PROSESS21

Critical and Strategic Raw Materials in Norway:
Positions and Potentials

PROSESS21

Purpose of this report

The purpose of this report is to provide a knowledge-based and coherent picture of Norway's role in value chains for critical and strategic raw materials. The report has been prepared as part of the follow-up to *White Paper No*. 16 (2024–2025) – *Industry: competitiveness for a new era*, in which it was decided to carry out a comprehensive mapping of Norwegian industry's role in national and allied strategic value chains.

The background for the work is a changing geopolitical and market landscape in which critical raw materials are increasingly positioned at the intersection of industrial, energy and security policy. Access to such materials is no longer solely a matter of cost-efficient trade, but also of security of supply, strategic autonomy and resilience in the face of vulnerabilities in global value chains. At the same time, global value flows are continuously affected by ongoing geopolitical developments. The conflict in the Middle East and developments in and around the Strait of Hormuz, for example, have implications not only for oil and gas markets, but also for exports of aluminium, mineral fertilisers and sulphuric acid from the region. Such dynamic conditions are described in this report.

The report takes a value chain perspective and maps Norway's position from geological resources and mineral extraction through to process industry and further processing of materials. The analysis builds on established international frameworks, including assessments from the EU, the United States, NATO and other allied countries regarding critical and strategic raw materials, and seeks to highlight how Norwegian resources and industrial capabilities are integrated into these value chains.

The main emphasis is placed on upstream and midstream activities, including geology, mineral extraction and process industry, where Norway currently has identifiable potential and established positions. Deliveries in downstream segments are discussed but are not included in the detailed mapping. The report therefore does not provide a full analysis of demand in end-use markets, but rather a structured overview of where Norway participates in value chains for critical and strategic raw materials, and how these activities affect security of supply and value creation for allied countries.

The objective is to establish an initial, shared knowledge base that can be used by authorities, industry and research environments in further work. The report aims to identify areas where Norway has strategic importance, provide a basis for vulnerability assessments, and indicate where further analyses, prioritisation and policy development are needed. It does not provide normative recommendations, but rather facilitates more targeted assessments of measures, policy instruments and strategic choices in follow-up work.

Executive summary for decision-makers

Why this is urgent – from industrial policy to security policy

Recent global developments have made it clear that access to critical and strategic raw materials is no longer primarily a question of markets and costs, but increasingly a matter of geopolitics, security and industrial resilience. Growing rivalry, the regionalisation of trade and the more active use of industrial policy instruments have changed the way value chains operate. At the same time, the energy transition, digitalisation and evolving security landscape are driving strong demand for a limited set of input factors.

Production, and in particular processing, of many of these materials is currently highly concentrated, with China as the dominant actor in several critical value chains. This creates structural vulnerabilities, which are further reinforced by the increased use of export restrictions, market interventions and state measures to secure national interests. In recent years, this has led to a clear policy shift in the EU, the United States, the United Kingdom and NATO, where critical raw materials have moved to the core of industrial and security policy.

Through the *Critical Raw Materials Act* (CRMA), the EU has established concrete targets for extraction, processing and recycling, while similar initiatives in the United States and among G7 countries point towards a more active use of market governance, including price floors, long-term agreements and public financing. Criticality is therefore no longer assessed solely based on raw material availability, but across the entire value chain, particularly in relation to processing stages, market power and geopolitical exposure.

This represents a fundamental shift. In a more fragmented and geopolitically shaped system, it is no longer sufficient to rely on imports from the most cost-efficient suppliers at any given time. Alignment with allied markets and integration into strategically prioritised value chains is becoming increasingly important, both for Norwegian industry's market access and for Norway's role as a partner to the EU, the United States and NATO.

Criticality in value chains – the link between technology and raw materials

In this context, it is essential to understand the relationship between critical and strategic value chains and critical raw materials. Value chains cannot function without access to materials with specific properties, and criticality arises only when materials are embedded in concrete technologies and industrial applications. A key point is that criticality is only to a limited extent about geology, and much more about the ability and willingness to extract, process and supply materials with the quality required for a given value chain.

This is particularly evident in the context of sensitive technologies, where a wide range of technologies considered critical to national security, from semiconductors to energy technologies and defence applications, depend on a set of critical raw materials. This underlines that access to raw materials is a prerequisite for technological and industrial development.

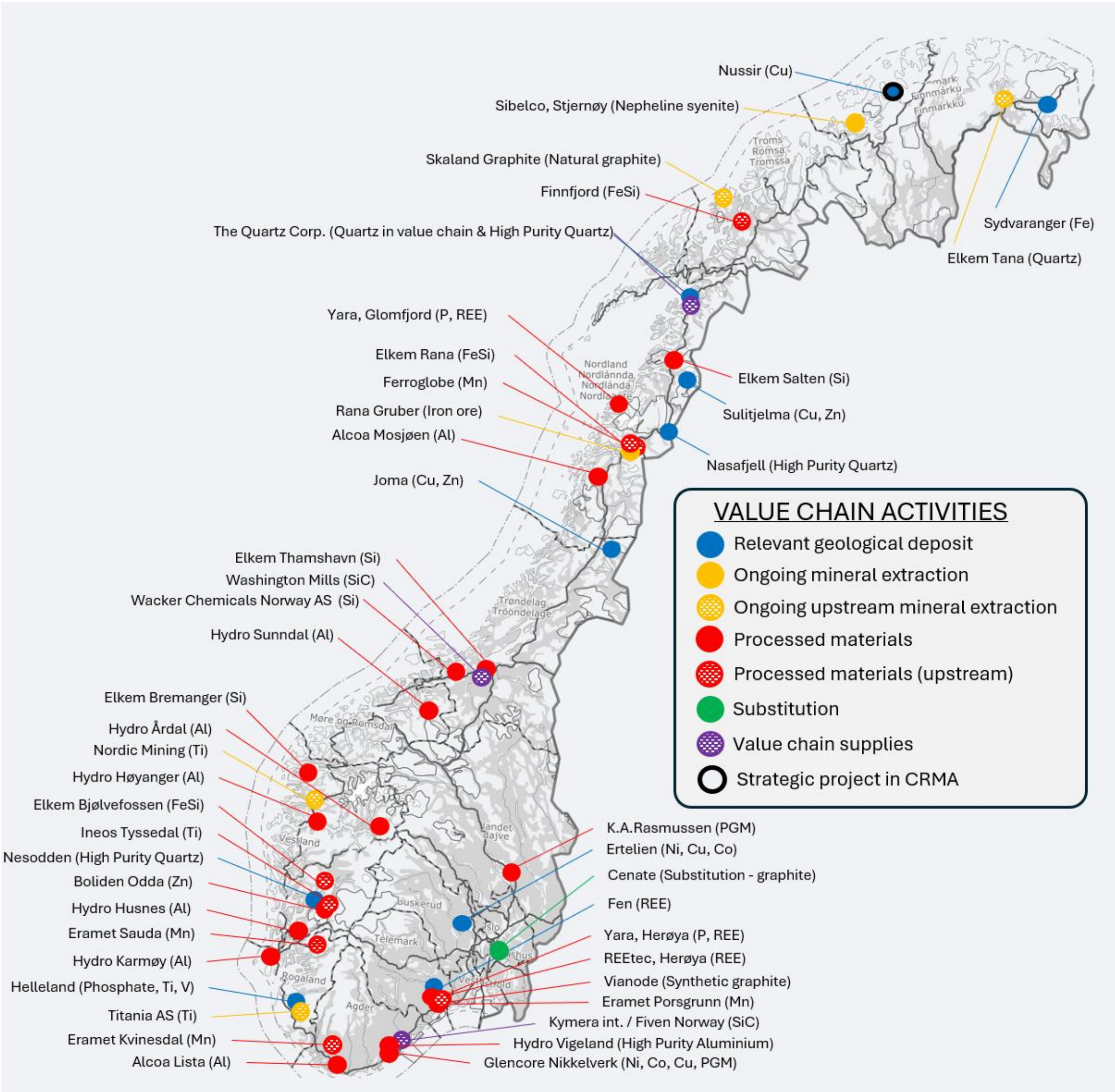
Norway's raw material base for critical and strategic value chains

The mapping conducted in this report is therefore based on Norway's role in the early stages of value chains. The analysis draws on the lists of critical raw materials developed by the EU, the United States, the United Kingdom and NATO and includes relevant geology, ongoing mineral extraction and processed materials from an established process industry, as well as how these activities are integrated into European and global value chains.

The mapping identifies seven (7) geological deposits of relevance to critical and strategic raw materials, five (5) ongoing mining operations that already supply input materials, and 17 process industry companies that either produce critical raw materials, supply inputs to critical value chains or develop materials that function as substitutes.

Norwegian positions in critical value chains – from geological potential to industrial value creation

A key finding is that Norway, particularly in interaction with Sweden and Finland, has a substantial geological resource base with potential for future extraction of critical and strategic raw materials. Several of these deposits are relevant within EU frameworks, and in 2025 the EU designated the copper project in Finnmark, Nussir, now operated by Blue Moon Metals, as a strategic project. These geological potentials represent important building blocks for the development of future European value chains. However, realisation lies in the medium to long term and depends on framework conditions, access to capital and execution capacity.



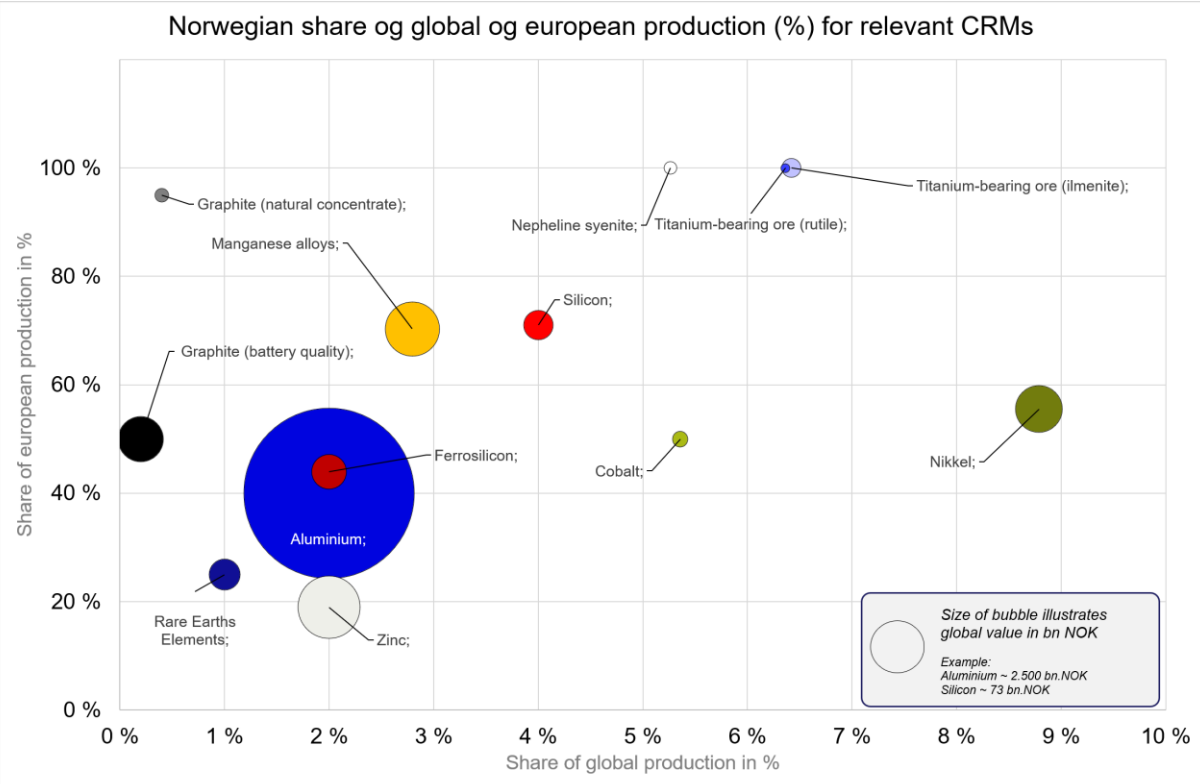
Current mineral extraction of critical raw materials has a more limited economic scale but is nonetheless of strategic importance. For several raw materials, Norwegian activity represents wholly or partially unique production capacity in a European context. This applies to titanium-bearing ores, nepheline syenite and natural graphite, where there are otherwise few or no alternative suppliers in Europe.

