Critical materials: How to plan for a resource scarce European business environment?

Point of View

November 2023

Monitor Deloitte.

This point of view aims to share insights into how the increasing demand for critical raw materials will impact different sectors and provide organisations with strategic recommendations on how address these upcoming challenges.

In our exponentially changing society, the demand for materials has surged due to their essential role in critical applications, from powering devices to advancing renewable energy, medicine, and defence. But resources aren't limitless, and the ongoing pressure on them will intensify due to factors such as global population growth, industrialisation, digitalisation, demands from developing nations, and the push for climate-neutrality transitions. According to OECD, the demand for global materials is expected to double by 2060, warning of fierce competition and a shift from oil dependence to critical materials.

In this context, Deloitte aims to share insights regarding the present situation in Europe, examine the specific sectors and technologies that will be threatened in the future, and provide key strategies to overcome the upcoming challenges.

Our primary focus is on materials projected to experience higher demand in the future and facing the most significant potential supply risks.

Overview sections

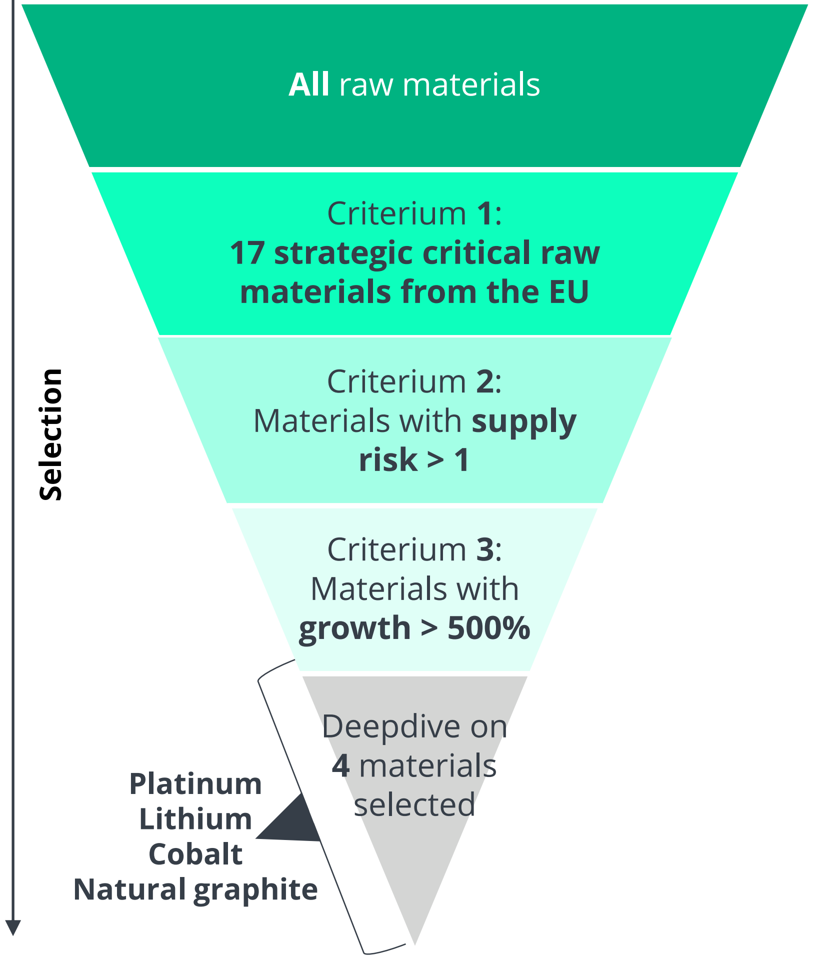
1. Projecting the criticality of materials in the future
2. Current allocation of materials: Overview
3. Economic impact forecast: Applications at risk
4. Addressing resource scarcity: Substitutes and sustainable measures

1 | Criticality of materials in the future

Projection

We will focus on the four most critical raw materials based on the predicted demand and availability as indicated in the latest EU critical raw materials act.

Deloitte's approach for materials deep-dive selection



To narrow down from all materials to our focused materials, we have defined three selection criteria:

Criterium **1**: The strategic critical raw materials. Those are defined in the EU critical raw materials act as:

- **A strategic critical raw material** is a metal, mineral or natural material that is most important economically, has a supply risk, and is expected to grow exponentially.
  e.g.., Platinum, Titanium, Cobalt, Gallium, Copper, etc.

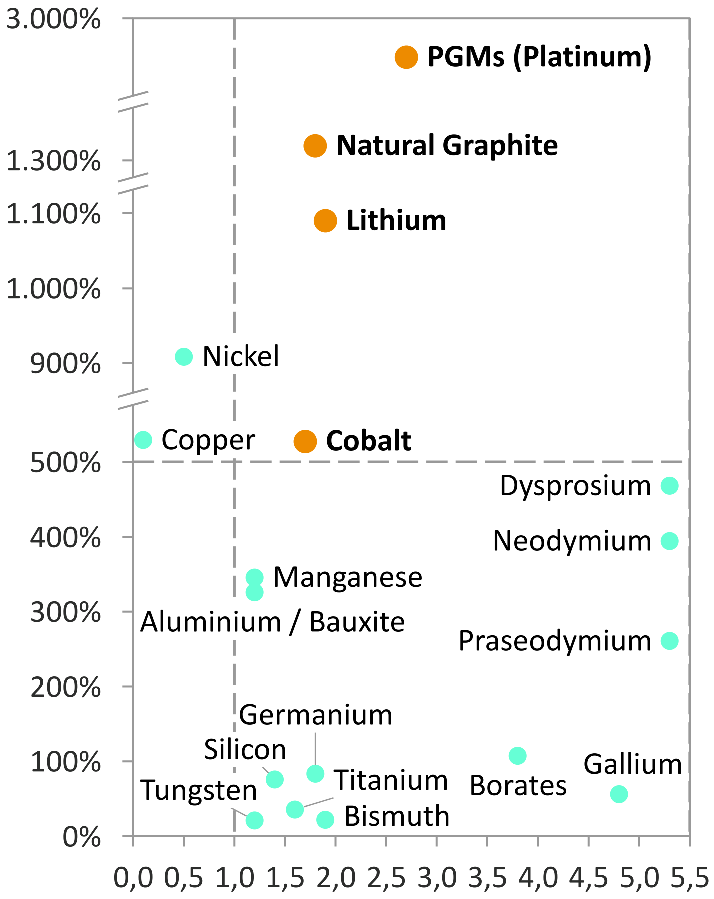
Criterium **2**: **Supply risk of the raw materials:**

- The supply risk is based on the supply concentration at global and EU levels weighted by a governance performance index and corrected by recycling and substitution parameters.
- The supply risk cutoff point is set at 1 where a **supply risk ≥ 1 implies criticality** and a supply risk < 1 implies a non-critical condition.

