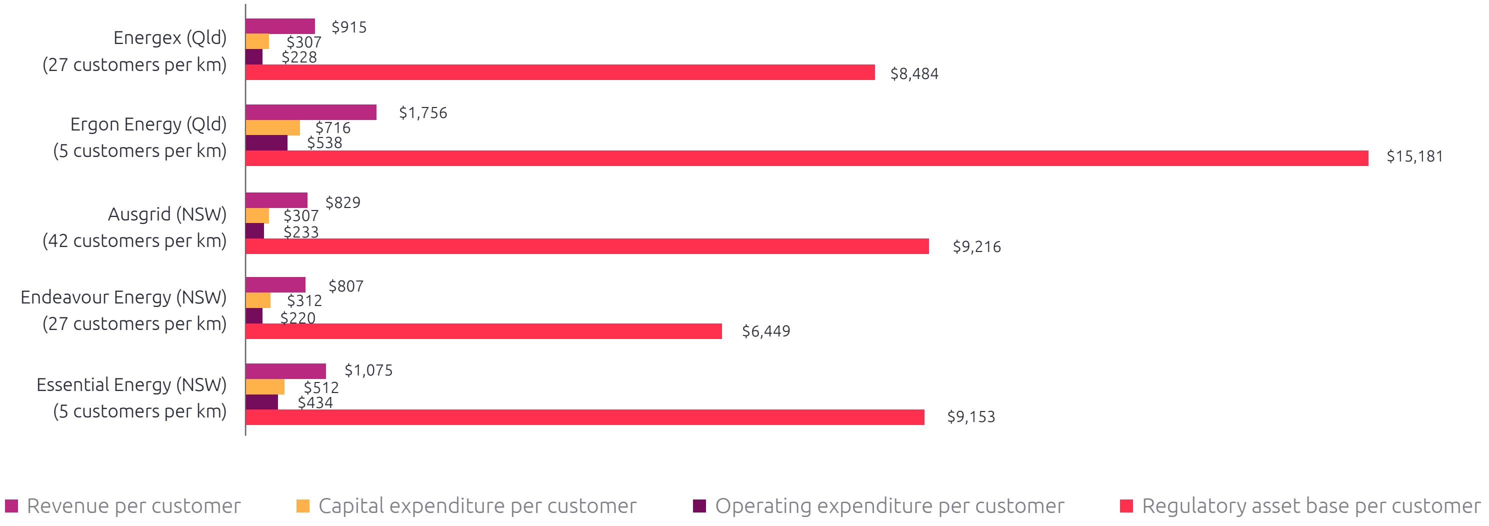
In 2020, END delivered 16,511 GWh to 1.05 million customers over 38,725 circuit kilometers of lines and cables. END distributes electricity to Sydney's Greater West, the Blue Mountains, Southern Highlands, the Illawarra, and the South Coast regions of NSW. **It is the second largest of the three NSW DNSPs in terms of customer numbers and energy throughput.**

Essential Energy:

In 2020, ESS delivered 12,450 GWh to 925,966 customers over 192,685 circuit kilometers of lines and cables. ESS distributes electricity throughout 95% of New South Wales land mass and parts of southern Queensland. **ESS is the fourth-largest NEM DNSP in terms of customer numbers and the largest in terms of network length.**

FIGURE 3

2021 DNSP Annual Benchmarking, Key Financial Indicators (2020)



Source: AER – State of the Energy Market Report, 2021 and 2021 DNSP Annual Benchmarking Report
https://www.aer.gov.au/system/files/State%20of%20the%20energy%20market%202021%20-%20Full%20report_1.pdf
https://www.aer.gov.au/system/files/Distribution%20-%20Report%20-%20Economic%20Insights.pdf

FIGURE 4

Key players in the Australian retail market

AGL Energy | Origin Energy | Energy Australia | Tier 1 | Tier 2 | Snowy Hydro | Alinta Energy | Simply Energy

AGL Energy, Origin Energy and EnergyAustralia are the major participants in the NEM retail market.

AGL supplies around 24% of the electricity customers and 33% of the gas customers in NEM. Its market share is highest in NSW, supplying 38% of electricity customers and 44% of gas customers.

Origin Energy supplies around 25% of the electricity customers and 23% of the gas customers in NEM. Its market share is highest in NSW, supplying 44% of electricity customers and 32% of gas customers.

Energy Australia supplies around 15% of the electricity customers and 18% of the gas customers in NEM. Its market share is highest in NSW, supplying 61% of electricity customers.

Snowy Hydro (owned by the Australian Government and trading as Red Energy and Lumo Energy) supplies around 7% of the electricity customers and 9% of the gas customers in NEM. Its market share is highest in Victoria, supplying 13% of electricity customers and 14% of gas customers.

Alinta Energy supplies 5% of the electricity customers and 3% of the gas customers in NEM. Its market share is highest in Queensland (where it is the third largest retailer in the southeast of the state, with 9% of the electricity customers and 1% of the gas customers) and South Australia (6% of the electricity customers and 5% of the gas customers).

Simply Energy (owned by ENGIE) supplies 4% of the electricity customers and 6% of the gas customers in NEM, including 9–10% of customers in Victoria and South Australia. It is the third largest energy retailer in South Australia.

Source: AER – State of the Energy Market Report, 2021
https://www.aer.gov.au/system/files/State%20of%20the%20energy%20market%202021%20-%20Full%20report_1.pdf

The energy market in Western Australia and the Wholesale Electricity Market (WEM)

The Western Australian government owns three corporations with active roles in the electricity supply chain[4].

- Synergy is responsible for the sale of electricity and power generation, providing 52% of the electricity sold to households and business customers in the SWIS[5]. It is the largest generator and retailer in the WEM.
- Western Power is responsible for building, maintaining, and operating the electricity network for 2.3 million customers within the Southwest Interconnected System (SWIS)[6].
- Horizon Power is responsible for the generation, distribution, and sale of electricity of its 1.15 million customers in regional towns and communities in areas outside of the SWIS in WA[7]. Horizon Power operates the Northwest Interconnected System (NWIS) in the Pilbara region, the smaller Esperance network, and microgrids across regional WA. Horizon delivers around 1,040.61 GWh of energy generated from gas, diesel, and renewable energy (solar, wind, and hydro).

Performance indicators:

- As of August 22, 2022, the top three energy generators in the WEM in Western Australian were Synergy (generating around 586 MW), followed by NewGen Kwinana (contributing around 184 MW), and then Alinta (generating approximately 178 MW)[8].
- Per the report by the Energy Council of Australia, "Revenue Adequacy for Generators in the WEM" (April 2022), three generators (Synergy, Summit Southern Cross Power, and Alinta) accounted for 90% of electricity generated[9].

Electricity distribution in WA:

According to the report written by the Economic Regulation Authority, "Annual Data Report 2020-21", the number of electricity distributors licensed to supply small use customers has not changed since 2019-20.

- Electricity distribution licensees that supply customers are Horizon Power, Rottnest Island Authority, Western Power, and Peel Renewable Energy Pty Ltd.
- Western Power and Horizon Power are the largest distributors of electricity in WA, having provided electricity connection to around 1,175,528 and 51,951 customers respectively, in 2020-21.
- Horizon Power is responsible for transporting power via 56,081 distribution poles and 8,356 kms of overhead and underground transmission and distribution lines whereas Western power is responsible for transporting power via 825,309 distribution poles and towers and 103,069km circuit wire.[10]
- Privately owned networks: Privately owned electricity transmission and distribution networks mainly service mining operations in the Pilbara.

Energy retail in WA:

- According to the report by the Economic Regulation Authority Western Australia, "Annual Data Report 2020-21", there were 13 licensed retailers that supplied electricity in WA. The two largest retailers were Synergy, serving around 1,023,854 residential customers, followed by Horizon Power, serving 36,256 residential and approximately 9,000 business customers.
    - Horizon Power also manages 38 microgrids in their service area.

The energy retailers, Synergy and Horizon Power, serve the highest number of customers. In 2020-21, Synergy served around 93,675 customers, Horizon served 7,456 followed by Alinta Energy with 3,509 customers, and Perth Energy with 1,051 customers.[11]

4 https://www.wa.gov.au/organisation/energy-policy-wa/electricity-industry#:~:text=Western%20Australia's%20largest%20generator%20is,West%20electricity%20market%20in%202016.
5 https://www.synergy.net.au/About-us/Who-we-are
6 https://www.westernpower.com.au/about/what-we-do/
7 https://www.westernpower.com.au/media/4768/annual-planning-report-2020-20210211v2.pdf
8 https://wa.aemo.com.au/energy-systems/electricity/wholesale-electricity-market-wem/data-wem/data-dashboard#generation-map
9 https://www.energycouncil.com.au/media/xlab4zma/mja-final-report-generator-revenue-adequacy.pdf
10 https://www.westernpower.com.au/media/4768/annual-planning-report-2020-20210211v2.pdf
11 https://www.erawa.com.au/cproot/22392/2/Final-for-publication---Annual-data-report---Energy-retailers-2020-21.pdf

The blurring of retail and distribution businesses

NEM average wholesale electricity prices rose sharply, due to which retailers are finding it difficult to manage profits with a few smaller retailers exiting the retail business[12].

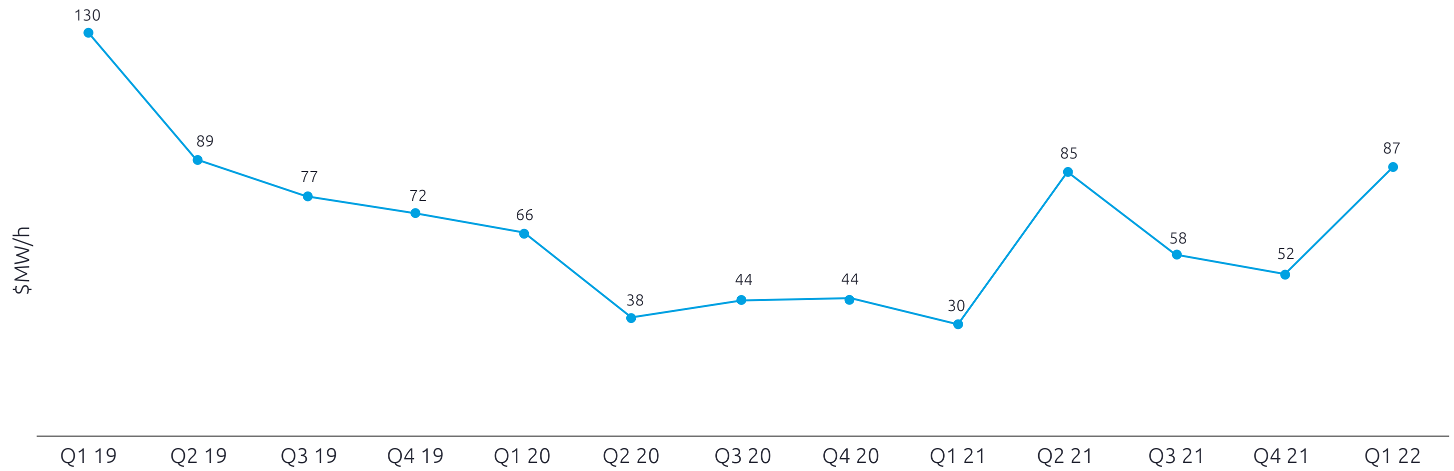
Recently, wholesale electricity prices have increased significantly. The Australian Electricity Market Operator (AEMO) reported that in the first quarter of 2022, wholesale prices went up 141% from the previous year, with the ASX showing prices of AUD $302 in Q2 2022[13].

- NEM wholesale electricity spot prices rose sharply in Q1 2022, averaging $87/MWh across the five NEM regions. This was up 67% from Q4 2021, and up 141% from Q1 2021.

Since May 2022, three retailers have failed. This required the AER to activate its "retailer of last resort" provision that transfers customers to backup suppliers.

FIGURE 5

NEM average wholesale electricity spot price



Source: AEMO - Quarterly Energy Dynamics, Q1 2022 (April 2022)
https://aemo.com.au/energy-systems/major-publications/quarterly-energy-dynamics-qed

12 https://www.aemo.com.au/-/media/files/major-publications/qed/2022/qed-q1-report.pdf?la=en&hash=981BA7016C0C9A25947F0F05198EDB
13 https://newsroom.unsw.edu.au/news/business-law/energy-crisis-why-are-electricity-prices-set-rise

Multiple factors have contributed to recent rising gas and coal prices. These include an increase in generation costs (due to unplanned outages at multiple generators leading to a reduction of thermal power generation), the Russia-Ukraine war threatening energy supplies, supply chain difficulties due to Covid-19 disruptions, a challenging global environment, and extreme weather events in NSW and South-East Queensland[14].

With an increase of 140% in the wholesale cost of producing electricity, households are concerned about their ability to pay their electricity bills. There is also concern about the viability of smaller electricity retailers. This has led to sharp and unpredictable spikes in energy demand.

This is an inherently tougher game for smaller retailers than it is for the "Big-3" gen-tailers (AGL, Origin Energy, and EnergyAustralia), who cater to the two-thirds of contestable NEM customers and hold the majority of the NEM operational volumes.They are also involved in their own energy generation, which means they are not entirely reliant on buying energy from the wholesale market.

- The article, "Locality Planning Energy" (June 2022), claimed that a small electricity retailer in Australia asked customers to switch providers, or face a huge rise in their power bills. RenewEconomy reported that LPE is certainly not the only company to have taken this approach to the ongoing crisis in the NEM. ReAmped Energy and Discover Energy also asked customers to leave, while other companies like Amber Electric and Diamond Energy have been limiting new sign-ups to customers with solar and/or a home battery[15].

14 https://www.mybusiness.com.au/resources/news/smes-brace-for-energy-crisis
15 https://reneweconomy.com.au/energy-retailer-cashes-out-of-market-after-telling-customers-to-go-elsewhere/

Implications:

Small electricity retailers are prepared to go to the wall, as they struggle to keep customers after increasing bills in the aftermath of the surging costs of wholesale production. However, Australia should avoid large-scale insolvencies, like those seen in Britain[16].