The most significant Norwegian position today is found in the process industry, where most of the value creation takes place. Here, materials are produced with properties that confer strategic importance in value chains, based primarily on imported raw materials and, to a lesser extent, on mineral extraction in Norway. This is also reflected in export values for critical raw materials, where the process industry accounts for close to NOK 100 billion compared to approximately NOK 3.5 billion for the mineral industry. Norwegian process industry, including the production of aluminium, nickel, silicon, ferroalloys and specialised materials, holds significant market shares in Europe and plays a central role in supplying allied value chains. At the same time, the industry is largely dependent on imported raw materials, resulting in a complex risk profile. Norway contributes to reducing vulnerability in downstream processing stages, while at the same time being exposed to global supply conditions.

Future value creation will increasingly depend on the ability to view geology, mineral extraction and material processing as one integrated value chain. While geological resources and mineral extraction form the foundation, value increases significantly as materials are further processed into more specialised products further downstream. This requires the availability of relevant technology, expertise and industrial environments capable of developing and producing such materials. This underlines the importance of further developing the existing process industry and strengthening the integration between upstream and downstream activities as a key basis for increased value creation and strategic relevance.

Norway's market position – strong in Europe, competing globally

Norway's relative market position in selected materials is illustrated in the figure below. The figure combines Norwegian actors' share of global production (x-axis), share of European production (y-axis), and the global market value of the materials and products (bubble size). Market shares are calculated within segments of comparable products and quality categories.



The figure shows that Norwegian companies are engaged in activities where, in certain cases, Norway is the only country in Europe with significant mineral extraction. This applies to titanium-bearing ores such as ilmenite and rutile, as well as nepheline syenite. These positions are primarily based on geological conditions and represent natural competitive advantages. At the same time, these are examples of global commodity flows, where demand is only to a limited extent linked to national or continental consumption. The minerals are largely exported to international markets, and the competitive landscape is therefore determined by global conditions.

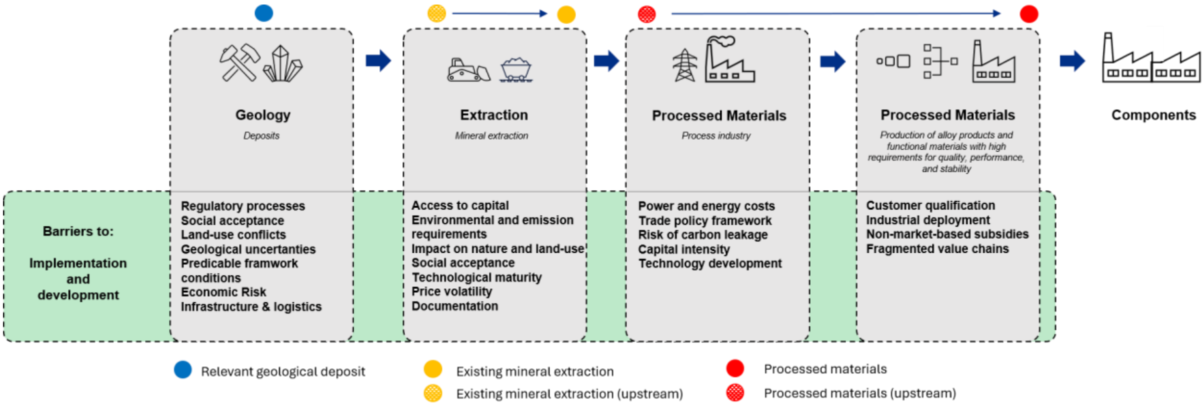
For the process industry, the figure clearly illustrates how dominant the market value of aluminium is compared with other activities where Norwegian actors have a position. This is reflected in the largest bubble in the figure, where aluminium represents a global market value of approximately NOK 2,500 billion. Norway accounts for around 40 percent of European production capacity and 2 percent of global capacity. At the same time, the figure shows that Norway holds significant shares of European production capacity for several materials, including manganese alloys at 70 percent, silicon at 68 percent, nickel at 56 percent and cobalt at 50 percent, where Norwegian actors constitute a substantial share of total European capacity. Norwegian nickel production also represents a significant share of global production at around 9 percent. For other materials, Norway's share of global capacity is generally moderate. This implies that Norwegian production units are important in a European context but operate in markets where competition is largely shaped by global capacity, cost levels and framework conditions. For zinc, Norway is also a significant actor with around 25 percent of European production capacity, although production capacity is more widely distributed across several European countries, resulting in a more diversified competitive landscape.

The figure also shows that Norway holds relevant positions in both natural graphite concentrates and synthetic graphite of battery grade, as well as in processing stages for rare earth elements. However, installed capacity in

Europe remains limited, and although Norwegian actors hold significant market shares in a European context, overall European activity remains relatively constrained.

Barriers across the value chain – from permitting to market

The analysis identifies several structural barriers that constrain development. In the early phase, long and complex permitting processes, land-use conflicts and social acceptance are decisive for whether mineral projects can be realised. In the development phase, access to capital and risk sharing are key challenges, particularly for capital-intensive projects with long-term horizons. In the process industry, competitiveness is increasingly linked to power prices, trade policy conditions and access to markets, while downstream segments face barriers related to qualification, technology scale-up and fragmented value chains.



A common feature of these barriers is that they vary across the value chain and, taken together, affect the ability to develop coherent and robust value chains in Norway. This implies that measures should not be directed at individual stages in isolation but must be considered in an integrated manner.

Opportunities and the way forward – the need for integration and coordination

The mapping also points to significant development potential. Norway has a strong starting point, based on relevant geology, an established process industry, access to renewable energy and a high level of technological competence. Further development of existing industry, stronger integration between upstream and downstream activities, and increased utilisation of side streams and secondary resources emerge as key opportunities. At the same time, the geopolitical shift implies that alignment with allied value chains and frameworks is increasingly decisive for market access and investment decisions.

Considering the EU's *Critical Raw Materials Act* (CRMA) and similar initiatives among allied countries, this implies that Norway must strengthen its ability to participate in and contribute to common European and allied structures. The ability to develop and link national capacities to such value chains will be decisive for Norway's future role. In this context, industrial diplomacy and strategic partnerships also take on greater importance, both for securing access to raw materials and for positioning Norwegian actors in prioritised value chains. Existing and future partnership agreements should therefore increasingly be filled with concrete content related to projects, technology development, investment and long-term supply, and be followed up through active participation in relevant international fora and bilateral cooperation.

Finally, the analysis highlights the need for a more integrated approach to the development of critical and strategic raw materials in Norway. The mapping reinforces the need to develop an integrated competence ecosystem that connects geology, industry, research and policy instruments. Such an ecosystem should cover the entire value chain, from resource mapping to finished material products and circular solutions, and be developed through close collaboration between industry, authorities and research and innovation environments. At the same time, it is important to emphasise that increased funding for research and participation in European programmes alone is not sufficient. The development of critical and strategic raw material value chains increasingly requires a more active and coordinated industrial policy approach.

Overall, the report shows that Norway's strategic importance does not primarily lie in individual deposits, but in the ability to develop and strengthen positions within value chains. This provides a basis for strengthening value creation, security of supply and industrial development in a more geopolitical and competitive landscape.

Contents

1. Introduction

The Government has, in *White Paper No. 16 (2024–2025) – Industry: competitiveness for a new era*, decided to carry out **a comprehensive mapping of Norwegian industry's role in national and allied strategic and critical value chains**. The objective of the mapping is to provide a stronger basis for decision-making in a context where security of supply, geopolitical developments and international dependencies increasingly affect industrial competitiveness, preparedness and the capacity for transformation.[1]

The mapping also supports broader efforts to strengthen national preparedness and security and reflects a shared recognition of the need for increased strategic autonomy and resilience in response to a more unpredictable geopolitical landscape. While industry bears the primary responsibility for identifying and managing risks in its own supply chains, public authorities play a key role in facilitating systematic insight, coordination and a coherent overview across sectors and levels of governance. A structured mapping provides a necessary foundation for more targeted policy instruments, stronger cooperation with allies and improved national crisis preparedness.

In its communication, the Ministry of Trade, Industry and Fisheries emphasises the need for a clearer overview of Norwegian capacities and vulnerabilities, both as a supplier of raw materials and processed materials and as part of allied value chains.[2] This project provides an initial, knowledge-based foundation that can be used to assess the need for further analyses and deeper studies, including which parts of the value chains should be examined in more detail considering market and geopolitical developments.

The relevance from a security policy perspective is also underlined in the National Security Strategy, where access to industrial production capacity and critical raw materials is highlighted as important for both Norway and Europe. The strategy emphasises that Norwegian industrial clusters and competence environments constitute important contributions to both national and allied security, and that Norway should contribute where it has strengths. A strong industrial base, including oil and gas, process industry, maritime industry and defence-related sectors, is therefore considered essential to meet both national and allied needs.[3]

The work has been carried out by Prosess21 in cooperation with the Research Council of Norway and the Geological Survey of Norway (NGU). The project builds on NGU's mapping of mineral resources and geological conditions and on Prosess21's knowledge of industry and value chains. Together, this provides an initial, high-level and knowledge-based overview of Norwegian activities in value chains for critical and strategic raw materials, with emphasis on geology and deposits, mineral extraction, processing and relevant export markets.

The work also forms part of the Research Council's follow-up of the Government's mineral strategy. The mandate from the Ministry of Trade, Industry and Fisheries specifies that the Research Council is to follow up the measures in the strategy, including recommendations from its June 2025 report on future R&D investments in land-based minerals. This work is carried out in dialogue with the Ministry and is intended to contribute to a coherent and knowledge-based basis for further policy development.[4]

The task of carrying out *a comprehensive mapping of Norwegian industry's role in strategic and critical value chains, both nationally and in cooperation with allies*, is inherently wide-ranging. While the broad formulation allows for different analytical approaches, the requirement that the work be *seen in the context of corresponding initiatives in the EU and other relevant countries* provides a clearer direction.