Criterium **3**: The **demand growth factor** shows the forecasted demand increase in 2030 (compared to 2020) in a world with rapid technology deployment (a high-demand scenario).

- The growth cut-off point is set at 500% to progress with the materials that will have the largest difference in demand compared to today.

Mapping of supply risk (>1, x-axis) and growth percentage from 2020 until 2030 (>500%, y-axis)



Sources: 1. Critical raw materials in technologies and sectors in the EU, European Union (2023); 2. An EU critical raw materials act for the future of EU supply chain, European Council (2023)

We will deep dive into each of the selected critical materials, investigating the current availability, future prospect, and impact on different applications and sectors.

What – Deep dive into critical materials and their impact on specific sectors

1	Supply deep-dive	This point of view starts from exploring the current availability of the critical materials, investigates future prospects, and highlights key challenges and opportunities.
2	Sector deep-dive	Next, the impact of the critical raw materials demand and supply is analysed within EU strategic sectors and their applications.
3	Economic impact	To conclude, a link will be made between the expected cost of the raw material based on demand and supply conditions and the dependency of the material for the EU strategic sectors and their applications.

Why – Specific applications and sectors have been chosen based on EU report data

- Raw materials are key enablers for all sectors of the EU economy. This study will focus in particular on the EU strategic sectors for which the critical raw materials are considered an essential prerequisites in their further growth.

Renewable Energy *E-Mobility* *ICT* *Aero & Defence*

- Within each of these strategic sectors, the applications have been selected for which data and models are available that show that they will push the future demand for raw materials needed based on the long-term decarbonisation journey.

How – Three scoring criteria have been identified to evaluate which sectors and applications will be impacted the most in the future

1. Application dependency

To assess material dependency of an application, three factors have been considered, each representing a specific weight in the final dependency score:

Factor	*Weight*
Weight content	▬▬
Physical & chemical properties	▬▬
Unavailability of substitutes	▬

Low ▬▬▭▭▭ High

2. Sector impact

Data from the EU study on critical raw materials in technologies and sectors has been used to classify the material sector impact into three categories.

🟢 Low 🟡 Medium 🔴 High

3. Economic impact

The economic application impact is calculated by considering the predicted price evolution of the different materials, sector impact and dependency. To categorise the applications in the green, yellow or red zone, a scoring system has been applied using the sector impact data .

🟢 1 point 🟡 2 points 🔴 3 points

To then position the applications in each of the three zones, the dependency is taken into account.

Low High

2 | Current allocation of materials

Overview

Natural graphite | Availability and supply deep-dive

CURRENT AVAILABILITY

- Graphite mining is **concentrated in specific regions** in China, Mozambique, Madagascar, Brazil, Russia and Ukraine. Each of these regions is characterised by specific supply risks, triggered by harsh weather conditions and political instability[4]
- **China covers 67% of global natural graphite output** due to refining capacity[1]
- Demand is mainly driven by graphite as a raw material **for battery anodes, fuel cells, unmanned vehicles**[1] **and anode material for robotics**[2]
- For anode production, **synthetic graphite is increasingly popular as an alternative** due to its material characteristics. However, as it is produced from the refining of coke, it is up to four times more carbon intensive than natural graphite and has a higher cost than natural graphite[2]

FUTURE PROSPECTS

- The largest increase in graphite demand is expected for **battery materials** for e-mobility and renewables. For 2030, an increase compared to 2020 demand of factor 12 is expected, for 2050 factor 21[2]
- Growing market for Li-ion batteries could represent an **increased demand for synthetic graphite**, while at the same time the **supply of synthetic demand would be at risk** with the decarbonisation of the steel industry[2]

CHALLENGES & OPPORTUNITIES

- **Global competition** among OEMs, cell manufacturers, and suppliers to secure access to graphite is expected[1]
- **Supply diversification opportunities** exist with new mining projects (e.g., in Africa[1] and Norway) for natural graphite flake as a potential reliable refined graphite source[2]
- New processing plants being built in the EU could expand **domestic refining capacity** for synthetic graphite[2]
- Graphite presents a challenge due to the global economy's **heavy reliance on China**. Yet, alternatives like **lignode and silicon** provide a real opportunity. Key levers for reducing dependence on a single region include **innovation, R&D, and government investment** in mineral processing facilities.

Sources: 1. Critical raw materials in technologies and sectors, European Union (2020); 2. CRMs for strategic technologies and sectors in the EU, European Union (2023); 3. Study on the critical raw materials for the EU, European Commission (2023); 4. ESG of graphite: how do synthetic graphite and natural graphite compare, Benchmark Source (2022)

Natural graphite | Application and sector deep-dive

🟢 Low 🟡 Medium 🔴 High

Application	Natural Graphite Dependency			Sector Impact			
	Low -> High		*wt%*	*Renewable Energy*	*E-Mobility*	*ICT*	*Aero & Defence*
Battery material	■■■■■	Graphite represents almost 50% of materials needed for batteries by weight and is crucial due to its low-cost and energy density.	40 - 50%	🟡	🔴	🟡	🟡
Refractories	■■□□□	Because of its high melting point, graphite is ideal to serve as refractory material. However, good substitutes are already available.	10 - 20%	🟢	🟡	🟢	🟡
Lubricants	■■□□□	Due to its atomic structure, graphite as lubricant improves the resistance to compression and wear. Substitutes are however available making the application less graphite dependent.	5 - 15%	🟢	🟢	🟢	🟢
Steel carburising	■■■□□	Graphite is used during the carburising process of iron/steel to give it unique characteristics to serve under high temperature and pressure.	1 – 5%	🟢	🟡	🟢	🔴
Fibre composites	■■■■■	The negative thermal expansion coefficient of graphite causes graphite fibre composites to be thermally stable and resistant to high pressures.	60 – 90%	🟢	🟡	🟢	🔴