16 https://www.afr.com/companies/energy/power-companies-to-customers-leave-us-we-re-too-expensive-20220519-

Fossil fuel players and their positioning within the utility sector

Many oil and gas players are retreating from Independent Power Producer (IPP) positions and looking at the alternative energy retail market as a way to offer more downstream services. Through new business models, these players are looking for ways to capitalize on the convergence of energy efficiency and distributed energy resources[17].

Ampol entered the energy retail market: In June 2022, the AER approved an electricity retailer authorization application from Ampol Energy (retail), under the Australian National Energy Retail Law [24]. Ampol Energy will utilize its existing infrastructure and its three million weekly customers, along with 80,000 corporate customers, as the basis of its energy retail offer. Ampol is focused on the evolving and changing energy market[18]. The company plans to offer electricity and gas products to all jurisdictions of the National Electricity Market (NEM) and to household customers, as well as to commercial and industrial businesses. In May last year, Ampol announced its plan to invest AUD $100 million over the next five years to develop new fuels, including green hydrogen, and increase electric vehicle charging[19].

Shell expanded into the Australian retail power market with an AUD $528 million acquisition: In Feb 2022, Shell completed its acquisition of green power. The company, Powershop Australia, will now operate as a wholly owned subsidiary of Shell, under the Powershop brand. This is within the Shell Energy business in Australia – part of Shell's global Renewables and Energy Solutions business[20]. The deal follows Shell's acquisition of the power supplier to commercial businesses in 2019 and is in line with its plans to double the amount of power it sells globally to retail and business customers by 2030 to around 560 terawatt hours annually. The deal is in line with Shell's aim to become a leading provider of clean power-as-a-service, and also broadens its customer portfolio in Australia to include households.

bp's acquisition of Asian Renewable Energy Hub: In June 2022, bp acquired a 40.5% stake in Asian Renewable Energy Hub (AREH) to become its operator. It has the potential to be one of the largest renewables and green hydrogen hubs in the world. bp is bringing the resources and capability to fulfill a long-held vision of the competitive production of green fuels at oil-and-gas scale from the AREH project. This will support the development of up to 26 GW of combined solar and wind power generating capacity and could produce 1.6 million tonnes of green hydrogen or nine million tonnes of green ammonia per annum. AREH has the potential to provide significant net renewable generating capacity for bp, as well as making a material contribution to its strategic aim in capturing a 10% share in core hydrogen markets globally[21].

17 https://www.cleantech.com/energy-retail-innovation-opportunities-to-improve-consumer-engagement/
18 https://www.pv-magazine-australia.com/2022/02/03/ampol-makes-move-into-energy-retail-market/
19 https://www.erpecnewslive.com/article/14770/ampol-to-spend-77-mln-on-future-fuels
20 https://www.pv-magazine-australia.com/2022/02/02/shell-completes-powershop-takeover-despite-widespread-outrage/
21 https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/news-and-insights/press-releases/bp-to-lead-and-operate-one-of-the-worlds-largest-renewables-and-green-hydrogen-energy-hubs-based-in-western-australia.pdf

Telco players' investment in energy

Telco players (such as Telstra) are diversifying their portfolio by investing in the creation of an energy retail business and offering. TPG Telecom and Telstra have set the pace for investments in the energy market. Most recently, Optus also committed to 100% renewable electricity[22].

As part of its T25 growth strategy, in November 2021, Telstra applied for a retail energy license to secure more than half a million customers. This would ensure they become one of the top five energy retailers within the next four years.

- After receiving an approval from AER to become an energy retailer in November 2021, Telstra Energy started its new phase. Telstra is already a significant participant in the energy market, generating enough renewable energy to power 100,000 homes[23].
- In February 2022, Telstra signed an AUD $100 million cellular IoT deal for four million smart meters. Telstra also announced a deal with utility services provider Intellihub to provide up to 4.1 million cellular IoT SIMs for smart energy meters in Australia over the next 10 years. The meters will be connected on Telstra's NB-IoT network. Many will be installed when customers take up its electricity retail offer through Telstra Energy[24].
- In June 2022, Telstra started taking registrations of interest for Telstra Energy. They began preparing their transition into the energy market by planning a smart, price-conscious, carbon-neutral offering, and asking customers to register expressions of interest to join. Telstra also guaranteed to be 100% carbon-neutral by offsetting the carbon emissions from energy use at no extra cost[25].

TPG Telecom dials up to 100% renewable electricity

- In March 2021, TPG Telecom announced plans to power its entire operations across Australia, with 100% renewable electricity by 2025. TPG Telecom partnered with South Pole to help them set their renewable electricity target and assess procurement options. In addition to TPG Telecom's own on-site solar generation, the commitment to 100% renewable electricity will be met by buying renewable energy products in Australia, providing a boost to the growth of renewable energy, and the transition of Australia's electricity grid[26].

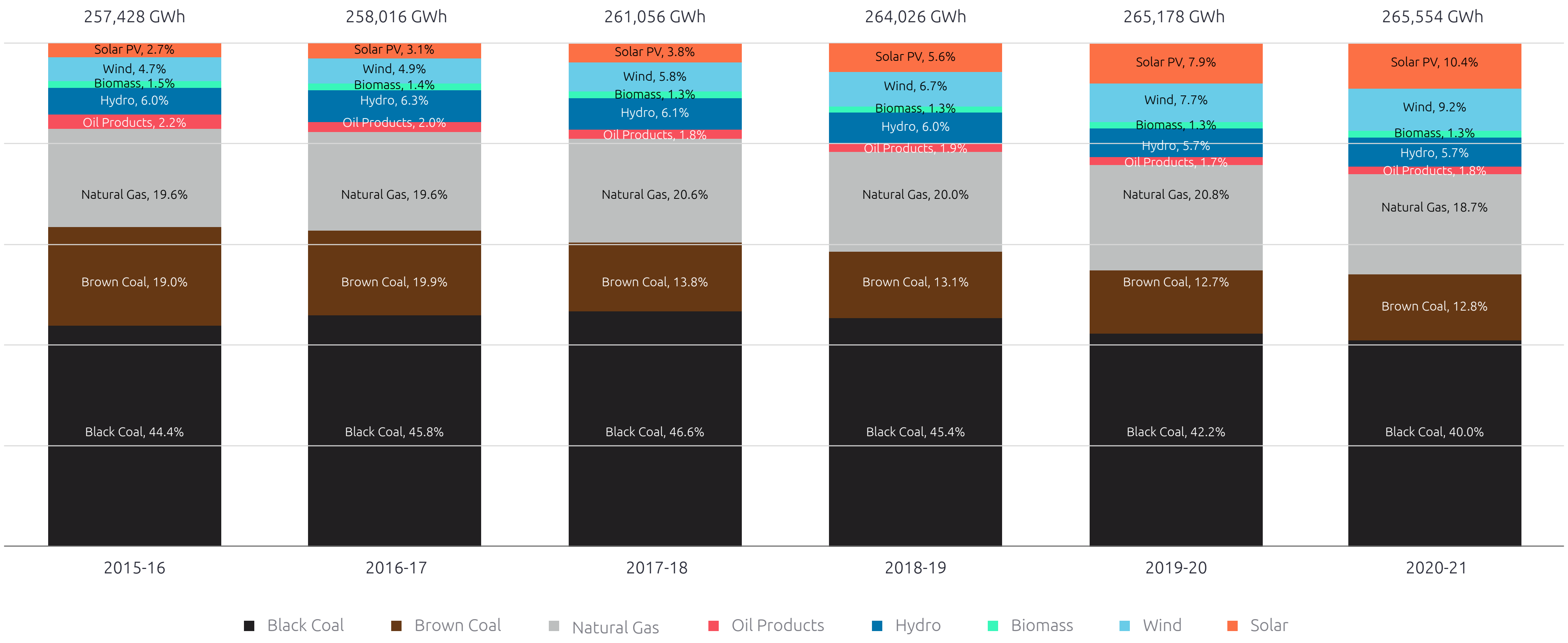
Optus pledges to be 100% "backed by renewables" by the end of 2025

- In May 2022, Op commitment to switch to 100% renewable electricity by the end of 2025, bringing the Singapore-owned Australian telco in line with its main industry rivals, Telstra and TPG. The telco will help customers who wish to up their sustainability game through offsetting, recycling and reducing waste [34]. Notably, Optus is the first telecommunications company to issue a Sustainability-Linked Bond in the Australian market and the broader Asia Pacific region. The bond will finance initiatives, as the company works to reduce its Scope 1 and 2 emissions by 25% by 2025 (from a 2015 baseline). The Clean Energy Finance Corporation (CEFC) invested AUD$60 million in the $300 million Optus Sustainability-Linked Bond[27].

22 https://www.greenpeace.org.au/news/tpg-telecom-dials-up-to-100-renewable-electricity/
23 https://www.aer.gov.au/communication/telstra-energy-retail-pty-ltd-granted-gas-and-electricity-retailer-authorisation
24 https://www.aer.gov.au/communication/telstra-energy-retail-pty-ltd-granted-gas-and-electricity-retailer-authorisation
25 https://agadir-group.com/telstra-taking-registrations-of-interest-for-telstra-energy/
26 https://www.southpole.com/fr/clients/tpg-telecom-sets-sights-on-100-renewable-electricity
27 https://www.cefc.com.au/where-we-invest/case-studies/optus-scores-clean-energy-first/

FIGURE 6

Electricity mix in Australia, 2016-2021



Source: Australian Energy Statistics, Table O Electricity generation by fuel type 2020-21 and 2021
Link: https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2020-21-and-2021

08 TRANSFORMATION

DIGITALIZATION UPDATE: DATA MASTERY, ARTIFICAL INTELLIGENCE, AND DIGITAL TWINS

DAVID BUTCHER
RAMYA KRISHNA PUTTUR
NANCY MANCHANDA

Data Mastery – Enhancing digital and data capabilities

Organizations in the energy sector are enhancing digital and data capabilities

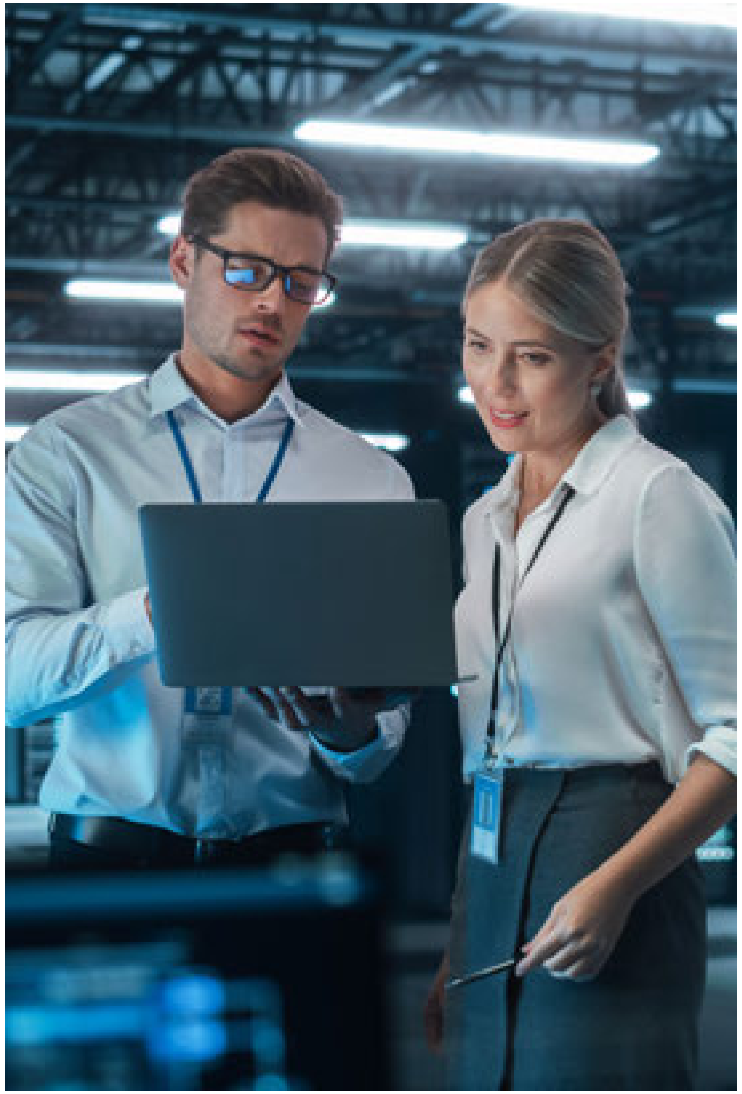
As the energy sector moves toward the use of digital twins and automation as the norm, data mastery is a building block that is essential to making this a reality. So, how is energy faring against other sectors with respect to becoming the data master they need to be?

What is data mastery?

A data master is a high-performing organization which is able to harness the full suite of data capabilities across its organization and ecosystem – turning insights into actions and beyond.

To ensure trusted data availability, energy organizations must focus on strong data management capabilities and invest in better data quality, given that quality is a major driver of a lack of trust. The consequences of poor data quality can be enormous, with serious implications for revenue, operational efficiency, productivity, regulatory compliance, scalability, and, ultimately, trust.

Data masters manage data as a strategic asset across multi-cloud environments. Cloud migration is already a priority at many energy organizations. The appetite for cloud-based systems is driven by a range of advantages – they are not only cost-efficient but help drive innovation. In addition, they enhance analytics capabilities at scale, increase development velocity, and harmonize datasets across multiple environments to provide a consistent view of the business.