To operationalise the mandate, it is necessary to clarify what is considered critical and strategic in a Norwegian context. This implies moving from a broad value chain perspective towards a more targeted assessment of which raw materials and processes are essential for national security of supply, industrial development and geopolitical resilience. Criticality should be understood considering both access to raw materials from reliable trading partners and the ability to process and supply these materials within a reasonable timeframe. The existence of deposits alone is not sufficient; industrial capacity and regulatory conditions that enable realisation are also required. Furthermore, the assessment must cover the entire life cycle of materials, including recycling and market access, particularly considering Norway's position outside the EU's customs union. This requires a comprehensive

[1] Meld. St. 16 (2024–2025) - regjeringen.no

[2] Starter kartlegging av strategiske og kritiske verdikjeder - regjeringen.no

[3] Nasjonal sikkerhetsstrategi - regjeringen.no

[4] Norges forskningsråd - tildelingsbrev for 2026

approach in which raw material supply, processing, recycling, substitution and trade policy are viewed in an integrated manner, and where Norway's strategic partnerships are assessed against actual delivery capacity and market access.

In positioning Norway within this landscape, it is natural to consider its most important market. The EU has developed a framework for critical and strategic raw materials aimed at securing access to materials essential for the green transition, digital development and defence preparedness. The framework seeks to reduce dependence on individual countries and insecure suppliers, including through the strengthening of European raw material production and the promotion of investment in sustainable value chains. The European Commission is expected to update its list of critical and strategic raw materials no later than early 2027.[5]

While vulnerabilities in supply chains have received increasing attention in analyses of the Norwegian economy, they have not been a primary focus of this report, which is centred on Norway's positions and potential within value chains. Nonetheless, such analyses provide an important backdrop for understanding the significance of the industrial activities described.

An analysis by Statistics Norway indicates that Norway's imports of intermediate goods are characterised by relatively high vulnerability, partly due to limited substitution capacity and significant exposure to suppliers outside Europe. The most important intermediate inputs in this context include raw materials and feedstocks for the process industry, such as nickel matte, alumina, manganese ore, acyclic hydrocarbons, electrodes and coal. These are largely used in metallurgical and petrochemical industries and correspond to the material streams and value chains described for Norwegian actors in Appendices 8.1–8.3. The analysis therefore highlights not only a potential vulnerability, but also the strategic importance of the Norwegian process industry as a processor of such inputs.[6]

[5] Dialog med EU kommisjonen ved DG Grow

[6] Høy sårbarhet i Norges import av innsatsvarer – SSB

2. Industrial policy context

Critical and strategic raw materials have in recent years assumed an increasingly central role in both industrial and security policy. This is because such materials constitute fundamental inputs in a range of technologies and value chains that are crucial to energy transition, digitalisation, defence and economic development. Metals such as copper, lithium, aluminium, nickel and graphite are indispensable for batteries, electricity grids and renewable energy generation, while materials such as gallium, germanium and high-purity silicon are critical for semiconductors, artificial intelligence and data centres. At the same time, materials such as titanium and tungsten play a decisive role in defence and aerospace applications. This broad range of applications explains why critical raw materials now lie at the intersection of technology, industry and geopolitics.

At the same time, developments in recent years have made it clear that the challenges associated with critical raw materials are not primarily about a lack of resources in the geological sense, but about how these resources are embedded in global value chains. Production of many of these materials is highly concentrated, particularly in the processing and refining stages, where a small number of countries control a large share of capacity. This concentration has increased over time and means that raw materials extracted in many different regions are transported to a limited number of countries for further processing. This gives rise to structural vulnerabilities in supply chains.

The high degree of concentration has concrete implications for both industry and society. Disruptions in production or trade, whether resulting from technical problems, natural events or political measures such as export restrictions, can quickly have consequences far beyond the individual material concerned. Since critical raw materials are embedded in key technologies, such disruptions may affect everything from the expansion of renewable energy and electrification to the production of technology and defence equipment. Risks related to security of supply have therefore become an integral part of the assessment of industrial competitiveness and national preparedness.

At the same time, demand for critical raw materials has increased significantly because of the energy transition and other technological development. New technologies are generally more material-intensive than those they replace. Electric vehicles require substantially more minerals than conventional cars, and renewable energy technologies such as wind power and solar panels involve far higher material consumption per unit of energy produced than fossil alternatives. This intensifies pressure on existing value chains and increases the need for new investment in both extraction and processing.

In this context, investment capacity and the pace of implementation emerge as decisive factors. Significant resource bases exist globally, but the central challenge is to bring these resources to market through investment in projects that are technically, economically and politically viable. This means that the analysis of critical raw materials cannot be limited to geology or market data alone but must include the entire value chain – from the resource base to processing, market access and in a geopolitical context.

Chapter 2 provides such an overarching backdrop. It describes how global drivers, market structure and policy developments shape access to critical and strategic raw materials, and how these factors together help define what is critical in today's value chains.

2.1 Geopolitical developments and the significance of critical raw materials

Europe faces a more acute geopolitical and industrial landscape, marked by increasing rivalry, economic uncertainty, regionalisation and trade conflicts that challenge both established trading systems and industrial resilience. At the same time, the EU maintains high climate ambitions and has made emission reductions a central part of its economic and industrial strategy. In March 2026, the EU adopted a new legally binding climate target for 2040, setting out that net greenhouse gas emissions are to be reduced by 90 percent compared with 1990 levels, as an important intermediate milestone on the path towards climate neutrality by 2050. The target is intended to provide greater predictability for industry and investors, but at the same time entails a rapid and far-reaching transformation of Europe's energy and industrial systems.[7]

Achieving these climate targets will require a significant increase in renewable energy production, the electrification of industry and transport, and the rapid deployment of new energy and climate technologies. This development has

[7] 2040 climate target: Council gives final green light - Consilium

already led to growing dependence on a limited set of technologies and value chains, including solar and wind power, batteries and power electronics. Today, large parts of these value chains are globally dominated by China, both in terms of production capacity, processing of input materials and control over key technology components. For Europe, this means that the climate transition is not only a question of pace and costs, but also of security of supply, strategic autonomy and vulnerability in the face of geopolitical tensions.

Over the past 25 years, China has built a dominant position in global industrial and raw material value chains through long-term state coordination, targeted industrial policy and large-scale investment. This strategy has focused particularly on processing and refining, where strategic control is greatest. As a result, China has acquired very high market shares in the processing of several critical raw materials, including graphite, rare earth elements, magnesium, lithium and cobalt.

This concentration, reinforced by large production volumes and investments in key processing stages, is making it increasingly difficult for European producers to compete for new technology and markets. The result is greater investment uncertainty in Europe, a pattern that was clearly visible in the solar cell industry 10–15 years ago and which is now increasingly affecting, for example, battery value chains.

China remains the most challenging counterpart in US trade policy. At the Trump–Xi meeting in Busan on 30 October 2025, the parties agreed a one-year trade truce, under which China suspended export controls on rare earth elements and the United States reduced certain tariffs. In the days that followed, Chinese authorities confirmed that export duties, some tariffs and other restrictive measures would also be halted for one year. In February 2026, the US Supreme Court ruled that President Trump had exceeded his authority by using the IEEPA[8] as the legal basis for the extensive “Liberation Day” tariffs. The Court concluded that the IEEPA does not authorise the President to impose tariffs, as this power rests with Congress under the Constitution.[9] The IEEPA-based tariffs were therefore invalidated. At the same time, the administration made clear that future trade measures would be anchored in other parts of US trade legislation.[10] Overall, the relationship is characterised by temporary de-escalation, continued structural rivalry, and a legal intervention that limits the United States’ use of emergency legislation to impose global tariffs.

In 2025, the G7 countries launched the *G7 Critical Minerals Action Plan*, a common framework developed under the 2023 and 2024 presidencies and formally adopted on 17 June 2025. Later the same year, the G7 followed up with the *Roadmap to Promote Standards-based Markets for Critical Minerals*. In the document, the G7 emphasises that non-market practices create significant risks for critical mineral value chains by reducing investment, increasing price volatility, impeding diversification and undermining both economic and security interests. The roadmap marks a shift towards more active market governance and states that the G7 countries will use “the tools at our disposal” to counter such practices. These include public procurement, tax measures, financial incentives, investment policy, trade-related measures and, where appropriate, the establishment of price floors or other mechanisms to support the development of robust and traceable markets for critical raw materials. Overall, the roadmap means that the G7 commits to a new and more active approach in which the market frameworks for critical raw materials are restructured to promote responsible production, strengthened traceability and increased investment in alternative, resilient global value chains.[11]

In 2026, the issue gained further prominence through a US initiative to shift the focus from the established *Mineral Security Partnership* (MSP) to a new and more politically anchored structure. At the Critical Minerals Ministerial on 4 February 2026, the United States launched the *Forum on Resource Geostrategic Engagement* (FORGE) as the successor to the MSP. The launch was accompanied by announcements of new bilateral agreements, financing mechanisms and measures for strategic stockpiling.[12] At the same event, the United States, the EU and Japan also issued a joint statement marking a shift towards closer coordination of policy, investment and market mechanisms in critical raw material value chains.[13] Coordination between the EU and the United States was formalised through a memorandum of understanding (MoU) signed in April 2026. The agreement covers the entire critical minerals

8 International Emergency Economic Powers Act

9 24-1287 Learning Resources, Inc. v. Trump (02/20/2026)

10 Ending Certain Tariff Actions – The White House

11 https://www.canada.ca/en/natural-resources-canada/news/2025/10/roadmap-to-promote-standards-based-markets-for-critical-minerals.html

12 2026 Critical Minerals Ministerial - United States Department of State

13 Joint press statement following February 4 Critical Minerals Ministerial

value chain, from mapping and extraction to processing, refining, recycling and stockpiling, and places particular emphasis on coordination related to investment de-risking, the handling of export restrictions and measures to prevent supply disruptions. Although the agreement is not legally binding, it illustrates how critical mineral value chains are increasingly being treated as a shared strategic concern across trade, industry and security policy.[14]

All in all, these developments represent a clear shift towards a more active form of industrial policy, in which allied countries seek to shape the framework conditions for global raw material markets and reduce dependence on individual actors with significant market power. The political direction is clear: critical minerals have been elevated to a core issue of security policy, and market interventions are now an explicit part of the policy toolkit. For Norway, this development means having to navigate a rapidly changing geopolitical landscape in which major actors are moving towards closer coordination of policy and attempts to reshape market design.