Key takeaways

- Graphite is a **key element** in the production of **battery materials** and as such its depleting availability is impacting the different sectors heavily.
- It is very **difficult to replace** graphite in the **carburising process** while still maintaining the same level of quality of the materials' physical properties. The availability of graphite in this process thus might affect its application in the car manufacturing and defence industries.
- Due to the **intrinsic physical and chemical properties**, graphite fibre composites are used in **high strength and high temperature environments** which makes them suitable for the aero and defence industry. As affordable and qualitative alternatives are difficult to find, the scarcity of graphite will have an impact on the sector.

Source: Graphite: An Essential Material in the Battery Supply Chain, Elements (2022); Gaphite Recarburizer Market, Business Research Insights (2022);

Lithium | Availability and supply deep-dive

CURRENT AVAILABILITY

- Approximately **90% of the world's lithium production** comes from, **China** (46%), **Chile** (40%), **Australia** (29%) and **Argentina** (16%)
- The primary **sources** of lithium are **brine** and **spodumene deposits**
  - China hosts the majority of global lithium hard-rock mineral refining facilities
  - Chile and Argentina dominate refined lithium capacity from brine operations
- The **demand for lithium** has been **steadily rising** due to the growing popularity of electric vehicles (EVs), particularly those using **lithium-ion (Li-ion) batteries**. In Li-ion batteries, lithium plays a critical role as **both lithium-cobalt oxide** in the **cathode** and as an **electrolyte in salt form**
- Similarly, lithium is also a crucial component in **energy storage system (ESS) batteries** used for renewables.
- **Shortages and price spikes** in lithium supply have been a recent concern

FUTURE PROSPECTS

- The largest increase in lithium demand is expected for **battery materials** for e-mobility and renewables. Globally, for 2030, an increase compared to 2020 demand of factor 18 is expected, for 2050 factor 90[2]
- Growing market for Li-ion batteries will represent an **increased demand for lithium**, in the medium-term, large investments are needed to avoid a significant market deficit beyond 2025

CHALLENGES & OPPORTUNITIES

- Lithium is widely **present in soil**, including **in Europe**. Streamlining the process of opening new mines could enhance global supply.
- **Global competition** among OEMs, cell manufacturers and suppliers to secure access to lithium is expected[1]
- **Strengthen refining capacity and accelerate the development of production capacity for battery components, to not rely on imports and to reduce supply risks for downstream manufacturers considerably**
- **EU and Chile** have concluded **a free trade agreement** to liberalise trade relations and give EU companies greater access to key raw materials for the EU's green transition, such as lithium and copper

Sources: 1. Critical raw materials in technologies and sectors, European Union (2020); 2. CRMs for strategic technologies and sectors in the EU, European Union (2023); 3. Study on the critical raw materials for the EU, European Commission (2023); 4. ESG of graphite: how do synthetic graphite and natural graphite compare, Benchmark Source (2022)

Lithium | Application and sector deep-dive

🟢 Low 🟡 Medium 🔴 High

Application	Lithium Dependency			Sector Impact			
	Low -> High		*wt%*	*Renewable Energy*	*E-Mobility*	*ICT*	*Aero & Defence*
Battery material	▰▰▰▰▱	By weight percentage, a typical lithium-ion battery comprises about 7% Li (1 g of lithium = 5.17 g LCE) and is crucial due to its low-cost and energy density.	10 – 15%	🟢	🔴	🔴	🟡
Ceramics & glass	▰▰▰▱▱	Because of its high melting point, lithium is ideal to strengthen, colour and improve durability in ceramics and glass. Main substitutes are spodumene (a lithium sourcing feldspar), calcium, and aluminum.	10 – 15%	🟢	🟡	🟢	🟡
Lubricants	▰▱▱▱▱	Lithium accounts for less than 2% in lubricants greases and substitute such as OBCS or aluminum complex do exist.	5 – 15%	🟢	🟢	🟢	🟢
Mold powders	▰▰▱▱▱	Lithium is crucial in continuous casting powder processes where lithium carbonate offers greater speed and fluidity in the molding process.	1 – 3%	🟡	🟡	🟡	🟡
Air treatment	▰▰▰▱▱	Lithium is used in industrial air conditioning and dehumidification systems in air conditioning, due to its highly hygroscopic properties that allow it to absorb moisture from the air.	40 – 60%	🟡	🟡	🟢	🟢

Key takeaways

- Lithium is a **key element** in the production of **battery materials** and as such its depleting availability is impacting the different sectors heavily.
- Lithium's importance spans multiple sectors, including **e-mobility** with emerging materials like lithium iron phosphate batteries and its potential role in **aerospace and defence** through alloys like aluminum-lithium and aluminum-scandium.
- The future of lithium faces **substantial supply challenges**, with battery demand, reliant on lithium and other materials, expected to surpass current mining capacity by 2029-2030, **requiring timely and substantial investment** to bridge the impending supply-demand gap.

