Capgemini

RACES:

RESOURCES AWARENESS AND CIRCULAR ECONOMY STRATEGY

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EDITORIAL

By Alain CHARDON
Capgemini Sustainability Platforms

Companies must transition from a paradigm of performance to a paradigm of resilience.
Recent world events have forced companies to be radically agile, have put procurement and crisis management departments to the test, and have stretched supply chains to the breaking point - pushing CxOs to change their take on corporate management.

The starting point for such a transformation is resources.
World-wide industrial activities are bound together by their dependence on the availability of natural resources. The demand is growing, driven by the advent of resource-intensive industries, like tech and digital. Low-carbon trajectories, involving the electrification of transport and the rise of renewables, are generating further pressure on resources. From the decadal assumption that resources are widely available, industrial stakeholders inherited a mindset whereby one is not properly vigilant regarding the availability of resources. Carelessness does not only cause damage to the environment — it also endangers a company's capacity to bounce back in times of trouble.

Companies are on the verge of a resource crisis which threatens their core-business.
In the near future, all business units from all companies – not only procurement teams – will bear the consequences of the 6 risks related to resources availability: geological and geopolitical availability of raw materials, competition between industrial sectors and countries, lack of substitution alternatives and recycling potential, and social and environmental impact. These risks will materialize through sky-rocketing commodity prices, severe supply chain disruptions and pressure from NGOs, customers and analysts to the point where the core-business is in jeopardy.

CxOs must make circularity their main objective to make their company resilient.
This pushes companies to rethink their resource management, – and beyond that, to transform their business model and purpose. The solution is to fully embrace circular models. This fundamentally changes our approach to the circular economy as circular initiatives which were mostly motivated by sustainability efforts, are now driven to the center stage in business-driven strategies by risk-management.

CxOs need a resource-aware vision and robust methods to achieve it.
Integrating resource criticality awareness to your vision will bring exhaustivity & coherence to your initiatives. Circularity will soon become a key strategic element in every industrial activity, unleashing a myriad of business opportunities. CxOs have so far been missing two vital elements to properly assess resource-related risks and protect themselves: 1/ a resource-aware vision, 2/ a robust approach and tools to achieve it. The purpose of this report is to provide CxOs with these elements.

RACES: Resource Awareness and Circular Economy Strategy
At Capgemini, we have developed a brand-new methodology built around two tangible tools, to evaluate your exposure to resource-related risks and assist you in building the best strategic response while improving business resilience:

- The 16 Circularity Business Segments (CBS) matrix to identify strategic levers of actions to achieve circularity, and business opportunities nestled in a circular model, each with a business case of their own.
- A new metric and Resource Criticality Factors (RCF) to quantify technologies, opportunities, business scenarios.

Combining both will lead to a prioritization of CBS in a robust corporate strategy,

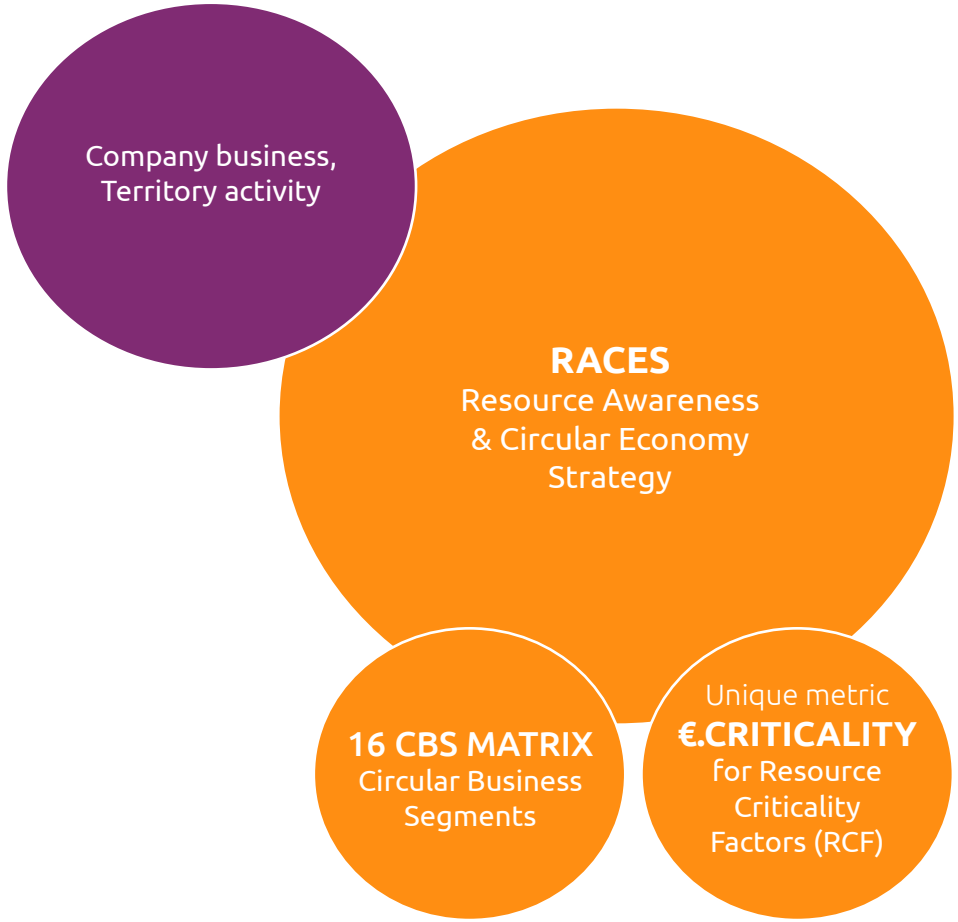
No matter your starting point, RACES can help you turn resource criticality into business opportunities.
In this report, you will find four different steps to build a robust corporate strategy leading to a successful, de-risked transformation and implementation phases on the field:

- Resource-awareness & vision to pre-assess vulnerability areas in your current AS IS business and start building a vision
- Circular Economy Strategy to identify opportunities using the 16 CBS and prepare robust TO BE scenarios
- Quantification of criticality and business case to make decisions, but also measure progress overtime
- Transformation plan with tangible action items and implementation examples.

We hope the report helps you adapt your strategy to implement circularity at each step of your value chain and gain resilience.

FIGURE 1

The RACES approach and its 2 tools for an actionable global corporate strategy



RACES: Resources Awareness and Circular Economy Strategy

Box – INEC Capgemini study

The examples displayed in this publication and the Resource Criticality Factor (RCF) have been created for the study "Circular low carbon economy – an integrated approach", co-published in April 2022 by Capgemini and the French National Institute for Circular Economy (INEC). In the study, the RCF quantification was derived for 15 product domains and 11 resources. Two strategic scenarios were scrutinized: low and high circularity.

The 16 CBS matrix is an additional creation for the present English publication.

The methodology is fully applicable by private companies for their products, branches, and geographies, whether their products are low carbon or not, as well as by public authorities for their territories.

Table of contents

INTRODUCTION: REDUCE RESOURCE RISKS AT SCALE WITH A QUANTIFIED CIRCULAR STRATEGY

Introduction: Reduce resource-risks at scale with a quantified circular strategy

Many industries are exposed to serious resource-related issues that will materialize as severe exposure to price surges, supply chain disruptions in a decoupling world exposed to sanitary and geopolitical crisis, and negative social and environmental impacts. Meanwhile, regulations evolve and gradually impose stricter rules on resource-management, by penalizing players trailing behind, but also by rewarding proactive actions resulting in reduced use and impact.

The Value Hill model[1]

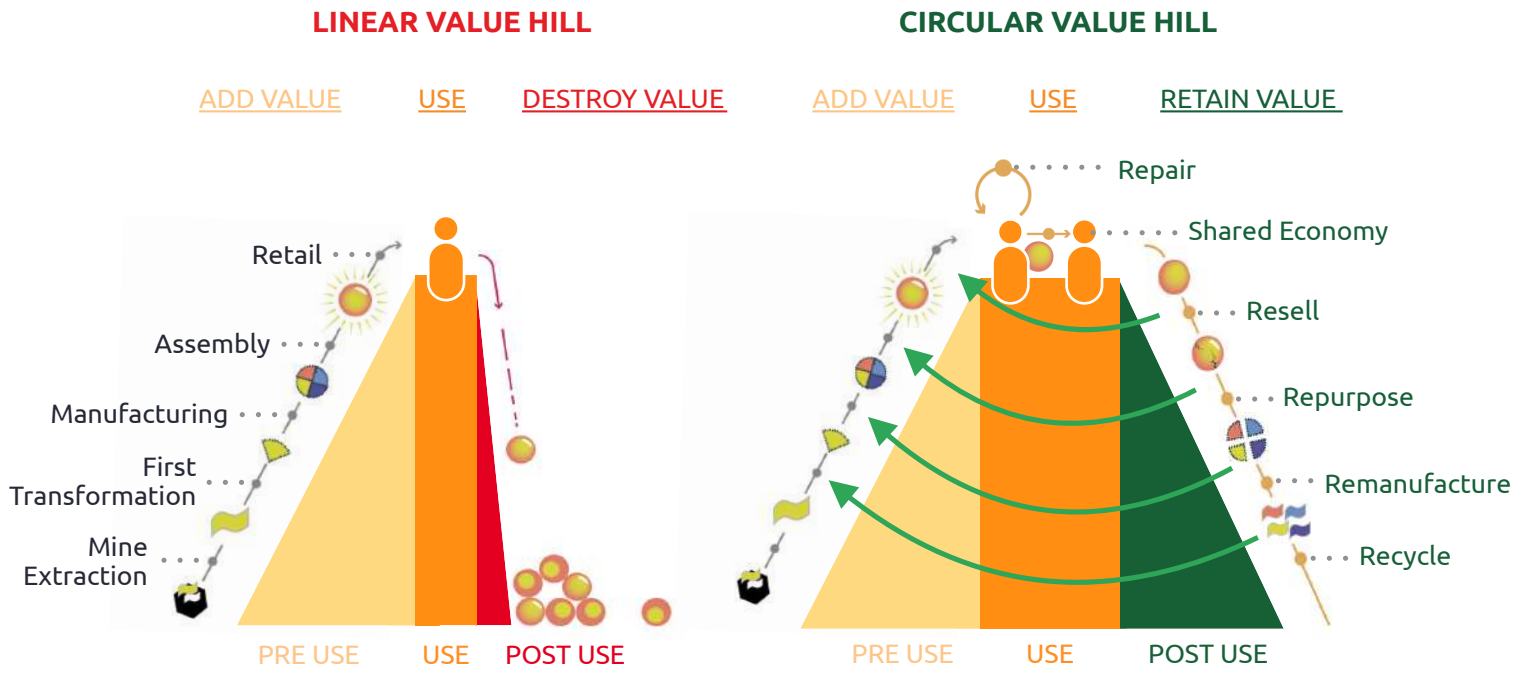
Industry **adds value** to the economy when products are transformed from raw materials to finished goods sold to consumers.

In the **linear economy Value Hill model**, after consumer use, **value is destroyed** each time a product is thrown away with all its included resources. Though material resources are as precious as energy to fuel the modern economies, they are spoiled.

In the **circular Value Hill model**, since a product's resources are only gradually destroyed when the product is damaged, each downhill stage is an opportunity to **retain value** and re-inject materials to the uphill path **back to their respective stages of production**.

FIGURE 2

The value hill resource management model



Source: circle-economy.com, Sustainable Finance Lab, Circle Economy, Nuovalente, TUDelft, Het Groene Brein, Capgemini analysis

1 Source: circle-economy.com

Multiple co-benefits but a double challenge

Private companies need to build a resource-aware vision of their business and actionable circular economy plans to gain resilience, ensure the viability of their business plans, and create new opportunities encompassing a broader view of their supply chain, stakeholders, and clients.

Moreover, as shown in Figure 3. a strategy taking into account resources and circular business cascades multiple co-benefits with high impact on nature and people, that would cost higher efforts to solve separately.

Nevertheless and beyond economic maturity, circular economy resists to C-level executives for at least two reasons, lack of holistic view and lack of single metric, This document proposes two innovative tools.

The 16 CBS matrix to build a holistic corporate strategy

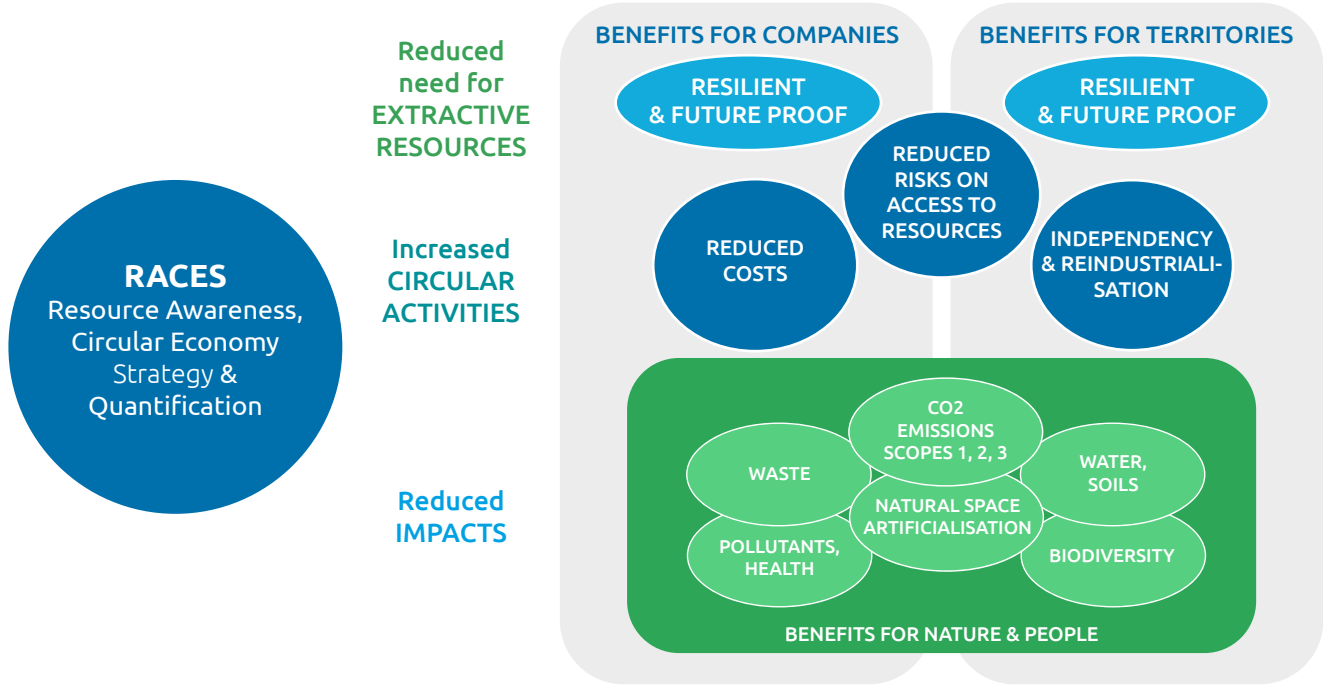
Building a global strategy remains a challenge as circular activities are currently scattered in a multiplication of local heterogeneous initiatives: per branch, per product, per stage of the value chain, per circular lever, per resource. The available frameworks (3Rs, 5Rs, 10Rs) remain quite theoretical, disconnected from the company departments, and keep more attached to resources than to businesses. That is why Capgemini has developed an actionable set of **16 Circularity Business Segments (CBSs)**. They will help industrial players to engage in solution-oriented actions to achieve circularity. Each segment can come with standalone business cases, which also bring along many benefits for companies & territories.

A single metric for resources, in the same way tCO2 are the single metric for climate

There is currently no official single indicator covering the diversity of resources and challenges. Turning to a resource aware strategy entails that criticality be as relevant and helpful as key indicators for business performance or carbon footprint[2]. CxOs need criticality measure to build and monitor a holistic resource vision and a circular strategy at the scale of their company. For that, Capgemini has built the ultimate **Resource Criticality Factor (RCF)**, expressed in €.criticality, resulting from the multiplication of volumes, price and impact. Resource Criticality Factors (RCF) can be used as prices and carbon emissions factors (CEF).
These two tools are embedded in a structured approach named RACES: Resource Awareness and Circular Economy Strategy. With RACES and its two tools, companies can now build potent holistic resource and circular economy strategy.

FIGURE 3

The value hill resource management model



2 Financial KPIs, starting with margin levels, are required of all company boards to evaluate a company's performance. The tCO2eq is used to report on a company's GHGs emissions and monitor the implementation of low-carbon strategies. There is no such indicator for criticality.

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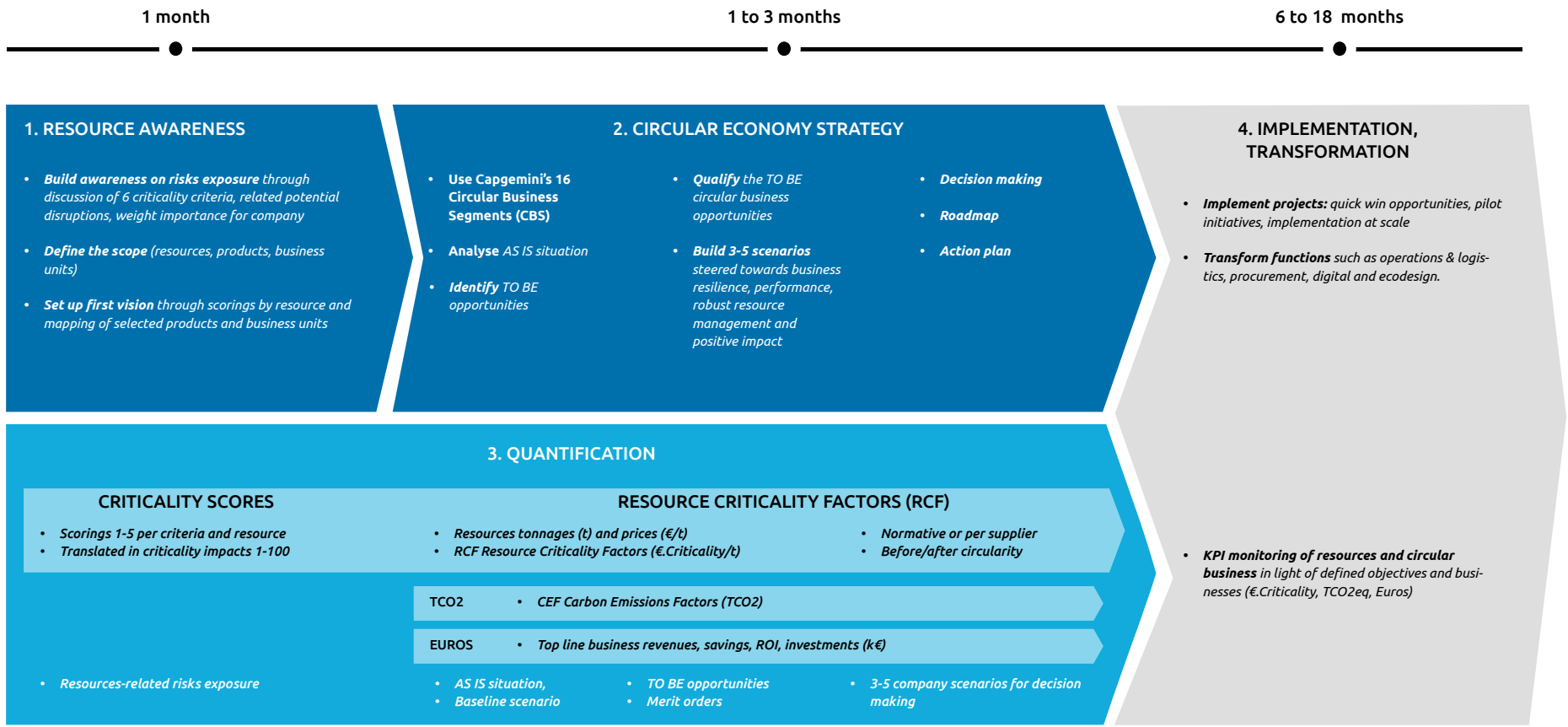
RACES approach: Resource Awareness & Circular Economy Strategy

FIGURE 4

RACES approach, 4 tasks from vision to implementation



RACES: Resources Awareness and Circular Economy Strategy

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RACES approach: Resource Awareness & Circular Economy Strategy