Enhancing the necessary digital and data capabilities

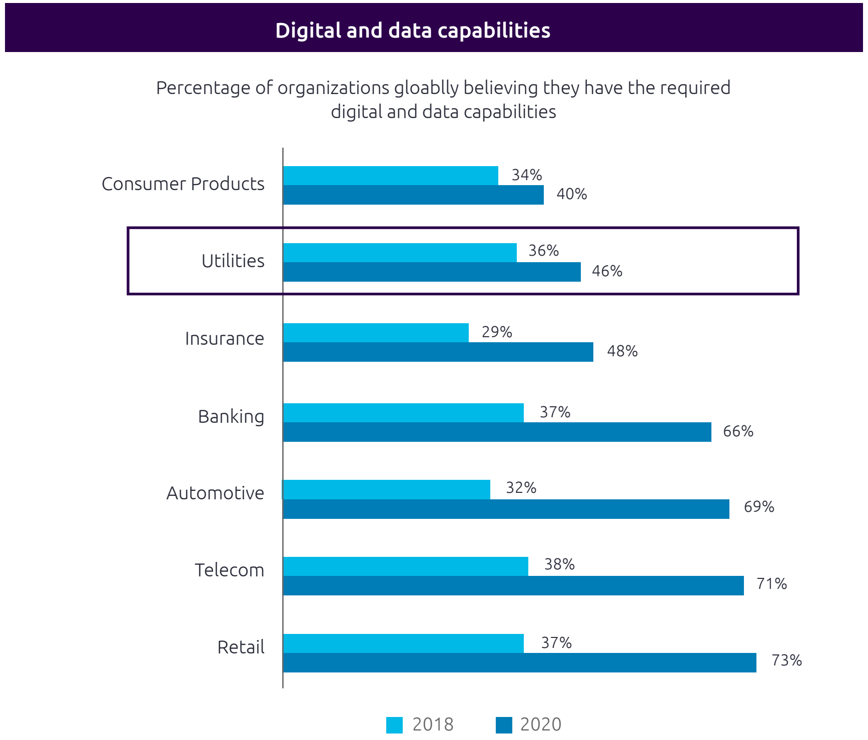
To take these steps, organizations must enhance their digital and data capabilities. As seen from the graph below, there has been progress in enhancing the required digital and data capabilities in energy.

The reasons behind the rapid increase in digital and data capability-building include; Covid-19 acting as an accelerant and forcing change; increased investments in digital transformations since 2018; increased adoption of emerging technologies; and a renewed focus on talent and culture.

However, it is clear that the energy sector has much to learn from other sectors; therefore, more progress and benefits can be gleaned from data

FIGURE 1

Digital and data capabilities



Source: Capgemini Research Institute, Digital Mastery Survey, April–May 2018, N=1,338 respondents, 757 organizations; Digital Maturity Survey, May–June 2020, N=1,000 respondents.

Data mastery – Exploiting artificial intelligence (AI)

How energy organizations ensure their data is trustworthy using AI

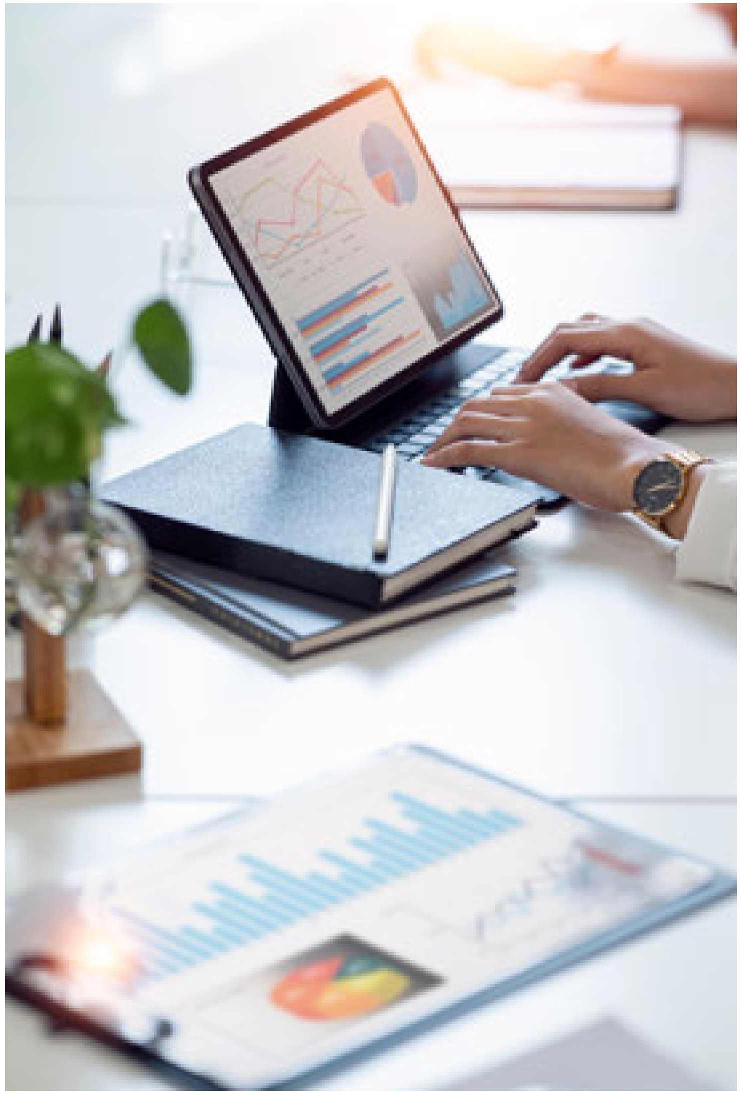
Fixing data integrity issues at the point of collection (or soon after) helps ensure data hygiene and provide quality data for business intelligence. However, maintaining data integrity is often a challenge when dealing with varied siloed data sources (particularly in the case of asset data). Issues such as transfer error, human error, or misconfigurations can make the integrity-checking process arduous. Organizations are turning to AI to help.

Example: Asset data quality

Geospatial information systems (GIS) representations of networks involve large volumes of data. When errors occur, they are not always easy to spot. The low voltage (LV) network is particularly extensive, and errors can go undetected as connectivity models are not always integral to the GIS.

Accurate LV representation is critical to support network investment as part of the energy transition. Inaccuracies in the GIS data could limit ambitions set out in digitalization strategies and constrain the future build of network topologies that support digital twins and automation. In addition, it reduces the value and wider use of GIS data by third parties.

Advanced analytics and machine learning are increasingly being used to identify and fix errors in GIS data. AI can focus on harder-to-fix errors which draw on multiple data sets and use machine learning/advanced approaches to identify errors and propose corrections. This improves the GIS data quality in ways that would otherwise require prohibitive manpower costs to audit the data.



Can energy organizations learn to trust the AI?

While the quality of data is one factor that impacts data trust, other issues include the "black-box" nature of AI algorithms and possible inherent bias. Unless business executives have a clear understanding of how AI works – and are confident in the fairness of the AI systems – they may not be able to trust the output of these algorithms.

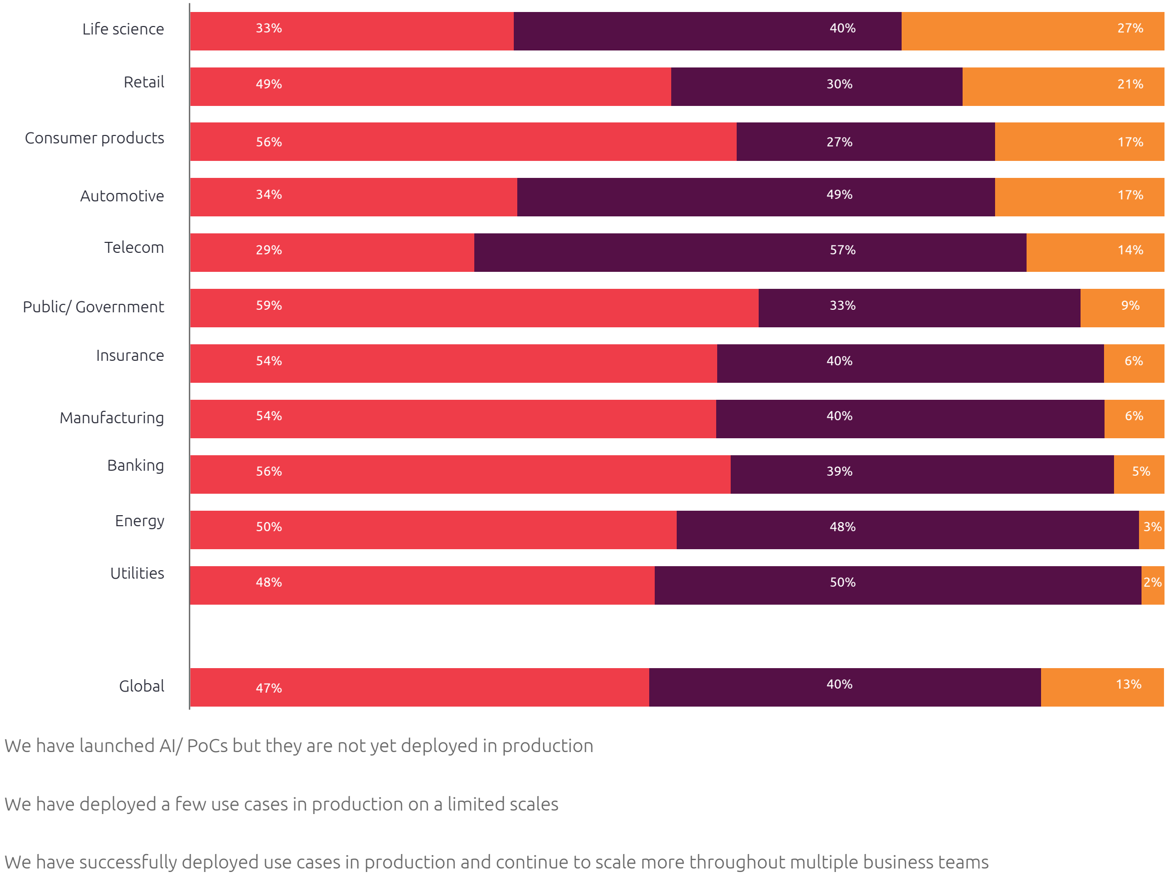
Adopting AI in energy is proving to be tough

While progress has been made in moving beyond pilots to deployment, scaling those AI deployments across the enterprise has proven to be tough. As the graph below shows, only 3% of energy organizations have rolled out multiple AI applications across numerous teams. This trails other leading sectors quite significantly.

To scale AI, energy organizations must ensure that the solution addresses both business and technology needs. This, in turn, demands collaboration between the business and IT.

FIGURE 2

AI implemention maturity by sector



Source: Capgemini Research Institute, State of AI survey, March–April 2020, N=954 organizations implementing AI.

AI – Successful scaling

Four principles energy organizations are embracing to scale AI

To catch up to AI-at-scale leading market sectors, energy organizations are starting to focus on four areas to scale their AI initiatives: Empower, operationalize, nurture, and monitor and amplify.

Empower: Build strong foundations providing easy access to trusted, quality data through the right data and AI platforms and tools, along with agile practices.

First, energy organizations are implementing DataOps. DataOps helps in the democratization of data and reduces the analytics cycle time. By facilitating data discovery, automating, and monitoring the different stages of data analytics pipelines, a DataOps team ensures data scientists and machine learning engineers are more focused on model development and deployment. They manage the infrastructure required for data organization.

Second, they are moving towards an agile culture. In an agile organization, the leadership mindset is attuned to a test-learn-validate cycle, giving more autonomy to teams and providing more accountability. Teams are also focused on delivering real business value, defining clear problem statements, and linking each solution to an overall goal. Finally, teams are more focused on delivering a functioning business application, progressively cutting the risk of failure.

Operationalize: Deploy AI through the right operating model and prioritize initiatives

Although different energy organizations apply different operating models to scale AI, a hybrid approach is optimal. This approach ideally comprises: a central team for policy and strategy; a center of excellence (CoE) (or a network of CoEs) and/or dedicated team(s) for collaboration, optimizing resources, and facilitation of ideas; and a business unit for division-level strategy and execution.

The above link AI strategy to overall business objectives and is how AI-at-scale leaders address this issue. They do so by bringing AI initiatives into the enterprise's wider digital transformation fold. AI initiatives are not scaled in a silo but impact multiple business units. Plus, AI resources are limited. To scale AI, top management should oversee how the resources are directed and used. In addition, with proliferating use cases of AI, companies need to understand which ones address their real business problems and then determine how to align those to capabilities.

Nurture: Build talent and collaboration with partners

AI programs require many types of talent, from architects to design the solution and its integration in the IT landscape, to data engineers to source and prepare the data, to data scientists and machine learning engineers needed to develop and deploy it in production. In addition to technical skills, organizations must not forget the important range of business and change management roles, including data strategists, AI ethicists, business consultants, and process and automation engineers.

Given the complexity of achieving scaled AI, along with the significant talent crunch, many energy organizations are working with service providers to address the challenges of this transformation. For example, 70% of energy and utilities organizations outsource the scaled deployment of solutions[1].

Monitor and amplify: Kickstart the virtuous AI circle

Most AI models, if not monitored, can begin to deteriorate in performance once deployed into production. The phenomenon is termed concept drift – encountering unknown or hidden relationships between variables. This is due to changes in the nature of data, assumptions, or new information.

Energy organizations with scaled AI will have a number of interconnected algorithms implemented across several functions or processes. Drift in one system can cause problems in many others. For instance, drift in a demand planning algorithm can affect asset operations, planning, and procurement.

1 Capgemini Research Institute, State of AI survey, March–April 2020, N=120 AI-at-scale leaders, N=44 organizations from Utilities.

Digital Twins – How can digital twins drive higher performance and sustainability?