Sources: 1. Statista (2023); Mineral commodities summary – Lihium, US Geological Survey (2022); Mould Powders, Valcra and EU Comission (2023)

Cobalt | Availability and supply deep-dive

CURRENT AVAILABILITY

- 63% of global reserves of cobalt are owned by the **Democratic Republic of the Congo**[1]
- Of these 63%, **70% of cobalt mines** in the Democratic Republic of the Congo are owned by **China** that decided to only supply to Chinese refineries[2]
- In the EU, Belgium remains an important player in the cobalt industry, with the EU processing and refining **17%** of its cobalt in **Finland, Belgium, and France**[3]
- Demand for cobalt as a raw material is mainly driven by their usage in **Li-ion battery, fuel cells, wind energy, robotics, drones, 3D printing, and digital technologies**[3]
- The **demand for cobalt** has been **steadily rising** due to the growing popularity of electric vehicles (EVs), with cobalt being a fundamental component of the **cathode** material used in **Li-on batteries**[2]

FUTURE PROSPECTS

- The largest increase in cobalt demand is expected for usage in **consumption batteries, fuel cells, wind turbines and photovoltaics** in renewables and e-mobility. For 2030, an increase compared to 2020 demand of factor 5 is expected, for 2050 factor 14[2]
- By 2030, the cobalt demand for batteries will represent almost **60% of the current world supply**. However, this will decrease in 2050 to 40%, partly due to the shift toward more nickel-rich batteries

CHALLENGES & OPPORTUNITIES

- **Global competition** among OEMs, cell manufacturers and suppliers to secure access to cobalt is expected[1]
- Cobalt largest global supplier, the Democratic Republic of the Congo faces **high political instability** posing significant concerns to meet demand in the future. A high proportion (10-20%) of **artisanal and small-scale mining** in the country's output also poses important concerns for the future[1]
- Over the years the **supply risk** for cobalt increased, moving from a risk rating of 1.1 in 2011 to 2.8 in 2023[3]
- **Ethical mining** is a big challenge for Cobalt, even with initiatives like the Cobalt Working Council trying to tackle the issue. Ongoing efforts aim to address the significant hurdle of ethical mining in the Cobalt industry.

Sources: 1. Critical raw materials in technologies and sectors, European Union (2020); 2. CRMs for strategic technologies and sectors in the EU, European Union (2023); 3. Study on the critical raw materials for the EU, European Commission (2023)

ALLOCATION OF MATERIALS

Cobalt | Application and sector deep-dive

🟢 Low 🟡 Medium 🔴 High

Application	Cobalt Dependency			Sector Impact			
	Low -> High		*wt%*	*Renewable Energy*	*E-Mobility*	*ICT*	*Aero & Defence*
Battery material	■■■□□	Cobalt is used in the cathodes of almost all lithium-ion batteries. However, cobalt usage in batteries could potentially be replaced by nickel as nickel-based lithium-ion batteries have shown to have a higher energy density.	10% - 15%	🟡	🟡	🔴	🟡
Super alloy	■■■□□	Cobalt represents between 10 and 60% of materials needed for super alloy by weight and is crucial due to its energy density. However, some substitutes exist as well.	10% - 60%	🟢	🟢	🟢	🟡
Catalyst	■■□□□	Cobalt's unique properties are valued for enabling specific reactions and promoting chemical transformation. A very vast number of substitutes exist to replace cobalt as catalyst.	5% - 20%	🟢	🟡	🟢	🔴
Magnet	■□□□□	Cobalt has an excellent temperature stability while maintaining its magnetic properties in extreme temperature conditions. Substitutes are however available making the application less cobalt dependent.	10% - 30%	🟢	🟢	🟢	🟢
Pigment & ink	■■□□□	Known for their vibrant colours, cobalt-based pigments are also highly stable, not fading easily when exposed to lights. Even though these unique properties make it highly valuable, available substitutes exist.	10% - 40%	🟢	🟢	🟢	🟢

Key takeaways

- The rise in demand for electric vehicles led to a significant increase in the demand for cobalt. However, **potential substitutes** to cobalt exist (e.g., nickel, manganese, …) which could lead to cobalt-free batteries in the future, hence **reducing the demand.**
- While very valuable for different applications, it is worth noting that **concerns** also exist related to cobalt **environmental** as well as **ethical** aspects. Indeed, cobalt mining can potentially have some adverse environmental impacts and labour conditions in some mining operations are deemed not optimal.
- For this reason, in many of these applications, attempts are ongoing to reduce the cobalt consumption to move toward more **sustainable** and **ethical** materials.

Sources: 1. Statista (2023); Flow cobalt free and solid state whats the future of rechargeable batteries, IEF (2022)

Platinum | Availability and supply deep-dive

CURRENT AVAILABILITY

- Platinum **supply is limited**, total mine production in 2022 amounted to only 190 metric tons
- **South Africa** accounts for 71% of global production, **Russia** covers another 16%, and **Zimbabwe** produces 6% of global volumes. Each of these regions faces supply risks, like harsh weather conditions and political instability
- Demand is primarily fuelled by the **automotive sector**, where it serves as an **electrocatalyst** for both fuel cell cathodes and anodes present in fuel cell electric vehicles, plug-in hybrids, and conventional vehicles[1]
- Due to its unique characteristics including high melting point, electrical conductivity, and resistance to corrosion and oxidation, platinum is also used in **electronic-, innovative glass-, and medical applications**[3]

FUTURE PROSPECTS

- Future demand for platinum-group metal (PGM) will be mainly driven by **fuel cell energy storage systems (ESS)** and **fuel cell electric vehicles.** The latter requires 10 times more PGM relative to average gasoline or diesel vehicles[1]
- Compared to 2020, global platinum demand from all sectors is expected to be 18 times higher in 2030 and 90 times higher in 2050. Although there is a substantial increase in demand, shortages are not expected. Nevertheless, prices are likely to rise, as the projected global demand for 2050 is estimated to be 0.6 times the current global supply[2]

CHALLENGES & OPPORTUNITIES

- While platinum is recycled quite readily, improvements in **recycling** efficiency and costs can further reduce supply risks[2]
- R&D efforts are made to **reduce the use of platinum in its main application, fuel cells**. Since 2005, the **PGM intensities** in proton-exchange membrane fuel cells has decreased by 80%[1]
- Platinum can be **substituted partially or totally** with other precious metals such as palladium and ruthenium. However, the supply of these materials is also finite[1]

Sources: 1. Critical raw materials in technologies and sectors, European Union (2020); 2. CRMs for strategic technologies and sectors in the EU, European Union (2023); 3. Sources and uses of high-tech materials, NSW Government (2022)