The World Bank Group, together with the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD) and several regional development banks, considers increasing concentration and strategic vulnerability in critical mineral value chains to be a central barrier to the energy transition, digital development and economic transformation. The institutions point out that limited access to capital, infrastructure and risk sharing is a particular constraint on the establishment of processing and refining capacity outside dominant producer countries. The multilateral development banks therefore signal a more coordinated effort directed at entire critical raw material value chains, with particular emphasis on processing, infrastructure, capital mobilisation and reducing investment risk, rather than extraction alone.[15]

As a concrete element of this shift, the United States under the Biden administration and Norway established a more operational knowledge base through the *U.S.-Norway Critical Minerals Memorandum of Cooperation Report on Non-Market Policies and Practices in the Critical Minerals Sector*.[16] The report describes how non-transparent and state-directed policy instruments in some countries can weaken competition, contribute to persistent overcapacity and push global prices down to levels that make it difficult to realise profitable investments in market-oriented economies. At the same time, it emphasises that the challenge is not only access to raw materials, but also concentration and vulnerability in processing and further refining stages, where criticality often arises. The analysis is illustrated through value chain examples for graphite, cobalt, nickel and magnesium, and shows how the combination of subsidised capital, state-owned actors, export restrictions and strategic foreign investments can create persistent market power across all or parts of the value chain. A central point is that market-oriented countries need to cooperate more closely to reduce vulnerability and counter such mechanisms, including through common standards, greater transparency, recycling and targeted measures that strengthen the investment basis for sustainable production and processing in allied countries.

At the same time, Europe faces a fundamental structural paradox. Although the continent has deposits of several critical minerals, the willingness to open new mines and processing facilities is weak. The public recognises the need for these materials, but opposition to activity in local communities is strong and increasing. As a result, extraction and especially processing largely have been moved to other regions. Access to raw materials is ultimately determined by geological conditions, and Norwegian process industry is today heavily dependent on raw materials located outside Europe. At the same time, China has, in addition to its own mining production, invested significantly in mining projects and associated infrastructure in these regions. On this basis, the country has over time built up an extensive and specialised industry in processing and further refining and has achieved a dominant position in several key stages of the value chains for critical raw materials.

This development has also contributed to a weakening of European educational environments in mining, geology and metallurgy, and several academic disciplines have been reduced or discontinued. As a result, both the skills base and the capacity to realise projects at the national level have been weakened.

When new European mineral projects are planned, project developers may find that projects become economically challenging or unprofitable as they approach the point of realisation. This is due to a combination of factors, including cost levels and framework conditions in Europe, as well as competition from other regions with lower costs and more supportive industrial and trade policies. China's position in several parts of the value chain, particularly in processing and further refining, also contributes to price pressure and increased investment risk. Similar

[14] EU and US launch strategic partnership on critical minerals
[15] Joint MDB Statement on Critical Minerals to Manufacturing Value Chains
[16] us_norway_critical_mineralsnmpp_jan-14-final.pdf

challenges apply to the development of specialised material qualities and advanced process industries, where investments are capital-intensive and dependent on stable market conditions and access to competitively priced input factors. Taken together, this widens the gap between Europe's geological and industrial potential and its actual capacity to develop competitive and strategically important value chains.

In response to these challenges, the EU has established an ambition through the *Critical Raw Materials Act* (CRMA). The ambition is that, by 2030, Europe should be capable of extracting at least 10 percent, processing at least 40 per cent and recycling at least 25 percent of its own consumption of strategic raw materials, and that no single third country should account for more than 65 percent of imports in key processing stages. The CRMA therefore represents a significant increase in European ambitions, moving from analysis and identification to concrete implementation. The EU's objective is not only to map resources, but to build actual value chains and reduce dependence on China in the most vulnerable segments.[17]

At the same time, implementation to date shows that the gap between ambition and reality is significant: social conflicts, insufficient processing capacity, a weak investment base and market prices dominated by China make it difficult to achieve the CRMA targets at the desired pace. Nevertheless, the CRMA has become a guiding framework for European industrial and security policy, and a central point of reference for how Member States – including Norway through the EEA – are expected to develop new resources, capacities and partnerships in the decade ahead.

The European Court of Auditors has also highlighted that the EU's ambitions in the field of critical raw materials face significant challenges in implementation. The report concludes that the CRMA provides an important strategic framework, but that the targets set are only to a limited extent underpinned by consistent data, clear prioritisation criteria and operational indicators of improved security of supply. It also points to a lack of overview of trade, processing and recycling, as well as a weak linkage between identified risks and the policy instruments applied. The report further emphasises that many measures involve long lead times and uncertain prospects for realisation, implying that their impact in the short to medium term may be limited. Overall, the report indicates that initiatives under the CRMA require a substantially strengthened knowledge base and clearer governance mechanisms to deliver on the overarching objectives.[18]

The Norwegian *National Security Strategy 2025* emphasises that security, the economy and technology are now increasingly intertwined, and that access to critical inputs therefore takes on a clear strategic dimension. Value chains previously regarded as purely economic are increasingly being treated as part of critical infrastructure. The strategy also notes that international assessments of Norway highlight the country's geological resources, process-industrial capacity and strong knowledge environments as important contributions to allied value chains and to European economic and security resilience.

2.2 Increasing use of export restrictions and industrial subsidies in markets for critical raw materials

Alongside growing demand for critical raw materials, the use of export restrictions has increased significantly over the past 15 years. This is documented in the OECD's annual *Inventory of Export Restrictions on Critical Raw Materials*, which provides a systematic overview of different types of measures that limit exports of raw materials, including export duties, licensing requirements, quotas and outright export bans. The most recent update shows that the number of export restrictions on critical raw materials has increased fivefold since 2009, and that the level of restrictions in 2024 remains historically high, despite a moderate slowdown in growth compared with the peak years of 2022 and 2023.[19]

The OECD analysis shows that export restrictions are increasingly affecting materials that are central to industrial production, the energy transition and defence-related value chains. Around 70 per cent of global exports of cobalt and manganese were subject to at least one export restriction in the period 2022–2024. Similarly high shares apply to graphite (47 per cent), rare earth elements (45 per cent) and tin (41 per cent). This means that a significant share of global trade in strategically important raw materials is now subject to political or administrative constraints, with

[17] Critical Raw Materials Act - Internal Market, Industry, Entrepreneurship and SMEs

[18] Special report 04/2026: Critical raw materials for the energy transition | European Court of Auditors

[19] OECD Inventory of Export Restrictions on Critical Raw Materials 2026 | OECD

clear implications for availability, price volatility and investment incentives in downstream value chains (i.e. closer to end use).

The restrictions are particularly concentrated in the most upstream segments of the value chains (minerals and processed materials). OECD data show that export restrictions on ores, concentrates and minerals have increased significantly faster than restrictions on more processed products. This development is largely consistent with stated industrial policy objectives in resource-rich countries, where export restrictions are used to promote local value addition, protect domestic industry or secure state revenues. At the same time, such measures have significant negative spillover effects for import-dependent countries, reinforcing concentration in value chains and contributing to increased price volatility.

Furthermore, the OECD report shows that the most restrictive measures, such as export bans and strict licensing regimes, have become more common since the late 2010s. In 2024, export bans accounted for nearly one quarter of all new restrictions introduced, while licensing requirements and export duties remain the most widely used measures overall. At the same time, the underlying motivations for export restrictions have shifted. Whereas considerations related to resource management and control previously dominated, objectives linked to state revenues, domestic value creation and industrial policy are now among the most frequently cited rationales.

Alongside this development, recent analyses by the OECD show that the use of industrial subsidies has also increased significantly and is increasingly influencing competitive conditions in the same value chains. The OECD's *MAGIC Database of Industrial Subsidies* documents that subsidies to industrial production in 2023–2024 reached their highest levels since the financial crisis, with support corresponding to approximately 1.3 per cent of companies' revenues across key industrial sectors. This increase does not appear to represent a temporary crisis response, but rather a more structural feature of current industrial policy.[20]

At the same time, subsidies are concentrated in sectors of relevance to critical raw materials and strategic value chains, including renewable energy technologies, semiconductors and heavy industries such as aluminium, steel and chemicals. These are also the sectors where demand for critical inputs is highest and where control over processing and material quality is increasingly decisive for market power. OECD analyses further indicate that subsidies have a significant impact on competitive conditions, including by explaining a substantial share of market share gains for certain actors over time.

A key feature is that subsidies in many cases are provided through instruments that are not fully transparent, including state financing on non-market terms and support channelled through state-owned enterprises. The role of state-owned companies and state-controlled financial institutions appears particularly important, both as recipients and intermediaries of support, further reinforcing competitive asymmetries in global markets.

Overall, this implies that export restrictions and subsidies should not be understood as separate policy instruments, but as complementary elements in a more active and strategic industrial policy. While export restrictions primarily affect access to raw materials in the upstream segments of value chains, subsidies operate by shaping capacity development, price formation and competitive conditions further downstream. The interaction between these instruments contributes to increased concentration, altered investment patterns and, in some cases, persistent overcapacity in global markets.

OECD analyses document a development in which government market intervention is increasingly acting as a structural feature of markets for critical raw materials, rather than as a temporary or exceptional measure. For import-dependent industrial economies, this entails a persistent risk related to security of supply, price stability and access to input materials for strategic value chains. This development forms an important backdrop to the establishment of new European and allied frameworks for critical raw materials, including the EU's *Critical Raw Materials Act*.

Recent analyses also suggest that control over critical raw materials is increasingly being used as a geo-economic instrument, whereby export restrictions, subsidies and other forms of market intervention are employed to influence industrial and security-related outcomes.[21]

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[20] OECD MAGIC Database of Industrial Subsidies (EN)

[21] Beijing's critical raw material weapon - And how to dismantle it | European Union Institute for Security Studies

2.3 From critical and strategic value chains to critical and strategic raw materials

Criticality in the European context is defined through the interaction between economic importance and supply risk. Economic importance reflects the role of the material in key economic activities and technologies, while supply risk is linked to factors such as concentration in production and processing, geopolitical exposure and trade-related conditions. Criticality therefore does not arise as a result of individual factors alone, but as the outcome of how these dimensions interact in markets and across value chains.

Developments in demand for different raw materials are closely linked to growth in specific technologies and markets. The energy transition, digitalisation and increased investment in defence and aerospace sectors are driving demand for a wide range of materials with specific technical properties and quality requirements. The International Energy Agency (IEA) shows that the energy transition alone accounts for a substantial share of the expected growth in demand for a range of minerals towards 2030–2040.[22] This contributes to intensifying pressure on those parts of value chains where supply is concentrated or difficult to scale.

Within the **energy transition**, the battery value chain is the single most important driver of demand. Modern Lithium-ion batteries require lithium, nickel, cobalt, graphite and manganese, often in quality grades that only a limited number of producers can supply globally. The solar industry is similarly dependent on high-purity silicon, silver, indium and gallium, while wind energy increasingly relies on permanent magnets based on rare earth elements such as neodymium, praseodymium, dysprosium and terbium. Electricity grid and storage infrastructure requires large volumes of copper and aluminium, while battery-based storage depends on significant quantities of nickel and both synthetic and natural graphite.

The defence and aerospace sectors reinforce this picture through their need for materials with high temperature resistance, strength and precision. Titanium, niobium, aluminium and tungsten are used in key structural components, while Manganese is an important input in high-alloy steels for armour, load-bearing structures and mechanical systems. gallium and germanium are also indispensable in radar, sensor and optoelectronic systems. A large share of modern missile systems, engines and control mechanisms relies on high-performance magnets containing rare earth elements. These materials are identified as critical or strategically important in both EU assessments and NATO frameworks.

