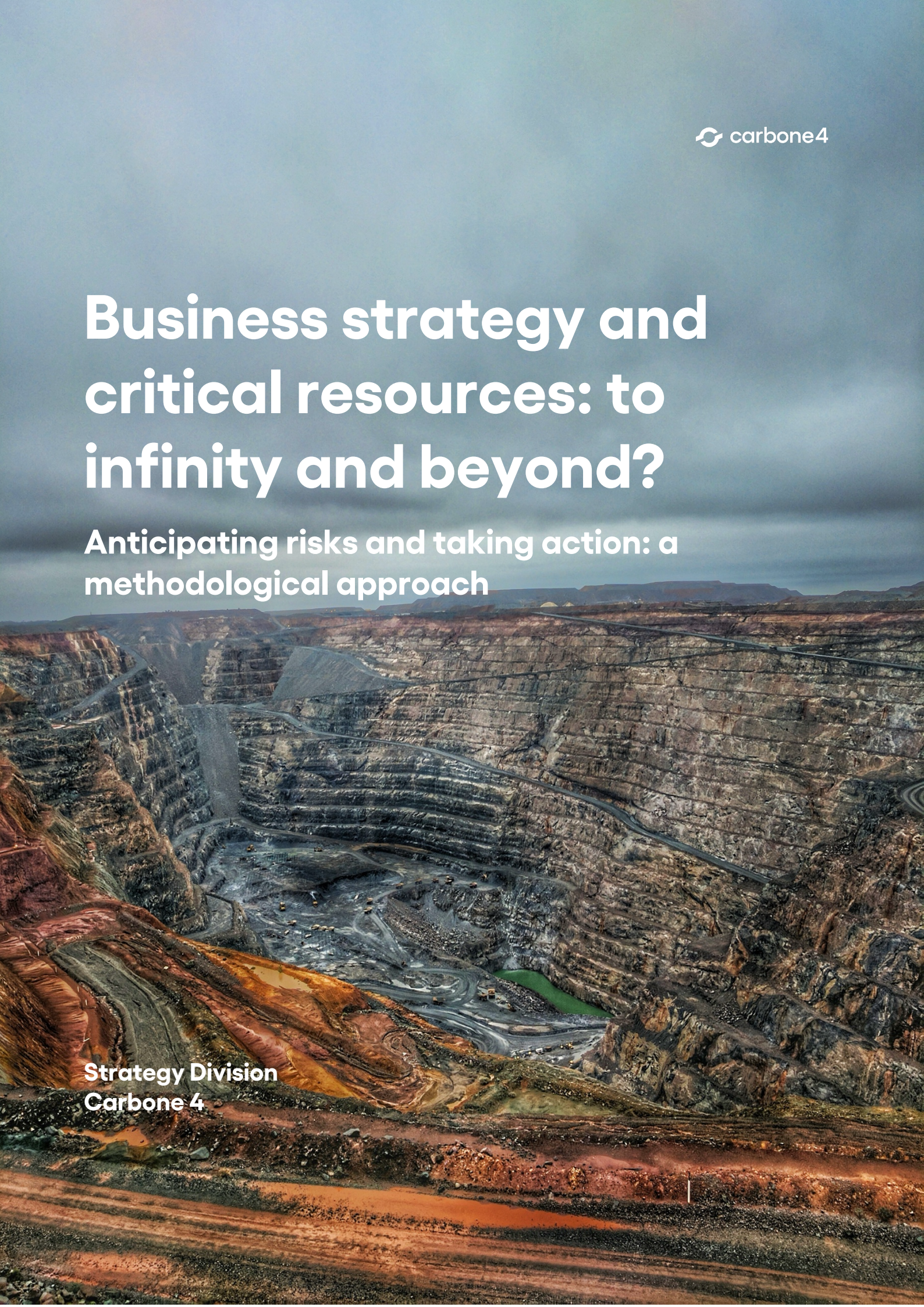
carbone4

Business strategy and critical resources: to infinity and beyond?

Anticipating risks and taking action: a methodological approach



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Introduction

In recent years, human societies have been confronted with numerous supply shortages, for a variety of reasons, in resources such as electronic chips, semi-conductors, paper, wood, construction materials, aluminum, wheat and fertilizers. These supply shortages have led to economic difficulties and, in some cases, put the lives of exposed human groups at risk, as in the case of the global food crisis. They highlight the dependence of the economic world on certain resources that are essential to its functioning in its current form.
It is highly likely that these limitations on the economy due to the availability of resources are not just a cyclical phenomenon resulting from a superposition of temporary crises. The prolonged crossing of planetary limits[1] , the decline in stocks of raw materials, the fragmentation of globalization and the new dependencies linked to the low-carbon transformation of the economy are exposing economies to supply-side constraints. If this new situation is to be managed sensibly and smoothly, strategic planning is needed that incorporates a detailed understanding of resource dependency and physical flows in the broadest sense.

The aim of this publication is to suggest ways of limiting the vulnerability of economic players to pressure on critical resources, by incorporating this aspect into their strategic thinking.

This publication complements the previous publication on corporate strategy in a low-carbon world published in December 2021[2] and echoes the article published in April 2022[3] .

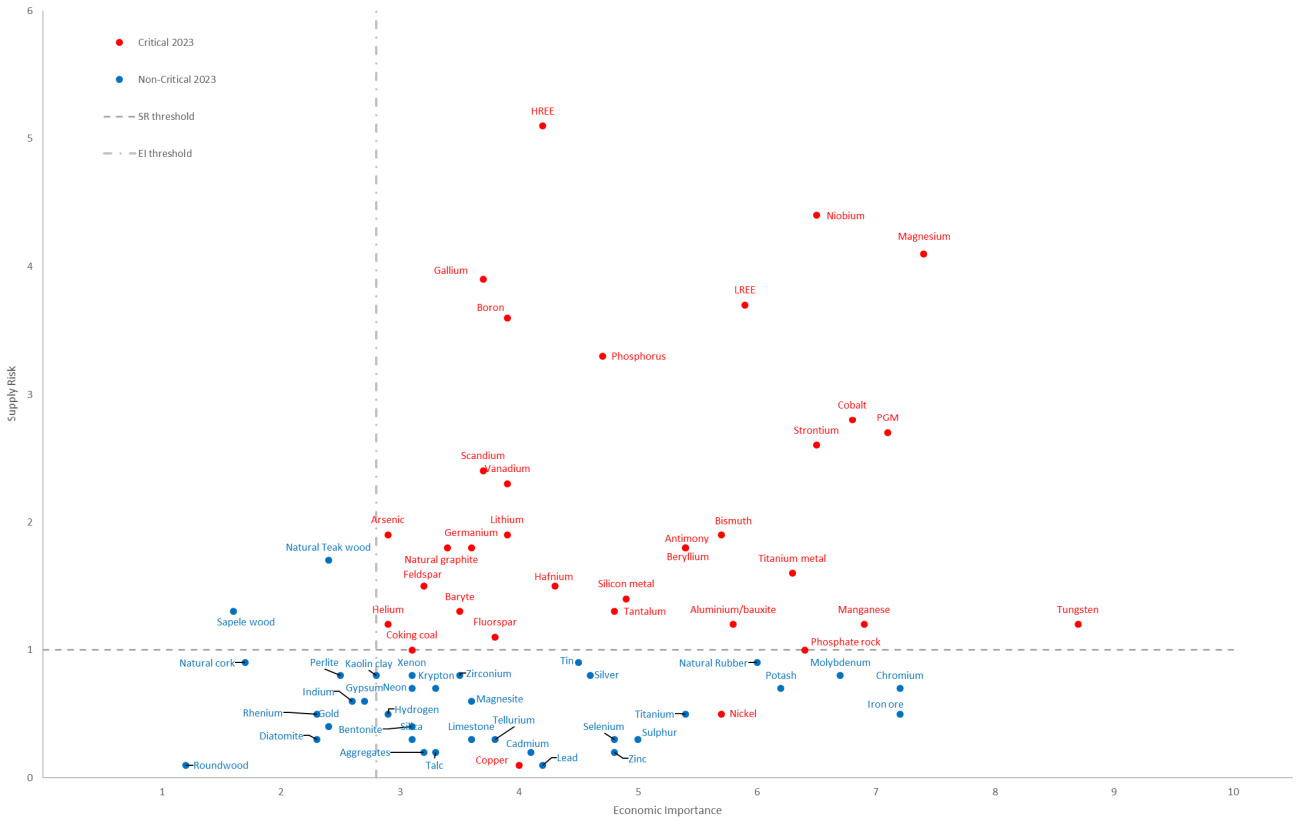
[1] https://www.stockholmresilience.org/research/planetary-boundaries.html
[2] https://www.carbone4.com/en/publication-strategy-scenario-analysis
[3] https://www.carbone4.com/en/analyse-war-and-decarbonization-raw-materials-dependency

Exposure of French and European companies to shortages of critical resources

A resource is said to be **strategic** if it is of **great economic importance** or in terms of **security** and **defense**, and if it **cannot be easily and quickly substituted**.