Energy organizations are looking to digital twins to address the various challenges

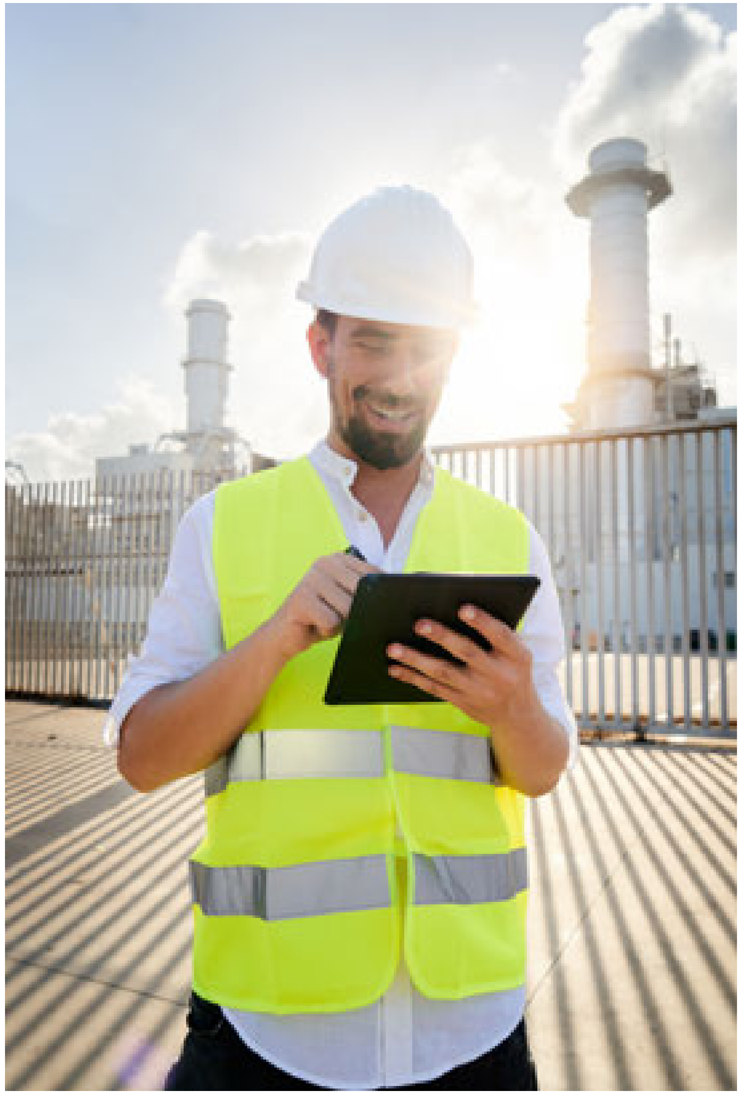
Energy organizations are looking to digital twins as a way to address various challenges, such as total cost of asset ownership, sustainability, regulatory compliance, etc.

A digital twin is a real catalyst for efficiency, effectiveness, and sustainability. It can function as a tool that allows experimentation with different scenarios and the opportunity to assess the impact of each decision without any real-world risks, thereby positively impacting key business metrics. This ensures effective decision-making and deployment of strategies that maximize profitability, maintain reliability, and improve sustainability.

Digital twins positively affect both top and bottom lines

Digital twins allow organizations to improve on a number of metrics, such as costs, operational efficiency, turn-around times, and sustainability.

Organizations have realized a 13% decrease in costs, on average, across the various use cases of digital twins and a 15% increase in operational efficiency[1]. Cost reduction, followed closely by technological advancement, are the top drivers of digital twin investments – with 79% and 77% of organizations, respectively, citing them as such[2].



1 Graph Source: Capgemini Research Institute, Digital Twins survey, September–October 2021, N=800 organizations, N=92 Energy & utilities organizations with ongoing Digital Twin programs, benefits averaged across the various use cases.
2 DIGITAL TWINS: ADDING INTELLIGENCE TO THE REAL WORLD – Capgemini Research Institute 2022

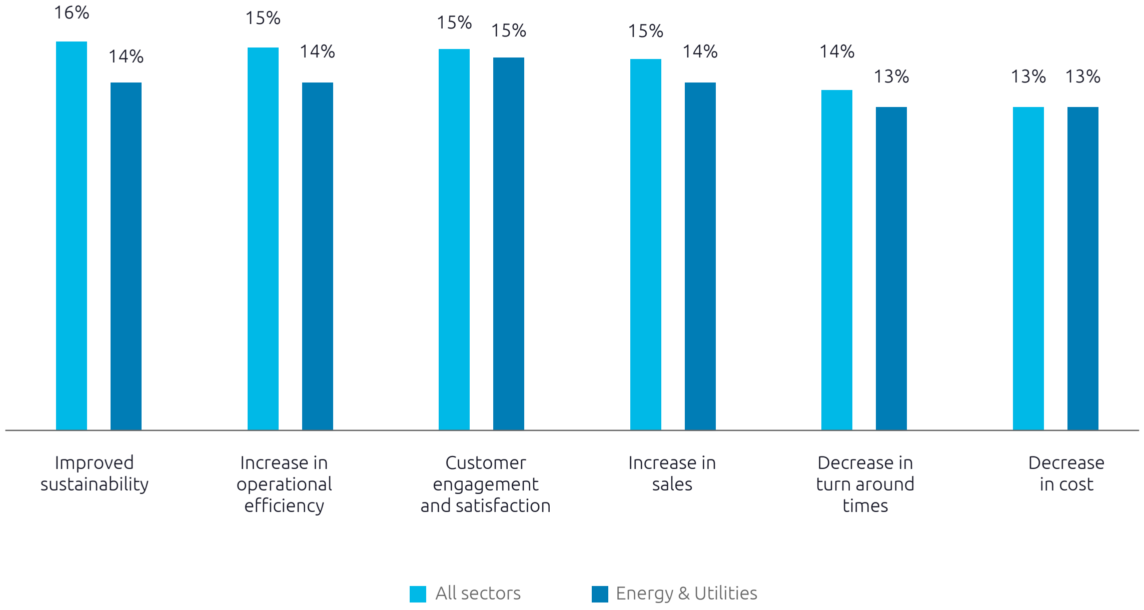
Digital twins augment the employee experience by improving safety, offering collaborative ways of working, and supplementing training.

Digital twins allow energy organizations to reduce health and safety risks for employees in addition to reducing supply-chain risks. Digital twins can increase employee safety by supporting remote operations and removing the need for direct human involvement in physically dangerous work situations.

Energy organizations cite increasing employee safety as one of the key drivers of their digital twin investments. Through its digital twin Echo, Equinor, an international energy company, has been able to achieve a reduction of up to 50% of offshore man hours at its Johan Sverdrup oil field, significantly cutting down on employee risk exposure[2].

FIGURE 3

Average benefits realized from various digital twin implementations



Source: Capgemini Research Institute, Digital Twins survey, September–October 2021, N=800 organizations, N=92 Energy & utilities organizations with ongoing Digital Twin programs, benefits averaged across the various use cases.

2 DIGITAL TWINS: ADDING INTELLIGENCE TO THE REAL WORLD – Capgemini Research Institute 2022

Digital twins – The path to successful digital twin deployment

The path to successful digital twin deployment is not hurdle-free

Although organizations have realized the benefits and applications of digital twins, there are a number of challenges to successful deployment. We identified the following four major challenges that are slowing digital twin deployment.

1. Overcoming a lack of strong vision, management support, and well-balanced governance
2. Development of core business and collaborative skills
3. Deployment and integration of a secured end-to-end architecture
4. Empowerment of the ecosystem

How does the energy sector compare in solving these challenges?

While the energy sector is ahead of other sectors in considering digital twins a strategic part of digitalization, over half cite a lack of vision. Similarly, while energy organizations are more likely to have a long-term roadmap, around half lack management commitment or investment.

For digital continuity issues, the energy sector is broadly in line with the wider economy, with 50-60% citing problems. As can be seen from the summary below, there is much work to be done.

All sectors

- Even though **55%** of organizations consider digital twins a strategic part of their digital transformation, around half **(42%)** lack a clear vision of how to deploy them.

- While **59%** of organizations claim to have drawn up a long-term (five years or more) roadmap to develop a digital twin system, about half of organizations **(43%)** report a lack of managerial commitment to digital twin initiatives, and 49% face the challenge of a lack of investment in the concept.

- **56%** of organizations are dealing with a lack of digital continuity across systems and processes and **55%** report a lack of cross-functional collaboration.

- The reported lack of strong governance also leads to inefficient program management. In one-third of the organizations surveyed, digital twin governance has not been formalized or is completely lacking.

Source: Capgemini Research Institute, Digital Twins survey, September–October 2021, N=800 organizations, N=92 Energy & utilities organizations with ongoing digital twin programs.

In the energy sector...

- **70%** say digital twins are considered a strategic part of the overall digital transformation of the organization.
- **52%** say the lack of a vision for digital continuity is a challenge for implementing digital twins.

- **71%** say they have a long-term roadmap (5 years or more) for digital twins.
- **48%** report the lack of management commitment to the digital twin initiatives.
- **51%** report lack of investment.

- **54%** report a lack of digital continuity across systems and processes.
- **58%** report a lack of cross-functional collaboration.

Digital twins – Frontrunners in the digital twin journey win the greatest benefits

Who are the frontrunners in this digital twin transformation?

While digital twins allow organizations to enjoy a multitude of benefits, energy organizations need to have certain elements in place to fully capitalize on the systemic enhancements.

Elements needed to be a digital twin frontrunner

Analyzing organizations in six affected areas[1]:

- Vision and leadership
- Technological integration, including collaborative platforms
- Intelligent systems: smart, connected, and sustainable
- System capabilities available
- Digital practices – data-driven and digital ways of working – within the organization
- Extended ecosystems
- Based on the above, three cohorts emerged:
- Frontrunners: Perform well in all areas
- Experimenters: Perform well in some of these six areas
- Novices: Perform poorly in all areas

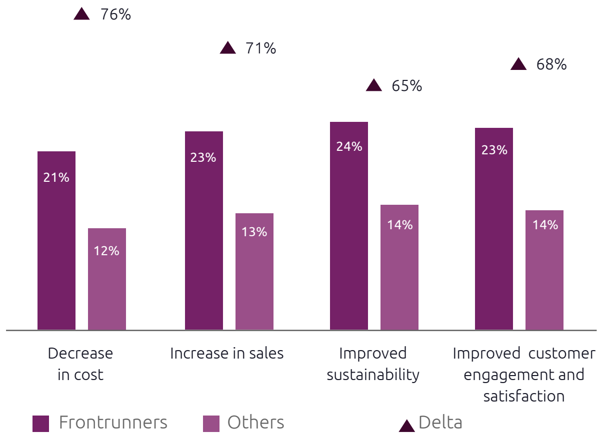
In our analysis, we found that frontrunners are in a position to realize higher benefits. Owing to digital twins, frontrunners, on average, report a 40% improvement in overall system performance, compared to 27% by others.

One of the reasons is that frontrunners can utilize efficiency by design and achieve operational efficiency to a much greater degree. Similarly, frontrunners report a 76% greater reduction in costs and 68% greater improvement in customer engagement.

Clearly, there is a benefit to the energy sector to accelerate towards being frontrunners in areas where they have traditionally lagged behind other industrial sectors.

FIGURE 4

Increased benefits for Frontrunners in the digital twin transformation journey



Source: Capgemini Research Institute, Digital Twins survey, September–October 2021, N=131 frontrunners, N=869 other organizations.

1 DIGITAL TWINS: ADDING INTELLIGENCE TO THE REAL WORLD – Capgemini Research Institute 2022

Digital twins – How can energy organizations accelerate their digital twin journey?

Energy organizations are investing to drive their digital twin transformation

Energy organizations worldwide are increasingly relying on digital twins to reduce time to market, improve operational efficiency, meet sustainability agendas, and improve customer experiences. However, many are yet to install the required infrastructure to scale digital twins successfully and enjoy the complete spectrum of benefits. Drawing on the best practices employed by early adopters, our survey results and market experience, we have identified the following areas in which energy organizations need to invest to drive their digital twin transformation at scale.

Develop a stepwise long-term roadmap for deployment, considering sustainability and safety goals

As many as 97% of frontrunners have a long-term roadmap (five years or more) for digital twins, compared to just 58% of others[1].

Deploy use cases that will address repetitive pain points or strategic issues first: It is advisable to take up the use cases where a digital twin has already proven beneficial and where its application will address some pain points or strategic issues.

Address quick wins to convince employees of the value addition: Whatever the type of digital twin, the value can only be unlocked when employees interacting with the twin can use the application for analysis, course correction, or prediction.

Strengthen key enablers required for scaling

To deploy digital twins at scale and obtain full benefit from the system, organizations must ensure certain foundations are in place:

- Secured connectivity
- Data management
- Capabilities
- Design capabilities
- Operate and serve capabilities
- Collaborative skills
- User experience and user interface

1 Capgemini Research Institute, Digital Twins survey, September–October 2021, N=131 frontrunners, N=869 other organizations

Design and implement a digital twin architecture

A digital twin architecture helps deliver the digital twin initiatives in a smooth manner. Three major technology foundations are required for delivery: the data management layer; the device layer; and the software layer; along with the services a digital twin enables.

A data management layer allows for easy analysis of data. A device and software layer allows employees and teams to interact with the twin. For simple use cases or quick wins, all three layers can be addressed separately or through model based systems engineering (MBSE). MBSE also provides interoperability among these layers, which is required for complex use cases.

Enhance data security and privacy across networks

Since a digital twin is connected to a number of systems and consequently opens access to inordinate amounts of sensitive information, hacking into an unsecured digital twin allows immediate access to the internal data of the entire business system.

Reinforced data security and privacy measures are, therefore, indispensable prior to digital twin deployments – a sentiment echoed by 69% of surveyed organizations (and 76% of energy organizations), who plan to effect major changes in their end-to-end cybersecurity[2].

2 Capgemini Research Institute, Digital Twins survey, September–October 2021, N=800 organizations, N=92 Energy organizations with ongoing digital twin programs

WORLD ENERGY MARKETS OBSERVATORY

BALANCING THE FIGHT AGAINST CLIMATE CHANGE WITH ENERGY SECURITY

About WEMO

The World Energy Markets Observatory (WEMO) is Capgemini's annual thought leadership and research report created in partnership with De Pardieu Brocas Maffei, Vaasa ETT, and Enerdata, that tracks the development and transformation of electricity and gas markets in Europe, North America, Australia, Southeast Asia, India, and China. Now in its 24th edition, the report focuses on the triggers and impact of several successive energy crises, including the Covid-19 pandemic, Russia-Ukraine war, and inflation consequences, most notably for Europe. As in years past, the latest edition of WEMO also includes in-depth coverage of: commodities markets, climate change and regulatory policies; energy transition and related technologies; infrastructure and adequacy of supply; supply and final customer; transformation; financials; and the Oil & Gas industry's shift from fossil fuels to low carbon (route to net zero).