The digital sector and semiconductor manufacturing require materials with extremely stringent quality requirements. Semiconductor-grade silicon, germanium, gallium and indium are essential for the production of advanced chip architecture, while copper is an indispensable input in data centres, electronics and network infrastructure. Demand for these materials is driven by rapidly increasing global digitalisation, growth in cloud platforms and increasing energy-intensive data processing.[23]

Traditional industry also entails significant material requirements. Aluminium, silicon, copper and zinc are fundamental to construction and transport and thereby underpin economic resilience. Graphite and magnesium are important lightweight and high-temperature materials widely used in transport, metals industries and the chemical sector. Such materials are not necessarily technologically new, but their role in large volumes and in system-critical industries makes them economically important.

These applications, however, do not define criticality in themselves. They drive demand for materials, but criticality arises only when this demand coincides with high supply risk, for example where there is strong concentration in production or processing.

Critical and strategic raw materials can therefore not be assessed independently of the value chains in which they are embedded. It is the structure of the value chains, rather than the mere occurrence of the raw material, that largely determines both supply risk and, consequently, criticality. Strategic value chains such as batteries, hydrogen equipment, solar panels, wind turbines, semiconductors and defence systems create demand for materials with specific technical and qualitative properties. Raw material only becomes strategically relevant once it is incorporated into the value chain through separation, refining, processing or component manufacturing. The International Energy

[22] Global Critical Minerals Outlook 2025 – Analysis - IEA

[23] Digital Economy Report 2024 | UN Trade and Development (UNCTAD)

Agency (IEA) emphasises that risk and vulnerability are increasingly concentrated in these processing and intermediate stages, where global capacity is highly concentrated and difficult to rebuild.[24]

Several analyses indicate that Europe's dependence on China in key green technologies and material value chains can to only a limited extent be explained by geological factors. Institut Montaigne shows that this dependence is largely the result of long-term industrial and institutional development, in which control over processing, intermediate products and production capacity has been decisive. China's dominant position is particularly evident in processing and technology segments, rather than in the extraction of primary raw materials considered in isolation. At the same time, extraction from Chinese or Chinese-controlled mines has been an important factor in securing China's dominance in processed materials. This implies that even where global raw material availability is relatively strong, access to strategically important material qualities and components may be concentrated among a limited number of actors. The analysis also emphasises that European countermeasures should not be understood as attempts at full self-sufficiency, but rather as a targeted effort to reduce vulnerability in strategic parts of the value chains.[25]

Many of the most critical materials are used across multiple sectors, which further reinforces vulnerability. Graphite, nickel, aluminium, rare earth elements, gallium, germanium and high-purity silicon are examples of such overlapping inputs that are required in the energy transition, digital infrastructure and the defence industry. Criticality increases further as materials must be refined through multiple stages of processing to reach, for example, battery-grade, semiconductor-grade or magnet-grade quality. As the number of suppliers declines sharply at each stage of processing, and global capacity is concentrated among a limited number of actors, criticality increases accordingly. This makes it necessary to understand criticality as a function of the technological requirements of value chains and global processing capacity, rather than of geological occurrence alone.

Critical and strategic value chains and raw materials are therefore mutually dependent. The criticality of a material has no meaning without the needs of the value chains in which it is used. In other words, criticality reflects structural vulnerability in technological value chains, where raw materials form the starting point, but purity, processing and industrial capacity determine the extent to which a value chain is ultimately exposed to risk.

For Norway, this implies a more complex, but at the same time more opportunity-rich strategic landscape, in which national initiatives may gain increased significance considering changing geopolitical and market conditions. Norway's minerals and process industries have strong advantages in the form of high levels of expertise, leading environments in mineral extraction, materials development and recycling, and robust technological capabilities. Further development will, however, require a more integrated national approach that enhances coordination, prioritisation and implementation capacity.

Did you know...?

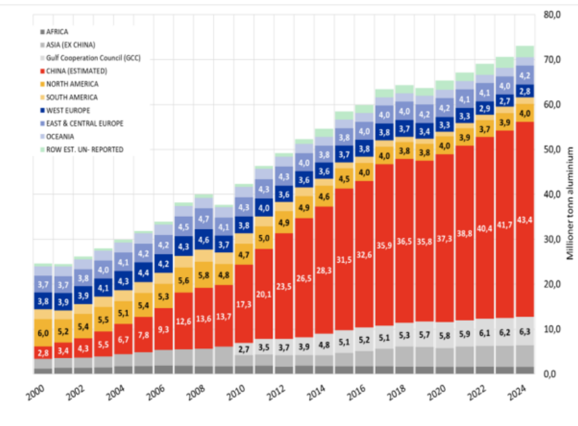
China's dominance in critical minerals is not driven by geology, but by a long-term and strategic policy pursued over several decades.

- As early as the 1970s, China established a targeted industrial policy to build domestic capacity in the production — and particularly the processing — of critical minerals. Among other measures, a dedicated Rare Earth Office was established around 1975, laying the foundation for a coordinated approach across the entire value chain.
- From the 1990s onwards, China intensified this strategy through subsidies, production quotas, and faster and more predictable permitting processes than those in Western countries. This enabled the development of a massive processing industry that outcompeted Western actors on cost.
- At the same time, China developed market infrastructure that gave it influence over global price formation. One example is the establishment of the **Baotou Rare Earth Exchange** in Inner Mongolia, as well as dedicated futures contracts for nickel, which gradually came to compete with traditional Western exchanges. This provided China with significant influence over global prices and market conditions.
- Following the financial crisis in 2008, China leveraged its market power to depress prices, acquire resource and processing assets in other countries, and consolidate state-owned enterprises to further strengthen control. As a result, Western financial institutions withdrew from the sector, which came to be seen as too risky and insufficiently profitable.
- China combined this with a global investment strategy in resource-rich countries, securing long-term upstream access to raw materials, while maintaining protected expertise in processing. This has created an asymmetry in global value chains.

The Result?

Today, China holds overwhelming market shares in the processing of a wide range of critical raw materials. This dominance is the outcome of a deliberate, coordinated, and effective state strategy pursued over 40–50 years.

Souce: Security Economics podcast by Peter Harrell, Sahar and Arnab join to talk critical minerals



Example illustrating how China has established itself as a dominant player. Example based on primary aluminium production from 1990 to 2024.

Souce: www.world-aluminium.org

[24] Global Critical Minerals Outlook 2025 – Analysis - IEA

[25] Cleantech: Reducing Europe's Strategic Dependence on China | Institut Montaigne

Norway is increasingly aligning itself with allied frameworks for critical and strategic raw materials, including the EU's framework for critical and strategic materials (CRMA) and NATO's list of twelve defence-critical materials. This reinforces the need to strengthen those parts of the value chains where Norway has genuine strategic relevance and can contribute to European and transatlantic security of supply.

In this landscape, work on critical raw materials and strategic value chains can no longer be regarded in isolation as industrial policy alone. The frameworks established by the EU, the United States and NATO define the conditions for market access, technological development, industrial partnerships and security policy. Taken together, this makes it necessary to map Norway's resources, capabilities and roles considering how allied countries are developing their lists and policy instruments, and to consider the obligations and opportunities arising from increased coordination at the European and transatlantic level.

2.4 Sensitive technologies and their reliance on critical and strategic raw materials

The government is currently developing a knowledge base for the assessment of **sensitive technologies**, which is intended to function as a framework for identifying technologies of relevance to national security, security of supply and strategic autonomy. The knowledge base is to provide a basis for assessments related to export controls, investment screening, security legislation and industrial and research policy. The objective is to establish an up-to-date, cross-sectoral picture of which technologies are security-sensitive and which actors are developing and deploying them.[26]

An important, but often under-communicated, aspect of this picture is that a large majority of the **technologies classified as sensitive rely on critical and strategic raw materials**. Many of the technologies[27] considered particularly relevant to security and emergency preparedness are not only vulnerable to technological competition or threats to digital infrastructure, but also to bottlenecks in raw material supply, processing and global industrial capacity. These dependencies are further reinforced by the geopolitical developments described in Chapter 2.1.

Sensitive technologies are largely built on critical and strategic raw materials. Technologies such as advanced semiconductors, quantum systems, photonics, sensors, autonomous systems, satellite infrastructure and high-performance energy technologies are all dependent on materials classified as critical or strategic by the EU, the United States and NATO. Several of these materials are also relevant in Norwegian geology, mineral extraction or process industry, including:

- **Nickel** – essential for high-energy batteries, superalloys and components used in aerospace and defence applications.
- **Cobalt** – critical for batteries, magnetic materials and specialised electronics.
- **Copper** – fundamental to applications ranging from data centres and AI infrastructure to high-efficiency electric motors and satellite communications.
- **Aluminium** – a material with a high strength-to-weight ratio, essential for lightweight structures in transport, aerospace and defence, as well as for power grids, electrification and energy infrastructure.
- **Rare earth elements (REE)** – indispensable in high-performance magnets, sensors (including sonar, radar and photonic systems), control systems and electric motors.
- **Graphite** – required in large volumes in all lithium-ion batteries and in several military applications.
- **Silicon (high-purity)** – the fundamental building block of microelectronics underpinning AI, quantum processing and solar energy.
- **Ferroalloys** (ferrosilicon, ferromanganese, silicomanganese, ferrochrome) – critical for high-grade steel, heat-resistant and corrosion-resistant alloys used in aerospace, defence, energy infrastructure and advanced manufacturing technologies.

These materials are not only important in themselves – they are fundamental inputs in the most sensitive technologies, for example:

- **Advanced semiconductors** require high-purity silicon, germanium, gallium, indium and copper.
- **Quantum technologies** rely on superconducting materials, germanium, niobium and precision alloys.
- **Photonics and high-energy lasers** depend on gallium, indium and rare earth elements.

[26] Kunnskapsgrunnlag for vurdering av sensitive teknologier (KVAST)
[27] kvast-sensitive-teknologier-for-norske-forhold.pdf

- **Robotics and autonomous systems** require advanced magnets (rare earth elements), advanced sensors and high-quality silicon.
- **Aerospace and hypersonic technologies** use titanium, nickel, aluminium, cobalt, niobium, tungsten and specialised ferroalloys.
- **Subsea technologies** depend on rare earth elements, copper-based high-capacity cable systems, advanced alloys and electro-optical materials.
- **Batteries** contain many critical materials, including graphite, nickel, cobalt and aluminium.

These examples illustrate that critical and strategic raw materials constitute the very foundation of the technological landscape.

In this context, the government has also joined the US-led initiative **Pax Silica**[28], which has been established to strengthen cooperation among selected allies on secure and reliable value chains for advanced technologies. The initiative focuses on artificial intelligence, semiconductors and other high-technology applications, and has the stated objective of reducing vulnerabilities associated with concentration in raw material supply, processing and production capacity for critical input materials. Pax Silica thus explicitly assumes that technological and economic security requires control and transparency across the full value chain, including access to high-purity silicon and other strategic materials used in microelectronics and digital infrastructure. Norwegian participation implies closer integration into allied structures for mapping, cooperation and policy dialogue on value chains that underpin the most sensitive technologies.[29]

2.5 Operationalising critical and strategic raw materials policy

As critical and strategic raw materials have increasingly been elevated to a central issue in both security and industrial policy, the need to translate overarching strategies into concrete policy instruments has become more evident. Internationally, the work on operationalisation is no longer primarily about defining which raw materials are critical, but about establishing governance structures, prioritisation mechanisms, and financial and regulatory instruments that directly influence investment, project realisation and value chain development. This chapter examines how the EU, the United States, the United Kingdom and NATO have moved from strategic goals and frameworks towards prioritising more operational measures, including the designation of strategic projects, targeted public–private partnerships, active supply chain management and the use of security policy instruments. Taken together, this illustrates a shift from analysis and ambition towards implementation and institutionalised practice in the management of critical and strategic raw materials.