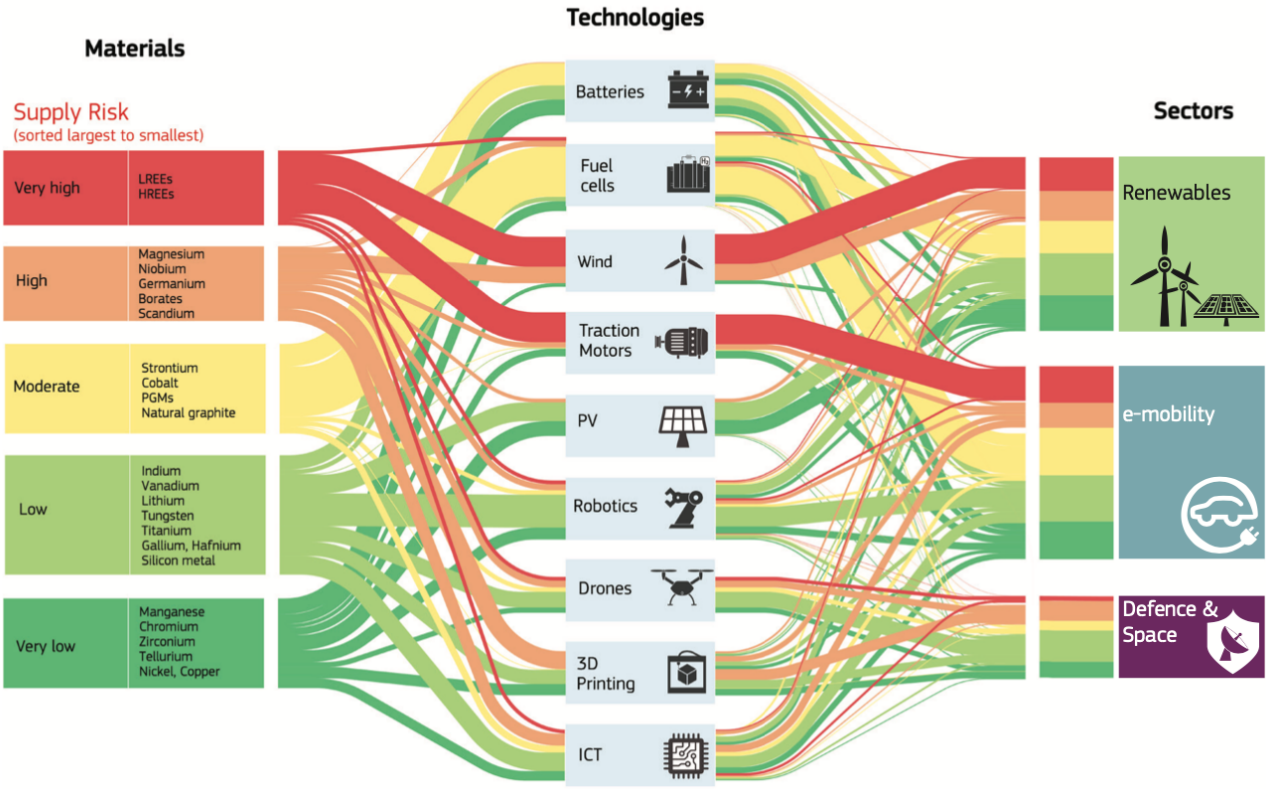
A **critical** resource is a strategic resource with a **high risk of supply shortages**.

The European Commission maintains an inventory of critical substances for European industry:



Source: European Commission, 2023 - Study on the Critical Raw Materials for the EU 2023

The necessary decarbonisation of our economies could lead to increased dependence on metals



Source: European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020
LREE/HREE = Light/Heavy Rare Earth Elements
Estimated supply risk in 2020

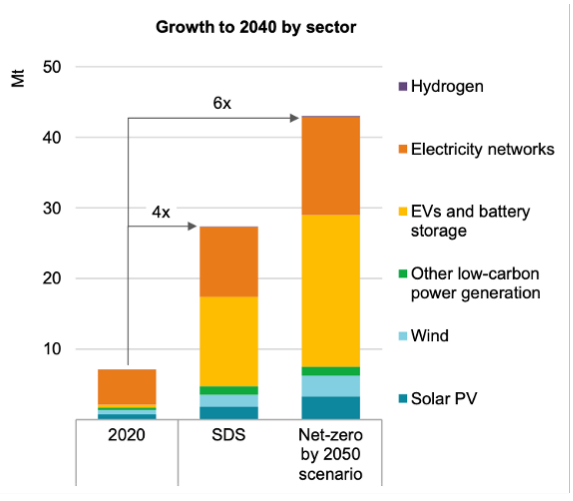
Lithium, nickel, cobalt and graphite are essential to produce batteries for electric vehicles, and rare earths elements for the permanent magnets used in offshore wind turbines and electric motors for electric vehicles.

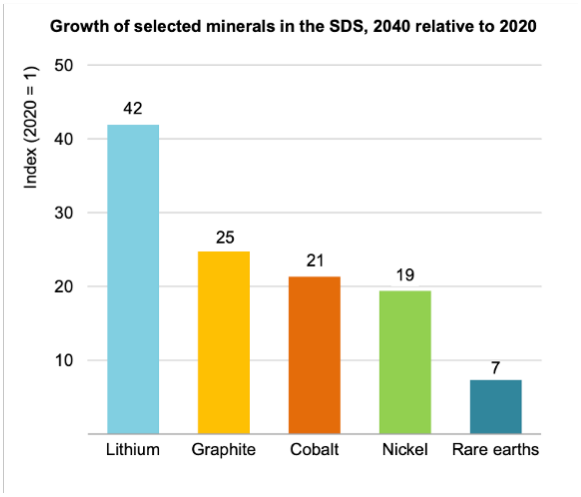
The necessary decarbonisation of our economies will therefore mean increased dependence on metals.

The low-carbon transition scenarios envisaged by the International Energy Agency (IEA) predict a considerable increase in demand for mineral resources, making them even more critical.

Trends in demand for minerals for low-carbon transition technologies

in the IEA scenarios





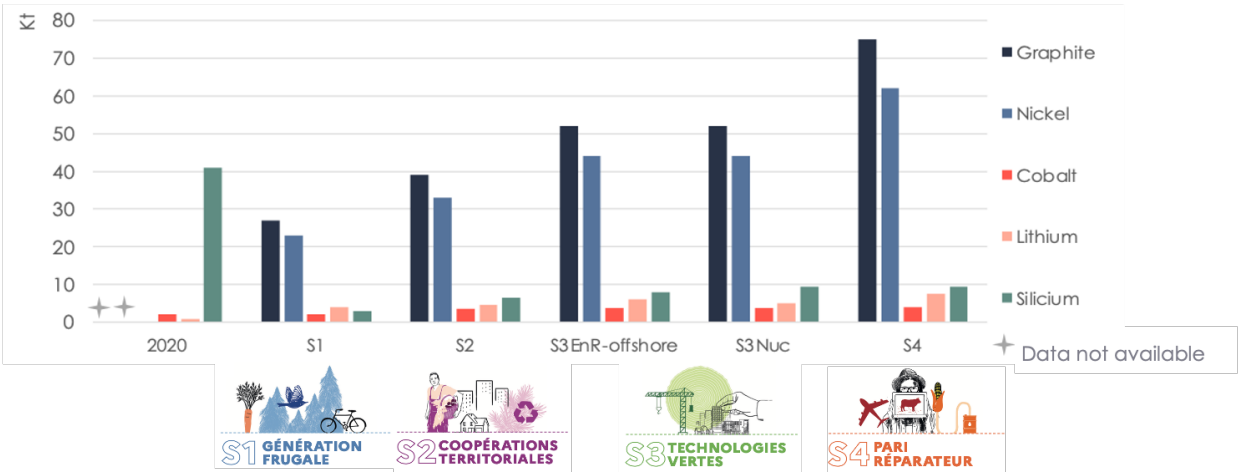
Source: International Energy Agency, The Role of Critical Minerals in Clean Energy Transition, 2021

The sharp increase in the need for mineral resources linked to the decarbonisation of human activities could increase the environmental and social risks associated with mining:

- Environmental: environmental damage caused by the extraction and processing of raw materials (emission of pollutants, use of water, destruction of ecosystems, GHG emissions).
- Social: Difficult and dangerous working conditions, child labour, pollution of ecosystems with consequences for local communities, unequal sharing of value, corruption and armed conflict.

The increase in these metal requirements depends on the choices we make as a society, and in particular on the degree to which we resort to sobriety. The socio-technical systems that can be envisaged for the future are more or less resource-intensive, depending on the volume of physical flows on which they depend. This is illustrated by ADEME's transition scenarios for France (S1 to S4, in descending order of use of sobriety).

Annual materials and metals requirements for ADEME scenarios - Average 2020-2050 | kt



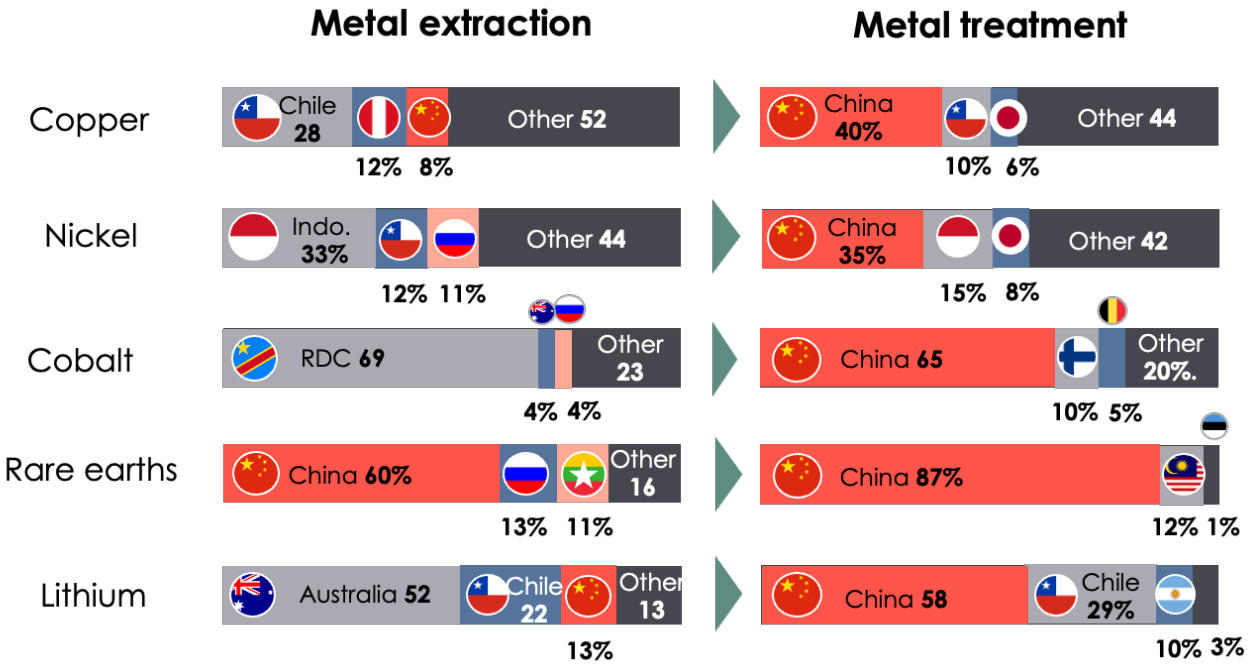
Source: ADEME Transitions 2050, Materials for energy transition series

There is an interrelationship between the level of material consumption and dependence on resources that are more or less easy and expensive to obtain today, and for which supply tensions are likely to increase for a variety of reasons over the course of the century. Let's take a closer look at the risk factors for resource supply.