Platinum| Application and sector deep-dive

🟢 Low 🟡 Medium 🔴 High

Application	Platinum Dependency			Sector Impact			
	Low -> High		*wt%*	*Renewable Energy*	*E-Mobility*	*ICT*	*Aero & Defence*
Fuel cells	■■■□□	Platinum is commonly used as a catalyst in fuel cells, accounting for ± 40% of the total cost of the cell[1]. Dependency can be reduced using low-platinum electrodes or using palladium as a substitute[2].	~1%	🟡	🔴	🟢	🟡
Industrial processes	■□□□□	Platinum serves as a catalyst in the production of nitric acid, a key component of fertiliser, and in the production of propylene, a key component for plastics and silicones[4].	0.1% - 5%	🟢	🟢	🟢	🟢
Special glass	■■■■□	Platinum's non-reaction with glass melts make it ideal for innovative glass applications like displays, camera lenses, and vaccine ampoules, as it neither discolours glass or alters its chemical composition[3].	~0.1%	🟡	🟡	🔴	🟡
Data storage & servers	■■■■■	Platinum is in the magnetic alloys used in hard disc drives (HDDs). It enhances thermal and magnetic stability and enables higher density storage. Modern HDDs could not exist without platinum[4].	~0.1%	🟡	🟡	🔴	🟡
Aerospace components	■■■■■	Platinum's alloys are used in the combustion chamber of space engines, enduring extreme heat and corrosion. Additionally, platinum-based coatings protect other space components[5].	>60%	🟢	🟢	🟢	🔴

Key takeaways

- For some applications in which platinum is used, such as fuel cells and industrial processes, alternatives to replace platinum partly or totally can be considered.
- However, for other applications including special glass, data storage and servers and aerospace components, platinum remains a preferred choice due to its unique properties.

Sources: 1. Current progress on hydrogen fuel cell vehicles, Aminudin (2023); 2. CRMs for strategic technologies and sectors in the EU, European Union (2023); 3. Platinum: indispensable for innovative glasses, Heraeus Group (2023); 4. Platinum industrial demand, CME group (2020); 5. Aerospace materials; Oxford – department of materials (2021).

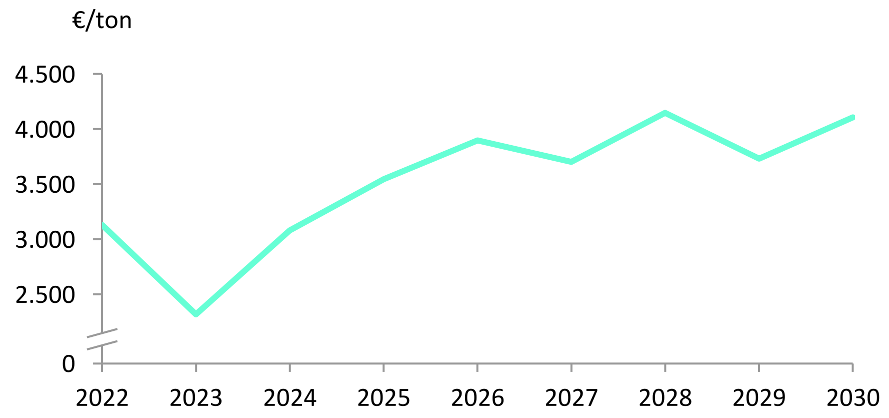
3 | *Economic impact forecast*

Applications at risk

Economic impact | Graphite and lithium heatmap

Material | **Price Forecast** | **Economical Impact Forecast**

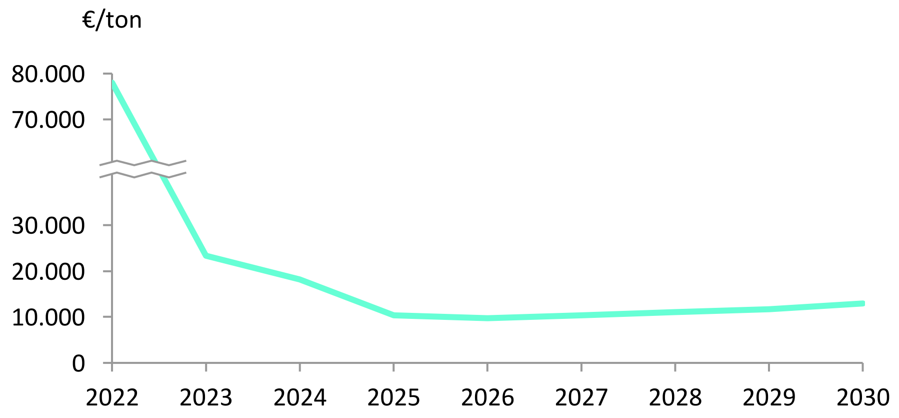
Graphite



Forecasted Graphite price (€/ton)

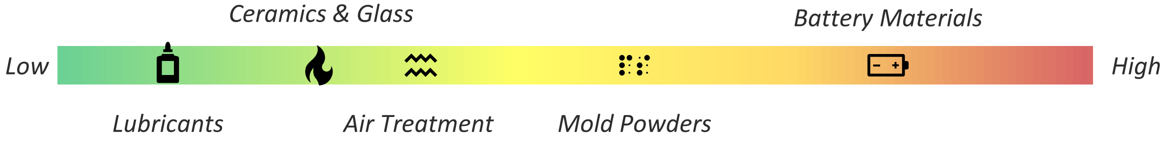
- A large **increase in graphite demand** is expected driven by the need for **battery** materials in the e-mobility sector. For 2030, an increase compared to 2020 demand of factor 12 is expected, for 2050 factor 21.
- The increasing demand combined with unstable supply conditions and increasing ESG regulations, will cause **graphite prices** to almost **double by 2030**.
- This price increase will not only affect the **e-mobility** sector as graphite makes up to 50% of the battery material but also the **aero and defence** industry which is highly dependent on the intrinsic graphite properties for its high-end applications for which viable substitutes are not yet available.