EU

The EU's work on critical raw materials has developed gradually since the EU Raw Materials Initiative was adopted in 2008[30] and the first list of critical raw materials was published in 2011, including through regular updates reflecting changes in markets, technology and supply risk. In response to increasing geopolitical uncertainty, rapid technological change and more ambitious climate targets, the EU's approach has evolved from a focus on risk assessments towards the inclusion of strategic considerations related to industry, resilience and security. This development culminated in the launch of the *Critical Raw Materials Act* (CRMA)[31], which for the first time establishes a formal distinction between critical and strategic raw materials and links these to concrete targets for extraction, processing and recycling in Europe. The current list[32] therefore reflects both long-term analytical work and evolving political priorities, and is designed to be updated regularly, with the next revision expected in early 2027.

A central feature of the EU's approach under the CRMA is that critical and strategic materials are not understood in isolation as raw materials, but as part of integrated value chains. This is explicitly reflected in the definitions set out in the CRMA Regulation, where the value chain of raw materials encompasses the full spectrum from exploration and extraction to processing, recycling and, in some cases, substitutions. In parallel, the EU has strengthened its industrial policy framework through related legislation. In the *Net Zero Industry Act* (NZIA)[33] strategic net-zero

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[28] Pax Silica - United States Department of State

[29] Norge slutter seg til Pax Silica-initiativet - regjeringen.no

[30] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0699:FIN:en:PDF

[31] Critical Raw Materials Act - Internal Market, Industry, Entrepreneurship and SMEs

[32] RMIS - Critical and Strategic Materials

[33] EUR-Lex - 52023PC0161 - EN - EUR-Lex

technologies are defined as particularly important for the energy transition, while the proposed *Industrial Accelerator Act* (IAA)[34] links certain energy-intensive industries more closely to strategic considerations related to competitiveness, security of supply and implementation capacity. Taken together, this means that strategic importance in EU policy does not necessarily follow individual materials, but rather specific combinations of materials, processes and technological applications.

As a central element of CRMA implementation, the EU has established a framework for the designation of strategic projects intended to strengthen Europe's security of supply for strategic raw materials. These projects are granted the status of being of common European interest and are prioritised through faster and more coordinated permitting processes, as well as improved access to both public and private financing. The framework reflects the EU's value chain approach by categorising projects across extraction, processing, recycling and substitution, and by assessing them based on their overall contribution to reducing strategic dependencies across different stages of the value chain.

In March 2025, the European Commission approved the first list of 47 strategic projects within the EU, followed in June 2025 by a separate list of projects outside the EU, in line with the CRMA Regulation's provision allowing the inclusion of projects in partner countries that contribute directly to European security of supply. The approved projects cover extraction, processing and recycling, with particular emphasis on value chains for copper, graphite, lithium, nickel and rare earth elements, and have been selected based on technical maturity, expected production volumes, sustainability and their contribution to reducing strategic dependencies.[35]

Among the designated strategic projects, two have a Norwegian connection. One is the copper project in Finnmark, formerly known as Nussir and now continued by Blue Moon Metals. The project involves the development of a new copper mine with associated infrastructure and is considered important for increasing European access to primary copper. GreenRoc is a natural graphite project in which raw material extraction takes place in Greenland, while further processing is planned to be established in Arendal. Piloting of processed products is currently taking place in Denmark.[36] The project is classified as strategic because it combines access to graphite feedstock outside China with the establishment of processing capacity in Europe, thereby addressing one of the most vulnerable links in the EU battery value chain. Taken together, these projects illustrate how the CRMA is used both to mobilise European raw material extraction and to integrate third countries and EEA-related actors into a more robust, diversified and strategically oriented raw materials policy.[37] A new application round for strategic projects has been completed, and the EU is expected to announce additional strategic projects during summer 2026.

The *RESourceEU* Action Plan from December 2025 shifts the focus from analysis to implementation through measures aimed at accelerating project delivery, de-risking investment and strengthening active supply management.[38] The plan builds on strategic projects, regulatory simplification, investment support and enhanced market intelligence, while also laying the foundation for the establishment of a *European Critical Raw Materials Centre*.[39] The centre will develop market and value chain data, support financing of priority projects, and coordinate potential stockpiling and joint procurement with Member States and industry. The *Raw Materials Mechanism*[40] will be introduced as a tool for coordinated demand, facilitation of long-term supply agreements and improved access to strategic materials for European industry. These measures are now being operationalised through the establishment of a *European Critical Raw Materials Board*.[41]

In parallel with the development of the CRMA, work is underway on an IPCEI (*Important Projects of Common European Interest*) for critical raw materials. The initiative remains under development, with participation from 13 Member States to date, and has now been approved by the European Commission to proceed to a design phase. Although the exact scope and participation have yet to be finalised, the initiative illustrates the EU's increasing

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34 Industrial Accelerator Act - Internal Market, Industry, Entrepreneurship and SMEs
35 Selected strategic projects under CRMA
36 GreenRoc Strategic builds up Denmark's graphite pilot plant - Mining.com.au
37 60c576a5-435e-43e6-83de-c81f3652259b_en
38 01c448d6-dc93-40d7-9afe-4c2af448d00c_en
39 See also: New EU Centre Launched to Strengthen Europe's Critical Raw Materials Intelligence - EuroGeoSurveys New EU Centre Critical Raw Materials Intelligence
40 EU Energy and Raw Materials Platform - Raw Materials Mechanism
41 The European Critical Raw Materials Board

emphasis on value chains, the need for coordinated mobilisation of resources, and the willingness of Member States to invest in collaborative projects in this area.[42]

USA

The United States applies an economic and risk-based criticality methodology developed by the U.S. Geological Survey (USGS) for the *Department of the Interior* (DOI). Criticality is assessed through (1) modelling of macroeconomic consequences across more than 1,200 trade disruption scenarios, and (2) the identification of "single points of failure" in domestic supply chains, where production depends on a single producer. The methodology is documented in the *USGS Open-File Report 2025–1047*[43] and forms the technical basis for the DOI's designation of critical minerals in the *Federal Register*.[44] The approach reflects a distinctly US focus on national security and systemic economic risk, whereby minerals with global availability may be classified as critical if the loss of a single node would have significant consequences for US industry and preparedness.

Alongside the development of new stockpiling and market mechanisms, US authorities have introduced extensive and targeted financial instruments to reduce investment risk for private investors in critical raw material value chains. Key instruments are deployed through the *Department of Energy* (DOE) and the *Department of Defense* (DoD), including the DOE *Loan Programs Office and the Defense Production Act Title III*. These schemes provide access to long-term loans, loan guarantees and direct capital injections in projects related to mining, processing and further refining of critical minerals such as lithium, graphite, cobalt, nickel and rare earth elements. The measures are explicitly aimed at closing financing gaps in projects that would otherwise be affected by high price volatility, long development timelines and limited private risk appetite, and imply an active state role in making projects "bankable" ahead of final investment decisions.[45]

In addition to project financing, the United States has moved towards a more explicit use of market design measures to stabilise price and revenue conditions in selected critical raw material markets. This includes the development of minimum prices, long-term offtake agreements and coordinated price support, both bilaterally and in cooperation with close trade partners. The objective is to counter persistent price suppression and market distortions driven in part by state-subsidised overcapacity, particularly in China, which over time has undermined the investment basis for market-oriented producers. These measures represent a clear departure from earlier US raw materials policy, where the state largely confined itself to modest forms of risk sharing, and mark a shift towards a more active role in influencing price formation to secure long-term capacity in strategic value chains.[46]

This shift towards a more active use of price and market mechanisms is also formally anchored in US trade policy. In February 2026, the Office of the United States Trade Representative (USTR) launched a consultation on the design of a plurilateral agreement on critical minerals among "like-minded" countries. A central element is the potential use of minimum prices, reference prices or other pricing mechanisms, possibly combined with border measures, to secure an investment basis for market-based production. The USTR argues that non-market practices and state-subsidised overcapacity in third countries have prevented market-oriented projects from achieving adequate risk-adjusted returns. The initiative marks a clear shift in which trade policy, price formation and security of supply are integrated into a common framework for building resilient and allied critical raw material value chains.[47]

The United States has also launched one of its most comprehensive initiatives to build up strategic stockpiles. At the core of this development is the establishment of *Project Vault*, a new commercially oriented initiative financed through *the Export–Import Bank* (EXIM), which provides approximately USD 10 billion in loan capital to a privately structured entity responsible for purchasing and managing minerals on behalf of US industrial companies. The scheme differs clearly from the traditional *National Defense Stockpile*, which is limited to military needs, in that Vault is designed to directly strengthen security of supply for major civilian end-users such as the automotive industry, technology companies and data centre operators. The initiative has broad industrial backing through the participation of several end-users and is structured around three leading private commodity traders, which are

[42] Design Support Hub - Competition Policy - European Commission

[43] Methodology and technical input for the 2025 U.S. List of Critical Minerals—Assessing the potential effects of mineral commodity supply chain disruptions on the U.S. economy

[44] Federal Register :: Final 2025 List of Critical Minerals

[45] CRITICAL MATERIALS PROJECTS | Department of Energy

[46] The New U.S. Government Critical Minerals Playbook | FTI

[47] Federal Register: Request for Comments on the Design of a Plurilateral Agreement on Trade in Critical Minerals and Policy Actions To Strengthen the Resilience of Critical Mineral Supply Chains

tasked with procuring materials globally and managing risks related to price volatility and storage. The measure is also designed to stabilise price formation in a market characterised by Chinese dominance and significant volatility, thereby providing US actors with more predictable conditions for investment and long-term procurement.[48]

The United States is also investing heavily in public–private partnerships to secure access to critical raw materials. A key example is the agreement between MP Materials and the *US Department of Defense* (DoD), which aims to strengthen US independence in the production of rare earth elements. The agreement includes long-term offtake contracts and financial guarantees, including a minimum price for neodymium and praseodymium, intended to protect US production from Chinese price suppression. According to MP Materials and the DoD[49] , the partnership is intended to support the development of a fully integrated rare earth value chain in the United States, thereby reducing strategic dependence on China.