Decline in resources and concentration of production increase the risk of shortages of these resources

The combination of resource depletion and production concentration is increasing the supply risk for strategic metals, some of which are essential to the low-carbon transition.

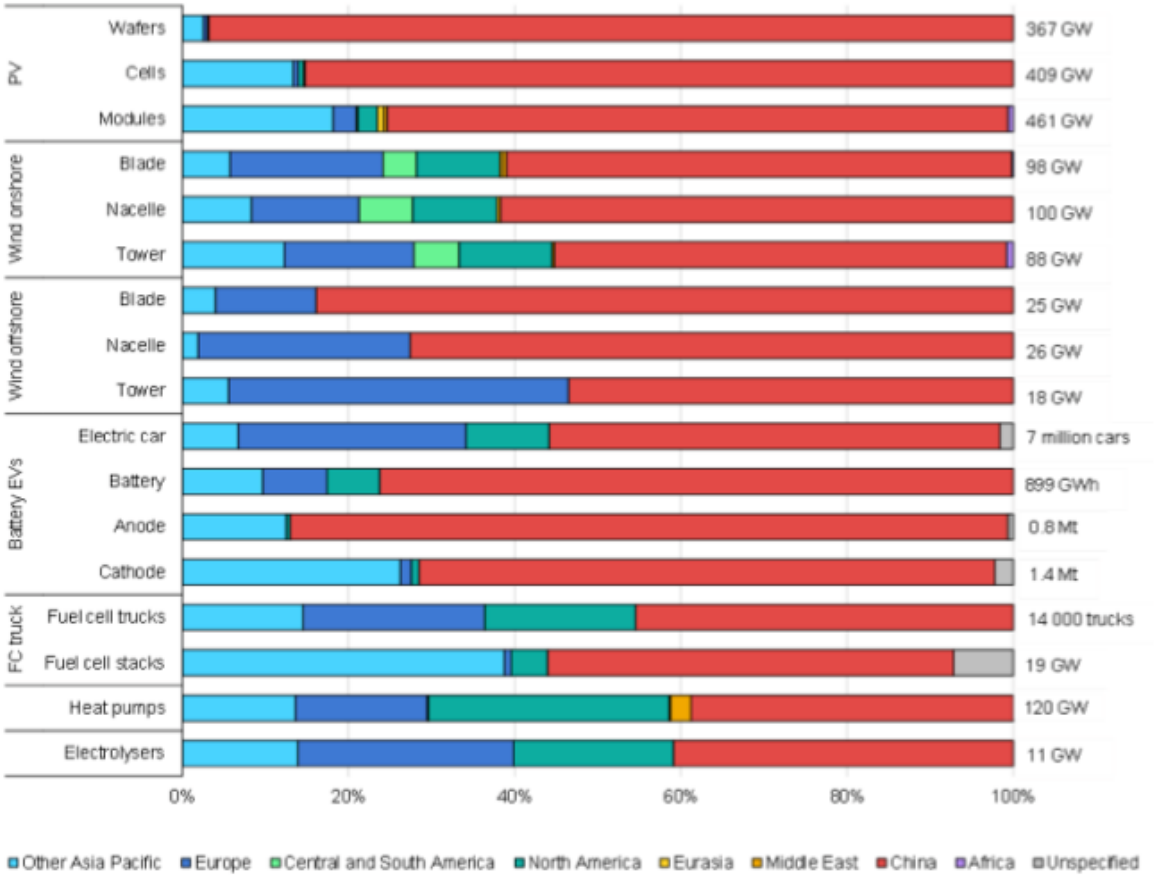
The mineral resources needed for the low-carbon transition come from a limited number of countries for mining, and an even more limited number for refining.



Source: International Energy Agency, The Role of Critical Minerals in Clean Energy Transition, 2021

China is a major player in the geopolitics of metals. This gives it a significant advantage in terms of its ability to produce and export certain technologies that are essential to the low-carbon transition. According to the IEA, the Asia-Pacific region accounts for 90% of the production capacity of the low-carbon technologies studied in its ETP 2023 report.

Figure 2.7 Regional shares of manufacturing capacity for selected mass-manufactured clean energy technologies and components, 2021



Notes: FC = fuel cell. Heat pumps capacity refers to thermal output.

Sources: IEA analysis based on InfoLink (2022); BNEF (2022); BNEF (2021b); Benchmark Mineral Intelligence (2022); GRV (2022); UN (2022a); Wood Mackenzie (2022).

Around 90% of mass-manufacturing capacity for several key clean energy technologies is concentrated in China and the Asia Pacific region.

Source: IEA ETP 2023

The new geopolitics of resources that is taking shape is drawing a new world order and poses a challenge to the success of the low-carbon transition at a pace sufficient to limit the consequences of climate change. In particular, the European and French economies are highly exposed to this geopolitical dependence and must equip themselves with the means to contain it if they are to remain masters of their own destiny.

In addition to the sharp increase in demand for metals and the high concentration of resources on a global scale, which could lead to tensions over supplies, there are physical limits to mineral extraction.

As the first deposits to be mined (which on average have the highest ore content) are depleted, ore grades are falling worldwide. [4]

Deposits are becoming increasingly difficult to exploit, as more and more resources (in particular energy and water) are needed to extract the same quantity of ore.

The combination of resource depletion and concentration of production means that strategic metals, some of which are essential to the functioning of economies in their current form, are at risk.

The table below summarises the various factors that can affect the supply of resources to governments and companies, in a more or less permanent way:

[4] Source: UNEP, Metal recycling - Opportunities, limits, infrastructure, 2013

Areas for consideration

Geological	• Risks linked to the availability of resources and the difficulties of exploiting them (accessibility, content), which may be exacerbated by other global limitations (climate change, consumption/pollution of scarce or finite resources (water), biodiversity).

Technical & technological	• Existence of alternative sourcing solutions :
	  ▪ sourcing of virgin materials
	  ▪ sourcing recycled materials
	• Existence of new competing solutions based on a different technology or production process

Environmental & social	• Carbon impact of current production and financial constraints in relation to the envisaged decarbonisation trajectory; consumption of scarce or finite resources; threats to biodiversity • Social impacts and risks on supply chains • Physical risks to supply chains (e.g. extreme weather events), amplified by climate disruption or other environmental degradation • Reputational risk

Legal & regulatory	• Regulatory
	  ▪ potential constraints (direct and indirect) on production
	• Fiscal
	  ▪ possible taxation of negative environmental externalities

Supplier risks	• Risk to the production of volumes at the required quality level
	• Risks to the current cost structure of suppliers of the material analysed
	  ▪ Energy consumption
	  ▪ Consumption of other resources
	• Risk to future cost structure

Market risks	• Competition and potential conflicts of use with other sectors for access to the resource • Volatility of commodity prices • Changes in consumer behaviour and habits • Societal changes and choices
Policy & Geopolitics	• Local or national political risks leading to a shift in production factors away from the resource under analysis. ▪ For example, changing land use to favour another crop • Opening up economies for the exchange of resources (conflict, economic protectionism) • Geographical concentration of supply sources

Faced with these challenges, some governments and companies are organizing themselves to secure the value chains that are essential to their operations, and thereby gain greater control over their destiny.

Actions by governments and businesses to limit their vulnerability to these risks

Mineral resources are therefore joining hydrocarbons as a major geopolitical issue. States are positioning themselves as potential rivals for critical raw materials, and some are developing a strategy of self-sufficiency or reduced dependence to secure supplies.

🇨🇳 China now controls a dominant share of metal processing, the result of a strategy implemented over several decades.
To ensure its industrial independence, it has organised a move upmarket and developed vertically integrated businesses, giving it control of key links in the value chains for these metals.

With government support, Chinese companies have invested in the mining industry in Guinea (iron), the DRC (cobalt and copper), Chile (lithium), Niger (uranium) and Tanzania (zirconium and monazite). [5]
The "Belt & Road Initiative" (New Silk Roads) strategy is playing a major role in structuring the infrastructure that will enable the flow of resources needed for Chinese economic activity. [6]
Thanks to its dominant position, it has been able to distort prices by cutting export quotas in 2011, and then by massively increasing domestic consumption, thereby maintaining de facto pressure on its importing customers, first and foremost the United States and Europe.

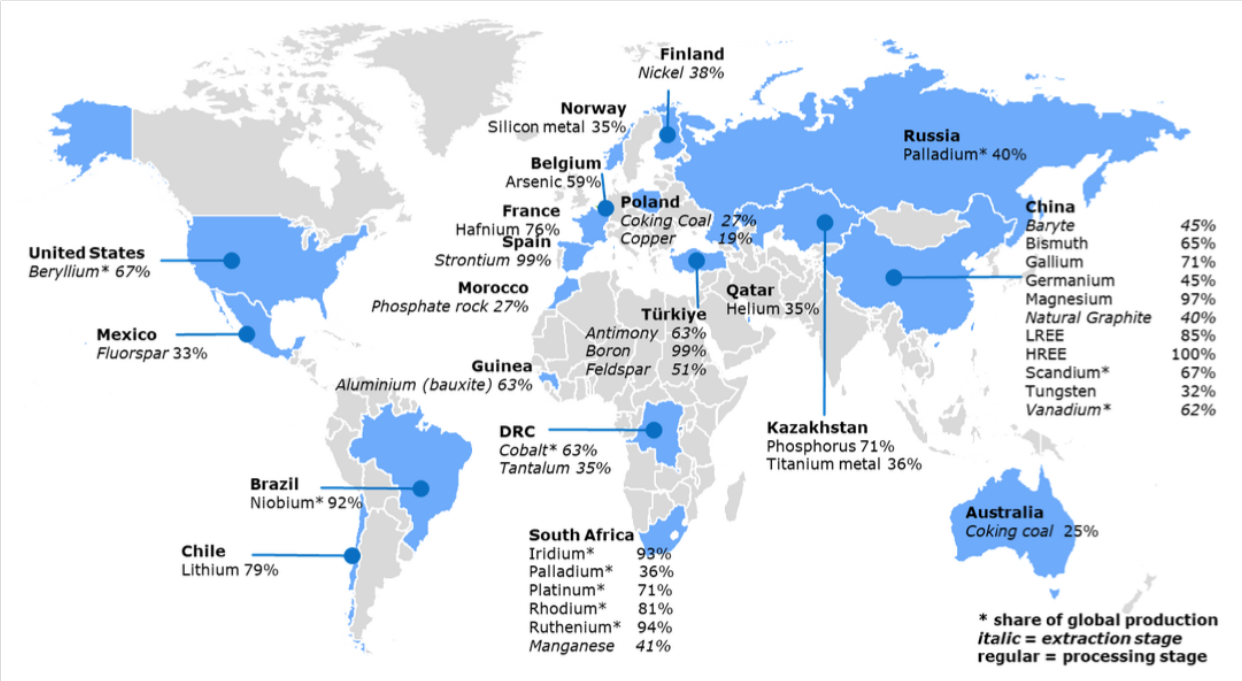
🇪🇺 With the Critical Raw Materials Act of March 2023, the European Union is defining a strategy and objectives for securing its supply of critical and strategic resources. The regulation sets benchmarks for domestic capacity and diversification of supply by 2030:

- "Extraction in the EU must produce at least 10% of its annual consumption,
- The processing carried out in the EU must enable at least 40% of its annual consumption to be produced,
- Recycling in the EU must produce at least 15% of its annual consumption,
- No more than 65% of the Union's annual consumption of each strategic raw material at any relevant processing stage may come from a single third country." [7]

These objectives should be set against the EU's current level of dependence on imports of critical raw materials, as illustrated by the following figures:

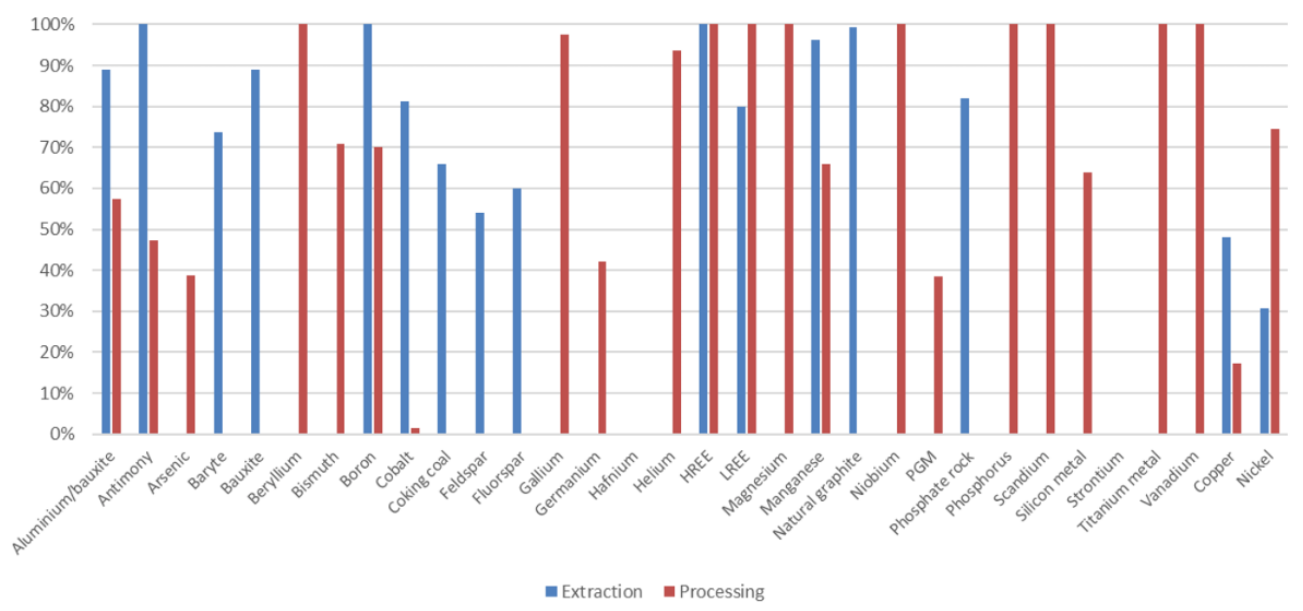
[5] Source: Analyse de la vulnérabilité d'approvisionnement en matières premières des entreprises françaises, March 2019, Ministry of the Economy and Finance.
[6] Source: The Belt and Road Initiative and the strategy to secure Chinese energy supplies in Africa, IRIS, October 2019 - https://www.iris-france.org/wp-content/uploads/2019/12/OBS-2018-02-Rapport-1-Final.pdf
[7] EU Critical Raw Materials ACT - http ss ://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661

Main EU suppliers of critical raw materials

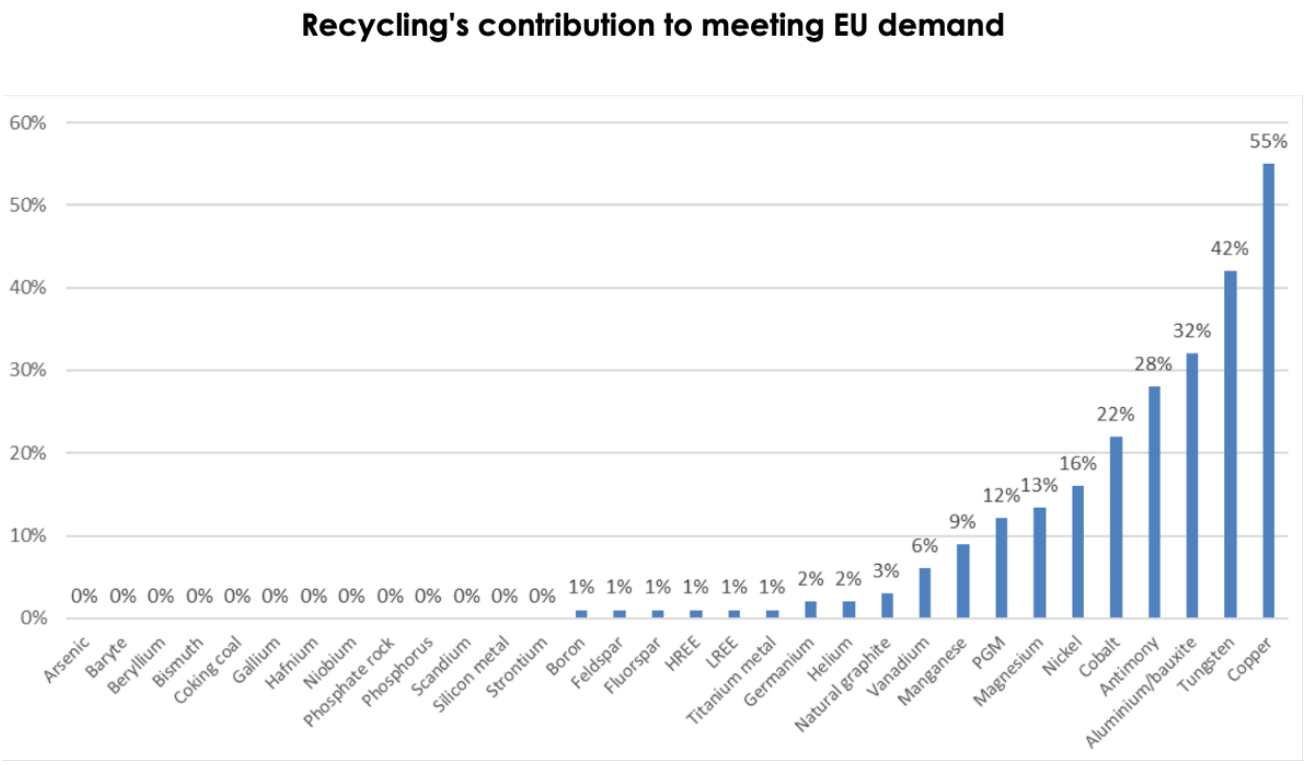


Source: European Commission, 2023 - Study on the Critical Raw Materials for the EU 2023

Rate of dependence on EU imports



Source: European Commission, 2023 - Study on the Critical Raw Materials for the EU 2023



Source: European Commission, 2023 - Study on the Critical Raw Materials for the EU 2023

Aware of the risks associated with critical and strategic resources weighing on its economy, the European Union is adopting a proactive strategy that can be strengthened in the coming years.

🇺🇸 The United States is a major global producer of minerals and metals. In particular, the country ranks in the world's top 5 for the production of copper, zinc, palladium, gold and molybdenum. Although the United States' very liberal mining law favours exploitation of the subsoil by private players, the number of active mines in the metal ore sector has been more than halved in thirty years, falling from 640 sites in 1990 to 278 in 2020, resulting in increased dependence of the United States on external supplies of ores and metals.

Since the rare earths crisis of 2010, securing the supply of critical resources has been at the heart of the administration's concerns. The US strategy is based on three pillars: (1) increasing domestic production of ores and primary metals through mining law reform and financial support, (2) reuse, recycling and the development of substitutes, and (3) coordination with US allies and partners to diversify and secure supply chains. A Mine Security Partnership was launched in June 2022 with 10 partners (Australia, Canada, Finland, France, Germany, Japan, South Korea, Sweden, the United Kingdom and the European Commission) to structure an international cooperation system to secure mineral supplies. [8]

🇮🇳 The mining industry plays an important role in India's "Make in India" economic sovereignty strategy. India is highlighting its large reserves of coal, iron ore, bauxite, chromium, manganese, barite and rare earths to attract foreign investment in this sector. Two priority resources stand out in the Indian government's communication: coal and steel, each of which has a dedicated

[8] La stratégie des États-Unis dans la géopolitique des métaux critiques, Observatoire de la sécurité des flux, et des matières énergétiques, Juin 2022 & Critical Minerals and Materials: U.S. Department of Energy's Strategy to Support Domestic Critical Mineral and Material Supply Chains (FY 2021-FY 2031)

ministry. The Ministry of Coal aims to increase coal production to 1.3 billion tons by 2025 and 1.5 billion tons by 2025, compared with 0.8 billion tons today.[9] The Ministry of Steel aims to increase steel production by more than 2.5 times, from 118 Mt in 2021 to 300 Mt in 2030.[10]

Japan is heavily dependent on imports for its supply of strategic resources, a significant proportion of which comes from China. For example, China accounts for around 60% of its imports of rare earths (METI[11]).
Aware of the risks posed by this dependence, the Japanese have developed a highly structured strategy that coordinates the efforts of the public authorities, industrialists in the sector and financial players:

- Diversification of supplies through cooperation agreements with producer countries (e.g. USA, Kazakhstan, India, Vietnam, South Africa)
- State financing of Japanese or foreign mining companies (co-investment and debt guarantee) and exploration projects in Africa
- Japan is also looking to exploit its deep-sea resources through a dedicated exploration programme.
- The Japanese government is co-financing national stockpiles of 34 strategic metals with a 60-day reserve.
- Japan is developing its metal recycling capacity and is relying on imports to increase the amount available, particularly from European electronic scrap. For example, in 2017, 78% of the copper and 83% of the zinc recycled in Japan came from imports, particularly from Europe. [12]

Limiting dependence on resources	• Reducing needs: sobriety, material efficiency • Develop your strategy, the products and services you sell and the markets you target • Substitution • Recycling, circularity of value chains
Securing access to the resource	• Diversification of supply sources • Building up stocks • Medium- to long-term contracts • Vertical integration (acquisition of interests in mining or metallurgical activities)

Companies are also exposed to these risks and can take action to limit their vulnerability, based on two main pillars:

The automotive industry, which must make a rapid transition to electric vehicles, is particularly concerned by the issue of dependence on critical resources. As a result, some manufacturers are implementing strategies to gain greater control over their value chain, through partnerships or by bringing new skills in-house:

[9] https://www.makeinindia.com/sector/mining
[10] https://steel.gov.in/en/make-india
[11] Japanese's Ministry of Economy, Trade and Industry, https://www.enecho.meti.go.jp/en/category/special/article/detail_158.html_158.html
[12] Source: Analyse de la vulnérabilité d'approvisionnement en matières premières des entreprises françaises, March 2019, Ministry of the Economy and Finance.

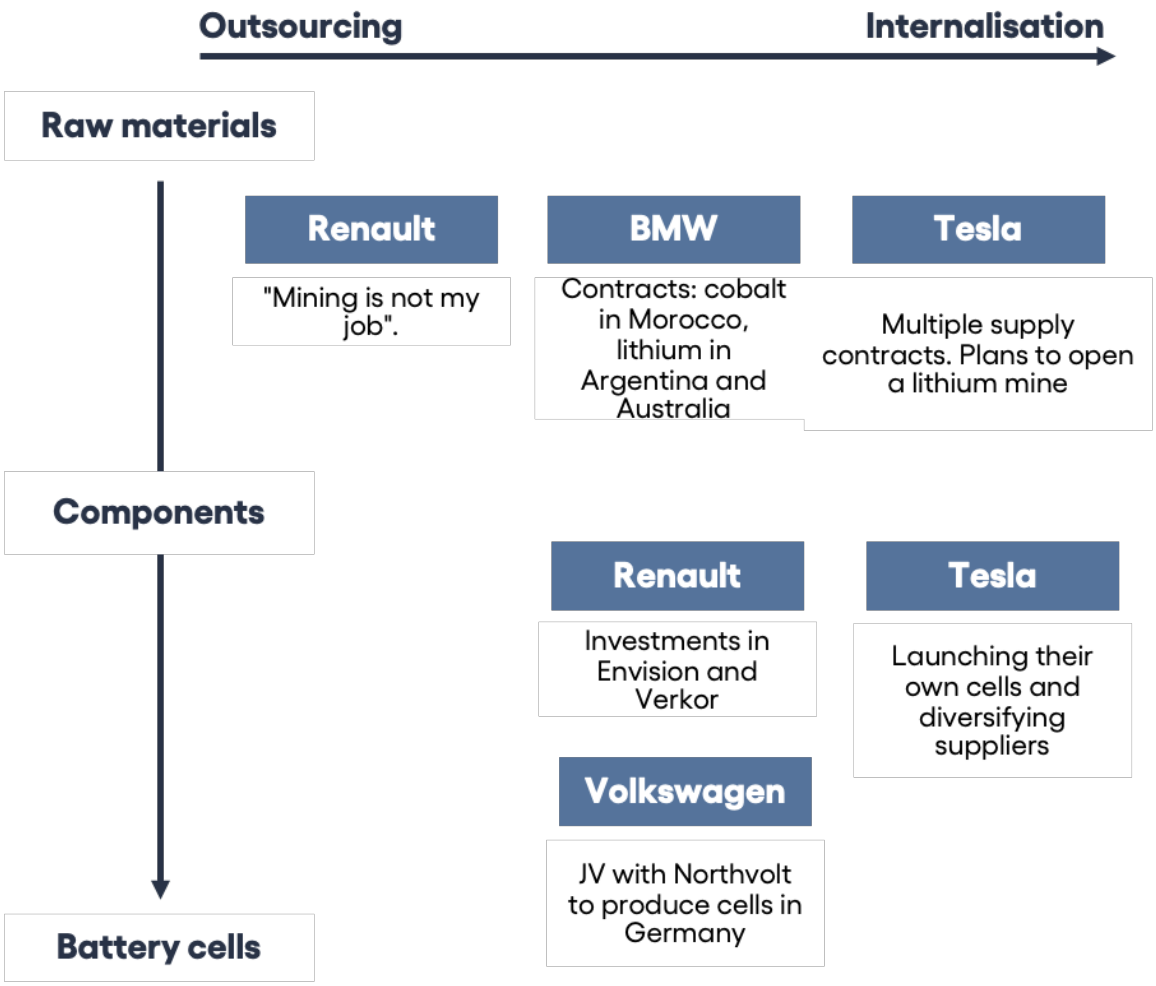
Tesla: With its in-depth knowledge of its value chain and considerable financial clout, Tesla is seeking to establish vertical integration from mine to finished product, as demonstrated by its recent discussions with Glencore and Sigma Lithium.

Renault: Renault has long been reluctant to develop activities other than assembly, but in 2021 it is joining forces with Solvay and Veolia to recycle batteries for electric vehicles.

The company is also looking to secure the production of battery cells through investments in Envision (a Chinese battery manufacturer) and Verkor (a French battery manufacturer).

BMW: Securing supply through contracts with the Moroccan miner Managem for cobalt, and in Australia and Argentina for lithium.

Volkswagen: Volkswagen is committed to vertical integration and is joining forces with Northvolt via a JV to produce its own battery cells.



Source: Léa Boudinet and Nour Khater, Comment sécuriser nos approvisionnements stratégiques? - Les Docs de La Fabrique, Paris, Presses des Mines, 2021.

The limitations of traditional approaches to corporate strategy in meeting these challenges

Corporate strategy is often based on a predictive approach with a relatively short-term horizon (3 to 5 years), and consists of projecting the next few years of business by extrapolating trends observed in the past, combined with changes perceived in its markets, for example the impact of megatrends (growth and ageing of the population, etc.). By construction, this excludes both potential disruptions and slow processes likely to be highly destabilizing for the company's business, including climate change and resource depletion.

The robustness of an economic activity is more often measured by economic indicators such as sales growth, cost reduction and cash availability than by considering the risks of supplying critical resources or the compatibility of its activity with planetary limits. The latter, in particular the consequences of climate change and potential supply chain disruptions, which are not easily monetized, are almost never incorporated into strategic thinking (or only to a very limited extent), because strategic thinking is often limited to factors that can be expressed in economic terms (market size, cost of production factors).

Furthermore, the notion of value is most often focused on financial performance. The social and environmental value provided to society, which is a determining factor in ensuring the relevance of the business in a world with limited resources, is too often overshadowed by these economic indicators, which are certainly important but incomplete.

In practice, this can lead to harmful trade-offs in the use of resources. As negative externalities have little value today, optimizing the economic value of resource use sometimes runs counter to maximizing its relevance in an efficient and sober socio-economic system. For example, hydrogen, which some people imagine will be used on a large scale in luxury cars, aeroplanes and even flying taxis in the short to medium term, should be prioritized for uses where its chemical properties are most useful to the greatest number of people, such as the production of ammonia, methanol, steel and marine fuels[13] .

Finally, silo thinking too often leads to an underestimation of the interdependencies between different sectors and activities, and the potential for competition in use. Failure to use systemic analysis in strategic thinking can lead to an incomplete understanding of an organization's dependencies and the risks weighing on its activities. This effect is reinforced by the fact that value chains are increasingly complex and interconnected on a global scale.

These elements are detailed in our previous publication[14] .

	Limits of the current business strategy	Associated risks
1	Corporate strategy is often based on a **predictive** approach with a **relatively short-term horizon**, and consists of projecting the next few years of business by extrapolating the trends observed in the past.	By construction, this excludes both **potential disruptions** and **slow processes** likely to be **highly destabilising** for the company's business, including **climate change** and **resource depletion.**
2	The **robustness of an** economic **activity** is more often measured by **economic indicators** than by considering the **risks of supplying** critical resources or the **compatibility of its activity with planetary limits**.	Failure to take account of these factors, which will shape the economy in the medium term, **leads to inappropriate business strategies, putting the long-term survival of companies at risk.**
3	The **notion of value** is most often focused on **financial performance**. The **social and environmental value** contributed to society is too often **overshadowed by these economic indicators**, which are certainly important but **incomplete.**	Does not allow us to set a course that will ensure the **relevance of the company's activity** in a low-carbon world with limited resources and its **resilience in the** medium term.
4	**Silo thinking** leads us to **underestimate the interdependence** between different sectors and activities, and the potential for **competing uses**.	An incomplete understanding of an organisation's dependencies and the risks weighing on its activities can **foster the illusion that a business model is compatible with the low-carbon transition.**

Scenario analysis is a strategic tool for anticipating and characterising future and characterise future uncertainties and disruptions.

[13] Find out more here: https://www.carbone4.com/en/publication-low-carbon-hydrogen
[14] Available here: https://www.carbone4.com/en/publication-strategy-scenario-analysis

Building a business strategy that incorporates resource risks: a methodological approach

How scenario analysis is a useful tool for anticipating resource-related business risks

Carbone 4 works with its customers to anticipate these risks and build business strategies that are resilient to planetary limits.
To do this, we use scenario analysis, which is a foresight method that involves envisaging possible futures and exploring the potential consequences for the company's activity, with a view to feeding into the strategic thinking process and informing action. This method is based on an analysis of the physical flows of the company's activity and on a systemic approach that considers the finiteness of resources, competition for use, the consequences of climate change and action to combat it. We imagine different future worlds based on proprietary Carbone 4 scenarios that describe in detail the potential market developments in these contrasting scenarios.