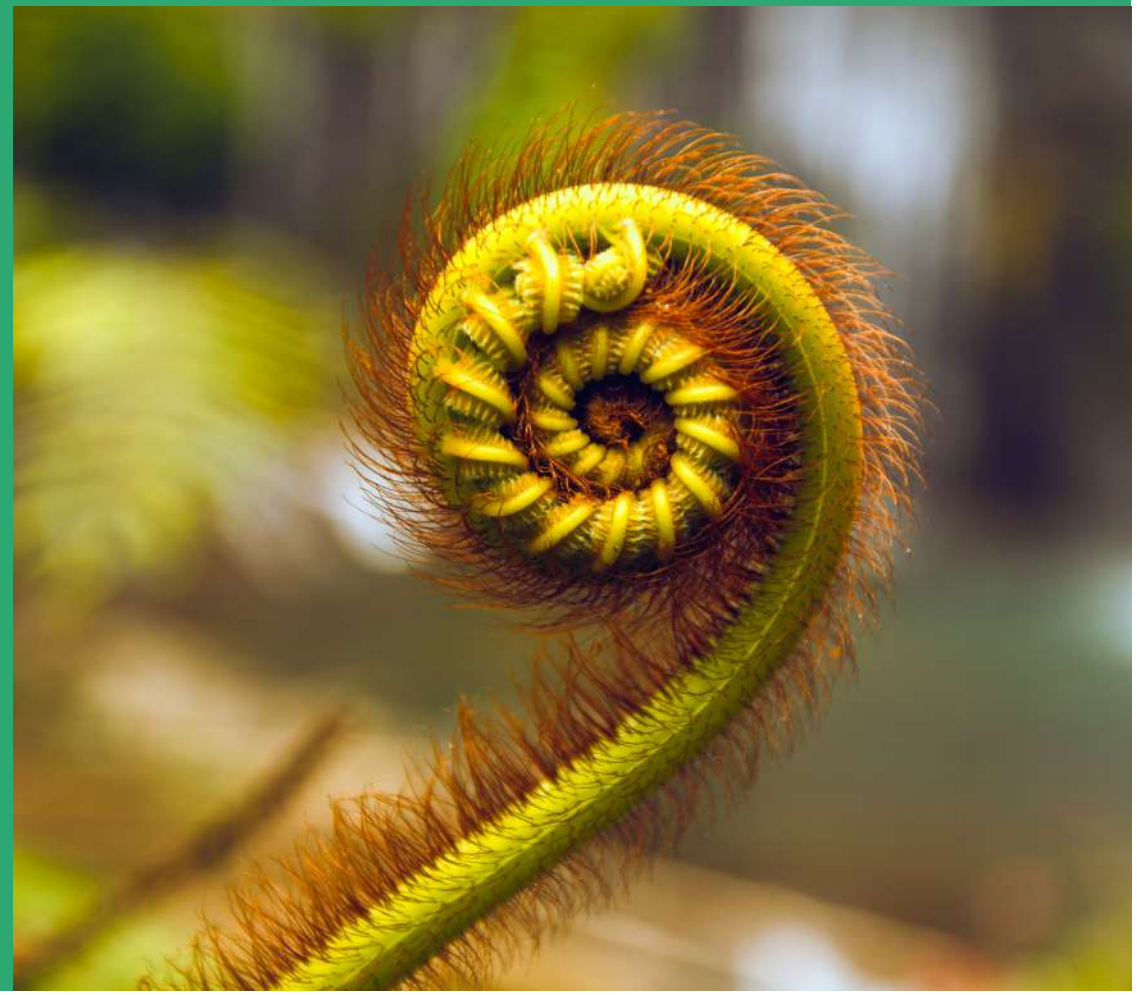
Four steps from vision to implementation
Capgemini's comprehensive approach boils down to 2+1 streams mirroring each other before implementation. Each relies on one new tool that Capgemini brings to the table. The two first streams aim to assess corporate vulnerability to resource-criticality and to uncover the potential of circular business opportunities; the associated tool is the 16 Circular Business Segments (CBS) strategic matrix. The third stream aims to quantify this vulnerability, potential and business opportunity taking into account criticality; the associated tool is the resource-criticality factor (RCF).

1. **The Resource Awareness (RA) phase is intended to determine your company's maturity and vision regarding resource-criticality.** These preliminary assessments include a first criticality-scoring to pinpoint factors contributing most to your risk exposure in terms of resource criticality, e.g. operational pain-points (key resources & products). This preliminary phase should conjure a big picture & outline strategic priorities to be considered in the next steps.

2. **Circular Economy Strategy (CES) comes in to enhance the traditional business approach with resource-criticality considerations.** The **16 Circular Business Segments (CBS)** will be key to assess your current circularity maturity and identify most relevant opportunities for the future. These opportunities will be leveraged into qualified business, resource-criticality wise. The opportunities will be rearranged in a few scenarios for decision-making and translated in a robust action plan down the line.

3. **The quantification stream provides the right decision-making metrics and enhances the opportunity qualification & scenario analysis.** CxOs will be able to compare the opportunities and scenarios in terms of volume, cost, and €.criticality; and infer business implications (€) in conjunction with operations and procurement departments. A circular and resource-aware strategy also comes with a co-benefits case, such as reduced carbon emissions, improved biodiversity footprint and lower social impact.

4. **Tangible implementation and transformation follow a robust strategy.** Quick wins and pilot initiatives need to go hand in hand with long-term scaling initiatives and will provide first feedback with KPI monitoring including criticality in light of defined objectives.



RACES: Resources Awareness and Circular Economy Strategy

01 RESOURCE-AWARENESS & VISION

A corporate strategy not tackling resource constraints jeopardizes the company

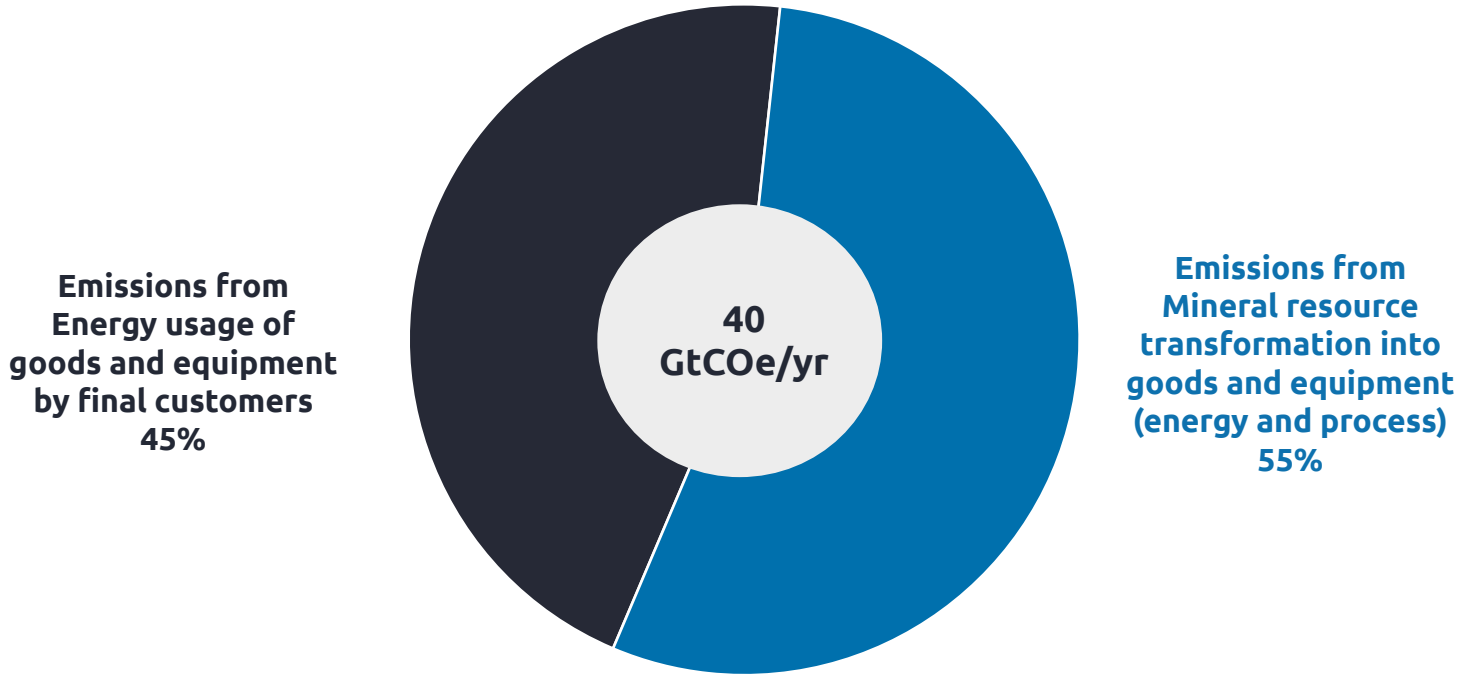
1.1 From carbon challenge to resource constraint

The carbon challenge is now on top of many CxOs agendas. Resources and circular economy are the next and soon-to-come frontier in their agendas for three reasons.

The first reason is that reducing GHG emissions to low levels requires necessarily reducing the impact of resources, both in terms of quantities extracted and in terms of transformation needed. Out of the 40 GtCO2e emitted yearly by human activities, the transformation of the mineral resources into goods and equipment by businesses account for 55%, i.e. more than the use of energy by final customers to run these goods, their homes and to travel, which only account for 45%[3].

FIGURE 5

Weight of transformation of mineral resources in global emissions: No Net-Zero without Circular economy



Source: World Resource Institute, 2019 figures, Capgemini analysis

3 10 GtCO2e/yr can be added for land, forest and related agro-industry emissions, summing up to 50 GTCO2e yearly.

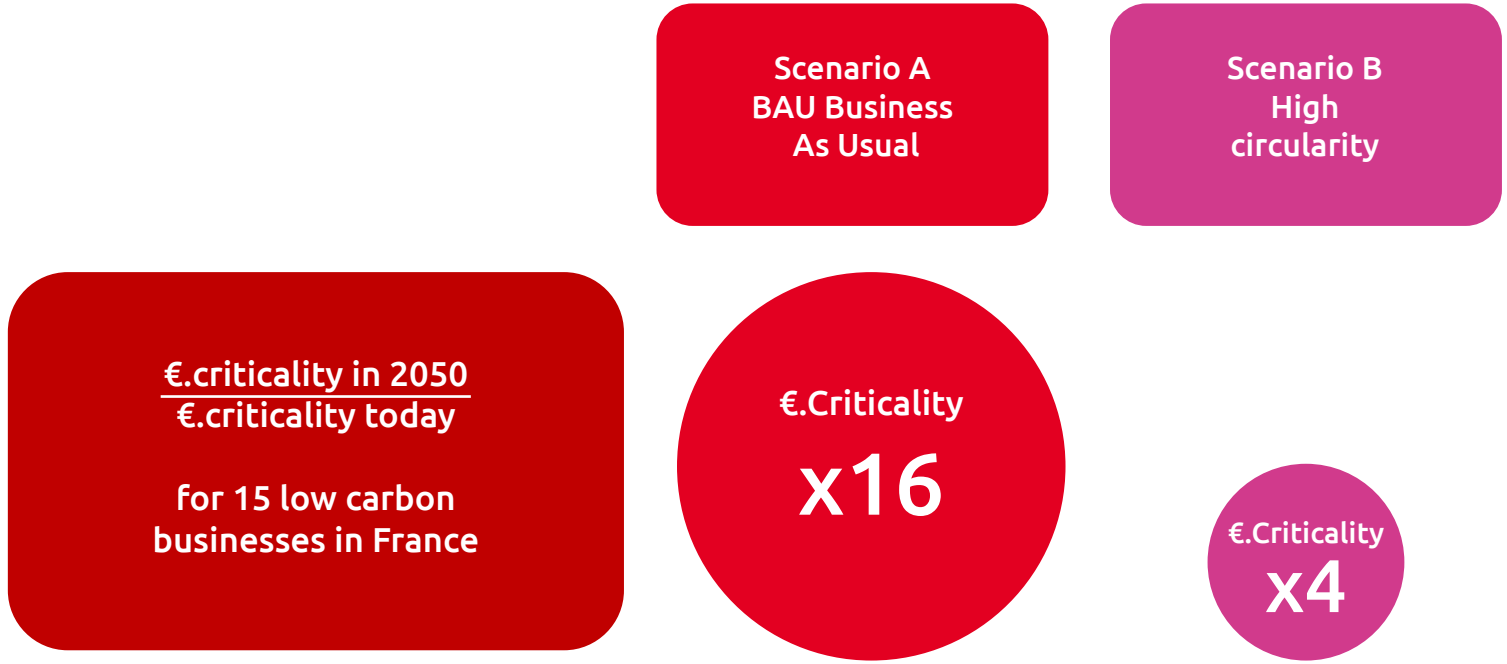
1.2 The resource constraint is exacerbated by the low carbon transition

The second reason why we are moving from carbon challenge to resource constraint is that decarbonization plans highly count on resource-intensive technologies.

Turning away from fossil-fuels means shifting the demand to other resources, inducing a major concern with the feasibility of many decarbonization strategies resource-wise. **Capgemini's research led for INEC at the** warns that if France's economy remains predominantly linear, implementing its low carbon strategy will increase the cumulated €.criticality[4] of metals and minerals by a factor of 16 at the country's scale by 2050 (cf Figure 8). Green technologies, deemed from a low carbon transition point of view, are in fact a high risk regarding resources, electric cars being the most blatant example. Electric mobility will be responsible for the 65% increase in criticality deriving from the expansion of low carbon technologies as per the French low carbon strategy (cf Chapter 3, Figure 18). A high circularity scenario would limit this multiplication to a factor of 4.

FIGURE 6

Low carbon high tech economy is not feasible without circular business (INEC Capgemini study)

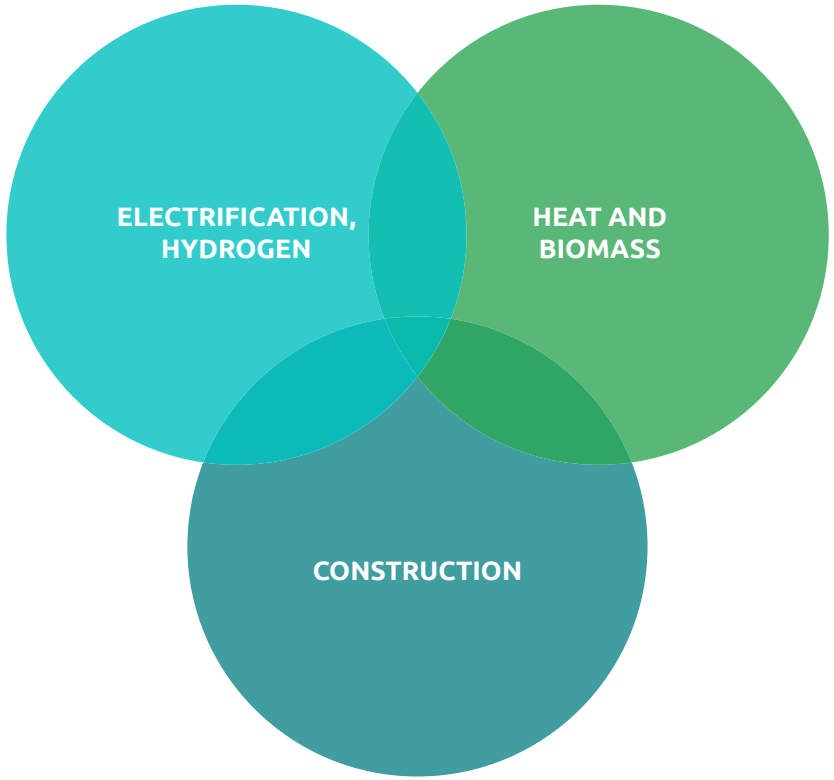


4 Cf explanation of the €.criticality new holistic metric in Chapter 3. Criticality quantification

FIGURE 6

Low carbon high tech economy is not feasible without circular business (INEC Capgemini study)

3 branches



15 business domains

Electrification, H2
- Electric vehicles
- Hydrogen vehicles
- H2 electrolysis
- Heat pumps
- Nuclear
- Onshore wind
- Offshore wind
- Solar PV
- Power grids

Heat and Biomass
- District heating
- Deep geothermal energy
- Gaseous biomass
- Solid biomass

Construction
- Buildings – New build
- Buildings - Retrofit

14 critical resources

Electrification, H2
- Lithium
- Cobalt
- Platinoids
- Rare earths
- Copper
- Graphite
- Silicon
- Aluminium
- Nickel
- Steel
- Concrete

Heat and Biomass
- Wood
- Agriculture
- Urban and industrial waste
- Steel
- Concrete

Construction
- Steel
- Aluminium
- Concrete

1.3 All industries are affected by resource stress in their core activity

The third reason why resource constraints join up carbon challenge in the CxO priorities is that **all the industries are impacted directly, intensifying in turn the need for resources and the impact on environment.**

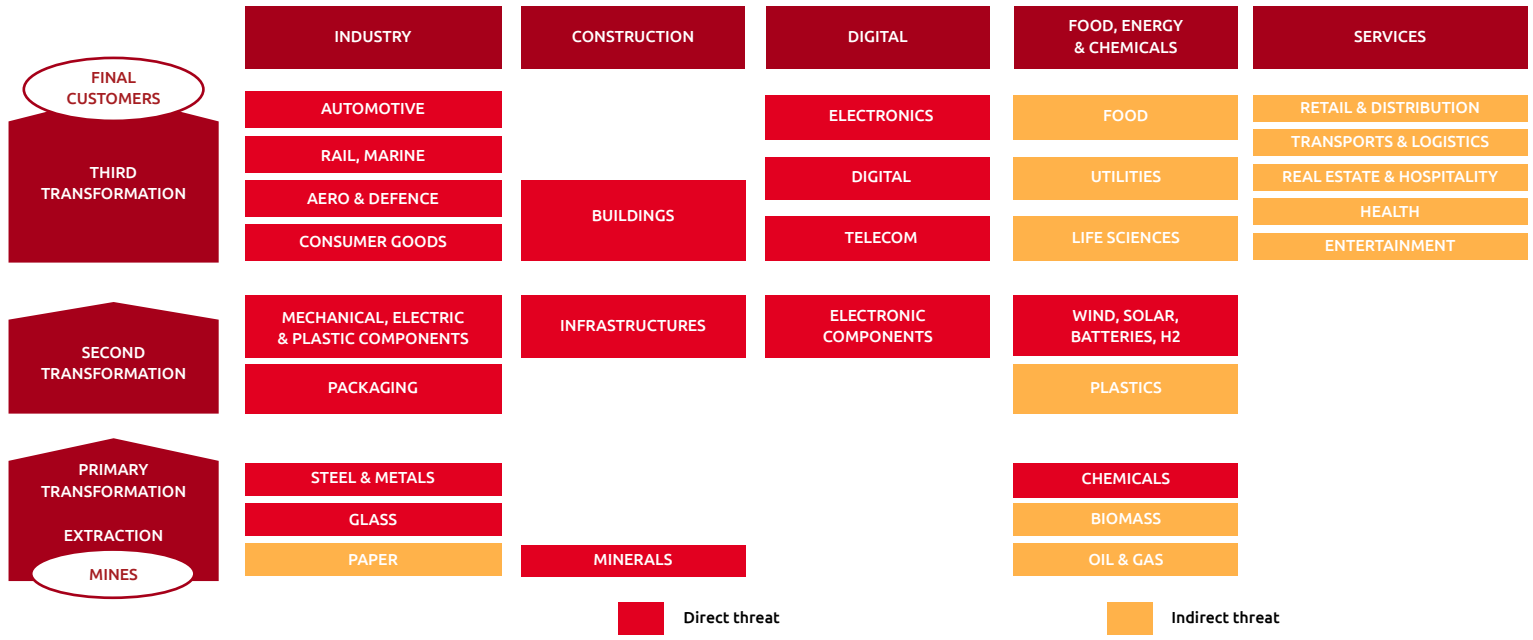
From high price volatility to geopolitical disruptions, access to natural resources gets more and more precarious. Technology possibilities do not always prevent from being dependent on specific resources. Sustainability impacts not only include climate, but also other social and environmental risks generated by the intensive extraction and transformation of minerals.

The service industry is exposed too: any weakness in the physical industry will pass on to the service industry, including financial services.

Quantification shows that a circular strategy optimising the use of resource is absolutely necessary to ensure the resilience of the overall economy, the feasibility of the low-carbon transition, and the conservation of people and ecosystems.

FIGURE 8

Most industries will be affected at different levels by mineral resource stress – even indirectly services as they need equipment to operate.