NATO

NATO has increasingly elevated raw material criticality as an issue of defence and security policy. In December 2024, the Alliance published its first list of twelve *defence-critical raw materials*, considered essential for the production and maintenance of key military capabilities, including fighter aircraft, missiles, armoured vehicles and submarines. The list was developed based on analyses by the NATO Industrial Advisory Group (NIAG) and a methodology explicitly grounded in military capability requirements, and forms part of a broader, ministerially endorsed *Roadmap on Defence Industrial Resilience* from June 2024. This roadmap aims to strengthen allied supply chains against geopolitical and market disruptions that could undermine NATO countries' deterrence and defence capabilities. The publication represents a first institutional step in which NATO identifies raw materials as drivers of risk for operational availability and industrial resilience and establishes a foundation for further work on joint assessments, industry dialogue and measures to reduce vulnerability in allied defence supply chains.[50]

NATO's list of defence-critical raw materials can be seen in conjunction with a defence-sector-specific approach developed in the report *Strategic raw materials for defence – Mapping European industry needs* (HCSS, 2023). The report starts from the premise that the defence sector is often less explicitly addressed in the broader debate on critical raw materials, even though modern military capabilities depend on a wide range of materials across air, maritime and land domains. The authors conduct a qualitative risk assessment of 40 raw materials considered critical or "near critical" for the European defence industry, where risk is defined as a combination of the likelihood of supply disruption and the consequences for operational capability. Likelihood is operationalised through a combined assessment of short- and long-term security of supply and geopolitical risk, while consequence is measured by the frequency with which a material is used across key defence applications and platforms. A key finding is that materials such as graphite and aluminium are assessed as particularly high-risk for the defence sector, as they are widely used in critical components and at the same time exhibit significant supplier concentration and geopolitical exposure. The report shows that defence-related criticality does not necessarily align with the EU's civilian assessments of criticality and highlights the need for a dedicated defence-specific risk perspective. The report concludes that security of supply for defence purposes should be addressed through a comprehensive strategy that combines national instruments with European coordination and transatlantic cooperation, and that alignment between civilian and military requirements will become increasingly important as competition for raw materials linked to the energy transition, digitalisation and defence intensifies.[51]

United Kingdom

The United Kingdom has, in the period 2025–2026, established an updated and operational framework through the *UK Critical Minerals Strategy – Vision 2035*.[52] The strategy defines critical minerals as a fundamental prerequisite for the country's industrial growth, energy security and defence technologies, and sets concrete targets for domestic capacity: by 2035, 10 percent of national demand is to be met through UK production and 20 percent through recycling. The strategy emphasises that the United Kingdom's primary strengths lie in midstream processing and

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[48] Introducing Project Vault, a critical mineral stockpile for American businesses 💎US – The White House

[49] MP Materials Announces Transformational Public-Private Partnership with the Department of Defense to Accelerate U.S. Rare Earth Magnet Independence | MP Materials

[50] NATO releases list of 12 defence-critical raw materials | NATO News

[51] Strategic-Raw-Materials-for-Defence-HCSS-2023-V2.pdf

[52] Vision 2035: Critical Minerals Strategy - GOV.UK

recycling capacity and is closely aligned with the *Industrial Strategy* from July 2025.[53] At the same time, it highlights that the global market structure, particularly China's dominant position in processing, makes UK supply chains vulnerable to price and trade shocks. In response, policy instruments are being strengthened to support domestic production, including energy cost compensation for energy-intensive industry and enhanced international cooperation. Measures are also being introduced to enable potential stockpiling of defence-related minerals through public procurement mechanisms. The strategy is supported by the *UK Critical Minerals Intelligence Centre (CMIC)*[54], which provides national risk assessments and supply chain analysis. Methodologically, the strategy draws on the risk assessments produced by CMIC, the *UK 2024 Criticality Assessment*[55] , which forms the analytical basis for the selection of policy instruments across production, recycling, trade and preparedness.

Canada

Canada has, over the past two years, further developed its framework for critical minerals into a more comprehensive and investment-oriented strategy. The *Canada's Critical Minerals Strategy – Progress Update*[56] (February 2026), building on *Canada's Critical Minerals Strategy*[57] reports significantly expanded capacity, including 56 active critical mineral mines, 31 processing facilities and 171 advanced projects, of which 28 relate to processing. The strategy is structured around three main pillars: strengthening domestic production and processing, safeguarding economic security and value chains, and fostering partnerships with Indigenous communities, industry and allied countries. At the same time, substantial financial instruments have been introduced, including the *Critical Minerals Production Alliance*[58] which across two funding rounds in 2025–2026 has mobilised CAD 18.5 billion in projects in cooperation with allied partners, as well as a new *Critical Minerals Sovereign Fund* of CAD 2 billion providing equity, loans and long-term offtake agreements for early-stage projects. Canada has also introduced the *Canadian Digital Core Library*, a national platform for digitised drill core data, and is strengthening its defence-oriented raw materials policy through the *Defence Industrial Strategy* (2026). This strategy identifies critical minerals as a foundation for strategic autonomy and commits the government to increasing production, processing and stockpiling of defence-related materials. Canadian authorities have further stated that the country already produces 10 of NATO's 12 defence-critical raw materials. However, it has not been specified whether this refers to primary production, processed materials or defence-qualified products.

Combined overview of critical and strategic raw materials

The review demonstrates how key international actors – the EU, the United States, NATO, the United Kingdom and Canada – are operationalising the concepts of critical and strategic raw materials through methodologies and policy instruments that link supply risk, industrial policy and economic security. Figure 1 provides a consolidated overview.

A common feature across these approaches is that criticality is not assessed in isolation based on raw material availability, but in relation to vulnerabilities across the entire value chain. This includes concentration in production and processing, geopolitical exposure, technological significance and limited flexibility on the supply side. These frameworks are increasingly used as active tools for shaping investment, trade, stockpiling and public demand, and together constitute a shared reference framework among allied countries.

At the same time, the review highlights that the main barrier to realising new, capital-intensive mining and processing projects does not primarily lie in technology or resource availability, but in a lack of market predictability and insufficient willingness to bear risk and invest. Long development timelines, high investment costs and limited flexibility to adjust capacity make such projects particularly vulnerable in markets where a single dominant actor – above all China – can influence price levels through rapid capacity expansion or temporary price suppression. In the absence of mechanisms that ensure predictable offtake and revenue streams, such as long-term offtake agreements, price support, strategic stockpiles or coordinated public demand, private capital is likely to remain cautious, even for cost-efficient and technologically advanced projects.

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53 Industrial Strategy - GOV.UK
54 UK Critical Minerals Intelligence Centre
55 UK 2024 criticality assessment
56 Canada's Critical Minerals Strategy: Progress update - Canada.ca
57 Canada's Critical Minerals Strategy - Canada.ca
58 Critical Minerals Production Alliance - Canada.ca

Raw material	Norwegian activities	EU Strategic	EU Critical	USA Critical	UK Critical	NATO Critical
Aluminium (Al)	Processed materials	✓ (+bauxitt/alumina)	✓ (+bauxitt/alumina)	✓	✓	✓
Antimony (Sb)			✓	✓	✓	
Arsenic (As)			✓	✓		
Beryllium (Be)			✓	✓		✓
Bismuth (Bi)		✓	✓	✓	✓	
Boron (B)		✓ (metallurgical)	✓	✓	✓ (borates)	
Cesium (Cs)				✓		
Cobalt (Co)	Processed materials; Relevant geological deposit	✓	✓	✓	✓	✓
Copper (Cu)	Processed materials; Relevant geological deposit	✓	✓	✓		
Chromium (Cr)				✓		
Gallium (Ga)		✓	✓	✓	✓	✓
Germanium (Ge)		✓	✓	✓	✓	✓
Hafnium (Hf)			✓	✓	✓	
Helium (He)			✓		✓	
Indium (In)				✓	✓	
Iron (Fe)	Ongoing mineral extraction (upstream); Relevant geological deposit				✓	
Lead (Pb)				✓		
Lithium (Li)		✓ (battery quality)	✓	✓	✓	✓
Magnesium (Mg)		✓ (metal)	✓	✓	✓ (magnesite)	
Manganese (Mn)	Processed materials (upstream)	✓ (battery quality)	✓	✓	✓	✓
Nickel (Ni)	Processed materials; Relevant geological deposit	✓ (battery quality)	✓ (battery quality)	✓	✓	
Niobium (Nb)			✓	✓	✓	
Phosphorus (P)	Processed materials; Relevant geological deposit		✓	✓	✓	
Rubidium (Rb)				✓		
Rhenium (Re)				✓	✓	
Scandium (Sc)			✓	✓		
Silicon (Si)	Processed materials; Relevant geological deposit	✓ (metal)	✓ (metal)	✓	✓	
Silver (Ag)				✓		
Strontium (Sr)			✓			
Tantalum (Ta)			✓	✓	✓	
Tellurium (Te)				✓	✓	
Tin (Sn)				✓	✓	
Titanium (Ti)	Ongoing mineral extraction (upstream); Processed materials (upstream); Relevant geological deposit	✓ (metal)	✓ (metal)	✓	✓	✓
Tungsten (W)		✓	✓	✓	✓	✓
Uranium (U)				✓		
Vanadium (V)	Relevant geological deposit		✓	✓	✓	
Zinc (Zn)	Processed materials; Relevant geological deposit			✓	✓	
Zirconium (Zr)				✓		
Platinum Group Metals (PGM)	Processed materials	✓	✓			
Iridium (Ir)				✓	✓	
Osmium (Os)						
Palladium (Pd)				✓		
Platinum (Pt)				✓	✓	✓
Rhodium (Rh)				✓	✓	
Ruthenium (Ru)				✓	✓	
Rare Earth Elements	Processed materials; Relevant geological deposit		✓		✓	✓
Lanthanum (La)				✓		
Cerium (Ce)		✓		✓		
Praseodymium (Pr)		✓		✓		
Neodymium (Nd)		✓		✓		
Promethium (Pm)						
Samarium (Sm)		✓		✓		
Europium (Eu)				✓		
Gadolinium (Gd)		✓		✓		
Terbium (Tb)		✓				
Dysprosium (Dy)		✓		✓		
Holmium (Ho)				✓		
Erbium (Er)				✓		
Thulium (Tm)				✓		
Ytterbium (Yb)				✓		
Lutetium (Lu)				✓		
Yttrium (Y)				✓		
Industrial products and minerals						
Sodium compounds					✓	
Feldspar	Ongoing mineral extraction		✓			
Fluorspar			✓	✓		
Graphite	Ongoing mineral extraction (upstream); Processed materials; Substitution	✓ (battery quality)	✓	✓	✓	✓
Phosphate (rock)			✓	✓		
Coaking/Metallurgical coal			✓	✓		
Potash				✓		
Barite			✓	✓		

ACTIVITIES IN VALUE CHAIN

Relevant geological deposit · Ongoing mineral extraction · Ongoing mineral extraction (upstream) · Processed materials · Processed materials (upstream) · Substitution

Figure 1 - Combined overview of materials classified as critical and strategic by the EU, the United States, the United Kingdom and NATO, with Norwegian activities illustrated across the value chains.