This enables companies to analyze potential changes in their economic environment and identify the risks and opportunities that are most relevant to their business.

Our approach is described in detail in the publication **"Corporate strategy in the era of climatic emergency: Are old recipes (still) viable?** [15]

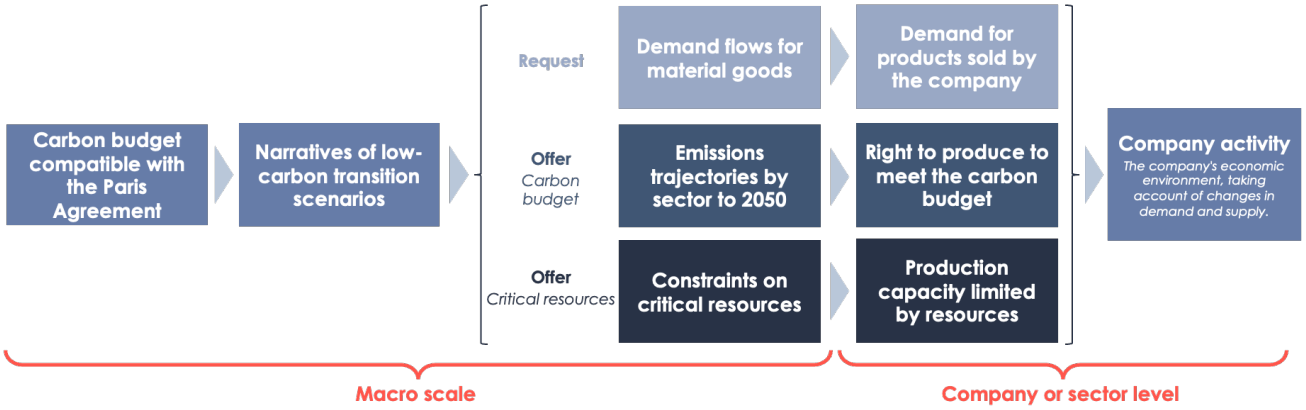
How Carbone 4's scenario analysis incorporates limits on resources

Based on the observation that dependence on critical resources is an increasingly pressing issue for our customers, and one that is too often underestimated, we have developed a native integration of the resource aspect into our approach. The consequences for the company's business of constraints on strategic resources other than carbon are at the heart of our scenario analyses and the identification of the resulting business risks and opportunities.

[15] https://www.carbone4.com/en/publication-strategy-scenario-analysis

The general approach is described in the figure below:

Main stages of analysis by physical flows



Resource constraints can affect companies in two ways:

- They can affect their ability to produce and market the goods and services they sell (upstream constraints). This is the case, for example, if a company is unable to obtain a resource necessary for its business.
- They may affect their ability to sell their products and services because of reduced consumer appetite caused by pressure on a resource and higher prices (downstream constraint). For example, this could be the case for aircraft manufacturers **who suffer from airlines' difficulty in obtaining low-cost fuels or alternatives**, making tickets sold significantly more expensive and thus destroying part of consumer demand for air transport.

The following section focuses on the first point, namely the upstream constraint.

The starting point for the analysis is to identify the company's strategic resources. The criteria used to define whether a resource is strategic are, for example:

- Proportion of the company's products containing this material
- Proportion of the company's sales and profits potentially affected by a disruption in supply of this material
- Share of the company's material consumption in the total volume available on the market, at the required quality level
- Existence of easily accessible substitutes for this material

These criteria need to be analyzed in dynamic terms, both at the time of the study and for future years.

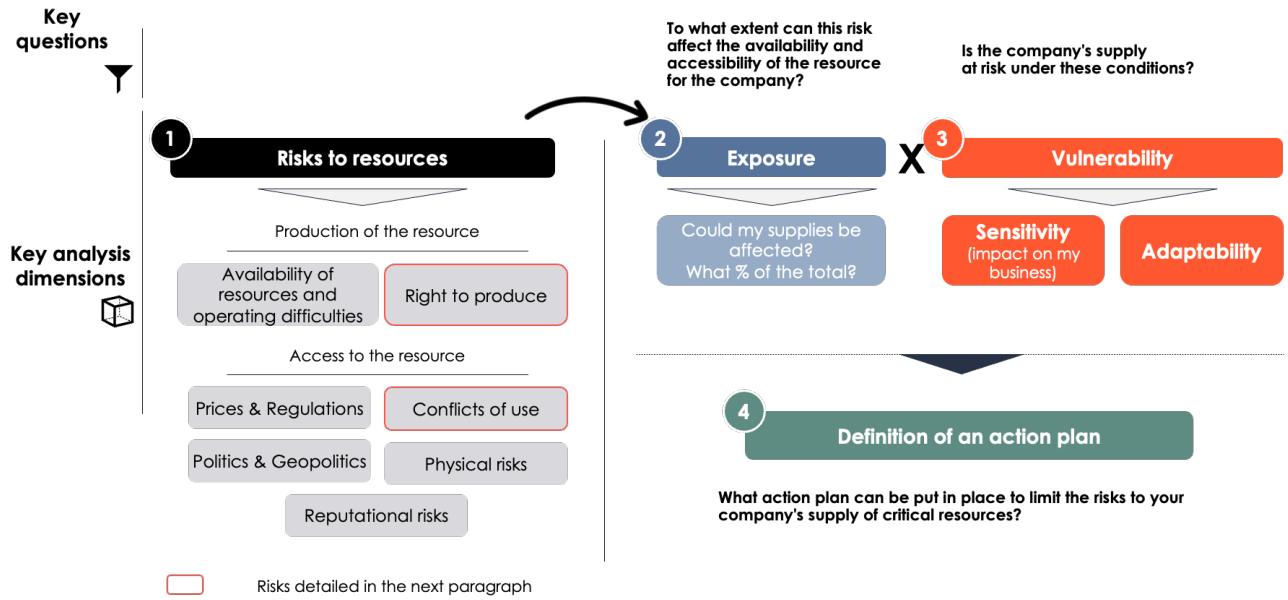
		Suggested criteria		
Level of importance of the resource - rating	**Description**	***Process-dependent share of sales***	***Minimum acceptable level of activity***	***Maximum permissible interruption duration***
Minor to negligible resource	**The resource contributes little to the company's business.**	***< 1%***	*The drop in supply of the resource **can exceed 50%** of its normal value.* *Example: The site can operate with just 500 litres of water per day instead of the normal 2,000 litres, without affecting its business in the short term.*	*The supply of the resource **may be** interrupted for **more than 6 months.***
Secondary resource	**The resource contributes to the company's activity.**	***Between 1% and 10%.***	*The drop in supply of the resource **must not exceed 50%** of its normal value.*	*The supply of the resource must not be interrupted for **more than 6 months.***
Important resource	**The company's business relies heavily on resources.**	***Between 10% and 20%.***	*The drop in the supply of the resource **must not exceed 20%** of its normal value.*	*The supply of the resource **must not be** interrupted for **more than 1 month.***
Major resource	**The company's business relies heavily on resources.**	***Between 20% and 30%.***	*The drop in the supply of the resource **must not exceed 10%** of its normal value.*	*The supply of the resource **must not be** interrupted for **more than 1 week.***
Vital resource	**The company's business is entirely resource-based.**	***More than 30%.***	***No reduction in the** supply of the resource is acceptable.* *Example: the site's activity is halted if there is a disruption to the electricity supply.*	*The supply of the resource must not be interrupted for **more than 1 day.***

Note: these thresholds are given for guidance only, as the assessment of the stakes and risks is subjective and varies greatly between companies. In some cases, for example, the resource is considered vital for a share of turnover >50%.

Quantitative thresholds can be introduced to objectify this selection stage, for example by associating an economic concept with a temporal concept, as illustrated in the table below:

Strategic resources are those categorized as major and vital.

The supply risks for these strategic resources are then analyzed in four stages.

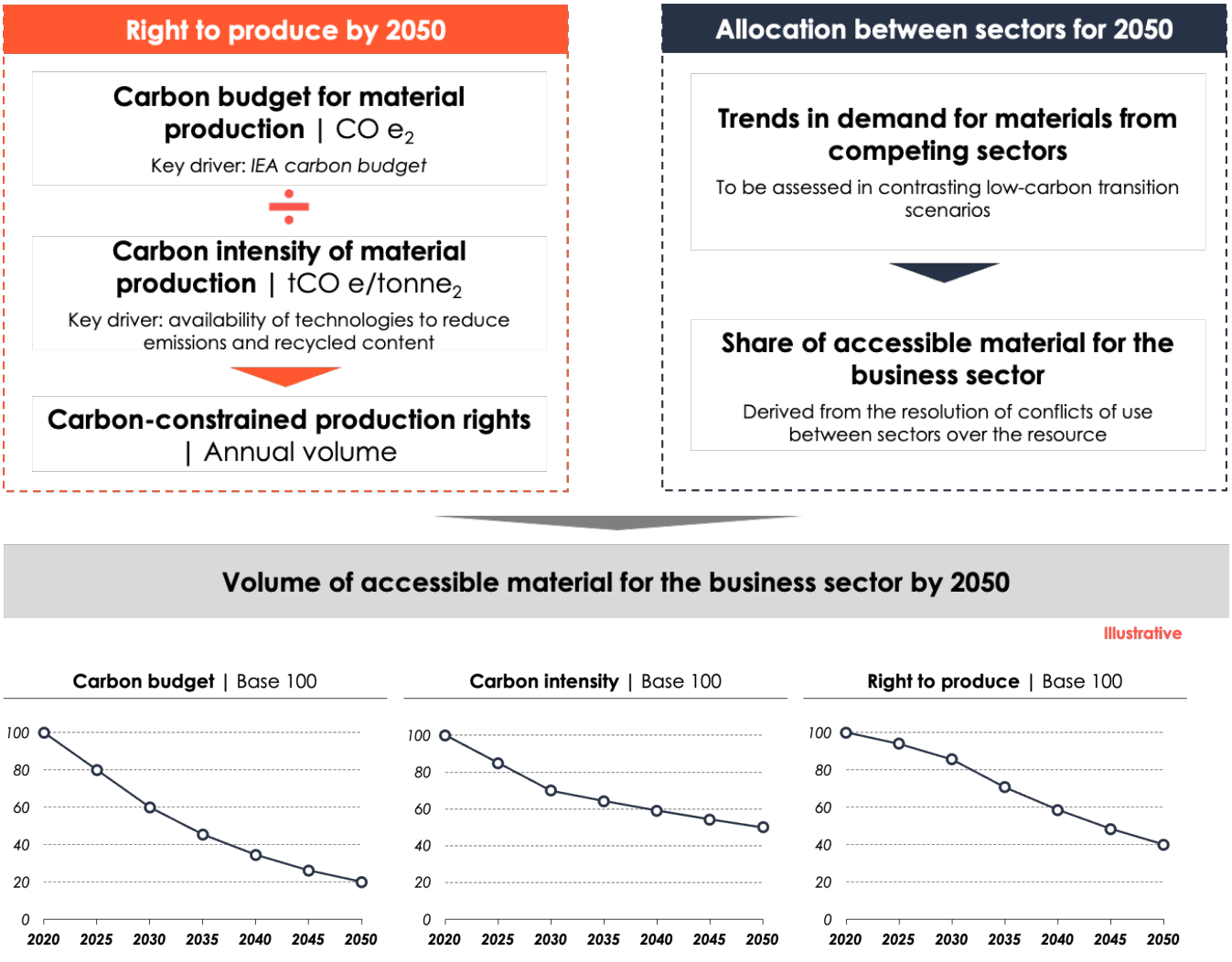


RESOURCE RISK

The first stage of the analysis is to identify the level of risk weighing on the resources identified as strategic for the company. These risks are of various kinds and may relate to limiting the production of the resource, access constraints for the company or reputational risks.