1.4 Six drivers of criticality convert resources in a challenge for CPOs, CTOs, and CSR leads.

Resources raise six challenges not only to public authorities, but also to private business CEOs and their departments:

- Chief Procurement officers (CPOs) must solve the challenge of accessibility to resource (reserves, concentration of suppliers, competition of usages)
- Chief Operations and Technology Officers (COOs, CTOs) are concerned with replaceability and recyclability.
- CSR leads face social and environmental proven impacts and future risks.

a. Geological reserves

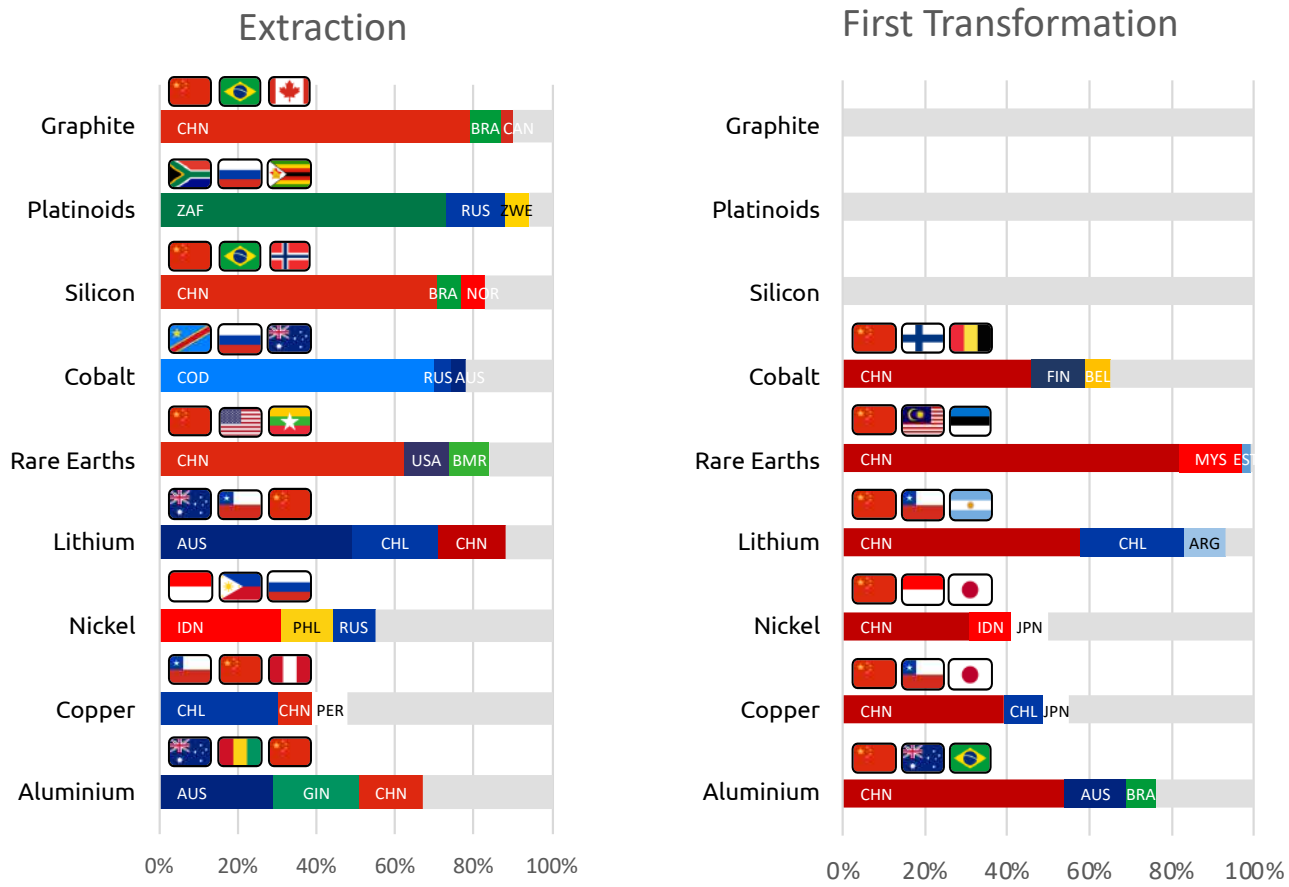
CPOs should assess if a resource is geologically scarce or if it will remain abundant and accessible for a long time. For instance, at current growth rate, the reserves for hafnium, antimony, strontium will be depleted in the 2020s and the reserves for lead, gold, tin, chromium, zinc, silver in the 2030s[5]. Possible investments in exploration and extraction might extend the access to certain resources, but overall reserves are declining.

b. Concentration of suppliers in a decoupling and multipolar world

When extraction and first transformation markets are concentrated or even monopolistic (Figure 8), CPOs need to consider the supply risk across the whole value chain. Depending on the industry, geopolitical trends can pose difficulties in terms of dependency and price stability.

FIGURE 9

Concentration of suppliers



5 USGS (2011 data), Barclays Research

c. Competition of usages:

Resources are coveted by many industries (low carbon industries, aerospace, defense, IT, digital equipment, telco, etc.) and countries, which CPOs need to monitor closely. Intense competition can inflate the demand and therefore criticality as well as questioning the willingness to pay in most exposed industries.

d. Substitutability

Early on the value chain, engineering & design functions must acquaint themselves with how much their business relies on a single kind of resource and look for available or soon available alternatives to reduce their exposure to criticality.

e. Recyclability

Product development departments need to have in mind the recyclability of each critical resource in light of their own technological maturity regarding the latter. Relying on easily recyclable materials and existing recycling processes can help alleviate resource criticality. For instance, lithium is not recyclable and alloyed metals are not massively separable. Integrating recyclability considerations in the process requires innovation and simpler component design.

f. Social and environmental impacts & risks

CSRs tackle a growing number of risks that arise in relation to the extraction and exploitation of natural resources. They span from minor to major impacts and can render specific supply channels unacceptable to end customers. Major environmental impacts on ecosystems include water and land contamination, soils degradation, wildlife space fragmentation, deforestation, biodiversity losses, while social risks can go as far as subjugation of local population, threats on livelihood and culture, forced displacements, migrations, modern slavery, child-labor and other violation of human rights.

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Choose the scope & raise awareness by pondering the criticality criteria

The scoring methodology developed in this paper can be applied at various levels, giving CxOs the possibility to choose a criticality-analysis perimeter (market, company, business unit, …)[6]. It provides a standard weighting grid to enable companies to compare to their peers (imagine an SBTi equivalent for resource-criticality), even though the analysis should be tailored to meet the company's assessment objectives. The scoring approach to criticality scoring follows 5 steps:

Discuss & raise awareness on risks exposure
Gather a transversal task force including strategy, operations, technology procurement, CSR. For each resource, discuss the underlying criticality factors to raise awareness regarding the six resource-related business risk and weight. In Figure 10, allocated coefficients are 1 1 1 1 1 1 in the example, but could be for instance 2 2 2 3 3 6 if company wishes to balance the three criticality families, ie access, dependency, sustainability.

Define the perimeter
Choose the branches, products, geographies, operations, value chain to be included the analytical scope, based on the awareness sessions and the business objectives.

6 An industry assessment on a global scale, based on international publications such as those from the International Energy Agency (IEA), the US SGDS agency and the European Commission, provides high-level resource-related stakes and macro-economic trends. More specific assessments by geography or by company will help assess how a better selection of supplier and procurement strategy can improve the rating, thus the resource-criticality exposure.

FIGURE 10

1-5 scores as weighted average of six criticality criteria

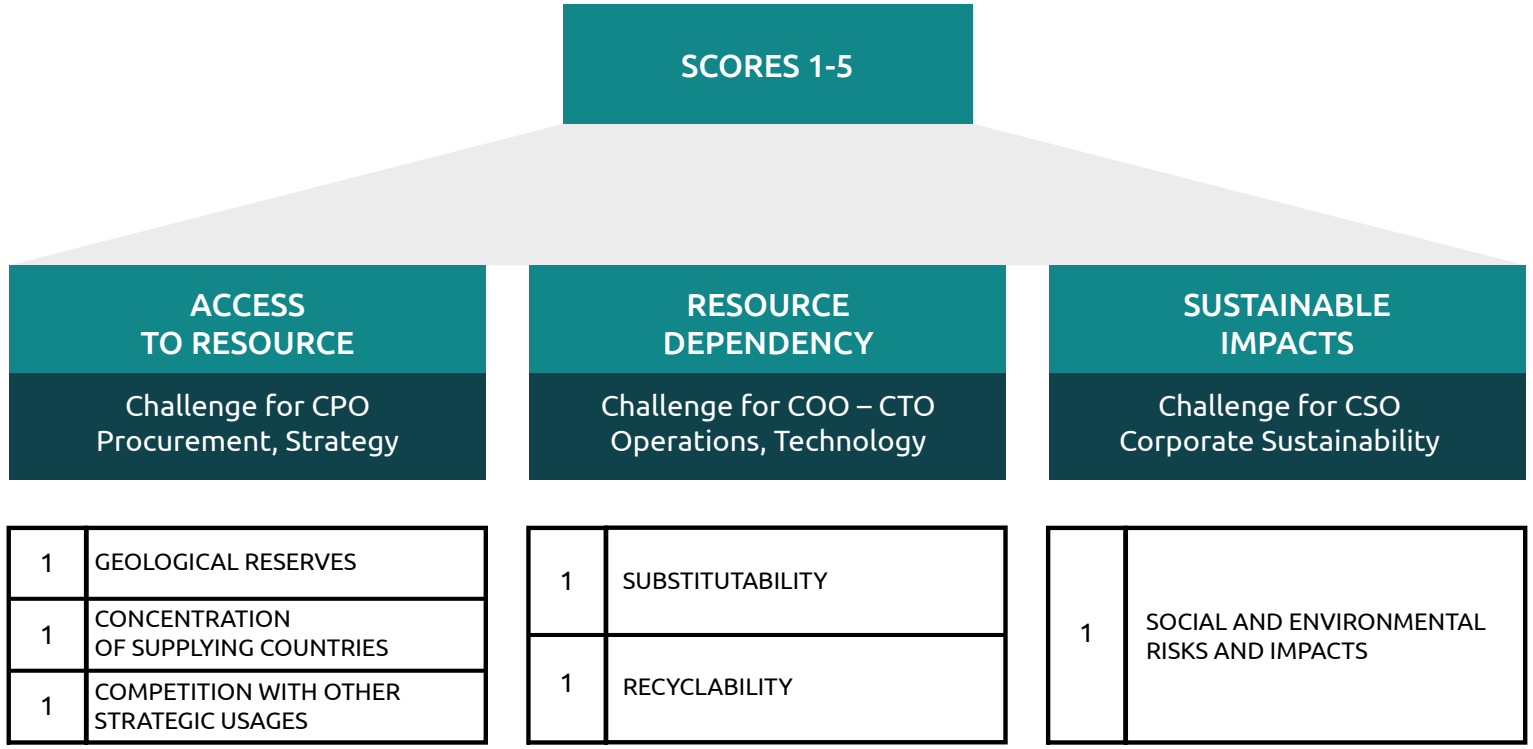


FIGURE 11

Scores 1-5 per resource

Scores 1-5 Resources	LITHIUM	COBALT	PLATINOIDS	RARE EARTHS	COPPER	GRAPHITE	SILICON	ALUMINIUM	NICKEL	STEEL	CONCRETE	WOOD BIOMASS	AGRICULTURE BIOMASS	WASTE BIOMASS
	LI	CO	PTD	RARE	CU	GR	SI	AL	NI	ST	CONC	WOOD	AGR	WAS
CPO: Geological reserves	4	4	4	1	4	3	1	4	2	1	3	3	3	1
CPO: Concentration of supplying countries	4	5	5	5	3	5	5	2	3	2	2	1	1	2
CPO: Competition with other strategic usages	5	4	4	5	4	3	2	3	3	1	1	4	4	2
CTO: Substitutability	4	3	5	3	4	1	3	3	4	4	3	3	3	3
CTO: Recyclability	3	3	1	4	1	5	4	1	2	1	1	1	1	1
CSR: Social and envivironmental risks and impacts	5	5	3	5	5	3	2	4	3	3	2	2	3	2
CPO average (Access to resource)	4.3	4.3	4.3	3.7	3.7	3.7	2.7	3.0	2.7	1.3	2.0	2.7	2.7	1.7
CTO average (Dependency to resource)	3.5	3.0	3.0	3.5	2.5	3.0	3.5	2.0	3.0	2.5	2.0	2.0	2.0	2.0
CSR average (Social and environmental)	5.0	5.0	3.0	5.0	5.0	3.0	2.0	4.0	3.0	3.0	2.0	2.0	3.0	2.0
Global Resource Score 1-5	**4.2**	**4.0**	**3.7**	**3.8**	**3.5**	**3.3**	**2.8**	**2.8**	**2.8**	**2.0**	**2.0**	**2.3**	**2.5**	**1.8**

Assess and aggregate the 1-5 scores per resource.
For each resource, proceed with the 6 multi-criteria scoring on a 1 to 5 scale. The 6 criteria are then averaged in a single score with the chosen weights (Figure 12). For the most mature companies, the scores may be differentiated per supplier.

FIGURE 12

Rating grid for 1-5 scores

SCORE	CRITICALITY	GEOLOGICAL RESERVES	CONCENTRATION OF SUPPLYING COUNTRIES				COMPETITION FOR RESOURCES	SOCIAL AND ENVIRONMENTAL
		R/P RESERVES VS PRODUCTION	EXTRACTION		FIRST TRANSFORMATION			
			TOP 1	TOP 3	TOP 1	TOP 3		
5	Major	<25 years	>60%	<80%	>60%	<80%	Major (Incl. military uses)	Deaths / Irreversible damages
4	Strong	<50 years	>40%	>60%	>40%	>60%	Strong (Incl. energy sector, high-tech and telecom uses)	Human Rights Violations / Extensive damage at a large scale
3	Medium	<100 years	>20%	>40%	>20%	>40%	Medium (other industrial sectors)	Social disparities / Environmental damage small-scale but frequent
2	Minor	<200 years	>10%	>20%	>10%	>20%	Minor	Low impacts, localized, rare
1	Not Critical	>200 years	<10%	<20%	<10%	<20%	None	None

Expose first hotpoints with the heatmap of the company
Build the heatmap (Figure 13) by crossing the branches or product lines with the resource scores. Get an overview of your overall risk exposure and highlight the hot points of criticality for your business.

Derive first elements of vision
Derive a first version of the learnings and vision for the future in terms of techs, business, suppliers, risks. Be aware that this phase is only qualitative. The full quantification described in Chapter 2 will deliver a more detailed picture, other learnings and food for action. Prepare in consequence the strategic and quantification phases (see chapters 2 & 3).

FIGURE 13

Qualitative heatmap per business domains

Resource Heatmap (1-5) per business domain		LITHIUM	COBALT	PLATINOIDS	RARE EARTHS	COPPER	GRAPHITE	SILICON	ALUMINIUM	NICKEL	STEEL	CONCRETE	WOOD BIOMASS	AGRICULTURE BIOMASS	WASTE BIOMASS
		LI	CO	PTD	RARE	CU	GR	SI	AL	NI	ST	CONC	WOOD	AGR	WAS
Electric Vehicles	3.2	4.2	4.0			3.5	3.3		2.8	2.8	2.0				
Hydrogen Vehicles	3.1			3.7	3.8	3.5	3.3		2.8	2.8	2.0				
Hydrogen Electrolysis	3.1			3.7	3.8	3.5	3.3		2.8	2.8	2.0				
Heat Pumps	2.8					3.5			2.8	2.8	2.0				
Nuclear	2.6					3.5				2.8	2.0	2.0			
Onshore Wind	2.8				3.8	3.5			2.8	2.8	2.0	2.0			
Offshore Wind	2.8				3.8	3.5			2.8	2.8	2.0	2.0			
Solar PV	2.6					3.5		2.8	2.8		2.0	2.0			
Electric Grids	2.6					3.5			2.8		2.0	2.0			
District Heating	2.0										2.0	2.0			
Deep Geothermal Energy	2.3									2.8	2.0	2.0			
Solid Biomass	2.0										2.0	2.0	2.3		1.8
Gaseous Biomass	2.1										2.0	2.0	2.3	2.5	1.8
Buildings - New Build	2.3								2.8		2.0	2.0			
Buildings - Retrofit	2.3								2.8		2.0	2.0			

02 CIRCULAR BUSINESS STRATEGY

Capgemini’s 16 circular business segments to steer your company towards a circular model

Capgemini has devised a strategic matrix featuring 16 "Circular Business Segments" (CBS). Each can bear a specific business plan and business case. The 16 CBS matrix enables you to roll-out a strategic process, from assessing your current maturity to generating opportunities and envision scenarios to build a resilient corporate business strategy.

2.1 Capgemini's 16 Circular Business Segments (CBS)

The 16 CBS provide an exhaustive approach to all opportunities in circular economy

The 16 CBS matrix outlines actions to undertake to transition from a linear to a circular model. It holistically covers all aspects to be examined yet avoids redundancy and echoes the value hill framework. It also contains the central-local-onsite breakdown - for easier appropriation by operational decision makers (CSO, CMO, COO, CTO, CPO, CSR).

This matrix will enable you to conduct a holistic assessment of what the state of art is in your firm in terms of circularity ("AS IS"), flag what is left to improve, and how. For each CBS, typical "To be" positioning decisions at short, medium and long term are

- No Go (let others try)
- Go (outsource),
- Go (insource)

The vertical axis indicates where the CBSs encompass the conventional value chain

The vertical axis follows the conventional value chain of linear extractive economy, from mining activities (bottom) to manufacturing and retail activities (top). It sets up the reference for where the circular economy loops in and comes out.

The Horizontal axis (1) reflects the direct and reverse operations

The horizontal axis distinguishes two parts: the direct manufacturing and service process to clients (left part) and the reverse process dealing with end-of-life equipment and recovering value from goods or parts (right part). The combination of both parts creates the circular opportunities.

The Horizontal axis (2) reflects the location and type of operations generated by the CBSs

- Onsite: in client's premises, as a part of the end-consumer's journey
- Local: close to the end-consumer's location (less than one hour or 100 km away)
- Centralized: the operations are carried out in large size sites serving a whole area, country or even region.

The shift towards circular economy can be compared to the transition in the energy sector. Business and operating models become complementary between centralized large facilities (nuclear or gas plants in energy, large manufacturing and remanufacturing plants in circular economy), in between local or regional operations (wind farms in energy, service centers for repairing and repurposing in circular economy) and local on-site operations (solar roofs in energy, equipment in clients' premises in circular economy).

Intermingled yet well differentiated CBS

Some CBSs **echo each other**, such as "recycle" vs "use recycled materials" or "repurpose" vs "use repurposed components". We have split the usual ambiguous word "Repurpose" into several CBSs, as it involves a complete value chain[7] on which the company must make strategic choices

- Collecting and sorting
- Repurposing end of life products, which entails operations that are usually the role of waste companies but may have in the future to be strategically incorporated in the activities of the company
- Sourcing internally or externally the repurposed parts
- Use them in the industrial activities of the company: repair, retrofit, remanufacture
- Use them in the commercial activities of the company: resell, marketplaces.