Glossary

ACER
Agency for the Cooperation of Energy Regulators, created under the EU Third Legislative Package, adopted in April 2009

ACORE
Stands for American Council on Renewable Energy, is a national non-profit organization that unites finance, policy and technology to accelerate the transition to a renewable energy economy.

AEMC
Set up by the Council of Australian Governments through the Ministerial Council on Energy in 2005, the Australian Energy Market Commission makes and amends the National Electricity Rules, National Gas Rules and National Energy Retail Rules, and also provides market development advice to governments.

AEMO
The Australian Energy Market Operator is responsible for operating Australia's largest gas and electricity markets and power systems, including the NEM and Wholesale Electricity Market (WEM) and power system in Western Australia.

AGA
American Gas Association Representing more than 200 local energy companies that deliver clean natural gas throughout the United States.

AMI
Stands for Advanced Metering Infrastructure, it is the collective term to describe the whole infrastructure from Smart Meter to two way-communication network to control center equipment and all the applications that enable the gathering and transfer of energy usage information in near real-time.

Asian Renewable Energy Hub
The Asian Renewable Energy Hub (AREH) is a proposal to create one of the world's largest renewable energy plant in the Pilbara region of Western Australia. It was first proposed in 2014, with plans for the project concept changing several times since then. As of June 2022, the project developers BP, Intercontinental Energy, CWP Global, Vestas and Pathway Investments were planning to build a mixture of wind power and solar energy power generators which would generate up to 26 gigawatts of power.

Backwardation/Contango
"Contango" means that long-term prices are more expensive than short-term prices, depicting a relaxed short-term market, whereas "backwardation" reveals more tension in the short-term reflected in higher short-term prices than in the long-term

Base load
The minimum amount of electricity delivered or required over a given period, at a constant rate

Battery of the Nation
The Battery of the Nation initiative is investigating and developing a pathway of future development opportunities for Tasmania to make a greater contribution to the NEM.

Bilateral contracts/OTC
A contractual system between a buyer and a seller agreed directly without using a third party (exchanges, etc.). Also named as OTC for Over The Counter

Black Certificates
Exchangeable or tradable CO_2 allowances or quotas within the European Trading Scheme and Kyoto protocol (see EUA)

CAISO
Stands for California Independent System Operator is the non-profit Independent System Operator serving California that oversees the operation of California's bulk electric power system, transmission lines, and electricity market generated and transmitted by its member utilities.

CAPEX
Capital Expenditure, funds used by a company to acquire or upgrade physical assets

Carbon Budget
Carbon budget' is the cumulative quantity of CO_2 emissions that are allowed in order to keep global warming below a certain warming threshold

Carbon Cost Coalition
A multi-state coalition of state legislators from 12 states of the USA, who are focused on reducing carbon emissions, ensuring equity in policy proposals, developing market-based solutions, creating a resilient local economy and improving public health.

CCGT/Combined cycle power plant
Combined Cycle Gas Turbine. Thermal power plant, usually running on gas-fired turbines, where electricity is generated at two consecutive levels: firstly by gas combustion in the turbines, and secondly by using energy from the product of the gas combustion process in boilers, which supply heat to steam turbo-generators.

This process provides high levels of thermal output (55 to 60%, compared with only 33 to 35% for conventional thermal power plants)

CCS
Carbon Capture and Storage. Technologies used for isolating carbon dioxide from fuel gas (at combustion plants) and storing it. This means that a significantly lower amount of CO_2 is emitted into the atmosphere

CDM
Clean Development Mechanisms, a mechanism under the Kyoto Protocol through which developed countries may finance greenhouse-gas emission reduction or removal projects in developing countries, and receive credits for doing so which they may apply towards meeting mandatory limits on their own emissions

CEER/ERGEG
Council of the European Energy Regulators and European Regulators Group for Electricity and Gas. ERGEG was dissolved with the creation of ACER, all ERGEG works are found in CEER website

CER
Certified Emission Reduction. Quotas issued for emission reductions from Clean Development Mechanism (CDM) project activities

CHP/Cogeneration
Combined Heat and Power. System of simultaneous generation of electricity and heat. The output from cogeneration plants is substantially better than it would be if they produced only electricity

Churn/Switch
Free (by choice) movement of a customer from one supplier to another

Clean Coal
New technologies and processes allowing electricity generation from coal while lowering CO_2 emissions

Clean Dark Spread/Clean Spark Spread
The Clean Dark Spread is the difference between electricity's spot market price and the cost of electricity produced with coal plus the price of related carbon dioxide allowances while the Clean Spark Spread is the same indicator but with electricity produced with natural gas

Climate Change
Climate change is any significant long-term change in the expected patterns of average weather of a region (or the whole Earth) over a significant period of time.

Climate Risk Index
Climate Risk Index is released by Germanwatch which analyses to what extent countries and regions have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.)

Copenhagen Accord
A voluntary agreement between the United States, China, Japan, Canada, Mexico, Russia and hundreds more making up over 80% of the global population and over 85% of global emissions that is based on goodwill of each member country assuming that each country will live up to their part in saving the climate by reducing greenhouse gases.

CSIRO
Commonwealth Scientific and Industrial Research Organization is an independent Australian federal government agency responsible for scientific research.

Decentralised generation
Production of electricity near the point of use, irrespective of size and technology, capacity and energy sources

Demand response
Any program which communicates with the end-users regarding price changes in the energy market and encourages them to reduce or shift their consumption

DER
Distributed Energy Resources refer to distribution level resources that produce electricity or actively manage consumer demand such as solar rooftop PVs, batteries; and demand response activities that manage hot water systems, pool pumps, smart appliances and air conditioning control.

Deregulated Market
A "deregulated electricity market" allows for the entrance of competitors to buy and sell electricity by permitting market participants to invest in power plants and transmission lines

Discom
Power Distribution Company of the state, responsible for distribution of electrical power in the region and associated activities.

DG Competition
European Union's Directorate General for Competition which role is to enforce the competition rules of the Community Treaties

DG TREN
European Union's Directorate General for Transport & Energy that develops EU policies in the energy and transport sectors

Distributed generation
Any technology that provides electricity closer to an end-user's site. It may involve a small on-site generating plant or fuel cell technology

Distribution System Loss
Distribution System Losses are losses pertaining to distribution of electricity. While technical losses are at times under the control of utilities, non-technical losses are external forces that impact the efficiency of the system and lead to revenue leakage

Dividend per share
Dividend per share (DPS) is the sum of declared dividends issued by a company for every ordinary share outstanding. The figure is calculated by dividing the total dividends paid out by a business, including interim dividends, over a period of time by the number of outstanding ordinary shares issued

DMO
Default market offers also known as the 'standing offers' are default, government-regulated energy offers which do not include any discount.

DOE (Philippines)
The Philippines' Department of Energy is the executive department of the Philippine Government responsible for preparing, integrating, manipulating, organizing, coordinating, supervising and controlling all plans, programs, projects and activities of the Government relative to energy exploration, development, utilization, distribution and conservation

Domestic consumers
Residential customers

Dual Monopoly
A situation wherein; two companies dominate the market . In other words two companies control production and supply of a product

EBIT
Earnings Before Interest and Taxes. EBIT may also be called operating income; i.e. the product of the company's industrial and commercial activities before its financing operations are taken into account. EBIT is a key ratio for gauging the financial performance of companies

EBITDA
Earnings Before Interest, Taxes, Depreciation and Amortization. EBITDA is a key ratio for gauging the cash flow of companies

Economic Regulation Authority
The ERA is Western Australia's independent economic regulator. The ERA's work ensures that Western Australian consumers and businesses have a fair, competitive and efficient environment.

EERS
Stands for Energy Efficiency Resource Standards establishes specific, long-term targets for energy savings that utilities or non-utility program administrators must meet through customer energy efficiency programs.

Electricity Tariffs
The amount of money frame by the supplier for the supply of electrical energy to various types of consumers in known as an electricity tariff

Eligible customer
Electricity or gas consumer authorised to turn to one or more electricity or gas suppliers of his choice

Energy Efficiency
Energy efficiency means using less energy to perform the same task

Energy Innovation and Carbon Dividend Act of 2019
The Energy Innovation and Carbon Dividend Act of 2019 is a bill in the United States House of Representatives that proposes a fee on carbon at the point of extraction to encourage market-driven innovation of clean energy technologies to reduce greenhouse gas emissions.

Energy Mix
Refers to the combination of the various primary energy sources used to meet energy needs in a given geographic region. It includes fossil fuels (oil, natural gas and coal), nuclear energy, non-renewable waste and the many sources of renewable energy (wood, biofuel, hydro, wind, solar, geothermal, heat from heat pumps, renewable waste and biogas).

Energy Regulatory Commission
Power Generation in Philippines is regulated by Energy Regulatory Commission (ERC). It is an independent electric power industry regulator that equitably promotes and protects the interests of consumers and other stakeholders, to enable the delivery of long-term benefits that contribute to sustained economic growth and an improved quality of life

Energy Transition Index
The Energy Transition Index(ETI) benchmarks countries on the performance of their energy system, as well as their readiness for transition to a secure and sustainable energy future.

The ETI aggregates indicators from 40 different energy, economic and environmental datasets in order to provide a comprehensive of the world's energy system

Energy Trilemma Index
The World Energy Trilemma Index is an annual comparative ranking of 125 countries on their ability to balance energy priorities

ENSO
Stands for El Niño-Southern Oscillation which is a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean, affecting the climate of much of the tropics and subtropics. The warming phase of the sea temperature is known as El Niño and the cooling phase as La Niña.

ENTSO-E
European Network of Transmission System Operators for Electricity. ENTSO-E, the unique association of all European TSOs, was created at the end of 2008 and is operational since July 1, 2009. All former TSOs associations such as UCTE or ETSO are now part of ENTSO-E

ENTSO-G
European Network of Transmission System Operators for Gas. ENTSO-G was created at the end of 2009 and comprises 32 gas TSOs from 22 European countries

EPIC
Stands for Energy Policy Institute at Chicago, it is an interdisciplinary research and training institute focused on the economic and social consequences of energy policies.

EPR
European Pressurized Reactor. Third generation of nuclear plant technology using advanced Pressurized Water Reactor (PWR)

ERU
European Reduction Unit. A unit referring to the reduction of greenhouse gases, particularly under the Joint Implementation where it represents one ton of CO_2 reduced

ETS
Emissions Trading Scheme. An administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. The European Union Emissions Trading Scheme has been in operation since January 1, 2005

EUA
European Union Allowances. Quotas allocated by the National Allocation Plans in compliance with the European Trading Scheme

Eurelectric
Professional association which represents the common interests of the Electricity industry at pan-European level

European Commission (EC)
A governing body of the European Union that oversees the organization's treaties, recommends actions under the treaties, and issues independent decisions on EU matters

European Council
A body formed when the heads of state or government of European Union member states meet. Held at least twice a year, these meetings determine the major guidelines for the EU's future development

European Parliament (EP)
The assembly of the representatives of the Union citizens

European Union (EU)
The European Union (EU) is a group of 28 countries that operates as a cohesive economic and political block

EVs
Electric vehicles is an alternative fuel automobile that uses electric motors and motor controllers for propulsion, in place of more common propulsion methods such as the internal combustion engine (ICE).

EWEA
European Wind Energy Association

FERC
Stands for The Federal Energy Regulatory Commission, is the United States federal agency that regulates the transmission and wholesale sale of electricity and natural gas in interstate commerce and regulates the transportation of oil by pipeline in interstate commerce.

FID
Final Investment Decision

FLNG
Stands for Floating Liquefied Natural Gas, efers to water-based liquefied natural gas (LNG) operations employing technologies designed to enable the development of offshore natural gas resources

Forwards
A standard contract agreement for delivery of a given quantity at a given price, for a given maturity (OTC markets)

Futures
A standard contract agreement for delivery of a given quantity at a given price, for a given maturity (organized exchanges). The maturities may differ across power exchanges (weekly, half-yearly, quarterly, monthly, annually). Maturity Y+1 corresponds to the calendar year after the current year

GCF
The Green Climate Fund is a global fund that was formed to support climate change vulnerable nations, especially the "Least Developed Countries" to fulfil their climate change goals and lower their GHG emissions.

GDP
Stands for Gross Domestic Product, is a monetary measure of the market value of all the final goods and services produced in a country over a specific time period, often annually.

GECF
Gas Exporting Countries Forum. GECF is a gathering of the world's leading gas producers

GIE
Gas Infrastructure Europe. GIE is the association representing gas transmission companies (GTE), storage system operators (GSE) and LNG terminal operators (GLE) in Europe

Green Bond
A green bond is a bond specifically earmarked to be used for climate and environmental projects. These bonds are typically asset-linked and backed by the issuer's balance sheet, and are also referred to as climate bonds

Green Certificates
A Guarantee of Origin certificate associated with renewable targets fixed by national governments. Green Certificates are often tradable

Greenhouse effect
The warming of the atmosphere caused by the build up of 'greenhouse' gases, which allow sunlight to heat the earth while absorbing the infrared radiation returning to space, preventing the heat from escaping. Excessive human emissions including carbon dioxide, methane and other gases contribute to climate change

Grid
An electrical grid, electric grid or power grid, is an interconnected network for delivering electricity from producers to consumers.

Grid 2.0
Grid 2.0 refers to the grid system which will transform how gas, solar and thermal energy is managed into a single intelligent network efficiently. This builds on Singapore's past investments in smart meters, grid storage, solar photovoltaics, as well as various energy efficiency and demand management solutions to address Singapore's unique energy challenges, and also grow the base of capabilities.