Let us now focus on the quantitative approach that can be used to deal with the limitation of the right to produce the strategic resource and the potential conflicts of use over its distribution.

In summary, the approach is as follows:



The first step is to define a right to produce by 2050, based on the carbon budget available to produce the material and the carbon intensity of its production.

The carbon budget per material is derived from global low-carbon transition scenarios, such as those of the International Energy Agency (IEA) or IRIS[16] from Carbone 4. It is fixed in the exercise and represents the right to emit for the production of the material in question. The carbon intensity of material production varies by 2050 depending on the scenario considered. In particular, it is the level of activation of technological levers to reduce production emissions and the rate of incorporation of recycled material that will determine the evolution of this carbon intensity.

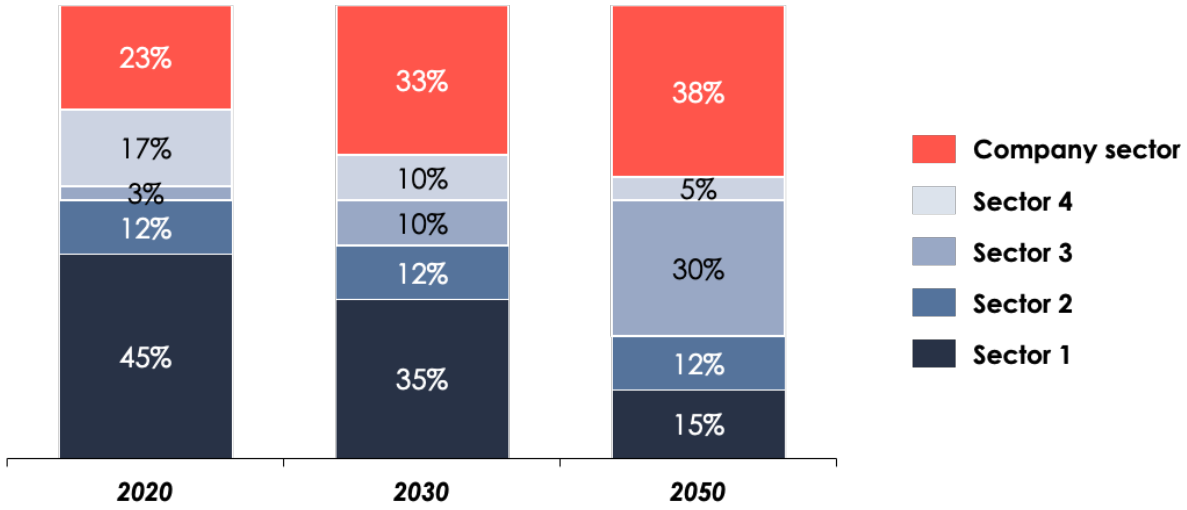
Once the right to produce has been quantified in various low-carbon transition scenarios for 2050, a second step is necessary to determine the quantity of material allocated to the company's sector. To do this, we need to assess trends in demand from other sectors for the same material. These trends vary according to the transition paths considered. This exercise can highlight potential conflicts of use. Several approaches can be used to resolve these conflicts of use, for example:

	Approach
Economic approach	**"The market decides"** Rule based on the technical and economic efficiency of using the material, and the price that each sector is prepared to pay for access to the resource.
Optimising decarbonisation	**"The resource goes where it best serves decarbonisation".** The main decarbonisation options by sector are listed, and the resource is allocated in such a way as to maximise the reduction in emissions, taking account of the alternatives.
Approach to best fit the predefined aspirational framework	**"The company decides"** A dominant aspirational framework in society is defined for the different low-carbon transition scenarios explored. This shared aspirational framework makes it possible to rank the needs and appetites within society. It structures lifestyles, the way the economy operates and the conditions for exchanging resources between countries, regions and communities. The distribution of resources between sectors is deduced from this overall framework.

The resolution of conflicts of use is used to deduce changes in the company sector's share of demand for the material under study.

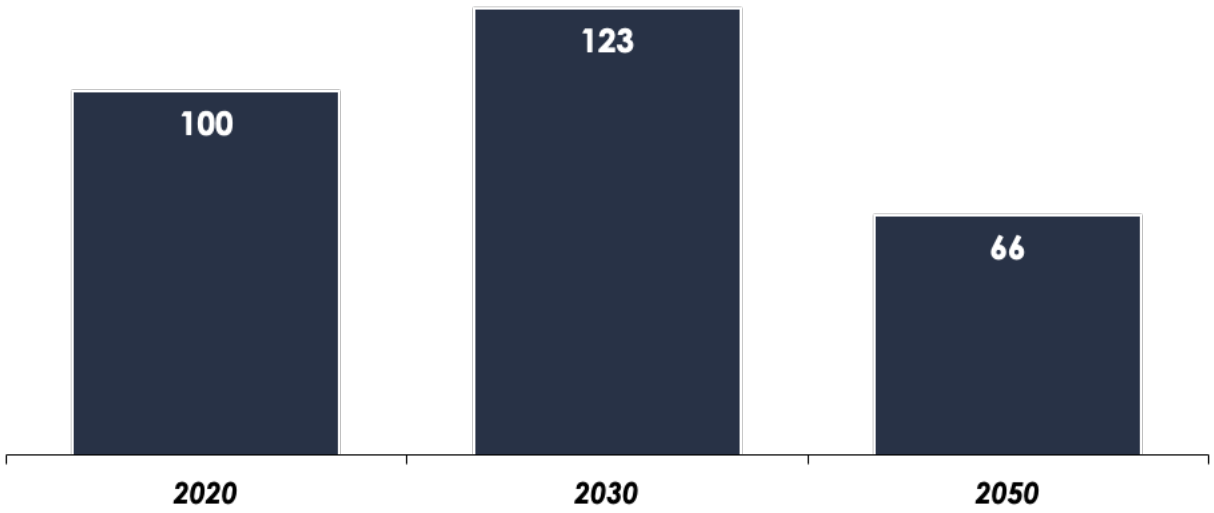
[16] https://www.carbone4.com/iris

Change in the share of the company's sector in demand | % (%)



Finally, the volume of material accessible to the company's sector by 2050 is calculated:

Volume of material accessible to the company's sector | Base 100

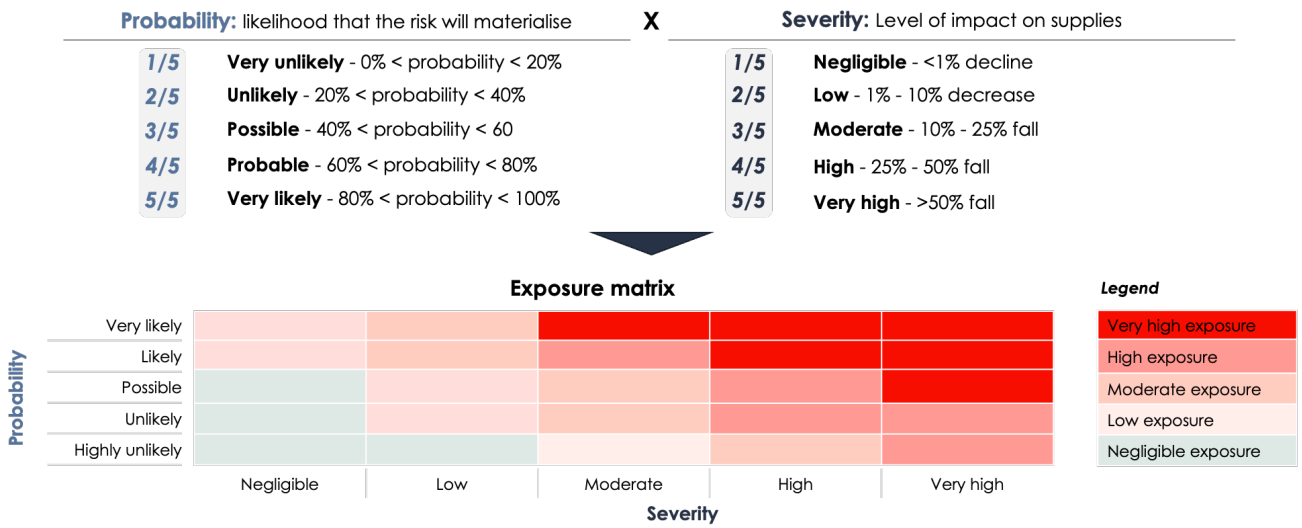


This approach makes it possible to quantify the risks associated with the right to produce the resource under carbon constraints and potential conflicts of use. Other specific approaches are used to analyze other types of risk, including the modelling of more or less prolonged shocks to supply.

This first part of the analysis provides a map of the risks weighing on the supply of strategic resources for the company.

EXPOSURE

Having mapped the supply risks precisely, the next step is to determine the organization's exposure to these risks. This exposure is the combination of the probability of the risk and its severity, i.e. its level of impact on the company's supplies.