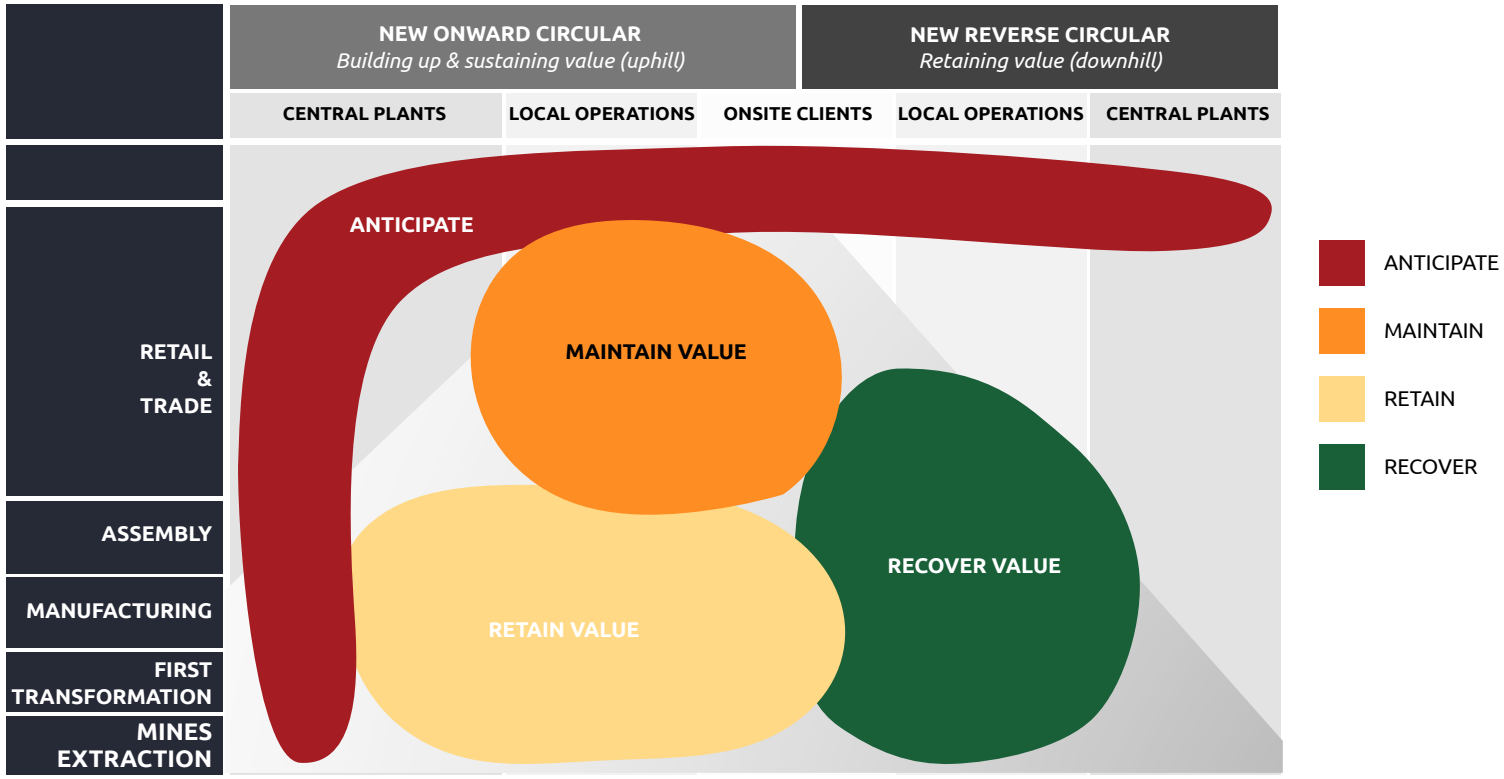
Conversely, the retrofit of a given equipment (left part) can use spare parts and materials from different origins (right part): repurposed second-life components, recycled materials, but also biomaterials and of course spare parts from conventional linear newbuilt origin.

Procurement becomes key, as repurposed components or recycled materials may come from internal activities or purchased from external suppliers. **Vice-versa**, end-of-life products that have been collected, disassembled, and sorted **may be sold rather than used internally.**

7 For the same reasons "Recycle" has been split in several CBS.

FIGURE 14

Mapping value chain, location and direct/reverse flows of circular activities



The role of CxOs[8] in the Value Hill triangle

The 16 CBS are divided into 4 categories regarding the ways of sustaining value, echoing the value hill framework (symbolized by the background triangle and shapes in Figure 18)

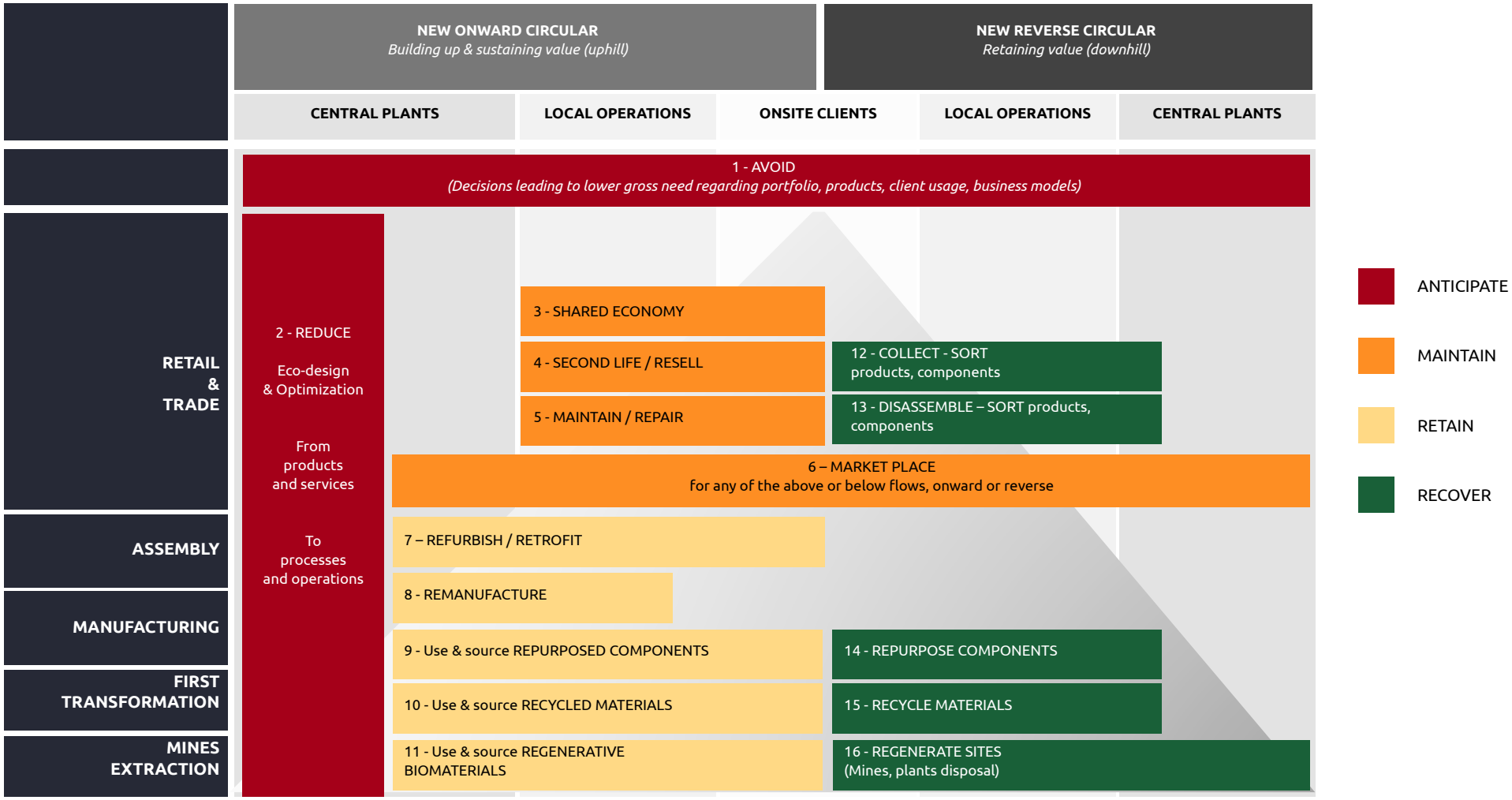
- **Anticipate:** Limit gross resource requirements, through avoiding (CSO) and reducing (CTO), are strategic steps to work with minimized efforts towards a circular model boosting resilience, decarbonization and conservation of ecosystems.
- **Maintain:** Create new profitable value propositions (CMO) based on products in good state seeing their lifespan and usage extended.
- **Retain:** Manage onward production steps to yield new products (COO) that integrate looped components or materials procured internally and externally (CPO).
- **Recover:** Manage reverse operations to recover value form discarded objects, parts and materials and prepare them to re-integrate the production and the commercial cycles (COO).

The circularity shift provides industrial players with the opportunity to selectively diversify activities and expand their presence on value chains.

8 CSO Chief Strategy Officer, CMO Chief Marketing officer in charge of products, clients, and experience marketing, COO Chief Operations Officer, CTO Chief Technology Officer, CPO Chief Procurement Officer, CSR Corporate Social Responsibility lead

FIGURE 15

The 16 CBS matrix (Circular Business Segments)



THE METHODOLOGY CORNER
The 16 CBS explained

16 CBS	Main CxO in charge	AS IS assessment, TO BE opportunities review (go insource, go outsource, no go, when)	Examples
Anticipate *Limit gross resource requirements, through avoiding (CSO) and reducing (CTO), are strategic steps to work with minimized efforts towards a circular model boosting resilience, decarbonization and conservation of ecosystems*			
1. Avoid	**CSO**	Make strategic decisions to minimize dependency on strategic resources with high social/environmental impact, divest and move from some businesses, product or technology families to others, or encourage clients to minimize the use of the product	• Orienting the business model to a service provision model, like energy-as-a-service • Substituting materials by others to relieve the pressure on critical resources, e.g. in kitchenware industry. • Crop size of vehicles for a given mobility service
2. Reduce	**CTO, COO**	Reduce the quantity of resource needed and of waste in each unit of product and in the manufacturing process, through improved eco-conception and engineering	• In the textile industry, optimizing cutting patterns to minimize fabric waste and energy consumption. • Sufficient products
Maintain value *Create new profitable value propositions (CMO) based on products in good state seeing their lifespan and usage extended..*			
3. Shared economy	**CMO**	Develop functional economy / shared services / product-as-a-service solutions	• Car sharing, co-working spaces, home rental, mobility as-a-service, tool and machinery rental, libraries of things
4. Second life/resell	**CMO**	Develop activities in sale of second life products and parts. Resold goods may come with minor repair and some components change - in that case spare parts may come from conventional linear new built economy, or from repurposed origin (#9), or from biomaterials origin (#11).	• Re-deploying professional solar panels becoming less performant by houses of individuals. • Exploiting mobility batteries becoming less performant for stationary use.
5. Maintain/repair	**CMO**	Provide repair and maintenance services to keep a product in service as long as possible. Spare parts may come from conventional linear new built economy, or from repurposed origin (#9), or from biomaterials origin (#11).	• Offering spare parts and tutorials for the user to fix their device themselves, like we see in sporting equipment. • Having repair corners at retailers, just as clothing brands now offer alterations
6. Market place (sell/re-sell)	**CMO**	Develop sell or resell platforms to manage your looped products, components, materials, externally in B2B, B2C and internally within your group.	• Platforms for construction materials • Platforms for power plants second life spare part • Platforms for repurposed parts of airplanes.

Retain value *Manage onward production to yield new products (COO) that integrate looped components or materials procured internally and externally (CPO).*			
7. Refurbish/retrofit	**COO**	Recondition and/or improve used products to extend their life, by changing significant components and/or upgrading software or hardware. Components may come from conventional linear new built economy, or from repurposed origin (#9), or from biomaterials origin (#11).	• Refurbishing smartphones to prolong their lives. • Retrofit buildings to make them more energy efficient.
8. Remanufacture	**COO**	Re-manufacture products - either similar or different from the initial ones - by integrating a mix of repurposed components (#9), new build components, recycled materials (#10) and/or regenerative biomaterials (#11).	• Reuse the foundations, masts, and electromechanical elements of old wind turbines for the construction of new generation ones.
9. Use repurposed components	**CPO**	Use repurposed components as part of your "Maintain" and "Retain" activities such as Second Life / resell (#4), Maintain / Repair (#5), Refurbish/ Retrofit (#7), Remanufacture (#8), Market place (#6). The CPO may procure the repurposed components from insourced activities (12, 13, 14) or purchased from external suppliers	• Repurposing newspaper or textile as insulation for building.
10. Use recycled Materials	**CPO**	Use recycled materials as part of your "Maintain" and "Retain" activities as well as conventional manufacturing (#2 reduce). The CPO may procure the recycled materials from insourced activities (#12, #13, #15) or purchased from external suppliers.	• Making paper sheets from industrial paper scraps or used paper. • Making pens or jumpers from old water bottles
11. Use regenerative Biomaterials	**CPO**	Use biomaterials as part of your "Maintain" and "Retain" activities as well as conventional manufacturing (#2 reduce). The CPO may procure the biomaterials from external suppliers	• Bioplastics in car interiors. • Using bio-sourced solvents or catalysts in the pharmaceutical industry.
	Recover value *Manage reverse operations to recover value form discarded objects, parts and materials and prepare them to re-integrate the production and the commercial cycles (COO).*		
12. Collect - Sort	**CMO, COO**	Develop activities in collecting and sorting used products, components and materials to feed the disassembling, repurposing and recycling process	• Collect the empty containers when you come in for the next delivery, as some bulk grocery and bottled water brands already do • Educating users to bring their used batteries or lightbulbs to collection points.
13. Disassemble - Sort	**COO**	Develop activities in disassembling and sorting used products, components and materials to feed the repurposing and recycling processes.	• Designing modular products so that they are easily dismantled

14. Repurpose components	**COO**	Develop own activities in repurposing components to resell them or to support your "Maintain" and "Retain"activities.	• Planning the architecture of buildings so that they can be reversed between office use and housing use.
15. Recycle Materials	**COO**	Develop activities to control and recycle the used materials to feed your internal uses or to resell materials.	• Shred and melt materials, e.g. glass or metal, into a new piece for assembly.
16. Regenerate sites	**CSR**	**Regenerate sites where you cease activities - industrial, logistic, mining, or waste disposal.**	• Leaving no social/health or environmental impact behind, for instance through processes and solutions to regenerate soils, biodiversity, and local human activities.

2.2 Our practical approach to conduct As-is and To-be opportunity identification

The 16 CBS matrix can be used as a support to a classic and robust strategic approach. Typically, a long list of 15-60 opportunities can be derived from the CBS matrix and the scan of the product lines, branches, and markets of the company.

Second, the qualification of the opportunities can be based on tools such as Osterwalder's Business Model Canvas[9] slightly adapted for circular business. After their qualification, all opportunities will be prioritized in a shorter list of 10-20 opportunities and cross-examined as part of scenarios, which will be used for decision-making down the line. The 3-5 scenarios will showcase different levels of ambitions and investment, and possibly point to different visions on how to retain resource value and develop business.

Third, the decision making is based on a business plan (activity, investment, ROI, break even..) and leverages the €.criticality metric to measure criticality improvement across multiple strategic resources and departments of the company. The quantification methodology in €.criticality is detailed in chapter 3.

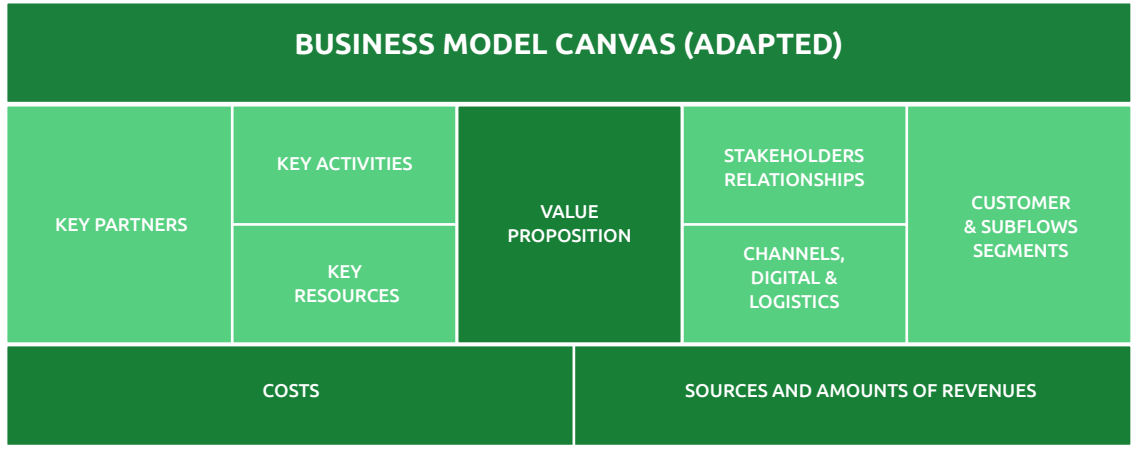
Last, outputs will provide both a short-term action plan to implement rapidly on favorable playfields, specific production sites or distribution perimeters. The output can also provide a roadmap with long-term initiatives to roll-out over several years, and which will challenge the way core-business is operated and help the large-scale shift towards circularity.

FIGURE 16

Phase 2 Circular Economy Strategy

FIGURE 17

Qualified the identified opportunities (example of tool)



9 Osterwalder, Alexander; Pigneur, Yves; Clark, Tim (2010). Business Model Generation: A Handbook For Visionaries, Game Changers, and Challengers.
https://www.strategyzer.com/canvas/business-model-canvas

03 CRITICALITY QUANTIFICATION

Capgemini’s criticality indicators allow companies to quantify resource criticality and assess their response.

3.1 How to build and unlock triple-metrics analytics

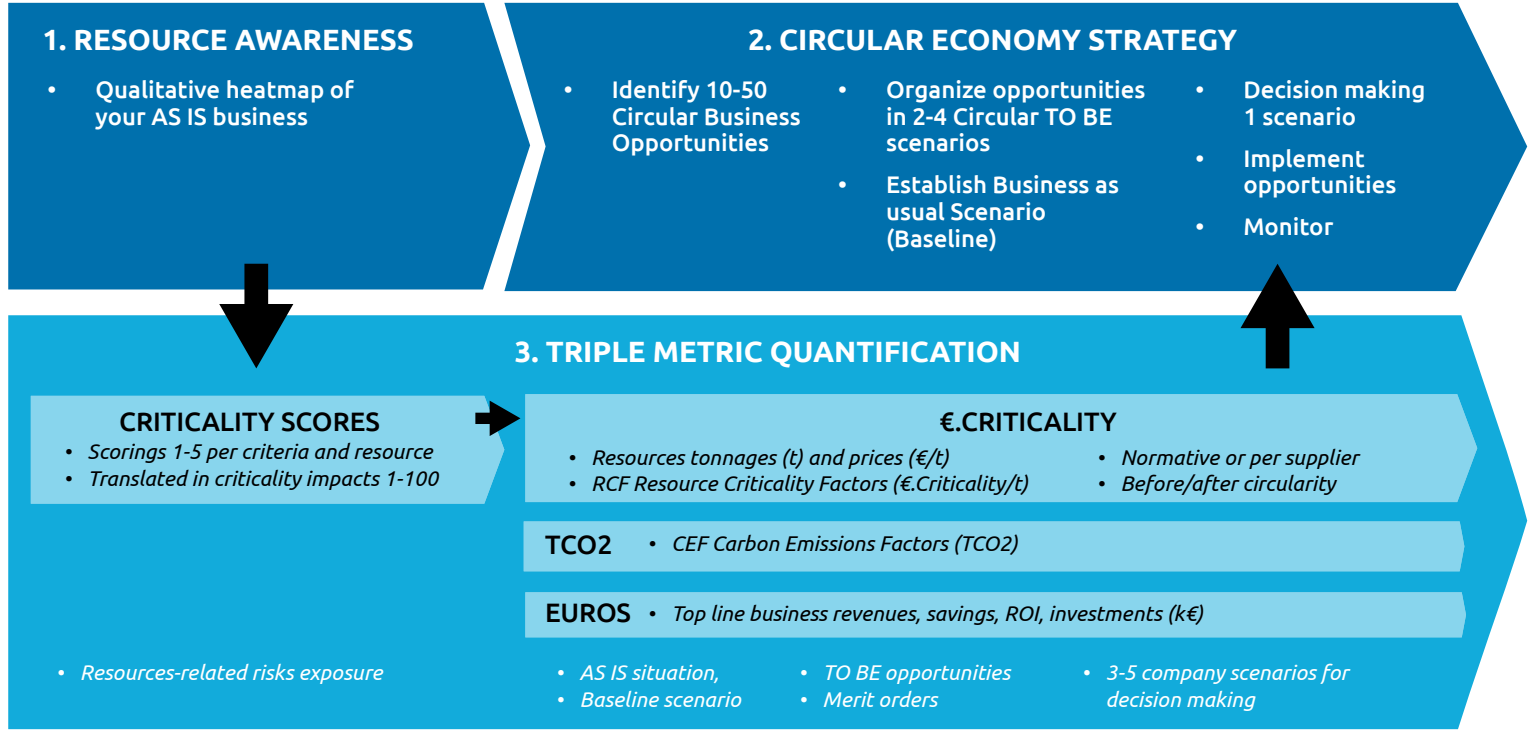
Complementing the global impact score and the 16 CBS methodologies defined previously, **Capgemini has defined a quantification methodology to assess your company's current vulnerability vis-a-vis resources, and to project future scenarios.** The quantification is centered around a new and single metric for criticality, €.Criticality, which can be compared along typical business KPIs. It results from the multiplication of volumes, price, and impact scores for each of the resources included.