Guarantee of Origin
A certificate stating a volume of electricity that was generated from renewable sources. In this way the quality of the electricity is decoupled from the actual physical volume. It can be used within feed in tariffs or Green Certificate systems

HHI
Herfindahl-Hirschman Index, a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in a market, and then summing the resulting numbers. The HHI number can range from close to zero to 10,000

Hub (gas)
Physical or virtual entry/exit points for natural Gas

Hub (retail)
Inter Company Data Exchange platform primarily enabling Suppliers and Distribution companies to exchange client related data and making supplier's switching more reliable

ICPT Mechanism
The ICPT is a mechanism approved by the Government and implemented by ST since 1 January 2014 as part of a wider regulatory reform called the Incentive Based Regulation ("IBR"). ICPT mechanism allows TNB to reflect changes in fuel and generation costs in consumer's electricity tariff every six months. This mechanism is implemented according to Section 26 of Electricity Supply Act 1990 [Act 447]. The impact of ICPT implementation is neutral on TNB and will not have any effect to its business operations and financial position

IED
Industrial Emissions Directive, a European Union Directive that sets strict limits on the pollutants that industrial installations are allowed to spew into the air, water and soil. Installations have until 2016 to comply with the limits

Incentive Based Regulation
An incentive-based regulatory approach aims to reduce environmentally-harmful pollutants by offering inducements to polluters who limit their emissions

Installed capacity
The installed capacity represents the maximum potential net generating capacity of electric utility companies and auto-producers in the countries concerned

International Energy Consultants
IEC is a Perth-based consulting firm which specializes in providing power market advisory services to companies operating in and associated with the IPP sector within the Asia-Pacific region

Investment Tax Credits
A tax related incentive that allows individuals or entities to deduct a certain percentage of specific investment related costs from their tax liability apart from usual allowances for depreciation.

IPCC
Intergovernmental Panel on Climate Change, the leading body for the assessment of climate change, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide a clear scientific view on the current state of climate change and its potential environmental and socio- economic consequences

IUS
Stands for the Integrated Utility Services, developed by Rocky Mountain Institute wherein utility companies could seamlessly blend an array of products, services and financing tools that have not previously been integrated.

JI
Joint Implementation, a mechanism under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment to invest in emission reducing projects in another industrialised country as an alternative to emission reductions in their own countries

Kyoto Protocol
The United Nations regulatory frame for greenhouse gases management, adopted in December 1997 and entered into force in February 2005. It encompasses 6 greenhouse gases: CO_2, CH_4, N_2O, HFC, PFC, SF_6

LCOE (levelized cost of energy)
LCOE is the cost of electricity produced by a generator calculated by accounting for all of a system's expected lifetime costs (including construction, financing, fuel, maintenance, taxes, insurance and incentives), which are then divided by the system's lifetime expected power output (kWh).

LCOS (levelized cost of storage)
It quantifies the discounted cost per unit of discharged electricity for a specific storage technology and application.

LCPD
Large Combustion Plant Directive, a European Union Directive that aims to reduce acidification, ground level ozone and particulates by controlling the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plant. All combustion plant built after 1987 must comply with the emission limits in LCPD. Those power stations in operation before 1987 are defined as 'existing plant'. Existing plant can either comply with the LCPD through installing emission abatement (Flue Gas Desulphurisation)equipment or 'opt-out' of the directive. An existing plant that chooses to 'opt-out' is restricted in its operation after 2007 and must close by the end of 2015

LNG
Liquefied Natural Gas. Natural gas that has been subjected to high pressure and very low temperatures and stored in a liquid state. It is returned to a gaseous state by the reverse process and is mainly used as a peaking fuel

LNG Netback Price
A measure of an export parity price that a gas supplier can expect to receive for exporting its gas.

Load balancing
Maintaining system integrity through measures which equalize pipeline (shipper) receipt volumes with delivery volumes during periods of high system usage. Withdrawal and injection operations into underground storage facilities are often used to balance load on a short-term basis

Load factor
Ratio of average daily deliveries to peak-day deliveries over a given time period

LTIFR: Lost Time Injury Frequency Rate
LTIFR refers to Lost Time Injury Frequency Rate, the number of lost time injuries occurring in a workplace per 1 million man-hours worked.

LULUCF
Referred to as Forestry and other land use defined as the greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.

Market coupling
Market coupling links together separate markets in a region, whereas market splitting divides a regional market into prices zones. Market coupling minimises prices differences and

makes them converging wherever transmission capacity is sufficient. Cross-border market coupling also drives better use of interconnection capacity

Market Liberalization
The process of removing government control and opening up the markets to private companies

Merit order
The merit order is a way of ranking available sources of energy, especially electrical generation, in ascending order of their short-run marginal costs of production, so that those with the lowest marginal costs are the first ones to be brought online to meet demand, and the plants with the highest marginal costs are the last to be brought on line

MESI 2.0
The Malaysian Electricity Supply Industry (MESI) under the MESI 2.0 initiative, has three key aims, which are to increase industry efficiency, future-proof the industry, and empower consumers

Metering
Measurement of the various characteristics of electricity or gas in order to determine the amount of energy produced or consumed

MyPower
MyPower, (which is a part of Malaysian Energy Supply Industry-MESI) stands for Malaysia Programme Office for Power Electricity Reform, will design and drive the implementation of energy reform over the next three years

MSCI ACWI IMI
MSCI (Morgan Stanley Capital Index) ACWI (All Country World Index) IMI (Investable Market Index) captures large, mid, and small cap representation across 23 Developed Markets (DM) and 24 Emerging Markets (EM) countries

NAP
National Allocation Plan. List of selected industrial and power installations with their specific emissions allowance (under the ETS system)

Natural Gas
Mixture of gases which are rich in hydrocarbons. Gases such as methane, nitrogen, carbon dioxide etc. are naturally found in atmosphere. Natural gas reserves are deep inside the earth near other solid & liquid hydrocarbons beds like coal and crude oil.

NDC
Stands for the Nationally Determined Contributions, it implies the achievement of long term goals made under the Paris Agreement which embody efforts by each country to reduce national emissions and adapt to the impacts of climate change.

NEEAPs
National Energy Efficient Action Plans, plans providing detailed roadmaps of how each Member State expects to reach its energy efficiency target by 2020

NEG
National Energy Guarantee was an energy policy proposed by the Turnbull government in late 2017 to deal with rising energy prices in Australia and lack of clarity for energy companies to invest in energy infrastructure.

NEM
The National Electricity Market of Australia interconnects five regional market jurisdictions – Queensland, New South Wales (including the Australian Capital Territory), Victoria, South Australia, and Tasmania.

Nomination
A request for a physical quantity of gas under a specific purchase or transportation agreement

Non-Domestic Consumers
Commercial and industrial customers, and others

NREAPs
National Renewable Energy Action Plans, plans providing detailed roadmaps of how each Member State expects to reach its legally binding 2020 target for the share of renewable energy in their final energy consumption

NTC
Net Transfer Capacity. NTC is the expected maximal electrical generation power that can be transported through the tie lines of two systems without any bottlenecks appearing in any system

Off-peak
Off-peak energy is the electric energy supplied during periods of relatively low system demands as specified by the supplier

On-peak
On-peak energy is electric energy supplied during periods of relatively high system demand as specified by the supplier

Optimal development path
The ODP comprises a range of projects classified as either actionable, committed and anticipated, or future. Together, these projects entail the development of 10,000 km of new transmission lines by 2050 under the Step Change and Progressive scenarios.

OPEC
Organization of the Petroleum Exporting Countries

Open season
A period (often 1 month) when a pipeline operator accepts offering bids from shippers and others for potential new transportation capacity. Bidders may or may not have to provide "earnest" money, depending upon the type of open season. If enough interest is shown in the announced new capacity, the pipeline operator will refine the proposal and prepare an application for construction before the appropriate regulatory body for approval

OPEX
Operational Expenditure, expenditures that a business incurs as a result of performing its normal business operations

P/E
Price / Earning ratio. The ratio of the share price to the Earning per share (EPS). P/E ratio is one of the tools most commonly used for valuing a company share

Paris Agreement
The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change, dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016.

Peak load
The highest electrical level of demand within a particular period of time

Peak shaving
Reduction of peak demand for natural gas or electricity

PPA
Stands for Power Purchase Agreements that freezes a price and a notional energy volume for both the buyer and seller of electricity for a specific period of time. This price agreement acts as the final agreed price for a development project that is either achieving financial close or remaining on the shelf. The agreement also includes reference to cases of failure to meet the contract terms and conditions including, the payment of liquidated damages.

PPU
(Programmations pluriannuelles de l'énergie) Multi-year Energy Programming, a tool for planning and steering national energy policy, which defines the priorities for actions and the specific objectives to be achieved over the period 2016-2023, targeting all energy sources, in order to achieve the national objectives set by the LTE

REBA
Stands for Renewable Energy Buyers Alliance, is a a membership association of large clean energy buyers, energy providers, and service providers that, together with NGO partners, are committed to unlocking the marketplace for all nonresidential energy buyers to lead a rapid transition to a cleaner, prosperous, zero-carbon energy future.

Regulated Market
A regulated electricity market contains utilities that own and operate all electricity

Retailer of Last Resort
The Retailer of Last Resort (RoLR) scheme was created under the energy laws to protect electricity and gas supply consumers if a retailer is no longer able to operate, ensuring your energy supply is not disrupted.

RES
Renewable Energy Sources. Energy (electricity or heat) produced using wind, sun, wood, biomass, hydro and geothermal. Their exploitation generates little or no waste or pollutant emissions

RGGI
Stands for Regional Greenhouse Gas Initiative, which is the first mandatory market based program in the United States to reduce greenhouse gas emissions is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont to cap and reduce carbon dioxide (CO_2) emissions from the power sector.

Rhodium Group
Rhodium Group is an independent research provider combining economic data and policy insight to analyze global trends.

South Australia Power Networks (SAPN)
SA Power Networks is the sole electricity distributor in the state of South Australia

SAIDI
Stands for System Average Interruption Duration Index that measures the average outage duration for each customer served in units of time, often minutes or hours.

SGIG
NA

Shippers
The party who contracts with a pipeline operator for transportation service. A shipper has the obligation to confirm that the volume of gas delivered to the transporter is consistent with nominations. The shipper is obligated to confirm that differences between the volume delivered in the pipeline and the volume delivered by the pipeline back to the shipper is brought into balance as quickly as possible

SLCP
Stands for Short-lived Climate Pollutants that identifies black carbon, methane, tropospheric ozone, and fluorinated gases. Currently, fluorinated gases (HFCs, perfluorocarbons (PFCs), SF6, and NF3) account for 3 percent of domestic greenhouse gas emissions in terms of carbon dioxide equivalency (CO_2e)

Smart Grid
An electricity supply network that uses digital communications technology to detect and react to local changes in usage.

Solar Power Europe
European Photovoltaic Industry Association. The association that represents the photovoltaic (PV) industry towards political institutions at European and international level.

Spot contract
Short-term contract, generally a day ahead

State Ownership
State ownership is the ownership of an industry, asset, or enterprise by the state or a public body representing a community as opposed to an individual or private party

Super Pollutants
Methane and black carbon identified as the Super Pollutants being some of the most aggressive contributors to global warming.

System Loss
System losses occur when 100% efficiency isn't achieved in either conversion or transport of energy.System losses are of two types:1. Technical Loss, driven by the characteristics for the equipment and materials 2. Non-technical Loss, driven by theft, meter readings, pilferage etc.

Take-or-pay contract
Contract whereby the agreed consumption has to be paid for, irrespective of whether the consumption has actually taken place

TCI
Stands for Transportation and Climate Initiative, it is a regional collaboration of 12 Northeast and Mid-Atlantic states and the District of Columbia that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector.

Third Energy Package
Third Energy Package. A legislative package proposed on September 19, 2007 by the EC in order to pursue the liberalisation of the electricity and gas markets

TPA
Third Party Access. Recognised right of each user (eligible customer, distributor, and producer) to access in a non discriminatory and efficient manner transmission or distribution systems in exchange for payment of access rights

UFC
Federal Union of Consumers

Unbundling
Separation of roles according to the value chain segment (generation, transmission, distribution, retail) required by European Directives for enabling fair competition rules

UNEP
United Nations Environment Program

US Climate Alliance
The United States Climate Alliance is a bipartisan coalition of governors committed to reducing greenhouse gas emissions consistent with the goals of the Paris Agreement

US Energy Information Administration
The U.S. Energy Information Administration (EIA) is a principal agency of the U.S. Federal Statistical System responsible for collecting, analyzing, and disseminating energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment.

Utility Death Spiral
In 2013, the Edison Electric Institute (EEI) released a report positing that an eroding revenue stream, declining profits, rising costs, and ever-weakening credit metrics would diminish the ability of electric utilities to survive in an increasingly off-the-grid world.

Victorian Default Offer
The Victorian Default Offer is a simple and trusted electricity price that is set by us, not energy companies.

Vehicle-to-grid
V2G technology refers to the process of feeding the electricity contained in an electric car's batteries back into the electrical grid while it is parked.