Lithium



Forecasted Lithium price (€/ton)

- As lithium is a key element in the production of battery materials, a large **increase in lithium demand** is expected driven by the booming e-mobility sector. For 2030, an increase compared to 2020 demand of factor 18 is expected, for 2050 factor 90.
- Lithium prices are now recovering after an exponential growth cycle due to the push of the e-mobility market. For the mid- and long-term, demand will increase but **prices** are expected to **stabilise** as mining companies will tighten investments in lithium and focus on a major lithium **recycling market**.
- As viable substitutes are available for other applications, it is expected that the supply and demand fluctuations of lithium will impact battery materials and the e-mobility sector the most.

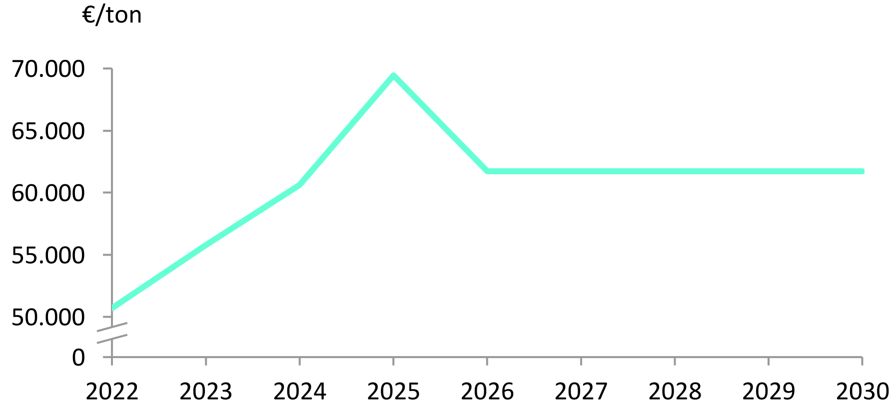


Source: 1. Graphite Market Outlook, Fastmarkets (2023) ; 2. Lithium Supply & Demand, Fastmarkets (2021)

Economical impact | Cobalt and platinum heatmap

Material | **Price Forecast** | **Economical Impact Forecast**

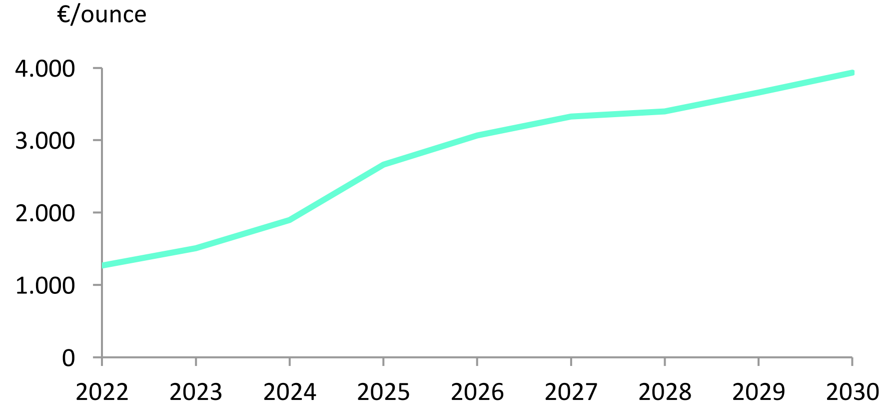
Cobalt



Forecasted Cobalt price (€/ton)

- The largest **increase in cobalt demand** is expected for usage in consumption batteries, fuel cells, wind turbines and photovoltaics in renewables and e-mobility. For 2030, an increase compared to 2020 demand of factor 5 is expected, for 2050, an increase with factor 14 is predicted.
- In the **short term** it is expected that supply risks, supply scarcity, and increasing demand will push the **cobalt price upwards**. In the **long term**, with the increasing focus on finding substitute materials and investing in more stable supply conditions, prices are expected to **stabilise**.
- Nevertheless, cobalt prices remain high and given the larger wt%, the highest impact is expected on **supper alloy applications**.

Platinum



Forecasted Platinum price (€/ounce)

- Future demand for platinum-group metal (PGM) will be mainly driven by fuel cell energy storage systems and fuel cell electric vehicles. Global **platinum demand** from all sectors is expected to be 18 times higher in 2030 and **90 times higher in 2050**.
- This increasing demand combined with limited supply due to resource scarcity will cause **platinum prices** to more than **triple by 2030**.
- This price increase will not only affect the **renewable energy** and **e-mobility** sectors as platinum is a key element in the production of fuel cells, but also the **ICT** and **aero and defence** industries which are highly dependent on the intrinsic graphite properties for their high-end applications for which viable substitutes are not yet available.

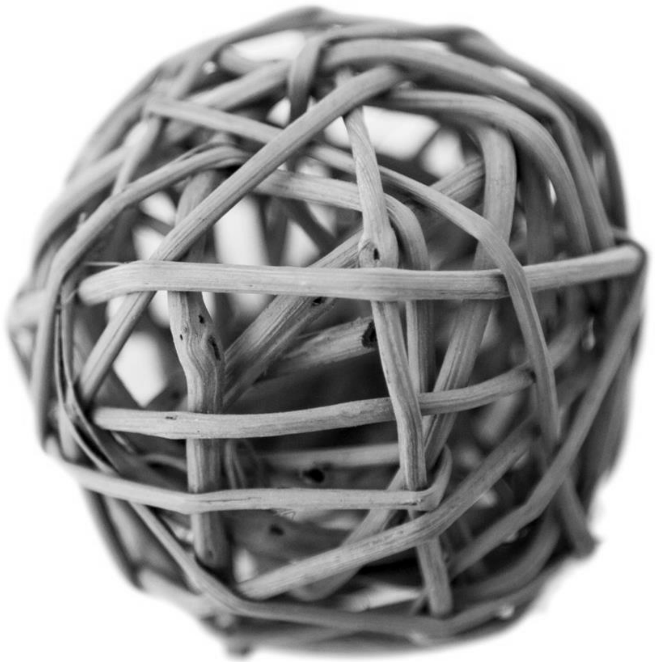
Source: 1. Cruxinvestor (2021) ; 2. Litefinance (2021)

4 | *Addressing resource scarcity*

Applications at risk

Mitigation levers to deal with supply risk

1	**Raw material sourcing diversification**	Seeking stability by expanding supplier bases based on geography, extraction origins, and supplier categories.
2	**Long-term contracts negotiation**	Securing stable supply at fixed prices to mitigate future risks from global competition and price instability.
3	**Recycling programme investment**	Investing in a programme focusing on material recovery from old products to reduce costs and energy, promoting sustainable production.
4	**Substitutes**	Exploring material alternatives to reduce one single material reliance and mitigate resource depletion, environmental damage, and supply chain disruptions while promoting sustainability.