The Resource Criticality Factors (RCF), expressed in €.Criticality, are the ultimate criticality indicators. They cover all underlying drivers & specificities of a given company and/or industrial activity.

Applied to your existing situation, they will allow you to gauge your vulnerability. Applied to your future scenarios they will allow you to appreciate to what extent implementing more circularity will protect you from resource scarcity, and will help prioritizing CBS wisely in your future strategy.

FIGURE 18

Criticality quantification for business



RACES: Resources Awareness and Circular Economy Strategy

THE METHODOLOGY CORNER (3). RESOURCE CRITICALITY FACTORS

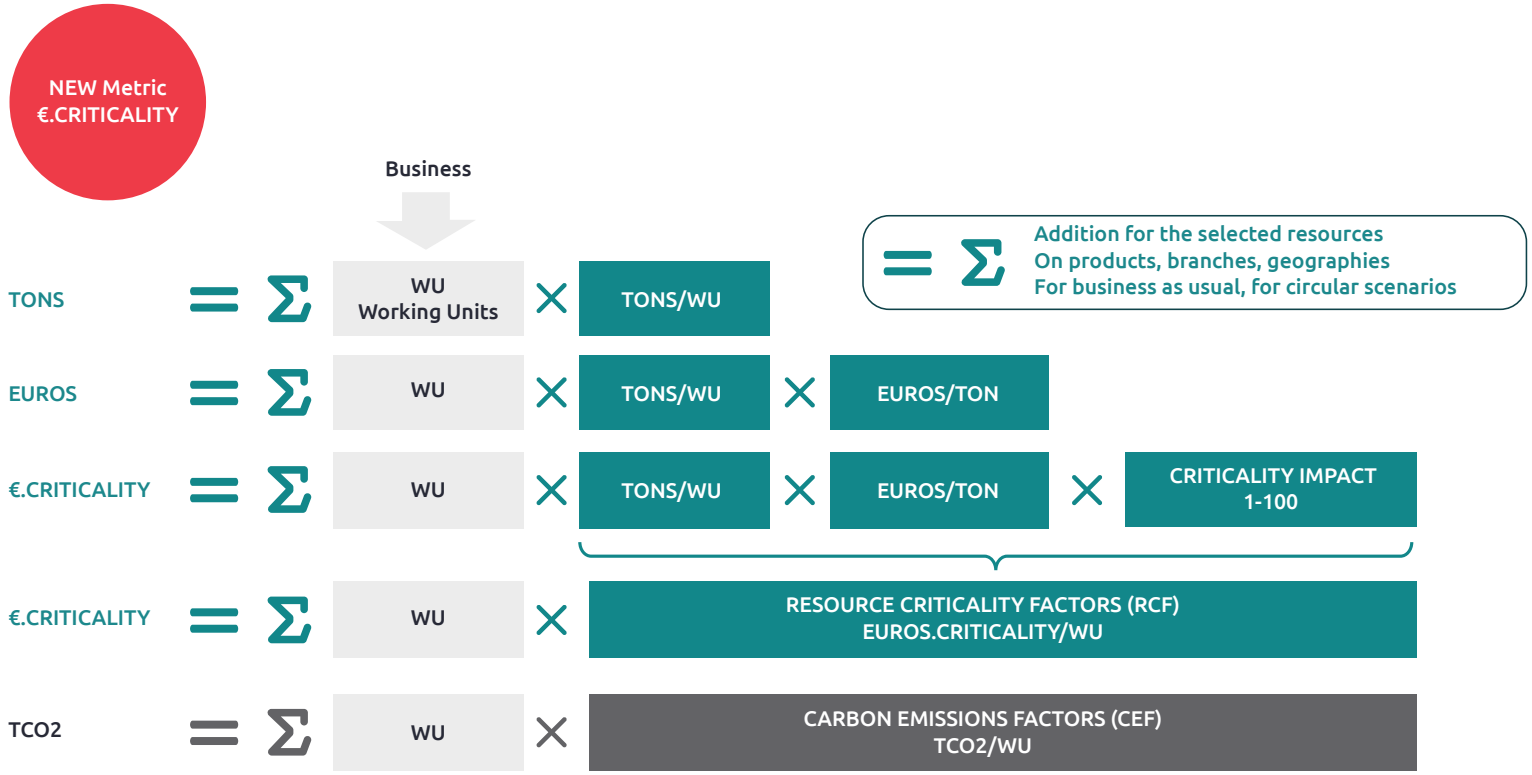
BECAUSE TONNES MATTER: the addition of the tonnes of resources included in the goods provide a first view of their importance to the decision- maker. But total tonnes hide the importance of strategic resources that are used in small volumes (platinoids, rare earths, …).

BECAUSE EUROS MATTER: Euros reflect the cost of resources in the business plan of the company and in the trade balance of a country. Yet euros only partially reflect the criticality in the future (risks on access to resource, on dependency to resource, on social and environmental impacts).

BECAUSE CRITICALITY MATTERS: That is why it is proposed to multiply each euro by the criticality impact of the associated resource.

FIGURE 19

Resource Criticality Factors (RCF) versus Carbon Emissions Factor (CEF)



THE METHODOLOGY CORNER (3). RESOURCE CRITICALITY FACTORS

In practice:

- Volumes: estimate the number of working units and the quantity of resources generated by your key products and activities. For a first global resources and circular strategy, rough estimates are more than enough.
- Prices: use the moving average commodity price, typically ten years. Projecting the price in the future is not a necessity as 1. Such projections are uncertain and time-consuming 2. The impact multiplier (see next) includes the propensity for price increase through the criteria of access and dependency to resource.
- Impacts: In the resource awareness phase, you have scored (1-5) the criticality of resources based on you own strategic weightings of 6 key criteria (reserves, oligopolies, competition for resource, replaceability, recyclability, social and environmental). The 5-point scale is expanded to a hundred-point scale to emphasize the impact of high criticality scores and better reflect the amplitude of the real-world hazards caused by resources criticality.
- Derive the RCFs for your key resources. RCF can be global, or specific per supplier or per product line (social and environmental differences, technology dependency on resource)
- Use RCFs and € criticality to quantify resources and circular opportunities (as you do with TCO2 for climate). Make wise strategic decisions by balancing EUROS, TCO2 and €.CRITICALITY.
- Monitor the implementation and progress with the three KPIs.

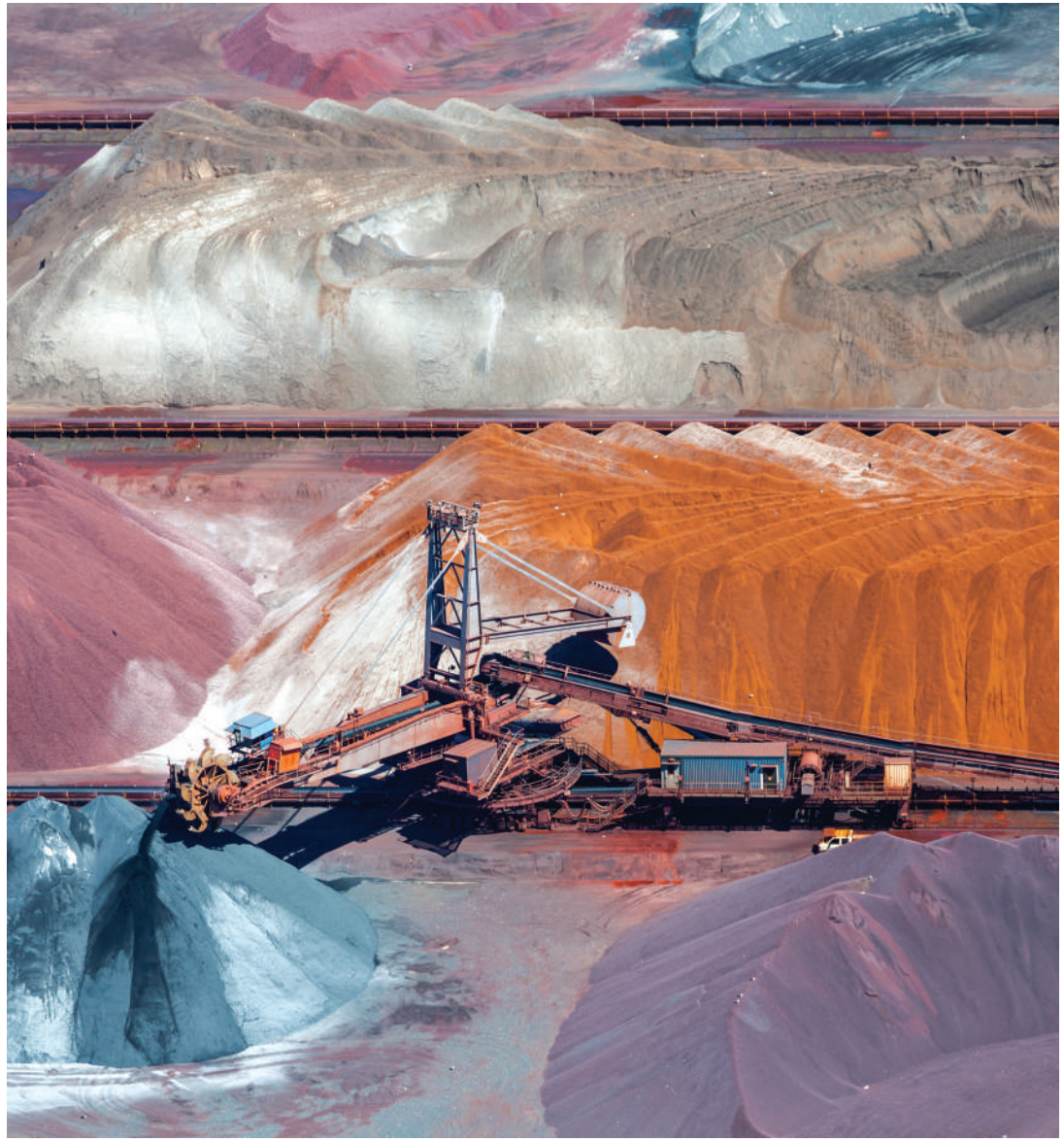


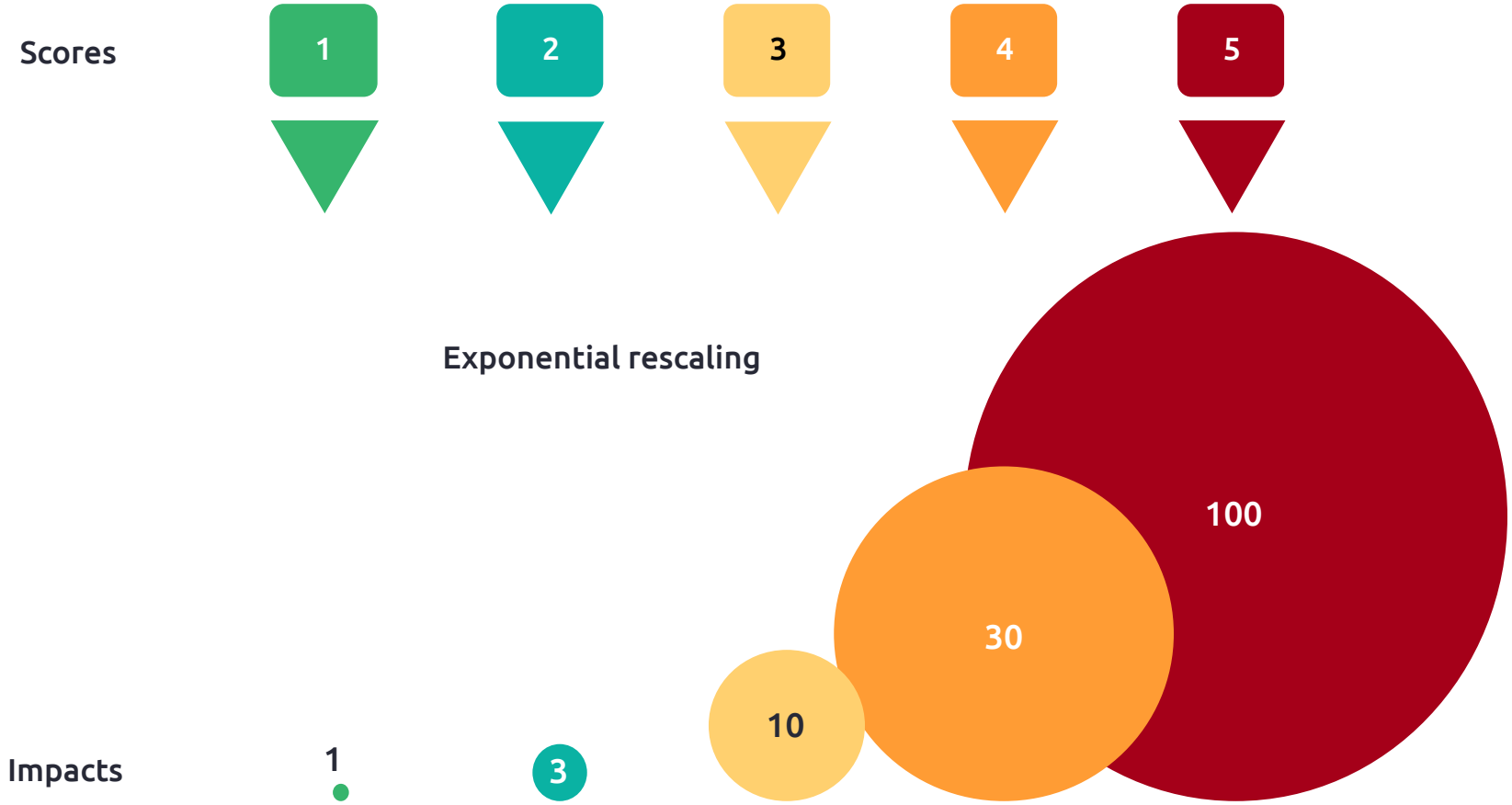
FIGURE 20

Calculation of Resource Criticality Factors (RCF)

RESOURCE CRITICALITY FACTORS		LITHIUM	COBALT	PLATINOIDS	RARE EARTHS	COPPER	GRAPHITE	SILICON	ALUMINIUM	NICKEL	STEEL	CONCRETE
		LI	CO	PTD	RARE	CU	GR	SI	AL	NI	ST	CONC
RESOURCE PRICES *kEuros/ton*	P	22	41	45 863	87	6,9	1,3	2,2	0,7	14	0,2	0,1
Resource Scores 1-5		4,2	4,0	3,7	3,8	3,5	3,3	2,8	2,8	2,8	2,0	2,0
RESOURCE IMPACTS 1-100	I	38,3	31,6	21,5	26,1	17,8	14,7	8,3	8,3	8,3	3,2	3,2
RESOURCE CRITICALITY FACTORS *kEuros.criticality/ton*	RCF = P*I	857	1 289	988 081	2 270	122	19	18	5,8	116	0,5	0,2

FIGURE 21

Rescaling 1-5 Scores into 1-100 Impacts



3.2 Key examples of utilization and findings

€.criticality and RCFs can be used in several manners for the decision making. This
section provides examples published by Capgemini and the French National Institute for Circular Economy (INEC) for a selection of 15 low carbon technologies and 11 mineral resources. These examples can be extrapolated to any business, product line or geography.

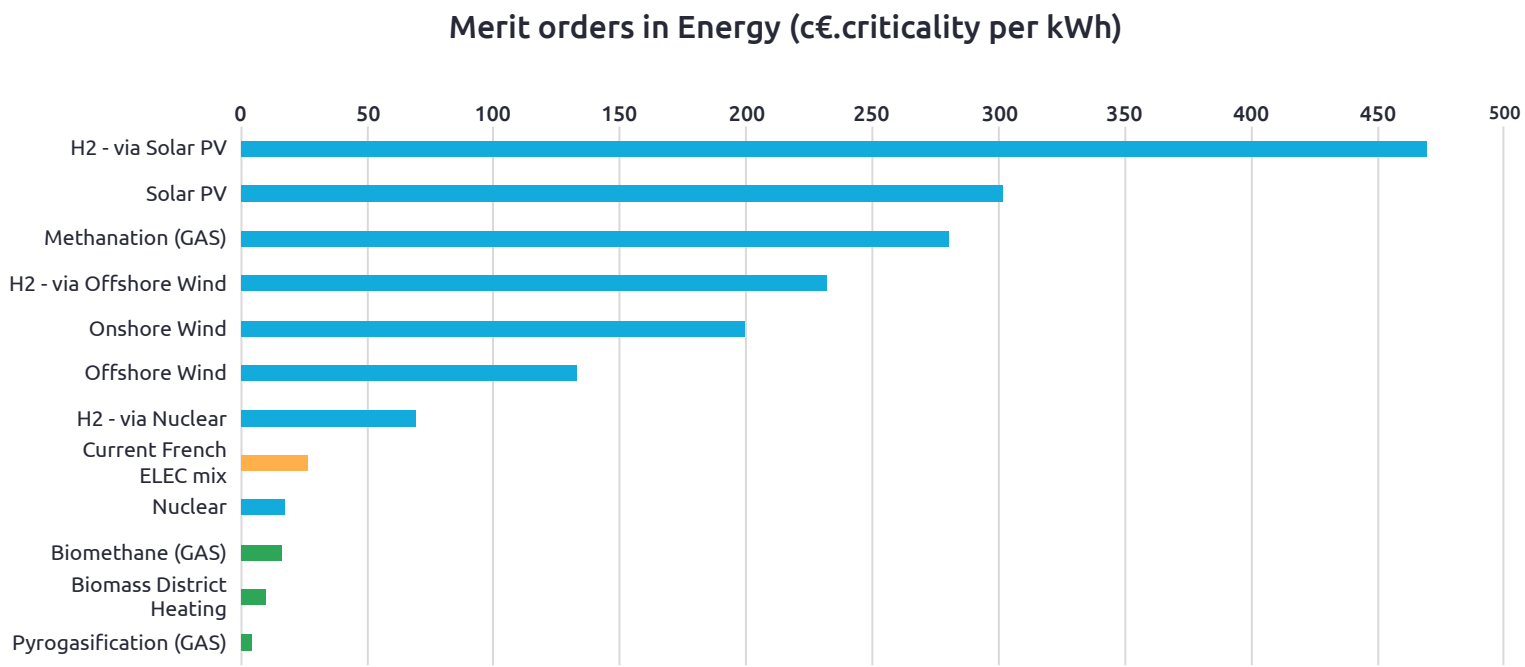
a. Merit orders in Energy, Automotive, Construction: does my technology portfolio make my company future proof?

Merit orders in Energy

Hydrogen and electrification are the most challenging. Their higher criticality per kWh clearly state that they will be a challenge in terms of procurement, technology and social and environmental impact. Biomass and biogas are a more resilient choice when applicable and respecting biodiversity.