White Certificate
A certificate stating a volume of engaged energy savings (electricity, gas, fuel, …) at end-users' site, like a home or a business. They are tradable or not

Wholesale Electricity Market
The wholesale market is where electricity is traded (bought and sold) before being delivered to end consumers (individuals, households or businesses) via the grid

LIST OF ACRONYMS

1 ACCC: Australia Competition and Consumer Commission
2 ACEEE: American Council for an Energy Efficient Economy
3 ACORE: American Council on Renewable Energy
4 ACT: Australian Capital Territory
5 ADIT: Accumulated Deferred Income Tax
6 AEMC: Australian Energy Market Commission
7 AEMO: Australian Energy Market Operator
8 AER: Australian Energy Regulator
9 AGA: Advanced Grid Analytics
10 AGD: Ausgrid
11 AMI: Advanced Metering Infrastructure
12 APEC: Asia-Pacific Economic Cooperation
13 APGCC: ASEAN Power Grid Consultative Committee
14 APRA: Australian Prudential Regulation Authority
15 APS: Announced Pledges Scenario
16 AREH: Asian Renewable Energy Hub
17 ARENA: Australian Renewable Energy Agency
18 ARFVTP: Alternative and Renewable Fuel and Vehicle Technology Program
19 ARRA: American Recovery and Reinvestment Act
20 ASEAN: Association of Southeast Asian Nations
21 ASEP: Access to Sustainable Energy Program
22 ASIC: Australian Securities & Investments Commission
23 ATF: Aviation Turbine Fuel
24 B2C: Business-to-Consumer
25 BAU: Business-as-usual
26 Bcm: Billion cubic meters
27 BESS: Battery Energy Storage System
28 BEV: Battery Electric Vehicle
29 Bloomberg NEF: Bloomberg New Energy Finance
30 BNEF: Bloomberg New Energy Finance
31 BoM: Bureau of Meteorology
32 CAFD: Cash Available for Distribution
33 CAFÉ: Corporate Average Fuel Economy
34 CAGR: Compound Annual Growth Rate
35 CAISO: California Independent System Operator
36 CapEx: Capital Expenditure
37 CARC: Customer Acquisition and Retention Costs
38 CAT: Climate Action Tracker
39 CC: Contestable Consumers
40 CCA: Climate Council Authority
41 CCC: Climate Change Commission
42 CCGT: Combined Cycle Gas Turbine
43 CCPI: Climate Change Performance Index
44 CCS: Carbon Capture and Storage
45 CCUS: Carbon Capture, Usage and Storage
46 CEFC: Clean Energy Finance Corporation
47 CER: Clean Energy Regulator
48 CEVS: Carbon Emissions-Based Vehicle Scheme
49 CFD: Contract for Difference
50 CO2: Carbon dioxide
51 CO2e: Carbon dioxide Equivalent
52 COAG: Council of Australian Governments
53 COP22: 22nd Conference of the Parties
54 COP26: Conference of the Parties - 26th United Nations Climate Change conference
55 CPI: Consumer Price Index
56 CPP: Clean Power Plan
57 CPPA: Corporate Power Purchase Agreement
58 CREZ: Competitive Renewable Energy Zones
59 CRI: Climate Risk Index
60 CRM: Customer relationship management
61 CSI: California Solar Initiative
62 CSI: Customer Satisfaction Index
63 CSIRO: Commonwealth Scientific and Industrial Research Organization
64 CSP: Competitive Selection Process
65 CSRD: Corporate Sustainability Reporting Directive
66 CSS: Customer self-service
67 CST: Concentrated Solar Thermal
68 CTA: Cost to Acquire
69 CTS: Costs to Serve
70 DEE: Department of Environment and Energy
71 DER: Distributed Energy Resource
72 DES: Distributed Electricity and Storage
73 DfE: Design for Efficiency
74 DILG: Department of the Interior and Local Government
75 DMIRS: Department of Mines, Industry Regulation and Safety
76 DMO: Default Market Offer (aka 'standing offers')
77 DMO: Distribution Market Operator
78 DNSP: Distribution Network Service providers
79 DoE: Department of Energy
80 DPPA: Direct Power Purchase Agreement
81 DREAMS: Development for Renewable Energy Applications Mainstreaming and Market Sustainability
82 DSL: Distribution System Loss
83 DSM: Demand-side Management
84 DSO: Distribution System Operator
85 DSP: Demand-side participation
86 DU: Distribution Utilities
87 EASe: Energy Efficiency Improvement Assistance Scheme
88 EBA: European Battery Alliance
89 EBITA: Earnings before Interest, Taxes, and Amortization
90 EBITDA: Earnings before Interest, Tax, Depreciation and Amortization
91 EBSS: Efficiency Benefit Sharing Scheme

92 EC: Energy Commission
93 eceee: European Council for an Energy Efficient Economy
94 ECF: Equity Crowd Funding
95 EE: Energy Efficiency
96 EERS: Energy Efficiency Resource Standards
97 EIA: Energy Information Administration
98 EMA: Electricity Market Authority
99 EMC: Energy Market Company
100 EMS: Energy Management System
101 END: Endeavour Energy
102 ENSO: El Niño-Southern Oscillation
103 ENTR: Electricity Network Transformation Roadmap
104 ENX: Energex
105 EPA: Environmental Protection Agency
106 EPBC: Environment Protection and Biodiversity Conservation
107 EPIC: Energy Policy Institute at University of Chicago
108 EPS: Earnings per Share
109 ERA: Economic Regulation Authority
110 ERC: Energy Regulatory Commission
111 ERCOT: The Electric Reliability Council of Texas
112 ERF: Emissions Reduction Fund
113 ERG: Ergon
114 ERP: Enterprise resource planning
115 ESB: Energy Security Board
116 ESCO: Energy Service Company
117 ESOO: Electricity Statement of Opportunities
118 ESS: Essential Energy
119 ETI: Energy Transition Index
120 ETS: Emissions Trading Scheme
121 EV: Electric Vehicle
122 EVN: Vietnam Electricity Company
123 FERC: The Federal Energy Regulatory Commission
124 FFO: Funds from Operation
125 FFR: Fast Frequency Response
126 FIT: Feed-in-Tariffs
127 FLNG: Floating liquefied natural gas
128 FMRS: Faster More Reliable Switching
129 FPA: Federal Power Act
130 FPSS: Future Power System Security
131 FRC: Full Retail Contestability
132 FUM: Forecast Uncertainty Measure
133 GCF: Green Climate Fund
134 GDP: Gross Domestic Product
135 GEOP: Green Energy Option Program
136 GHG: Greenhouse Gas
137 GIS: Geographic Information System
138 GJ: Gigajoules
139 GMI: Grid Modernization Initiative
140 GMLC: Grid Modernization Lab Consortium
141 GMRG: Gas Market Reform Group
142 GREET: Grant for Energy Efficient Technologies
143 GSOO: Gas Statement of Opportunities
144 GSSF: Grid Scale Storage Fund
145 GTFS: Green Technology Financing Scheme
146 GW: Gigawatt
147 GWh: Gigawatt-hours
148 HDB: Housing and Development Board
149 HEV: Hybrid Electric Vehicle
150 HFCs: Hydrofluorocarbons
151 HGL: Hydrocarbon Gas Liquids
152 HK Electric: Hongkong Electric Company
153 HKSAR: Hong Kong Special Administrative Region
154 HVAC: Heating, Cooling & Ventilation
155 IA: Investment Allowance
156 IBR: Incentive Based Regulation
157 ICE: Internal combustion engine
158 ICPT: Imbalance Cost Pass-Through
159 ICT: Information and Communication Technologies
160 IEA: International Energy Agency
161 IEC: International Energy Consultants
162 IEMOP: Independent Electricity Market Operator of the Philippines
163 IEP: International Environmental Partnership
164 IFC: The International Finance Corp
165 INDC: Intended Nationally Determined Contribution
166 IoT: Internet of Things
167 IOUs: Investor-owned Utilities
168 IPCC: Intergovernmental Panel on Climate Change
169 IPP: Independent Power Producer
170 IPv6: Internet Protocol version 6
171 IRS: Internal Revenue Service
172 ISEM: Institute for Superconducting and Electronic Materials
173 ISO: International Organization for Standardization
174 ISP: Integrated System Plan
175 ITC: Investment Tax Credits
176 IUS: Integrated Utility Services
177 IVR: Interactive Voice Response
178 kgoe: Kilograms of oil equivalent
179 KV: Kilovolt
180 KW: Kilowatt
181 KWh: Kilowatt-hours
182 LCOE: Levelized Cost of Energy/Electricity
183 LDC: Least Developed Countries
184 LDV: Light Duty Vehicle
185 LED: Light Emitting Diode
186 LNG: Liquefied Natural Gas
187 LPE: Local Planning Energy
188 LPG: Liquefied Petroleum Gas
189 LRET: Large-scale Renewable Energy Target
190 LSS: Large Solar Scale

191 LTIFR: Lost Time Injury Frequency Rate
192 LULUCF: Land Use, Land Use Change and Forestry
193 M&A: Merger and Acquisition
194 M2M: Machine to Machine
195 MDB: Multilateral development banks
196 MDM: Meter Data Management
197 MENA: Middle East and North Africa region
198 MESI: Malaysian Energy Supply Industry
199 MESTECC: Minister of Energy, Science, Technology, Environment and Climate Change
200 MIDA: Malaysian Investment Development Authority
201 MIT: Massachusetts Institute of Technology
202 MMBTU: Million Metric British Thermal Units
203 MMHS: Market-wide Half Hourly Settlement
204 MMT: Million Metric Tonnes
205 MMTPA: Million Metric Tonnes Per Annum
206 MNCAA: The Mayors National Climate Action Agenda
207 MOEA: Ministry of Economic Affairs
208 MOIT: Ministry of Industry and Trade
209 MoT: Ministry of Transport
210 MOU: Memorandum of Understanding
211 MSCI: Morgan Stanley Capital International
212 Mt: Million Tonnes
213 MtCO2-e: Million Tonnes of Carbon Dioxide Equivalent
214 Mtoe: Million Tonnes of Oil Equivalent
215 MW: Megawatt
216 MWe: Mega Watt Electrical
217 MWh: Megawatt-hours
218 MWp: Mega Watt Peak
219 NAFTA: North American Free Trade Agreement
220 NAPCC: National Action Plan on Climate Change
221 NCOS: National Carbon Offset Standard
222 NDC: Nationally Determined Contributions
223 NEA: National Environment Agency
224 NEA: Nuclear Energy Agency
225 NEB: National Energy Board
226 NECF: National Energy Customer Framework
227 NEM: National Electricity Market
228 NEM: Net Energy Metering
229 NEMEMF: National Electricity Market Emergency Management Forum
230 NEMS: National Energy Modeling System
231 NEPA: National Environmental Policy Act
232 NEV: New Energy Vehicle
233 NGERAC: National Gas Emergency Response Advisory Committee
234 NGV: Natural Gas Vehicle
235 NIA: National Irrigation Administration
236 NIC: Network Interface Card
237 NOAA: National Oceanic and Atmospheric Administration
238 NOL: Net Operating Loss
239 NREP: National Renewable Energy Program
240 NSP: Network Service Providers
241 NSPS: New Source Performance Standards
242 NSW: New South Wales
243 NT: Northern Territory
244 NWIS: Northwest Interconnected System
245 NZE: Net Zero Emissions
246 OBPS: Output Based Pricing System
247 OCBC: Oversea-Chinese Banking Corporation
248 ODP: Optimal development path
249 OECD: Organization for Economic Co-operation and Development
250 OEM: Open Electricity Market
251 OWZ: Offshore Wind Zones
252 PACE: Property Assessed Clean Energy
253 PAG: Providence Asset Group
254 PASA: Projected Assessment of System Adequacy
255 PBR: Performance-Based Ratemaking
256 PDP: Power Development Plan
257 PEV: Plug-in Electric Vehicle
258 PHES: Pumped Heat Electrical Storage
259 PHEV: Plug-in Hybrid Electric Vehicle
260 PJ: Petajoule
261 PLI: Production Linked Incentive
262 PNOC: Philippine National Oil Company
263 PPAs: Power Purchasing Agreements
264 PPI: Producer Price Index
265 PPM: Parts per million
266 PPP: Public Private Partnership
267 PSA: Power Supply Agreements
268 PV: Photovoltaic
269 PVN: PetroVietnam
270 QLD: Queensland
271 R&D: Research and Development
272 RAB: Regulated Asset Base
273 RE: Renewable Energy
274 REBA: Renewable Energy Buyers Alliance
275 REC: Renewable Energy Certificate
276 REDD+: Reduce Emissions from Deforestation and Forest Degradation
277 REJI: Renewable Energy (Jobs and Investment)
278 REP: Retail Electric Provider
279 REPI: Retail Electricity Pricing Inquiry
280 REPPA: Renewable Energy Power Purchase Agreement
281 RERT: Reliability and Emergency Reserve Trader
282 RES: Renewable Energy Sources
283 RET: Renewable Energy Target
284 RETF: Renewable Energy Trust Fund
285 RETR: Renewable Energy Transition Roadmap
286 REZ: Renewable Energy Zones

287 RGGI: Regional Greenhouse Gas Initiative
288 RIT-T: Regulatory Investment Test for Transmission
289 ROLR: Retailer of Last Resort
290 RPS: Renewable Portfolio Standards
291 RRO: Regional Reliability Organizations
292 RTO: Regional Transmission Organization
293 S&P: Standard & Poor's
294 SA: Southern Australia
295 SAIDI: System Average Interruption Duration Index
296 SAIFI: System Average Interruption Frequency Index
297 SAPN: South Australia Power Networks
298 SARE: Supply Agreement for Renewable Energy
299 SCA: Scheme of Control Agreement
300 SCADA: Supervisory Control and Data Acquisition
301 SCC: Social Cost of Carbon
302 SCEM: Singapore Certified Energy Manager
303 SDS: Sustainable Development Scenario
304 SEA: Southeast Asia
305 SGER: Specified Gas Emitters Regulation
306 SGIG: Smart Grid Investment Matching Grant
307 SLCP: Short-lived Climate Pollutants
308 SMOC: Streaming Media Online Charging System
309 SMR: Small Modular Reactors
310 SoC: Scheme of Control
311 SRES: Small-scale Renewable Energy Scheme
312 SSR: Summer Saver Rebate
313 STEPS: Stated Policies Scenario
314 SWIS: Southwest Interconnected System
315 T&D: Transmission and Distribution
316 TAITRA: Taiwan External Trade Development Council
317 TAS: Tasmania
318 TCF: Trillion cubic feet
319 TCI: Transportation and Climate Initiative
320 TNB: Tenaga Nasional Berhad
321 TNSP: Transmission Network Service Providers
322 ToU: Time-of-Use
323 TWh: Terawatt-hours
324 UNCED: United Nations' Conference on Environment and Development
325 UNEP: United Nations Environment Programme
326 UNFCCC: United Nations Framework Convention on Climate Change
327 UOB: United Overseas Bank
328 US EIA: United States Energy Information Administration
329 USAID: United States Agency for International Development
330 USTDA: United States Trade and Development Agency
331 UTP: Uniform Tariff Policy
332 V2G: vehicle-to-grid
333 VDO: Victorian Default Offer
334 VES: Vehicular Emissions Scheme
335 VIC: Victoria
336 V-LEEP: Vietnam Low Emission Energy Program
337 VPP: Virtual Power Plant
338 VRE: Variable Renewable Electricity
339 VRET: Victorian Renewable Energy Target
340 VWEM: Vietnam Competitive Wholesale Electricity Market
341 WA: Western Australia
342 WEM: Wholesale Electricity Market
343 WESM: Wholesale Electricity Spot Market
344 WPI: Wholesale Price Index
345 WSD: Water Supplies Department
346 WTE: Waste-to-Energy
347 WTO: The World Trade Organization
348 WWII: World War II
349 YTD: Year to date
350 ZEV: Zero-Emission Vehicle