DEEP-DIVE

Raw material sourcing diversification

To ensure a consistent and uninterrupted supply of materials, technology manufacturers should consider diversifying their sourcing in terms of geographic location, extraction methods, and supplier types.

Mitigation levers for each material and at-risk technology

	Graphite	**Lithium**	**Cobalt**	**Platinum**
	Battery materials *Fibre composite*	*Battery materials*	*Super alloy*	*Fuel cells* *Data storage & servers*
Geography	China, Japan, USA	Latin America, USA, Australia	Congo, USA, Canada, Australia	South Africa, Russia, Zimbabwe, Canada, USA
Extraction	Polyacrylonitrile (PAN), rayon, petroleum pitch	Brine deposits in salt flats, pegmatite deposits, volcanic clay deposits	Underground and surface mining, CO and NI hydro-metallurgical and pyrometallurgical	Mineral cooperite, or from copper and nickel refining
Supplier	Custom and industrial manufacturers, distributors, service companies	M&A, national lithium companies, multinationals, startups	Artisanal small and large-scale mining companies, recycling fed	World Platinum Investment Council, manufacturer, producer, service provider

Use case

Tesla is securing its battery production by establishing partnerships globally:

- Currently, Tesla relies on Ganfeng Lithium, the largest lithium supplier in China
- But to ensure an uninterrupted supply, they are in talks with Sigma, a Brazilian start-up, granted a mining license by the Environmental Authority of the State of Minas Gerais
- Tesla, traditionally partnered with Panasonic, explores new suppliers due to trade tensions
- It acquired Maxwell Technologies to advance battery technology beyond its current partnership with Panasonic, extending its capabilities

Sources: 1. Cobalt Institute (2023); 2. Lithium Extraction & Industrialization, ECLAC (2023); 3. Navigating the special Graphite market, Tech News and Update (2023); 4. Sources of Platinum, Specialty Metals (2023).

DEEP-DIVE

Negotiate long-term contracts

Securing long-term contracts with suppliers ensures a stable supply at a fixed price over a longer time horizon, offering vital protection against future supply risks and price fluctuations, particularly in anticipation of surging raw material demand in the coming years.

Mitigation levers for each material and at-risk technology

Graphite

Battery materials

Fibre composite

Lithium

Battery materials

Cobalt

Super alloy

Platinum

Fuel cells

Data storage & servers

- It is essential to partner with suppliers to share supply-chain risk by using fixed, long-term contracts[1].
- Forward contracts (type of hedging strategy) is another option to reduce the risk exposure to fluctuations in raw material prices and guarantee supply. It manages residual risk and risk of default[2].
- Members of the European Parliament have also stressed the importance of nations securing long-term strategic partnerships to facilitate knowledge and technology transfer for mutual benefits[3].
- A risk sharing agreement between the buyer and the supplier would help mitigate risks in the long-term contract and ensure to compensate one another in the event of loss or disruption.

Use case

Electra and LG Energy Solution sign a three-year cobalt supply agreement:

- › Electra will supply LGES with 7,000 tons of battery grade cobalt between 2023-2025 under an agreed pricing mechanism
- › Partnership with an aim to secure a key raw material supply chain in the region for LGES, with a focus on the growing EV market
- › Further ensures steady delivery of LGES products, advancing global transition to EVs and ultimately to a sustainable future

Sources: 1. Hedging Techniques for Critical Minerals, UNCTAD (2023); 2. Electra and LG Energy Solution Sign Three-year Cobalt Supply Agreement, PR Newswire (2022); 4.

DEEP-DIVE

Invest in recycling programmes

Cobalt and platinum recycling is growing, creating an excess of usable materials, while lithium and graphite recycling is promising. Partnering with recycling firms eases sustainability concerns and improves access to these materials.

Mitigation levers for each material and at-risk technology

Graphite	**Lithium**	**Cobalt**	**Platinum**
Battery materials *Fibre composite*	*Battery materials*	*Super alloy*	*Fuel cells* *Data storage & servers*
Starting to recycle	Companies are further developing lithium recycling methods	22% of total supply comes from recycling	25% of total supply comes from recycling
Recycling graphite into dust and solid chunks is starting due to the necessity of multiunit operations, high energy consumption, and financial burdens to start recycling.	Lithium is mainly used in batteries and recycling occurs mostly from the black mass of these li-ion batteries. Recycling from other dissipative applications such as greases is unfortunately not possible.	Most cobalt is recovered from production processes of applications such as hard metals or Li-ion rechargeable batteries. Cobalt can also be recovered from end-of-life products but those are now recycled in a lower proportion.	Most of the recycling volumes come from spent automotive catalysts, old jewellery and electronics. In addition to end-of-life recycling, significant volumes of platinum are used in closed-loop production processes.

Use case

Industry-leading innovation paves new path for key recycled metals in batteries, magnets, and circuit boards:

- Apple has significantly expanded the use of 100 percent certified recycled cobalt over the past three years, making it possible to include in all Apple-designed batteries by 2025. In 2022, a quarter of all cobalt found in Apple products came from recycled material, up from 13 percent the previous year.

BMW is building hydrogen fuel cell cars with recycled platinum:

- Platinum acts as a catalyst in electricity generation in hydrogen fuel cell cars. To produce one fuel-cell stack BMW iX5, the platinum from the catalytic converters of two retired ICE cars are needed.