FIGURE 22

Merit orders in Energy (c€.criticality per kWh)

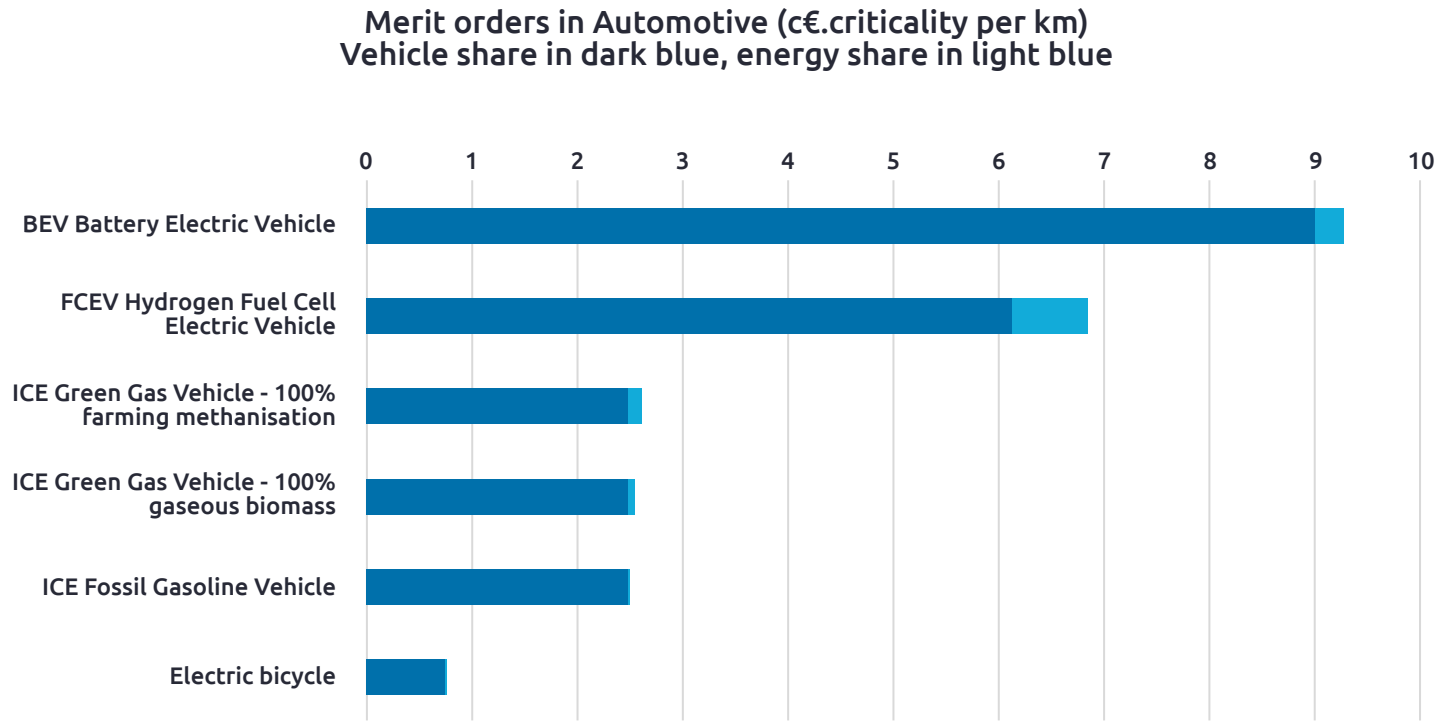


Merit orders in Automotive

Is going 100% electric in mobility sensible? Net zero biogas with Internal Combustion Engines vehicles (ICE) are three times less critical per km than Battery Electric Vehicles (BEV). Biogas is limited by potentials and respect of biodiversity; nevertheless, they are obviously part of the mobility mix of solutions, combined with the downsizing and sufficient use of vehicles and circular levers.
Research and development to change chemistry and make lithium recyclable is a must have.

FIGURE 23

Merit orders in Automotive (c€.criticality per km) Vehicle share in dark blue, energy share in light blue

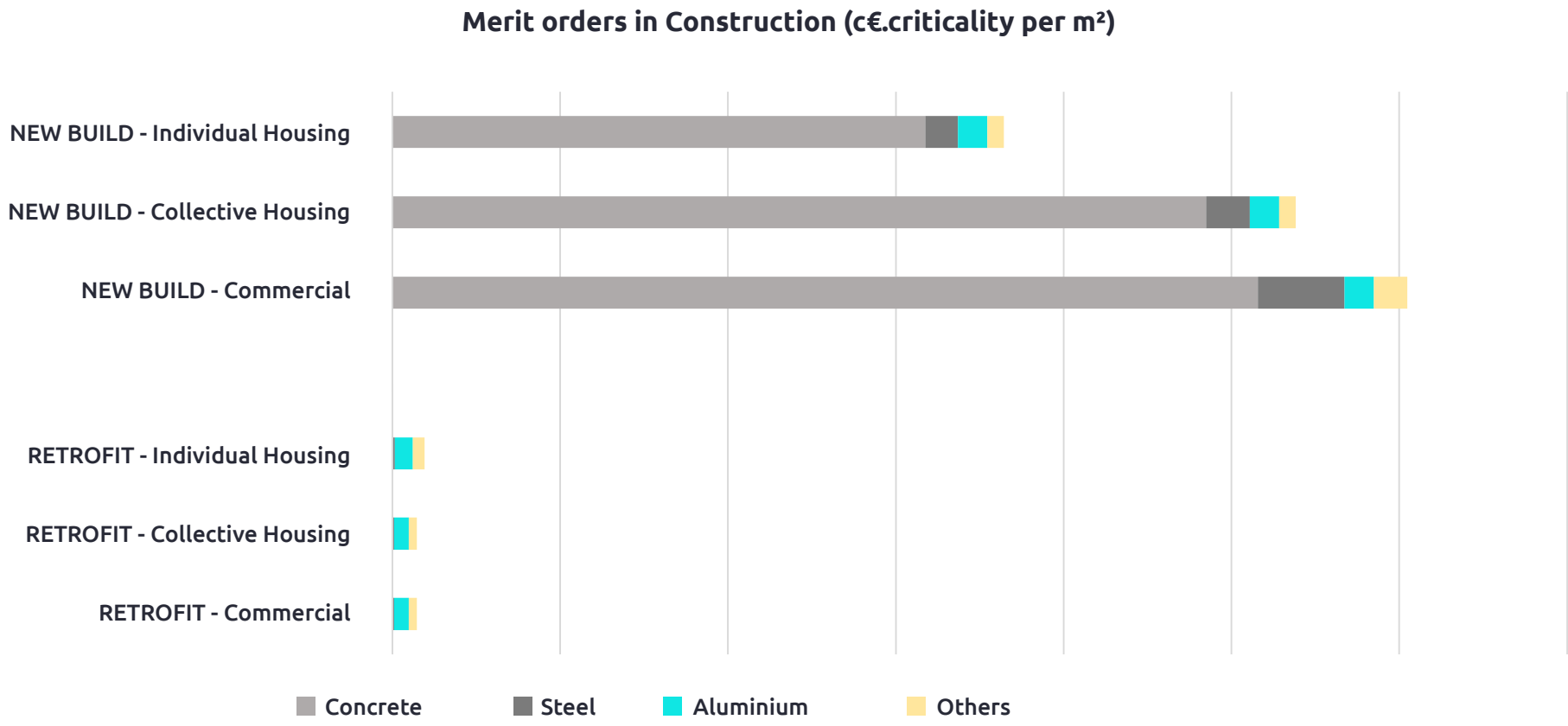


Merit orders in Construction

New build consumes resources but also artificializes natural spaces and hits biodiversity. High energy performance retrofit generate 40 to 70 times less criticality per m², and even less with improved circular economy operations.

FIGURE 24

Merit orders in Construction (c€.criticality per m²)



b. Triple metrics: how do scenarios compare?

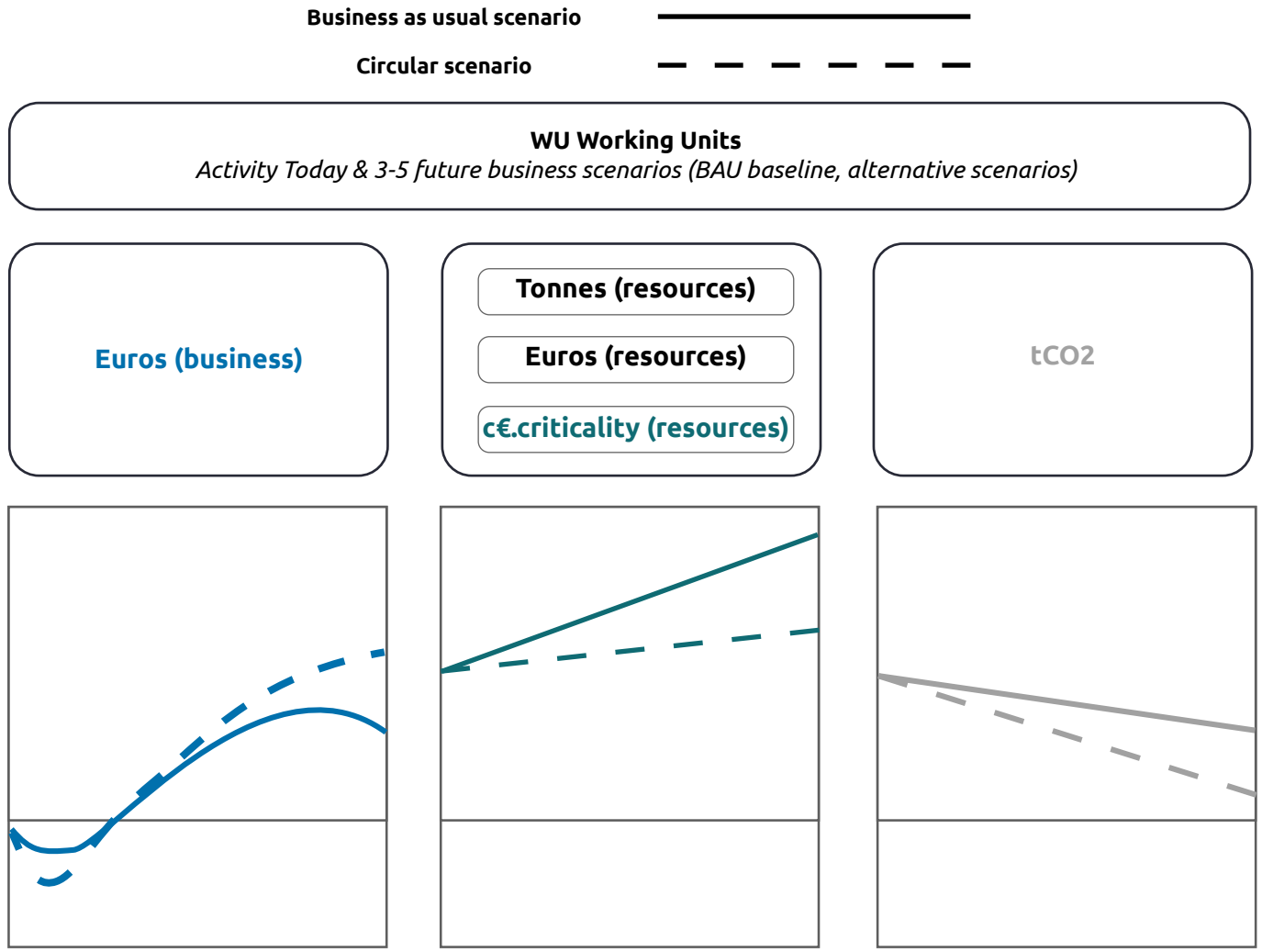
New circular business requires additional investment compared to ruling Business As Usual. At short-term additional circular business partly cannibalize the conventional linear business. At long-term the growth of linear business is at risk because of the constraints and scarceness of resources. Circularity provides a greater business resiliency to the company.

€.criticality are bound to rise due to the uptake of low carbon technologies and high-technology in the businesses of the company. Circular economy can shave this rise, as the Capgemini-INEC study has shown: the increase in €.criticality shows up to a 75% difference between the Business As Usual scenario and the circular scenario.

Regarding tCO2, corporates engage in decreasing their emissions. They start with direct fossil energy emissions for stationary and mobility uses. The next frontier is reducing the use of extracted and transformed resources thanks to circular business. These savings generate additional CO2 savings. They also drive reductions of the footprint on water, space usage, biodiversity, social impacts.

FIGURE 25

Triple quantification of a corporate Circular Economy Strategy



c. Product lines and resources: what is the exposure to risk in my Business As Usual scenario?

Economic activities span across a variety of resources and product lines. In Figure 26, the decision maker gets three different views, with rising stakes from left to right, applicable to resources in the upper line and to product domains in the lower line.

The first view in tonnes per year show where the logistic challenges lie.

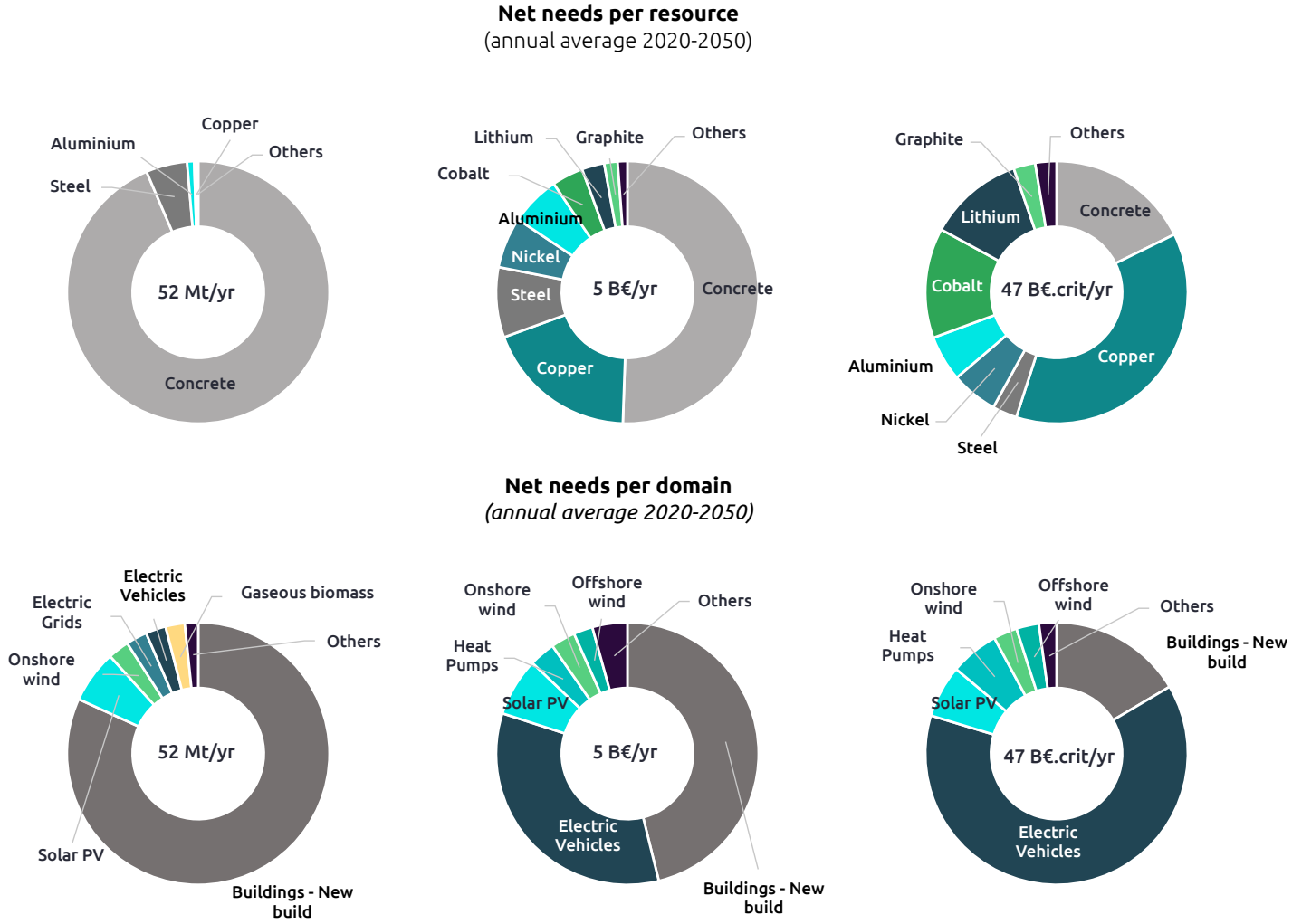
The second view in euros per year of resources included in the goods can be compared to the turnover of the company. This "resource intensity" expressed in Euros is somewhat like the "Energy intensity". It gives an appraisal of the exposure to economic risk.

The third view in €.criticality per year unveils where and with which magnitude the strategic, resiliency and environmental risks lie.

Such complementary quantifications will help companies build accurate resource and circular strategies for their business.

FIGURE 26

Triple metric resource requirement at the scale or an organization or a country - here France's low carbon strategy in a BAU circular scenario i.e. if economy remains predominantly linear



Important conclusions can be drawn from the quantification we conducted for INEC on the French Low Carbon Strategy. They are likely to translate to industries or companies. The qualitative analysis based only on 1-5 scores pinpointed the criticality of lithium, cobalt, platinoids, rare earths. But the triple metric analysis bear surprises:

Volume effects on concrete & steel must be anticipated.
Concrete and steel have a relatively low criticality scores but high overall €.criticality impact because of the large quantities required, notably by the construction industry for efficient buildings. Criticality is located close to the urban areas (100 km radius), as a result of the high number of quarries to be operated, doubled by the need for waste disposals for the deconstruction materials. Recycling, reusing and retrofit instead of newbuild can drastically cut volumes, CO2 emissions and impact on environment.

Value effects to be noted for minerals & metals.
Used in small volumes compared to concrete & steel, mineral & metal resources stand out in the second chart because of their high unit value (€/t).

Criticality is amplified for most minerals & metals, in conjunction with underlying drivers.
Copper emerges as a major concern (1/3) of total criticality of the low carbon transition. The immense pressure on resources like copper can be explained by small global reserves, low substitution potential and noticeable environmental impacts. Similarly, platinoids have a high criticality despite being used in small volumes.

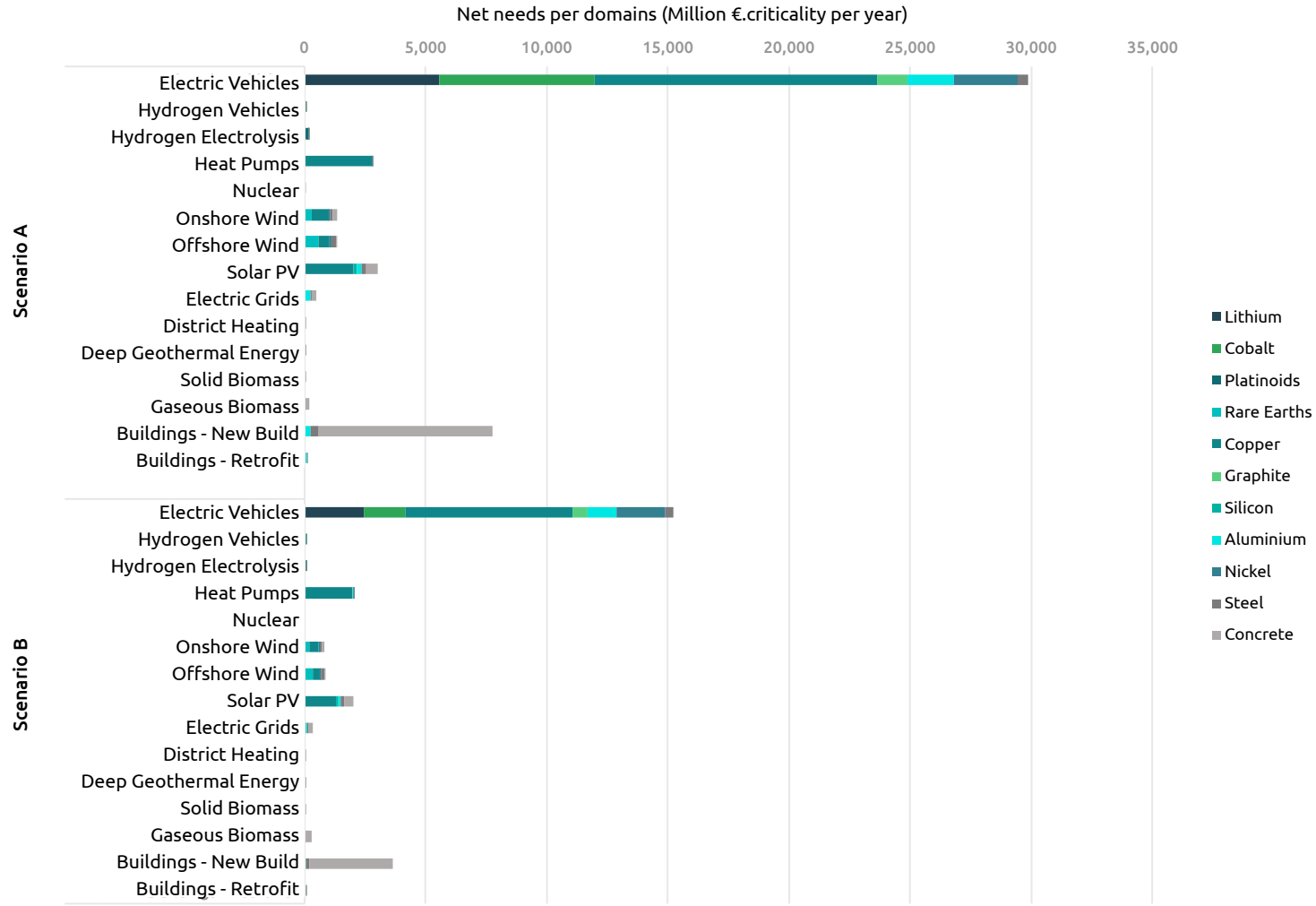
Lithium also stands out in the third chart despite the low volume & value effects due to the high demand coming from the booming electric vehicles industry and its low recyclability. Therefore, electric vehicles deemed very desirable are the major challenge, with 2/3 of the total criticality. It is nearly twice as much as the 15 other key low carbon sectors that it entails (hydrogen, renewables, grids, construction, biomass, etc.).

d. Product lines and resources: what is the detailed breakdown of criticality in both scenarios?