Examples:

- A power cut lasting more than 24 hours at a company's main site is a highly unlikely event with a very high level of impact. The company's exposure to this risk is therefore high.
- Breach of a contract with a foreign supplier representing 15% of a battery manufacturer's lithium supplies is a possible risk with a moderate level of impact. The company's exposure to this risk is therefore moderate.

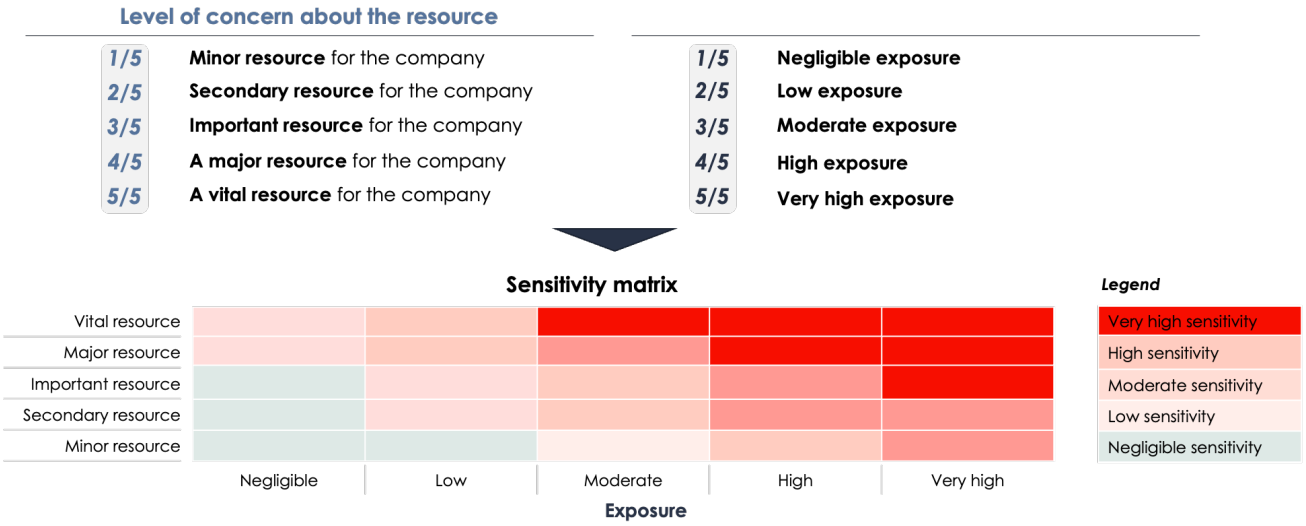
This step adds an extra dimension to the risk map drawn up in step 1 by highlighting the level of risk to the company's supplies. Once this vision has been obtained, the next step is to analyze the company's vulnerability to these risks.

VULNERABILITY

A company's vulnerability to supply risks is the result of two factors:

- The sensitivity of its business to these risks, i.e. the impact of potential supply shortages on its business.
- The company's adaptability to these risks.

Sensitivity :



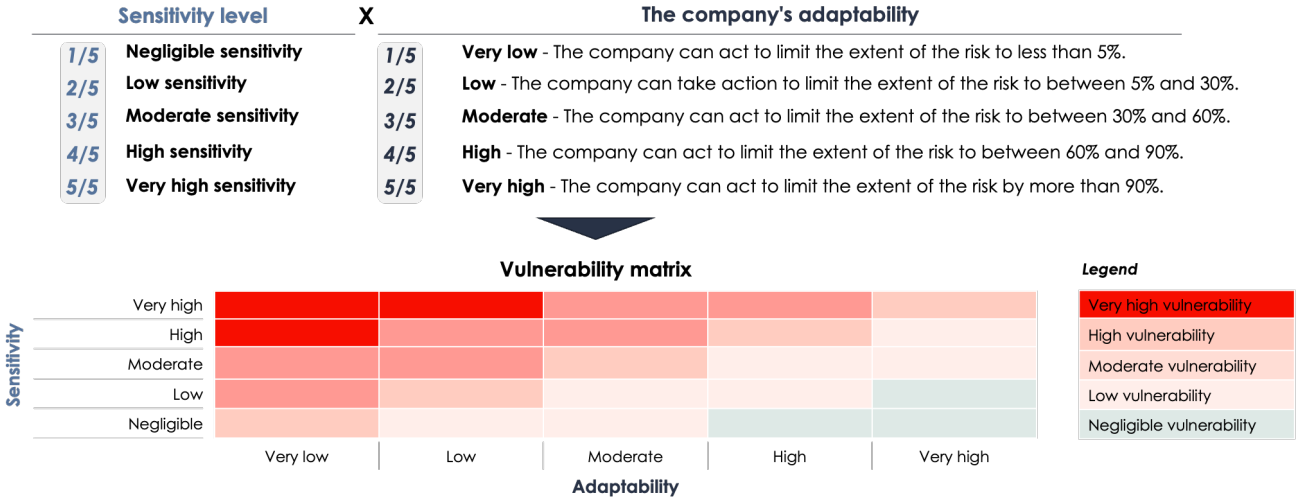
A new matrix can be constructed to illustrate the organization's sensitivity to resource risks, by combining the results of the preliminary analysis used to identify strategic resources with those of the risk exposure analysis.

Examples:

- If electricity is a vital resource for the company (the site's activity comes to a halt if there is a disruption in the electricity supply) and the company's exposure to this risk is high, the company's sensitivity to this risk is very high.
- Similarly, the lithium resource is vital to the battery production business and its exposure is moderate, so the company's sensitivity to this risk is very high.

Adaptability:

Finally, vulnerability to supply risk is a combination of the company's level of sensitivity and its adaptability. For example, a company can increase its capacity to adapt by developing its ability to use alternatives to the critical resource under study, by reducing its need for resources (sobriety), by joining an efficient recycling chain or by diversifying its suppliers.



	Availability of resources	Prices & Regulations	Politics & Geopolitics	Reputational risks
Probability of risk	High • At the current rate of mining and demand, resources will not be sufficient to meet demand.	Very high • B material bills are currently being examined by MEPs: CBAM and EU-ETS.	High • Production of material A is highly concentrated worldwide.	Moderate • Consumer sensitivity to ESG conditions in the Material B mining industry is increasing, but remains moderate.
Exposure of the company	High • The company's products are essential and should take priority over the available resources of material A.	Moderate • 10% of the company's supplies of material B are likely to be affected.	Very high • The company depends on a single supplier for its supply of material A, located outside Europe.	Low • 10% of the company's supplies of material B are likely to be affected.
Sensitivity of the company	Very high • Material A is a vital resource for the company's business to date.	Low • Material B's share of the company's cost structure is low, so a price increase would be absorbed.	Very high • Material A is a vital resource for the company's business to date.	High • Material B is a major resource for the company's business to date.
Adaptability	Moderate • The company has the opportunity to invest in existing solutions for recycling A materials. Not very effective in the short term, however.	High • The company can mitigate its risk on the price of material B by selecting more virtuous suppliers.	Moderate • The company can take action by diversifying its supplies and developing substitutes in the medium term. In the short term, the room for manoeuvre is limited by supply.	High • The company can draw up a list of its suppliers of A materials and monitor them to ensure that their activities comply with ESG criteria, and change supplier if necessary.
Vulnerability	High	Low	High	Moderate

Here is a case study illustrating the approach for two materials, A and B:

DEFINITION OF AN ACTION PLAN

The results thus obtained on the company's vulnerability about its supply of strategic resources complement the findings of the carbon-constrained scenario analysis.
This approach, which natively integrates resource limits, provides a more complete description of the physical context of the company's current and future activities, enabling it to work in a more enlightened way to build a resilient business strategy, i.e. one that contributes to the construction of a socio-economic system that is fulfilling for living beings and compatible with the planet's physical limits.

To support this work, **5 families of actions can be cited to reduce the vulnerability of companies about their dependence on resources**:

- **Sobriety**: reducing the need for resources.
- **Circularity**: substitution of virgin material with recycled material.
- **Diversification of resource supply**: both geographically and in the number of suppliers.
- **Structuring sustainable value chains**: relocating sourcing, integrating the company more vertically into the value chain, establishing long-term supply contracts that are fair to all parties.
- **Contribute to the development of a new relationship with resources**, seen as a common good for humanity, and appropriate governance.

These actions must be accompanied by more fundamental reflection on the compatibility of the company's activity with an economy that will enable it to achieve global carbon neutrality. Indeed, in the course of the low-carbon transition, some activities will have to be abandoned and others created, which can significantly reshuffle the cards in terms of an organization’s dependence on resources.

Conclusion

To make a success of its necessary low-carbon transformation, Europe must adopt a concerted strategy to remain in control of its own destiny in the face of the many risks of tensions over essential raw materials. Several factors are fueling these risks, in particular the sharp rise in demand for strategic resources for the low-carbon transition, the limits on global reserves of these resources, Europe's heavy dependence on imports of these resources, the high concentration of the metals extraction and processing sector, and the low contribution of recycling to meeting current demand.
The current geopolitical context only adds to this urgency.
Five levers are available[17]: sobriety, circularity, diversification of supply, structuring sustainable value chains and developing appropriate governance and a new relationship with resources, seen as a common good for humanity.

Given their place in the metabolism of human societies, companies have a central role to play in defining and implementing this strategy. However, the traditional approach to corporate strategy has certain limitations that can lead to an incomplete understanding of the issues. It is often based on a relatively short-term predictive approach, takes little account of the physical context of the company's activity beyond economic indicators, and tends to underestimate the interdependencies within systems.

Anticipating the consequences of the profound upheavals that are beginning to materialize calls for the development of new approaches, incorporating a more detailed understanding of physical flows. The methodological approach described in this publication aims to contribute to this by enabling companies to analyze the risks weighing on their supply of strategic resources.
It's a question of survival and control over their future, but also an opportunity to imagine a new development model that is less resource-intensive and more virtuous.

[17] https://www.carbone4.com/en/analyse-war-and-decarbonization-raw-materials-dependency

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Carbone 4 is the leading independent consultancy specializing in low-carbon strategy and adaptation to climate change.

Always on the lookout for weak signals, we deploy a systemic vision of the energy-climate constraint and put all our rigor and creativity into transforming our customers into leaders in the climate challenge.

Contact: contact@carbone4.com