Sources: 1. Cobalt in iPhones, Apple (2023); 2.Hydrogen cars, BMW (2023); 3. Recycled Graphite, Iop Science (2023); 4. Lithium Recycling, arsTechnica (2023); 5. Material System Analysis of 5 battery-related materials, European Commission (2020); 6. Battery recycling for cobalt and lithium, S&P Global (2021); 7. Platinum recycling, CME Group (2023)

DEEP-DIVE

Raw material substitutes

In the battery market, manufacturers are actively exploring alternative materials to replace critical components. However, the viability and commercialization of these alternatives requires further research.

Mitigation levers for each material and at-risk technology

	Graphite	**Lithium**	**Cobalt**	**Platinum**
				
	Battery materials	*Battery materials*	*Battery materials*	*Fuel cells*
Substitute	Silicon *	Sodium* Magnesium*	Manganese* Nickel* Seawater*	Iron* Nickel*
Expected timeline	Starting as of 2025, companies are expected to be using silicon as a substitute material in batteries.	By 2030, sodium and magnesium-ion batteries could account for 23% of the stationary storage market.	A 6% share of the battery market is forecasted for nickel manganese batteries in 2030.	Replacement of platinum in fuel cells is still in early research phase. Currently no reliable timeline can be set.

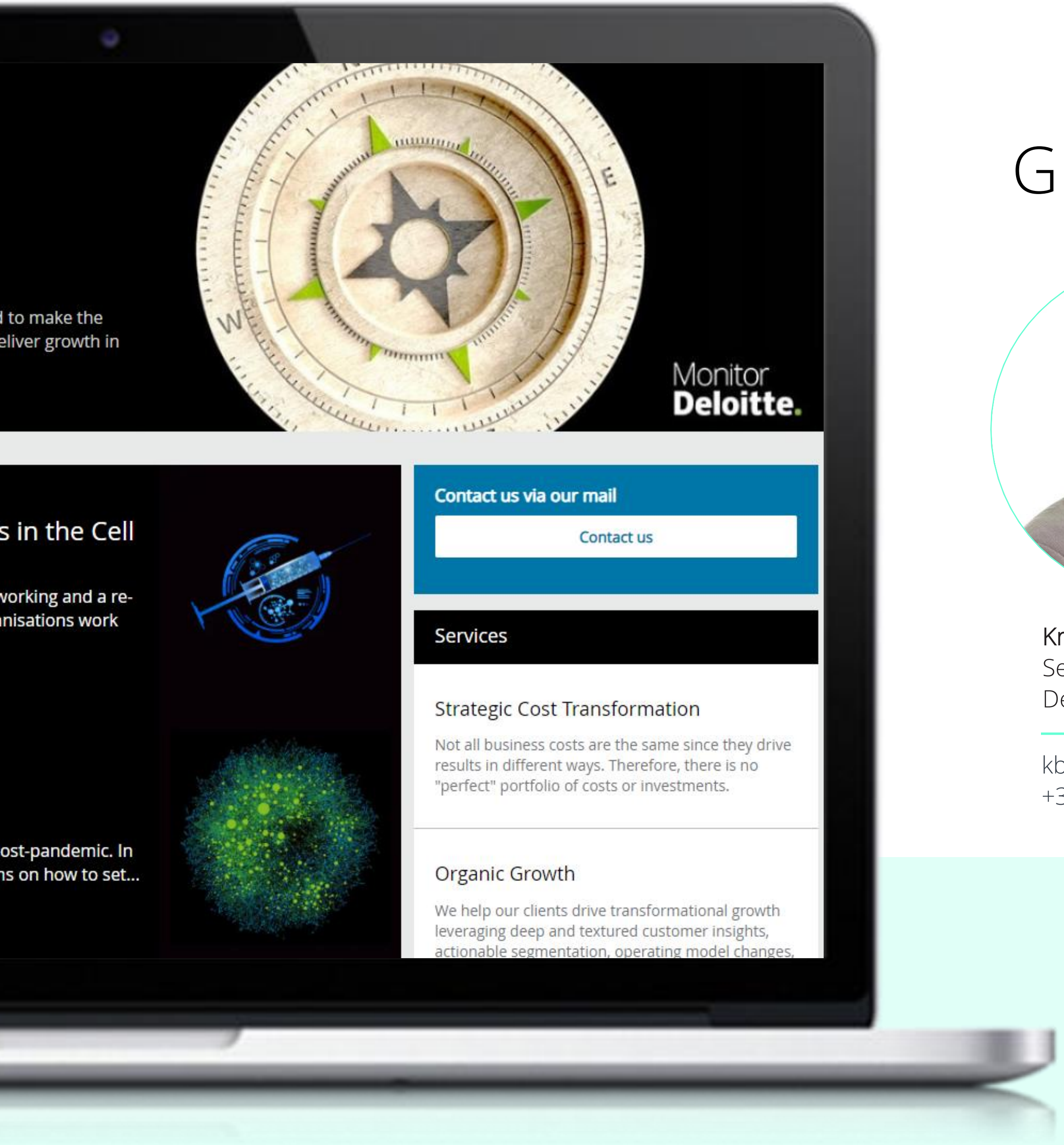
**In research phase*

Use case

IBM has created a battery design that uses materials extracted from seawater:

- › The expansion of the EV market will result in shortages of cobalt, mainly found in the DRC
- › Therefore, top battery makers scramble to reduce cobalt content in lithium-ion batteries
- › IBM has partnered wit the research wing of **Mercedes-Benz**, battery electrolyte supplier **Central Glass,** and battery manufacturer **Sidus Energy** for the commercial development of the new design

Sources: 1. IBM heft ontwerp voor battery zonder kobalt, Knack (2019), 2. New silicon anodes could help EV batteries go farther, charge faster, Reuters (2023), 3. Sodium-ion batteries: the revolution in renewable energy storage, Iberdrola (2023), 4. 6 crucial metals for the future of fuel cells, Horizon Education (2023) 5. Researchers eye manganese as key to safer, cheaper lithium-ion batteries, Argonne National Laboratory (2020), 6. UC Irvine scientists create long-lasting, cobalt-free, lithium-ion batteries, UCI News (2023)



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Strategic Cost Transformation

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