Cross-referencing the analysis between domains and resources helps identifying the hot points and making priorities. Looking only tonnes and euros may hide the critical points for resources used in small volumes but cumulating high price and high criticality.
In the example, circular scenario B saves proportionally more Cobalt than Platinoids net needs compared to Business As Usual scenario A.

FIGURE 27

Net needs per domain in scenarios A and B (French 15 low carbon businesses, M€.criticality per year)



e. What new balance sheet to measure the progress of my business? Circular flows, gross and net needs, and waste.

Gross material needs, required for production of goods, are provided by both circular flows ("Reuse" and "Recycle"), and net needs supplied by newly extracted resources from mines. Gross waste from products' end-of-life, are partly reused in circular flows, while remaining incompressible waste (net end-of-life) will be disposed.

Triple metrics applied to the 16 CBS opportunities can be synthetized in the global resource balance sheet of the company. The Figure 28 shows the gains of the activation of CBS opportunities (scenario B) versus the Business As Usual baseline (Scenario A)

In BAU scenario A, the construction of equipment planned by the low-carbon strategy (vehicles, energy facilities, networks, new buildings and energy-efficient renovation, etc.) implies a 21% increase in gross materials needs by 2050. This might not seem shocking over 30 years, but over the same period **costs of resources will triple, and their €.criticality will be multiplied by 8.1[10].**

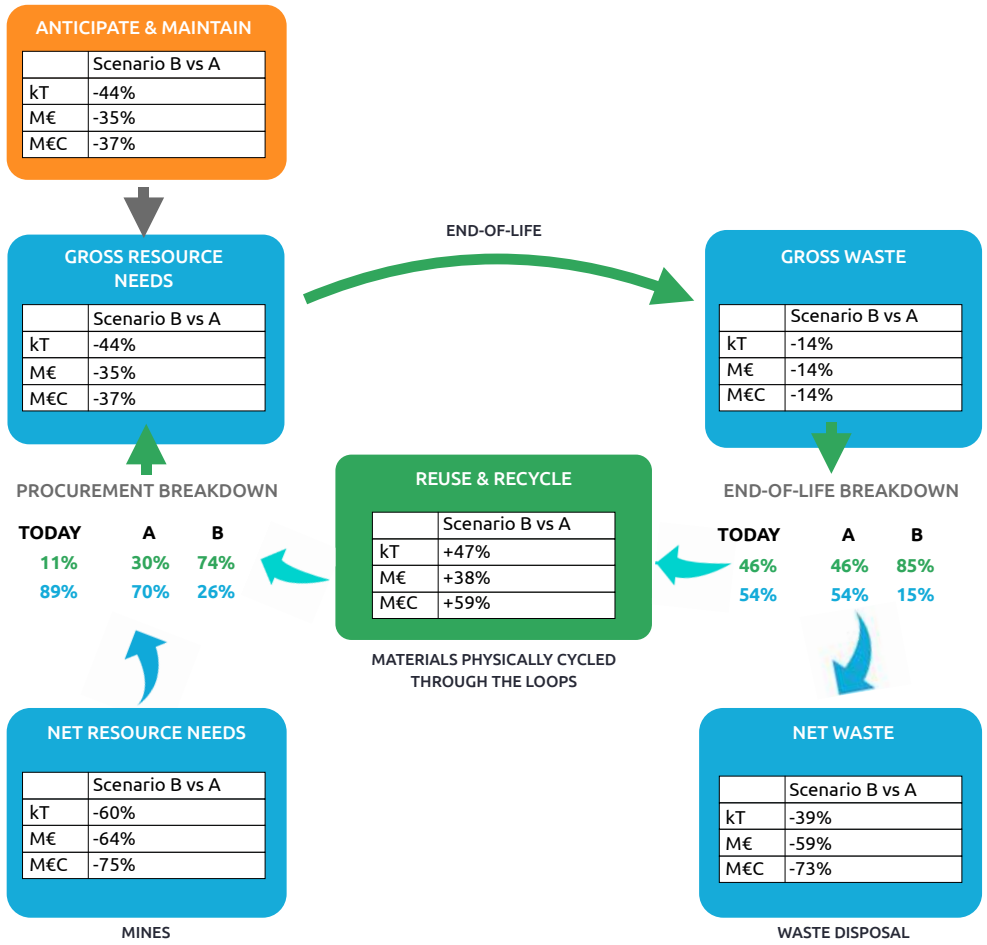
In circular scenario B, avoid and reduce CBS alone induce a **44% decrease in gross resource needs,** and a 14% decrease in gross end-of-life deposits. This relieves by the same amplitude the pressure on ecosystems caused by extraction and waste respectively.

If the transition towards a circular economy is not undertaken promptly and vigorously, criticality will be multiplied by 6.1. **The implementation of the BAU strategy would then be thwarted, not to say impossible. By contrast, by reinforcing circularity,** France would be able to achieve its low-carbon strategy objectives, limiting the increase of net criticality to a factor of 1.5 relative to 2020, **i.e. 75% less in net needs and 73% less in net waste.**

10 And even by 20.7 for metals alone

FIGURE 28

Global resource balance sheet BAU scenario A and circular scenario B combining all metals and minerals required by 15 sectors of the French low carbon transition



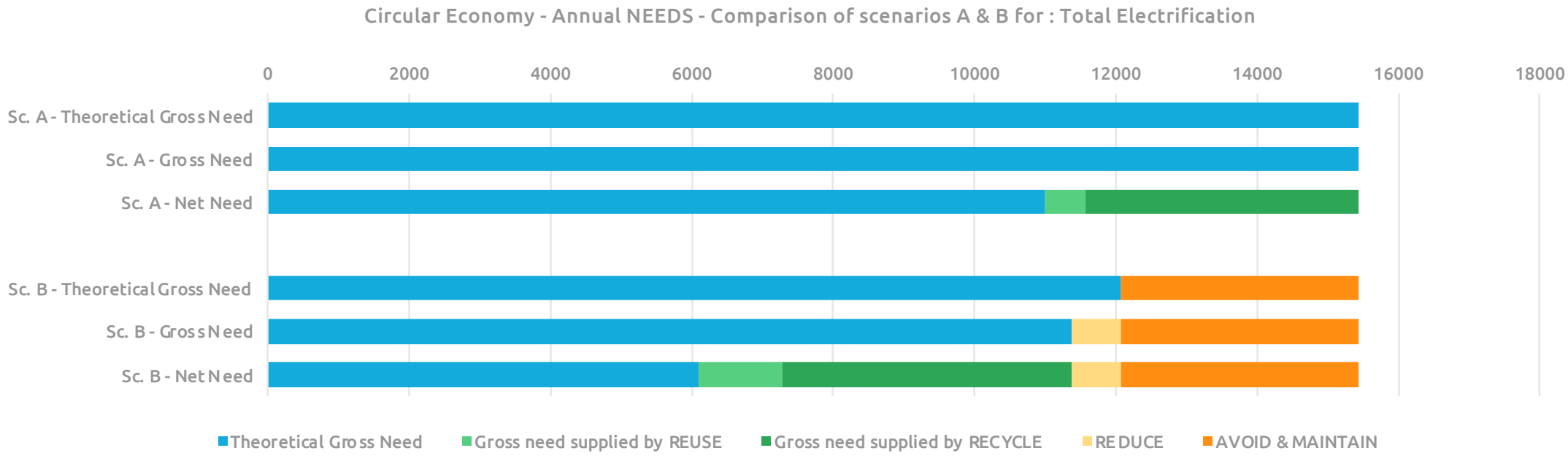
f. How will the CBS opportunities reduce my exposure?

In the example provided, the avoid lever provides more savings than the reduce lever. Circular scenario B includes more shared vehicles. The vehicle mix is no longer 100% electric or hydrogen, as there is a share of internal combustion engine with biomethane. Some minor additional progress is made in the proportion of end of lives recycled. Reuse is doubled.

The gross need in resources for the production of goods is cut by 25%, and the net need in resources coming from mines and extraction is cut by 45%.

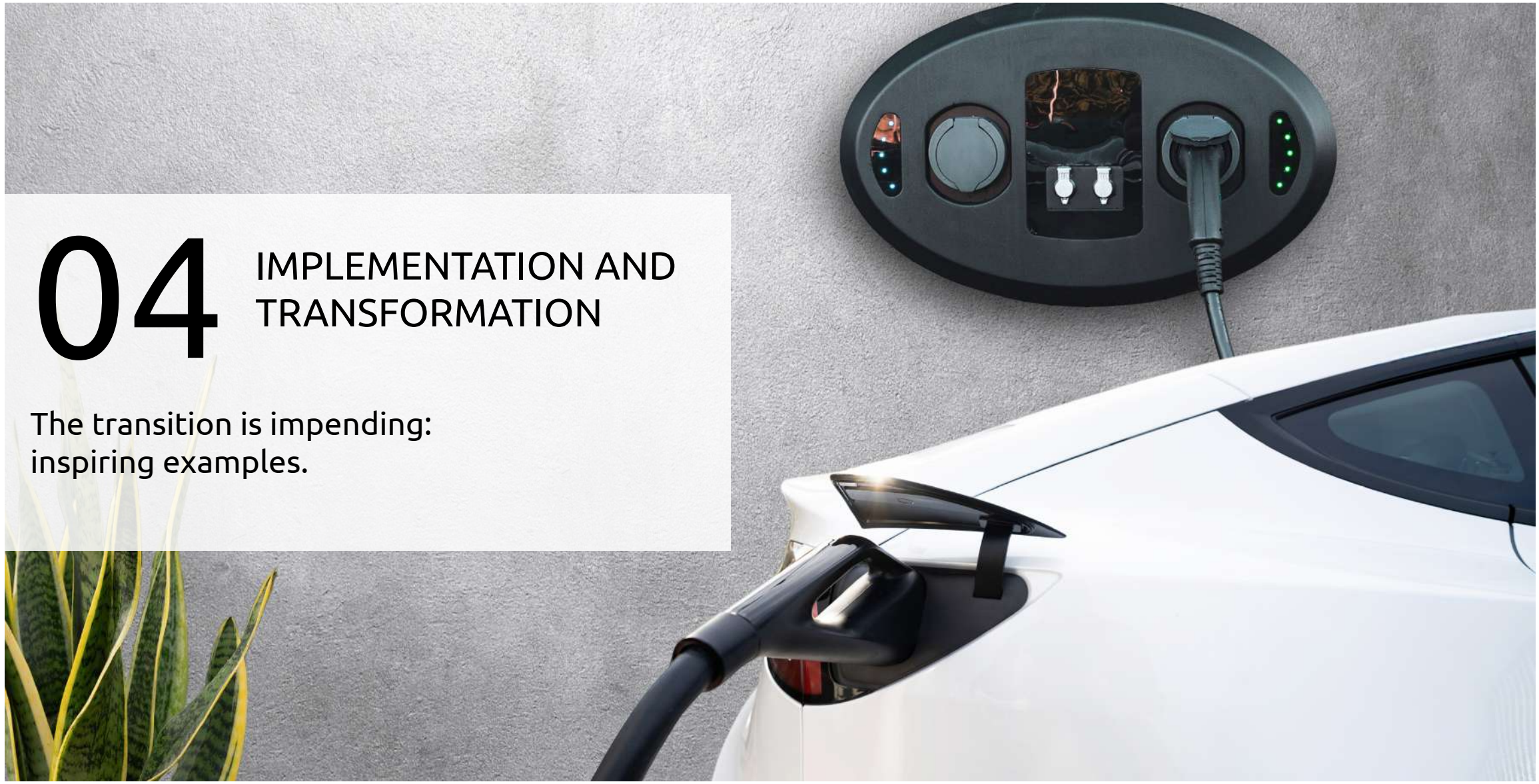
FIGURE 29

Savings enabled by Avoid, Reuse, Reduce, Recyle on Gross and net needs in Circular scenario B compared to BAU scenario A (French low carbon transition, focus on 9 electrification domains in hydrogen, low carbon electricity and transport €.criticality/year



04 IMPLEMENTATION AND TRANSFORMATION

The transition is impending:
inspiring examples.



4.1 Major strategic stakes & tangible implementation examples for a few handpicked industries

Each company or industrial sector deserves to be gone over with a fine-tooth comb to extract precise and actionable insights for CxOs, based on their operational & supply environment, material resources, data and strategic objectives.

We have inferred resource-criticality related stakes at a macro-level for four industrial sectors. Here are the main disruptions to expect, and inspirations to tackle them.

a. Transports: resource-criticality is heightened by the massive move for electrification

The automobile industry is subject to a strong electrification trend, which exacerbates the demand for critical resources contained in batteries, especially lithium, cobalt and nickel. The criticality of these resources will soar imminently, and so will their market prices. Eventually, other use cases with a lower willingness to pay on the end-consumer side will have to resort to alternative materials or reinvent themselves entirely to survive.

Explosive growth & standardization exacerbate criticality on key resources.

In the rush to conquer the gigantic emerging market of electric cars, brands converge towards the same Li-ion technologies. This is reinforced by the need for standardized solutions: e-car manufacturers are urged to build a cross-brand network of vehicles and infrastructure for optimized convenience and scalability potential. The rapidity of this convergence pulls the rug from under R&D efforts to find alternatives, like sand-based batteries. Substitution of critical resources, which feeds into the reduce CBS (#2), is however more necessary than ever. In a circular model, complementary players can team up to create new materials and components. For instance, Volvo Group and SSAB have signed a collaboration agreement on fossil-free steel, using hydrogen[11].

Automotive players are starting to implement circular initiatives.

All loops of the circular model can be implemented in the automotive sector, and initiatives have already bloomed. Embracing the shared economy (CBS #3), Renault experiences a business model based on mobility-as-a-service rather than ownership with its initiative Mobilize[12]. Renault Flins factory, launched in 2020, is dedicated to car refurbishment. Furthermore, in line with CBS #12, collect, #15, recycle, and #8, remanufacture, Renault, Solvay and Veolia launched a combined initiative to collect used batteries and turn them into new ones[13].

Implementing several business segments of the circular economy is a chance for re-industrialization and relocation of industrial activities. Stellantis sees it also as an accretive business[14]. In October 2022 Stellantis announced a comprehensive plan for its Circular Economy Business Unit to achieve more than €2 billion in revenues by 2030. One of the brands of Stellantis, Citroën, has developed a concept car named 'OLI' [all-ë][15], as a nod to the AMI car, the small successful older sister developed with Capgemini Engineering. OLI explores end-to-end circular concepts with a rigorous, 360-degree approach based on the 4R strategy – reman, repair, reuse, and recycle. Within the product it includes simple, intuitive and joyful approaches experimented in AMI such as identical parts for left and right doors and for front and rear central bumpers, or lightweight roof flat bed panels made from recycled carboard and plastic formed in honeycomb structure; AMI also explores the manufacturing concept, with the possibility to remanufacture new cars with reused parts of end-of-life OLIs, leading to a full life duration of up to 50 years.

11 https://www.volvogroup.com/en/news-and-media/news/2021/apr/news-3938822.html
12 https://www.mobilize.com/en/
13 https://www.largus.fr/pros/actualite-automobile/renault-forme-un-consortium-pour-le-recyclage-de-batteries-10570404.html
14 https://www.stellantis.com/en/news/press-releases/2022/october/stellantis-fosters-circular-economy-ambitions-with-dedicated-business-unit-to-power-new-era-of-sustainable-manufacturing-and-consumption
15 https://www.media.stellantis.com/em-en/citroen/press/citroen-oli-all-e-radical-responsible-and-optimistic-approach-initiates-audacious-future-intentions-for-the-brand

b. Construction: accelerating the penetration of circularity drivers requires large-scale design projects at all stages of the value chain

Criticality in construction is driven by volumes.

With its monumental demand of raw materials (concrete, sand, steel, aluminum, copper), energy (furnaces, transportation, ...), and significant social & environmental impact, notably on biodiversity, the construction industry is both driver and victim of soaring resource-criticality.
For France, our research evaluated the **criticality score of the construction sector to 2.3 out of 5** (2.8 aluminum and 2.0 on steel / concrete). Yet, the size of the tonnages involved in both construction and deconstruction, mainly in the periphery of large urban areas, make circularity a very urgent issue for all involved players. It also shows that about 20 million tons of resources[16], i.e. half of the tonnages, could be avoided by making strong strategic choices in favor of renovation and circularity.

The industry is already facing tensions from all sides: supply, regulation, …

Although aggregates are abundant, raw material demand keeps sustained, and lead to localized concrete shortages putting construction sites under pressure down the line.
In addition, regulation is progressively governing building activities beyond GHGs emissions, for example framing land restoration and waste management.

Most CBS are relevant, but pose serious implementation challenges

In the building industry, regenerating sites (#16) is particularly important, since quarries, former building sites, etc. must be brought back to healthy states for biodiversity and human populations to thrive.
In waste management, collect (#12) and disassemble (#13) show great improvement potential but also implementation challenges: Since constructions are not standardized and have a 40+ year long life span, large-scale components reuse entails that easy dismantling will have to be part of the early-stage design process. Similarly, maintenance management solutions, usually BIM-based (Building Information Modeling) help optimize resource use in the construction phase.

Distribution networks will need to intertwine points of sale & collection, ideally operated by different distributors to densify the grid. Whether existing or new entrants, players need to consider the service space, even if it means introducing new business models: Les Ripeurs, is a successful circularity waste management service. Inspired by leasing services, some players might start selling lifespan or usage instead of material goods.

All players involved in the construction value chain, from financing & commissioning to property, maintenance, and end-of-life, need to make resource-constrained eco-design a top priority and to work hand-in-hand with local partners.

16 https://www.capgemini.com/fr-fr/wp-content/uploads/sites/6/2022/07/220615-Rapport-INEC-Capgemini-VF-web-single-page.pdf

c. Equipment & High-Tech: hardware producers and retailers (tech, appliances, machines,…) players are facing a paradigm shift from mass-market and single-use to component circularity

The rise of reuse, refurbishing and remanufacturing platforms such as Backmarket or Asgoodasnew can be observed for electronic devices, as well as PAAS and sharing models in the household industry or circular reuse of plastics in the retailer industry. Like other CPRD industries, hardware providers aim to meet the ever-growing demand of consumers, juggling high volumes and optimized prices. This typical linear model is squeezed between their high dependence on raw materials on the one hand and a calamitous impact of waste on the other. Many workers are exploited in developing countries, natural environments are polluted, and transportation on international value chains causes incremental CO2 emissions besides production processes.

Hardware retailers are an excellent example of the direct-reverse duality of the CBS. As they deliver (e.g. mattresses or home appliances), they collect the discarded ones (CBS #12). These first steps must be followed by additional circularity initiatives, more ambitious yet more challenging.

In strong consumer-facing industries like food and beverage or cosmetics, circular solutions are often antagonistic towards convenience or accessibility and will automatically slow down consumer adoption, or even drive consumers away. As a consequence, it is crucial that hardware players find the right balance between the consumer behavior gap and education opportunities to push new habits forward and overcome consumer-adoption barriers.

New sub-products are on the march.

A slight relocation trend has started, which, on a large scale, will highly impact their costs and question the entire mass-market business model, thus their value proposition and market positioning. Symbiotic operational relationships with other up- and downstream players might provide opportunities to restrain price surges on raw materials. The trend of sufficient products (#2 reduce) is growing, driven by growing consumer awareness: ex - telephones without ancillary functionalities or that are restrained to essential functions.

Finally, tackling less common CBS, some players are starting to experiment with component products (#5, #14), which will likely take off in the hardware segment, where components have a high potential of value retention given their technological complexity (compared to packaging) or the value of basic components. Philips has introduced a hairdryer compatible with replaceable parts, Fair Phones facilitate value retention CBS compared to traditional brands.

As many consumers are increasingly questioning the impact of CPRD and demanding that brands take responsibility, tackling resource criticality by bringing circularity to the next level is urgent. Prices for major and small domestic appliances (SDA/MDA) may have to increase, while the high-end segments could lead others in their transition: having a greater financial leeway to experiment with new business models, they have the opportunity to make re-source-less consumer patterns desirable.

d. Mines and Waste: extraction and first transformation industries and waste managers seem about to be left on the sideline by the advent of large-scale circularity but have in fact a lot to gain in it.