COUNTRY ABBREVIATIONS AND ENERGY AUTHORITIES

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Austria	AT	E-Control	Ministry of Agriculture, Forestry, Environment and Water Management: www.bmlfuw.gv.at/ Environment Agency: www.umweltbundesamt.at/ Competition Authority: http://www.bwb.gv.at/
Belgium	BE	CREG (national) BRUGEL (Brussels) CWAPE (Walloon) VREG (Flanders)	Ministry of Economic Affairs: http://economie.fgov.be/
Bulgaria	BG	DKER	Ministry of Economy and Energy: www.mi.government.bg/
Canada	CA	NEB	National Energy Board: www.neb-one.gc.ca Ministry of Energy: http://www.energy.gov.on.ca
Croatia	HR	HERA	Ministry of Economy, Labour and Entrepreneurship: www.mingo.hr/
Czech Republic	CZ	ERU	Ministry of Industry and Trade: www.mpo.cz/ Competition Office: www.compet.cz/
Denmark	DK	DERA NordREG	Energy Agency: www.ens.dk/ Ministry of Economic and Business Affairs: www.evm.dk/ Ministry of Environment: www.mim.dk/
Estonia	EE	ETI	Ministry of Economic Affairs: www.mkm.ee/ Competition Authority: www.konkurentsiamet.ee/
Finland	FI	EMV NordREG	Ministry of Employment and the Economy: www.tem.fi/ Ministry of Environment: www.ymparisto.fi/ Competition Authority: www.kilpailuvirasto.fi/
France	FR	CRE	Ministry of Ecology, Sustainable Development and Energy: www.developpement-durable.gouv.fr/
Germany	DE	BNetzA UNFCCC	Federal Environment Ministry: www.bmu.de/ Energy Agency: www.dena.de/ United Nations Framework Convention on Climate Change https://unfccc.int/ Competition Authority: www.bundeskartellamt.de/

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Greece	GR	RAE	Ministry of Development: www.mindev.gov.gr/el/ Ministry of Environment, Energy and Climate Change: www.ypeka.gr/ Competition Commission: www.epant.gr/
Hungary	HU	MEH	Energy Office: www.mekh.hu/
Hong-Kong	HK	EMSD HKSAR	Electrical and Mechanical Services Department: www.emsd.gov.hk Hong Kong Special Administrative Region Environment Bureau: http://www.enb.gov.hk/en/
Ireland	IE	CER (Republic of Ireland)	Department of Communications, Energy & Natural Resources: www.dcenr.gov.ie/Energy/ NIAUR (Northern Ireland)
Italy	IT	AEEG	Ministry of Environment: www.minambiente.it/ Ministry of Economic Development: www.sviluppoeconomico.gov.it/ Competition Authority: www.agcm.it/
Latvia	LV	SRPK	Ministry of Economy: www.em.gov.lv/ Competition Council: www.kp.gov.lv/
Lithuania	LT	REGULA	Ministry of Economy: www.ukmin.lt/
Luxemburg	LU	ILR	Ministry of Economic Affairs: www.eco.public.lu/
Malaysia	MY	ST MESTECC MoT MESI	Energy Commission : www.st.gov.my Minister of Energy, Science, Technology, Environment and Climate Change https://www.mestecc.gov.my/web/en/ Ministry of Transport Malaysian Energy Supply Industry
Mexico	MX	SENER	Secretaría de Energía de México: www.gob.mx Comisión Federal de Electricidad: http://www.cfe.gob.mx
Netherlands	NL	DTe	Ministry of Economic Affairs: www.rijksoverheid.nl/ Energy Council: www.algemene-energieraad.nl/ Competition Authority: www.nmanet.nl/
Norway	NO	NVE NordREG	Oil and Energy Ministry: www.regjeringen.no/ Competition Authority: www.konkurransetilsynet.no/

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Philippines	PH	ERC DILG ERC IEMOP DOE	Energy Regulatory Commission: www.erc.gov.ph Department of the Interior and Local Government https://www.dilg.gov.ph/ Energy Regulatory Commission https://www.erc.gov.ph/ Independent Electricity Market Operator of the Philippines http://www.iemop.ph/ Department of Energy https://www.doe.gov.ph/
Poland	PL	URE	Ministry of Economy: www.me.gov.pl
Portugal	PT	ERSE	Ministry of Economy: www.min-economia.pt/ Directorate General for Energy and Geology: www.dgeg.pt/
Romania	RO	ANRE	Ministry of Energy and Resources: www.minind.ro/
Singapore	SG	EMA HDB EDB	Energy Market Authority: www.ema.gov.sg Housing and Development Board https://www.hdb.gov.sg/cs/infoweb/homepage The Singapore Economic Development Board https://www.edb.gov.sg/
Slovakia	SK	URSO	Ministry of Economy: www.economy.gov.sk/ Ministry of Environment: www.enviro.sk/
Slovenia	SI	AGEN	Ministry of Infrastructure: www.mzip.gov.si/
Spain	ES	CNMC	Ministry of Industry, Energy and Tourism: www.minetur.gob.es/ Ministry of Agriculture, Fishing & Food: www.mapa.gob.es/ Ministry of Ecologic Transition: www.miteco.gob.es/
Sweden	SE	EI NordREG	Ministry of Energy: www.regeringen.se/ Competition Authority: www.kkv.se/
Switzerland	CH	BFE IPCC	Federal Department of Environment, Transport, Energy and Communications: www.uvek.admin.ch/ Intergovernmental Panel on Climate Change http://www.ipcc.ch/ Competition Authority: www.weko.admin.ch/

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Taiwan	TW	BOE TAITRA MOEA	Bureau of Energy, Ministry of Economic Affairs: www.moeaboe.gov.tw Taiwan External Trade Development Council https://en.taitra.org.tw/ Ministry of Economic Affairs https://www.moea.gov.tw/Mns/english/home/English.aspx
United Kingdom	UK	OFGEM	Department of Energy and Climate Change: www.decc.gov.uk/ Competition Authority: www.gov.uk/government/organisations/competition-and-markets-authority
United States of America	USA	DoE EIA US Climate Alliance FERC	U.S. Department of Energy: https://www.energy.gov/ US Energy Information Administration: https://www.eia.gov/ https://www.usclimatealliance.org/ Federal Energy Regulatory Commission (FERC): https://www.ferc.gov/
Vietnam	VN	MOIT	Ministry of Industry and Trade: www.moit.gov.vn
Australia	AUS	ACCC AEMO AEMC AER APRA CSIRO COAG ARENA CER DEE	Australian Competition and Consumer Commission https://www.accc.gov.au/ Australian Energy Market Operator https://www.aemo.com.au/ Australian Energy Market Commission https://www.aemc.gov.au/ Australian Energy Regulator https://www.aer.gov.au/ Australian Prudential Regulation Authority https://www.apra.gov.au/ Commonwealth Scientific and Industrial Research Organisation https://www.csiro.au/ Council of Australian Governments Energy Council http://coagenergycouncil.gov.au/ Australian Renewable Energy Agency https://arena.gov.au/ Clean Energy Regulator http://www.cleanenergyregulator.gov.au/ Department of the Environment and Energy http://www.environment.gov.au/

TEAM AND AUTHORS

Report Sponsor

James Forrest
james.forrest@capgemini.com

Colette Lewiner
colette.lewiner.externe@capgemini.com

Advisor

Philippe Vié
philippe.vie.externe@capgemini.com

Alexandra Bonanni
alexandra.bonanni@capgemni.com

Project Manager

Nupur Sinha
nupur.sinha@capgemni.com

Global Outlook

Colette Lewiner
colette.lewiner.externe@capgemni.com

Marketing & Sales Team

Vito Labate
vito.labate@capgemini.com

Mayank Shah
mayank.b.shah@capgemini.com

Lucy Colling
lucy.colling@capgemini.com

Vicky Parmar
vicky.parmar@capgemini.com

Design Team

Jay Kartha
jayakumar.kartha@capgemini.com

Kristin Morris
kristin.morris@capgemini.com

Manas Kar
manas.kar@capgemini.com

EUROPE - Partners

Switching and pricing insights-VaasaETT

Rafaila Grigoriou
rafaila.grigoriou@vaasaett.com

Iliana Papamarkou
iliana.papamarkou@vaasaett.com

Chuyi Feng
chuyi.feng@vaasaett.com

Enerdata

Christian Mollard
Christian.mollard@enerdata.net

Overview of National Energy and Climate Plans of EU's Member States - De Pardieu Brocas Maffei

Christine Le Bihan Graff
le-bihan-graf@de-pardieu.com

Maxime Gardellin
GARDELIN@de-pardieu.com

Laure Rosenblieh
ROSENBLIEH @de-pardieu.com

Sandra Hahn Durraffourg
HAHNDURAFFOURG@de-pardieu.com

Zoe Berchem
BERCHEM@de-pardieu.com

Commodities and Technologies

Claire Gotham

Alejandro Benguigui Nadal

Debarghya Mukherjee

Peter King

Philippe Vié

David Steiger

David Perez Lopez

Richard Biagioni

Benoit Calatayud

Jean Luc Chabaudie

Pierre Bagnon

Simon Schäfer

David Mandrysch

Lars Falch

Tom Erdkamp

Simon Brod

Thomas Schoot

Igor Lelieveld

Eva Hoftijzer

Kim Sillekens

Maxime Gardellin

Laure Reosenblieh

Regions ID card

Marie Vermersch

Debarghya Mukherjee

Ishandeep

Nupur Sinha

Swetanta Lahiri

Climate change and Energy Transition

Elfije Lemaitre

Claire Gotham

Tyler Williams

Vinnie Nair

Nicole Alley

David Perez Lopez

Marne Shafer

Debarghya Mukherjee

Peter King

Alain Chardon

Philippe Vié

Colette Talbot

Abhishek Gokhale

Aniket Mahato

Alexander Rodriguez

Lars Falch

Tom Erdkamp

Simon Brod

Thomas Schoot

Igor Lelieveld

Eva Hoftijzer

Kim Sillekens

Anne Sophie Herbert

Maxime Gardellin

Laure Reosenblieh

Sandra Hahn Durraffourg

Zoe Berchem

Christine Le Bihan Graf

Sara Stritharan

Swetanta Lahiri

Animesh Bose

Alexandra Bonanni

Nupur Sinha

Monica Vaswani

Ishandeep

Pratik Rajmane

Infrastructure & Adequacy Of Supply

Antoine Lalande

Arnaud Stricher

Charles Dagicour

Debarghya Mukherjee

Stephane Coucke

Fabian Decour

Oussama Zekkari Emrani

Louis Soumoy

Thierry Batut

Alexander Rodriguez

Sara Stritharan

Ishandeep

Vinnie Nair

Nicole Alley

Alex Lam

Nupur Sinha

Alexandra Bonanni

Retail markets

Guido Wendt

Robert Rehner

Marissa Papas

Jon Nelmes

Raphael Heimel

Franziska Hoock

Hariharan Krishnamurthy

Alexander Rodriguez

Sara Stritharan

Swetanta Lahiri

Parikshit Vyas

Swetanta Lahiri

Ishandeep

Pratik Rajmane

Finance

Florian Schall

Charles Dagicour

Ibtihal Karfia

Debarghya Mukherjee

Alexander Rodriguez

Sara Stritharan

Swetanta Lahiri

Nupur Sinha

Vinnie Nair

Nicole Alley

Ishandeep

Nick McFarlane

Alexandra Bonanni

Marie Vermersch

Transformation

David Butcher

Ramya Krishna Puttur

Nancy Manchanda

Enerdata

DE PARDIEU BROCAS MAFFEI
AVOCATS

vaasa ETT

About Enerdata

Enerdata is an independent research company that specialises in the analysis and forecasting of energy and climate issues, at a variety of different geographic and business / sector levels. The company is headquartered in Grenoble, France, where it was founded in 1991, and has a subsidiary in Singapore. Leveraging its globally recognised databases, business intelligence processes, and prospective models, Enerdata assists clients – which include companies, investors, and public authorities around the world – in designing their policies, strategies, and business plans.

About DE PARDIEU BROCAS MAFFEI

De Pardieu Brocas Maffei is one of France's leading independent business law firms and currently has 38 partners. Founded in 1993, the Firm has become a key player in French business law and also has a highly regarded international practice. The firm's lawyers regularly advise on both domestic and international matters, and clients primarily include large French and overseas corporations. In addition, the Firm works with an extensive network of referral law firms in the main financial centers in different parts of the world.

About VaasaETT

De Pardieu Brocas Maffei is one of France's leading independent business law firms and currently has 38 partners. Founded in 1993, the Firm has become a key player in French business law and also has a highly regarded international practice. The firm's lawyers regularly advise on both domestic and international matters, and clients primarily include large French and overseas corporations. In addition, the Firm works with an extensive network of referral law firms in the main financial centers in different parts of the world.

About Capgemini

Capgemini is a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided everyday by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of over 350,000 team members in more than 50 countries.

With its strong 55-year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs,
from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms.

The Group reported in 2021 global revenues of €18 billion.

GET THE FUTURE YOU WANT

www.capgemini.com/wemo

The information contained in this document is proprietary. ©2022 Capgemini. All rights reserved.

Capgemini