Mining & first transformation industries would see their business decline in a sustainable limited world

As the starting point of linear supply chains, they will be at the forefront of resource depletion issues. In addition, governments of countries where reserves are located are likely to leverage their advantage to secure their national supply, and to impose their rules on foreign trade, for instance raising taxes on foreign firms exploiting their reserves.

Conversely, countries that do not have resources buried in their territory also need to secure their supply. Relocating resource access is for them a paramount priority. This is where mining & first transformation players have a trump to play. Those who have progressively expanded their activities to other continents over the past decades have a major opportunity to impulse a re-industrialization trend. One option is to initiate new extraction projects locally, even though it will initially face opposition on the grounds of social and environmental impacts, as observed recently for lithium extraction projects in Europe[17].

With waste managers, they have an opportunity to capitalize on their experience of handling and transforming raw materials to enter the recycling business. With their valuable knowledge of materials & transformation processes, they could seize many opportunities in a global move towards circularity:

Develop & patent efficient & scalable recycling processes.

Become the agnostic industry referencing materials, providing quality assessment services and defining new norms to help players choose the right material for their respective use cases. Indeed, second life and sell-resell CBS (#4) do not require the very best quality of material (though they demand it currently), opening up a space for sufficient materials for each application, and directing high-quality or even freshly extracted materials only to use cases that truly require it, thereby alleviating the stress on critical resources.

An agnostic role to facilitate cross-industry collaborations, but a risk to become competitors.

At the crossroads of many industries, their guidance & expertise is very valuable and could help them become builders of industrial symbiosis networks between supply chains in different industries working with similar resources. Their convergence to similar roles might require both industries to choose more specific value propositions, relying on differentiating assets.

17 https://www.usinenouvelle.com/article/la-course-a-obstacles-au-lithium-en-europe.N2007317

4.2 All CXOs and their departments have a role to play in circular business.

Circular business drives changes in the company's economic and operational models, along with the coordinated mobilization of all its functions: strategic management, product and service marketing, design offices, process teams, logistics and customer marketing. A bottom-up approach is a start but is not enough to germinate a large-scale change.

e. Eco-design, a transformative approach of products, services, as well as corporate strategy.

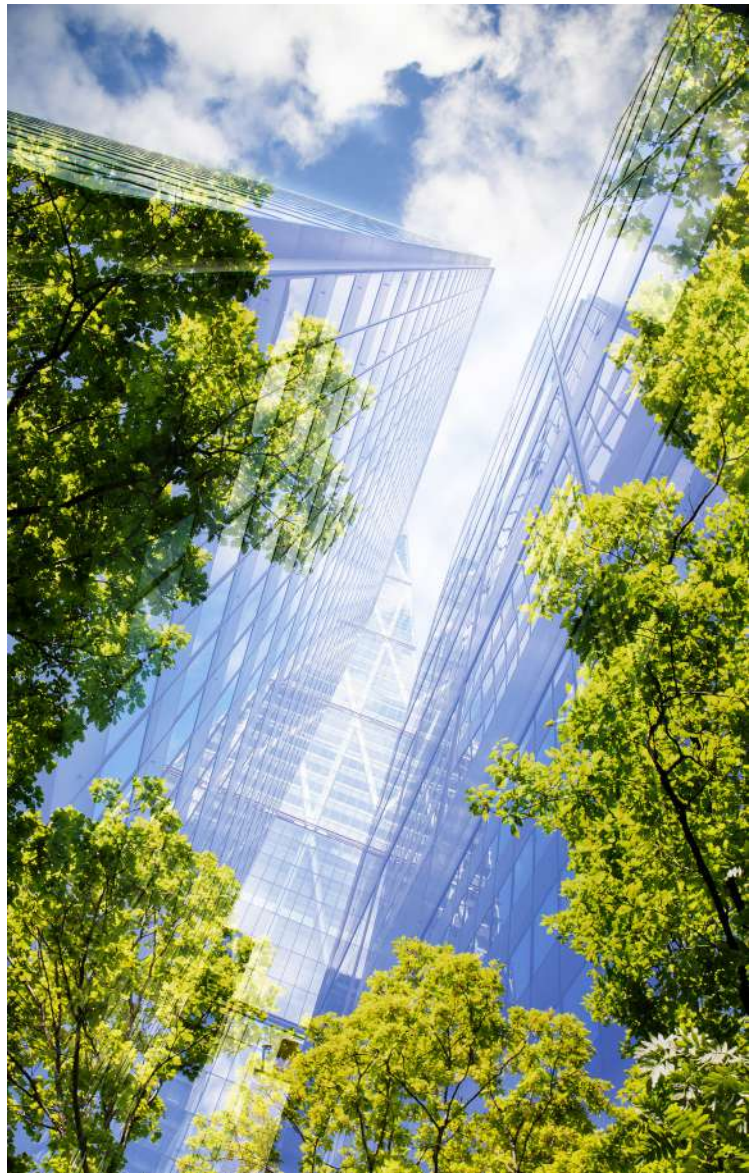
Eco-design aims at designing a strategy, products, or services by anticipating the impacts and opportunities over their entire life cycle.

Ecodesigning products and services requires the coordinated mobilization of customer marketing, product design, process engineering and service teams. It challenges the whole designing process to reduce the amount of critical resources (CBS #2 Reduce), to create products that can be easily repaired, refurbished, remanufactured (CBS #5, #7, #8) with higher shares of materials from circular origin or substituted with biomaterials (#CBS #9, #10, #11), sometimes specially designed for shared economy (CBS # 3), and easily disassembled, repurposed, recycled (CBS #12, #13, #14, #15). This shift generates exciting challenges regarding early-stage functional, technical and aesthetic dimensions of design. A careful end-to-end eco-design leads **to less resource needed for each unit of final usage** by the customer.

Eco designing the corporate strategy involves the strategy, the finance, and the marketing departments. It leverages the highly strategic #1 lever, "Avoiding", which can be seen as an adaptation to resource of the statement of Sun Tzu in The Art of War: "He who excels in solving difficulties does so before they arise". The eco-designed strategy considers the resiliency of business, the carbon challenge and the resource constraints in anticipating problems at different levels of corporate decisions: technology portfolios balancing high-tech and so-called low-tech, product portfolio from sufficient attractive products to high-end products, business model portfolios moving from product to service provision, corporate M&A, investing in resource resilient businesses and divesting from activities at risk. The financial profile, including investment, risk, ROE ratios may progressively change with the evolution of business models, and thus require explaining and validating the strategic moves with the shareholders and markets.

Avoiding also includes deliberate communication and education activities targeting at large scale customers, employees, and partners. The objective will be to change their perception on resources and circular economy, to prefer long lasting products, to make more desirable the shift towards being served rather than bearing ownership, to parallel the reduction of the use and the size of the products with a deeper and improved sense of satisfaction.

Eco-design transforms the way products and services are delivered, the way revenues and margin are generated and ultimately the company itself.



f. Operations: Onward and reverse circular operations in the field requires the COO to plan and run coordinated central, local and onsite activities.

Building a circular economy means tying together a network of actors and physical flows, within sectoral value chains, and between different sectors operating in the same territory.

The **new "Maintain and Retain" onward circular businesses** are somewhat close to the existing operations of the companies (Cf Figure 15, Circular Business Segments matrix). The change of scale nevertheless requires significant adaptations of the operating model of the company, for the activities spanning from onsite interventions to local facilities up to central industrial sites. The new operating model must carefully organize at each scale the repairing, retrofitting and remanufacturing operations. The industrial process itself evolves, with components and parts from more heterogeneous origins, wider tree of next operations in the plant floor and stronger need for traceability, as discussed in further section devoted to Digital.

On the opposite, **the new "Recover" reverse circular businesses** shown in Figure 15 are more distant from the usual operations of the industry and closer to the activities of the waste operators. But for strategic reasons regarding brand value, business growth and adaptation to the future resource constraints, the company may decide to increase its control on collecting, sorting, and repurposing spare parts, and even recycling must-have materials. These activities may be controlled through direct insetting[18], or through joint ventures and other forms of partnerships, under closer control from the parent brand. The COO and its teams will be in first line to organize, deliver and control these new operations.

18 For instance, Schwarz Gruppe, the largest retailer in Europe (LIDL, Kaufland) has created a dedicated branch called PreZero in order to be "in the driver's seat". PreZero hosts plastic recycling plants and handles recycled material passing through its 13,300 stores globally.

In between onward and reverse operations, **the logistic master plan** will have to integrate the new flows at the central, local and end-point scales. The loops and flows of materials can take place between companies from different fields but requiring the same materials, or between companies when one can exploit the other's by-product or waste, at large or even better at a territorial scale.

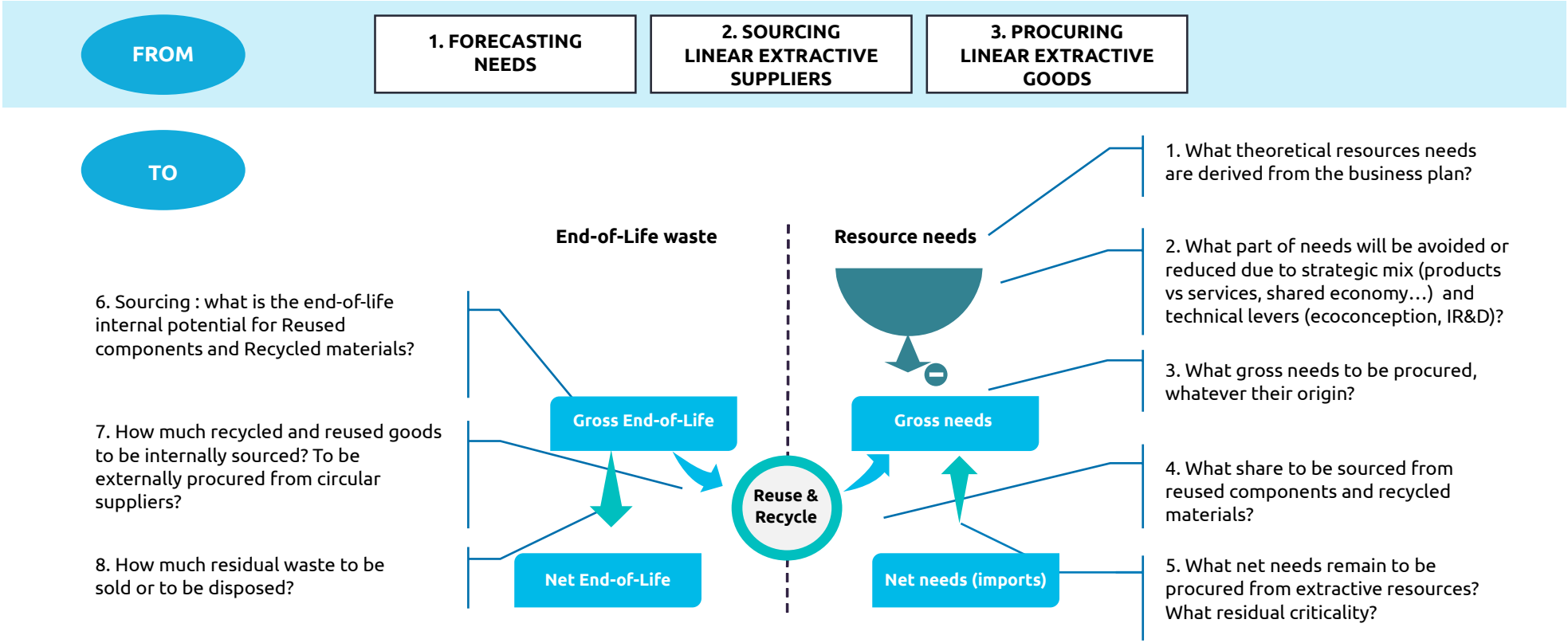
g. Procurement is deeply impacted as materials flows and services change in nature.

The procurement department is directly involved in forecasts and purchases for at least three of the CBS: use & source repurposed components, use & source recycled materials, use & source regenerative biomaterials.

The Figure 31 lists the new challenges for the CPO through the angle of the end of life and needs flows. Sourcing the new flows can be done internally across the entities of the group (operations, reverse logistics back from customers, geographies) or externally from partners inside the same industry or from other industries, with trade-offs to be done between cost, impacts and distance. For this reason €.criticality becomes a new metric to be inserted in the procurement criteria and data, along with price and CO2., and more qualitative criteria as supply resiliency.

FIGURE 31

Impact of the implementation of the global circular economy strategy of the procurement department



h. Digital: CDOs shall catalyze traceability, insurability and cost competitiveness in complexified circular operations

Digital will be instrumental for circular business at 4 levels

- **B2B platforms** enable the large-scale circular trade of disassembled, repurposed and recycled goods, as well as second life products, connecting stakeholders and orchestrating physical flows along the **same vertical sector and horizontally at the scale of local territories. B2C platforms** support selling shared services, second life products, repairing services or collection of end-of-life products with creative value models.
- **Computer-aided eco-design** is strongly needed to better anticipate all the steps of product life, from #2 to #16 BCS, i.e. from cradle to cradle.
- **Digital operations:** circular operations are potentially more complex as they are less standard than linear manufacturing. Digital has a key role to improve their cost competitiveness and automate them, be it in central or local plant floors as well as in mobile operations on customer premises. Drones, 3D scanning, state recognition and computer aided next operation, augmented operator tools (robots augmented reality, exoskeletons, robots) could help workers or technicians perform complex and arduous tasks seamlessly, for instance in (de)construction for onsite dismantling and sorting, or in electronic goods such as smart phones repurposing plants.
- **Last not least: Traceability and insurability.** An important barrier to circular economy adoption in automotive industry, in buildings, in B2B equipment is the uncertainty on the state and origin of the second life components incorporated in the product. Improved traceability along the whole value chain (NSP #2 to #15), individual information gathered in the Digital Product Passports, as well as statistical return of experience will also be key to improve the insurability of circular equipment, which is a barrier for wider adoption. This information is also useful for improving the maintenance and repairability and extend the life of such products.

FIGURE 32

Digital levers mapped against the 16 circular business segments (CBS)

Digital for Circular Resources	1. AVOID	2. REDUCE	3. SHRED ECONOMY	4. SECOND LIFE / RESELL	5. MAINTAIN / REPAIR	6. MARKET PLACE	7. REFURBISH / RETROFIT	8. REMANUFACTURE	9. Use & source REPURPOSED COMPONENTS	10. Use & source RECYCLED MATERIALS	11. Use & source REGENERATIVE BIOMATERIALS	12. COLLECT - SORT	13. DISASSEMBLE- SORT	14. REPURPOSE COMPONENTS	15. RECYCLE MATERIALS	16. REGENERATE SITES
B2C Platforms	#1		#3	#4	#5	#6						#12				
B2B Platforms						#6			#9	#10	#11		#13	#14	#15	
Computer aided product design	#1	#2	#3	#4	#5		#7	#8	#9	#10	#11		#13	#14	#15	
Computer aided manufacturing process		#2	#3	#4	#5		#7	#8				#12	#13	#14	#15	
AI for scrap reduction		#2			#5		#7	#8						#14	#15	
Mobile operations digitalization			#3		#5		#7					#12	#13	#14	#15	
3D scanning					#5		#7	#8				#12	#13	#14	#15	
AI for recognition, state diagnosis, next op recommendation					#5		#7	#8				#12	#13	#14	#15	
Augmented operator, advanced robots, drones													#13	#14	#15	
IOT, radio & optic tags, sensors & actuators		#2	#3	#4	#5		#7	#8				#12	#13	#14	#15	
Traceability / Product digital passport / Asset Digital twin / 3D continuity		#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	
Blockchain		#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	
Extended enterprise operations (out-sourced controlled activities)			#3	#4	#5		#7	#8	#9	#10	#11	#12	#13	#14	#15	
AI, satellite and aerial imagery for environmental assessment and monitoring	#1															#16

ANTICIPATE
MAINTAIN
RETAIN
RECOVER

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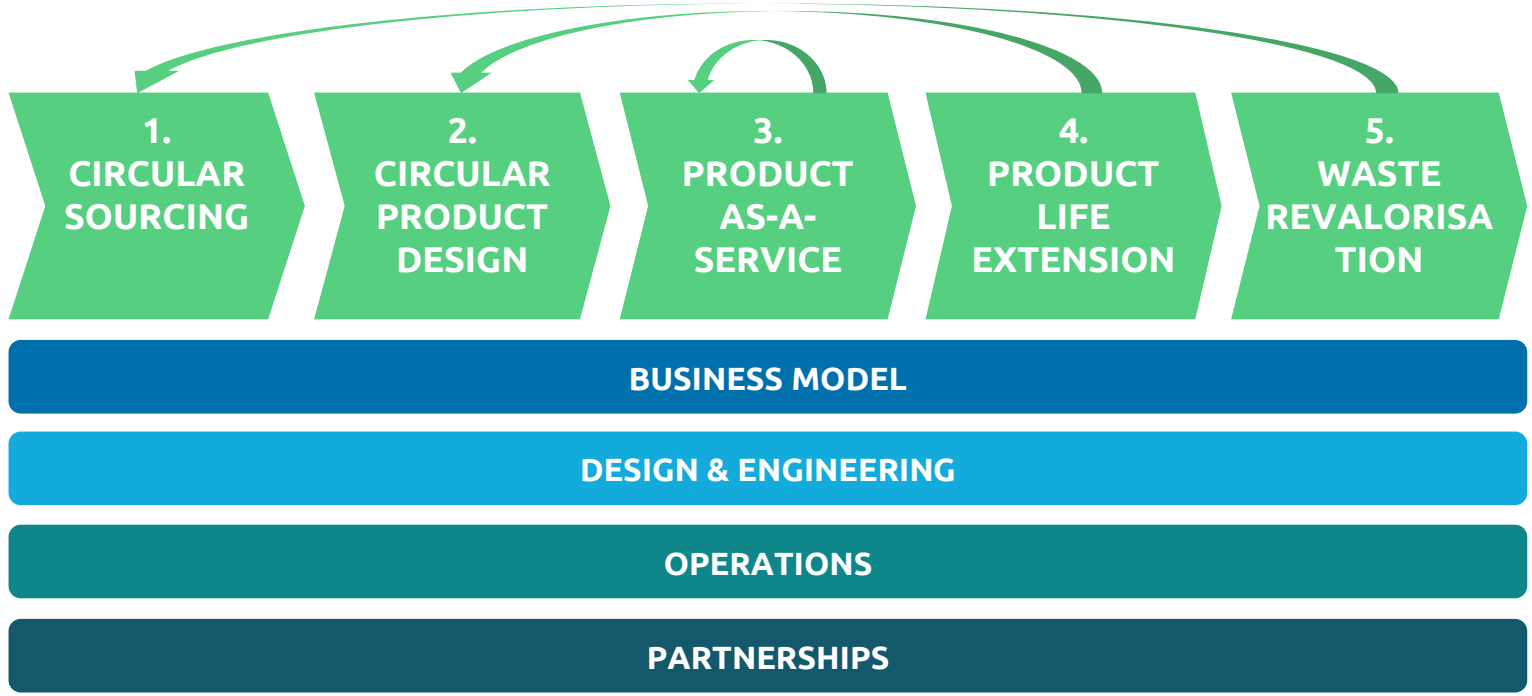
Secure the future of your business, develop a resource and circular economy strategy at scale
With our RACES approach, we help you assess your business vulnerability regarding resources, identify opportunities, design a consistent global corporate strategy, strengthen your performance and resilience on the three business, climate and resource dimensions.

Bring circular economy to life, implement your business opportunities in the field, transform the company
Capgemini Invent, with its specialized design entities such as Frog, Synapse, Cambridge, Possible Future, and Capgemini's branches Engineering, Applications, Technology, and Operations deliver end-to-end service to implement five families of circular projects covering a world of possibilities. We help you transform and diversify activities and business models in the field, extend eco-design principles, engineer your products, build and run operations and develop local synergies and cooperation with other players.

Quantify, assess the existing situation, monitor progress
We have a variety of tools and quantified methodologies to support your progress: RACES resource criticality factors, company maturity assessment tools checking the "what" and the "how" (AWS Capgemini partnership), detailed product portfolio vulnerability down to LCA, products circularity measure through MCI (Material Circularity Indicator) of the Ellen MacArthur foundation, PCI (Product Circularity Indicator) by Bracquené, NCI (Nano Circularity Indicator) by Capgemini Engineering, and much more adapted to your specific needs.



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