Recent analyses by the International Energy Agency (IEA) also show that strategic stockpiling of critical minerals can function as a temporary risk-mitigating measure in the event of acute supply disruptions, but that such arrangements must be designed selectively and, on a material specific basis to achieve the desired effect. The IEA emphasises that strategic stockpiles should primarily ensure continuity in critical value chains in the short term and should not be used as an instrument for long-term price management or as a substitute for investment in new production and processing capacity. Furthermore, it is noted that storage costs, shelf life, material form and governance models vary significantly across minerals, implying that stockpiling should be considered as one of several complementary measures within a broader strategy for security of supply.[59]

Assessments of strategic stockpiling must therefore, in line with the IEA's approach, be based on an overall evaluation of supply risk, strategic importance and practical feasibility for each individual material. The IEA's analysis indicates that high concentration in refining, limited availability of alternative supply sources, elevated export restriction risk and strong dependence on by-product extraction all increase the relevance of stockpiling for selected materials. At the same time, it is emphasised that stockpiling is only effective where the stored material can be used directly in critical applications during a disruption, without the need for further processing in third countries.

The IEA further underlines that the physical and chemical properties of materials are decisive for the design of stockpiling strategies. For certain strategic materials, such as rare earth elements, Gallium and synthetic Graphite, requirements related to temperature control, moisture protection, packaging and frequent rotation may involve significant storage costs and operational constraints. This implies that stockpiling cannot be based on general volume targets or uniform models but must be adapted to material-specific storage requirements, shelf life and industrial use. In value chains where materials exist in multiple variants and quality grades tailored to specific end applications, stockpiling therefore emerges as a targeted and selective instrument for ensuring short-term continuity, rather than a universal measure for addressing structural supply risk.

For the Norwegian assessment, this implies that the concepts of "critical" and "strategic" must be understood considering multiple overlapping frameworks. The CRMA defines what is strategically important for European value chains, while the USGS methodology applied in the United States illustrates how individual nodes can be critical even in global markets. NATO's assessments point to materials that are essential for allied defence capability. **Taken together, this implies that Norway's relevance is not primarily determined by a national list, but by the country's actual and potential contribution to allied value chains.** The mapping of Norwegian positions and potential – particularly in processing, recycling and the supply of high-quality and reliable materials – therefore provides a key basis for assessing where Norway can play a strategic role and which framework conditions are required to realise that potential.

2.6 Criticality in value chains – from refined material products to structural bottlenecks

In analyses of critical and strategic raw materials, materials are often described in terms of elements or broad categories of raw materials, as they appear in the periodic table or in national and international criticality lists. In practice, however, it is rarely the element itself that constitutes the relevant input in industrial and technological value chains. Value creation and supply vulnerability instead arise in the transition from raw materials to functional material products, where specific properties, qualities and performance requirements are decisive for subsequent use.

This transition requires extensive processing through refining, metallurgy, chemical processing and materials engineering. Requirements related to purity, microstructure, performance losses, stable performance over time and durability mean that materials only acquire strategic significance at a stage between raw material and product. At the same time, these refining stages of the value chain are characterised by high capital intensity, long development and scale-up timelines, technological complexity and strong geographical and industrial concentration. As a result, supply vulnerability in critical and strategic value chains is increasingly linked to access to highly refined material qualities, rather than to the global availability of raw materials.

[59] Designing an effective strategic stockpiling system for critical minerals – Analysis - IEA

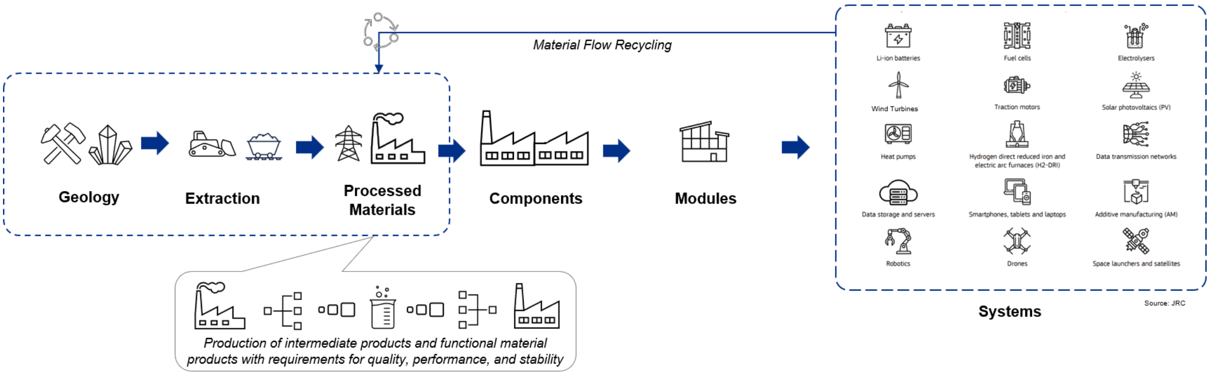

Figure 2 - Illustration of the value chain from geological deposits, through mineral extraction and material processing, to component manufacturing, assembly into modular systems, and ultimately complete systems entering the market. Recycling of materials and components may be reintroduced at various stages of the value chain (illustrated here only as reintroduced at the processing stage). Material processing typically involves multiple processing steps across different actors, requiring extensive treatment of intermediate products through refining, metallurgy and chemical processing.

This pattern is particularly evident in value chains related to electrification, power systems, digital infrastructure and advanced industry, where even small deviations in material quality can have significant consequences for efficiency, system stability and lifetime performance. When the analysis moves from an aggregate raw material perspective to specific material and product categories, it becomes clear that criticality in practice is linked to qualities and processing stages within the value chain.

Silicon carbide and electrical steel provide clear examples. Silicon-based power electronics still dominate the market, primarily due to low costs and mature production technologies. At the same time, increasing requirements for power density, efficiency and thermal performance are driving greater use of silicon carbide (SiC) in charging infrastructure, renewable energy systems and industrial drive systems. Although the raw materials used in SiC production (coke and quartz) are relatively abundant, the production of semiconductor- and energy-grade silicon carbide is technologically complex, capital-intensive and concentrated among a limited number of global actors. Strategic vulnerability therefore lies in access to processing capacity and material quality, rather than in the availability of raw materials as such.

Electrical steel represents a similar case. The material is based on iron and silicon, but its magnetic properties depend on precisely controlled crystal structures and advanced processing. Grain-oriented electrical steel, used in power transformers, is produced through precise hot rolling and heat treatment to minimise losses in a single direction. Non-oriented electrical steel is used in motors and generators, where uniform magnetic properties in multiple directions are essential for efficiency. Amorphous electrical steel, which lacks a crystalline structure, provides further loss reduction but requires highly specialised production processes with very limited global capacity. It is these quality and processing requirements, rather than the availability of iron and silicon as raw materials, that make electrical steel an energy-critical material.[60]

A similar dependence on highly refined material qualities is evident across a range of other technology areas. In batteries, access to battery-grade materials is critical, for example graphite for anodes, where chemical purification, particle control and surface treatment are essential for performance and lifetime. For electric motors and windmills, the bottleneck lies in magnet quality, particularly NdFeB (neodymium–iron–boron), where alloying, metallurgy and magnet production are far more constraining than the availability of rare earth oxides in isolation. In digitalisation and power electronics, high-purity gallium is required for the production of gallium nitride (GaN) and gallium arsenide (GaAs) semiconductor components, and such material is currently produced in very limited volumes globally. In hydrogen technologies, access to platinum- and iridium-based materials tailored for electrolysers is

[60] 2023 DOE Critical Materials Assessment | Department of Energy

critical for scaling up PEM[61] technology, where iridium is already considered a potential absolute bottleneck towards 2035.[62]

Criticality thus arises from structural relationships between actors within value chains. Modern industrial systems impose requirements regarding volume, quality and reliability of supply that can only be met by a limited number of processing and refining stages, often concentrated in specific countries. It is only when concentrates are transformed into refined metals, chemicals or specialised materials, and in some cases further into components, that strategic control points emerge.

Three key mechanisms contribute to the criticality of processing stages. First, geographical and industrial concentration, where a limited number of actors dominate key parts of the value chain. Second, the use of non-market measures such as subsidies, state financing, export controls and coordinated industrial policy, which may result in persistent overcapacity and systemic price pressure. Third, quality requirements and qualification barriers, where downstream markets demand specific material qualities that only a limited number of global suppliers can deliver.

This value chain logic is directly relevant to Norway. The country holds distinct positions in processing industries, refining and advanced materials production, even though much of the raw material base is imported. Norwegian capacity in aluminium, silicon, ferroalloys, nickel, cobalt, zinc, natural and synthetic graphite, and silicon carbide means that Norway already supplies high-quality input materials to allied value chains. At the same time, complex permitting processes and high capital requirements make new projects difficult to realise rapidly. For a Norwegian assessment, it is therefore essential to focus on where in the value chains Norway actively contributes with processed, high-quality materials, where there is potential for further upgrading, and where the country remains dependent on imported intermediates or processing in third countries.

2.7 Capital intensity, risk and execution capacity in critical raw material value chains

The development of new mining projects and processing capacity for critical and strategic raw materials is currently among the most fundamental bottlenecks in establishing robust value chains. International analyses show that these challenges are only to a limited extent due to a lack of geological resources, but primarily to structural factors related to capital intensity, risk and execution capacity. A key conclusion from the World Economic Forum is that the main challenge is not the availability of capital per se, but whether projects are perceived as bankable, given the combination of risk, time horizons and revenue uncertainty.[63]

The International Energy Agency (IEA) estimates, in *Global Critical Minerals Outlook 2025*, that approximately USD 500–600 billion in new investment in mining will be required by 2040 to meet demand for selected energy-related minerals (copper, lithium, nickel, cobalt, graphite and rare earth elements). These estimates are based on the IEA scenarios STEPS (*Stated Policies Scenario*) and APS (*Announced Pledges Scenario*), with the latter reflecting stronger demand growth and thus higher investment requirements. The same report shows that capital intensity is increasing over time, due in part to declining ore grades, more complex deposits and rising processing requirements before materials can be integrated into value chains.[64]

From a broader value chain perspective, analyses by the World Bank indicate that total investment needs, including mining, processing and associated infrastructure, may exceed USD 1.7 trillion by 2050. The World Bank also emphasises that mineral projects are generally "capital intensive and high risk", and that access to long-term capital remains one of the most important constraints on the development of new projects.[65]

Capital intensity has several structural drivers. A key factor is that new projects are increasingly being developed in areas with more complex geology and less developed infrastructure. This entails significant additional investment in power supply, transport and water infrastructure prior to commercial operations. The World Bank highlights that the lack of such basic infrastructure is often a decisive barrier to project implementation. At the same time,

[61] PEM: Proton Exchange Membrane

[62] JRC Publications Repository - Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study

[63] WEF_Making_Critical_Minerals_Bankable_2026.pdf

[64] Global Critical Minerals Outlook 2025

[65] Metals and Minerals | World Bank Group

increasing technological requirements for processing quality are shifting a larger share of value creation towards capital-intensive intermediate and refining stages. The World Economic Forum notes that long development timelines, combined with high upfront capital requirements and uncertain revenue streams, make such projects difficult to finance through traditional capital markets.

At the same time, capital requirements and risk vary significantly across the project lifecycle. In the early phase, risks are primarily geological, while capital requirements remain relatively limited. During the development phase, both capital requirements and regulatory risk increase, whereas the construction phase is by far the most capital-intensive. It is particularly in the transition from development to construction that financing often breaks down. The World Economic Forum documents that different types of capital and policy instruments are required at different stages, and that a lack of risk-sharing and revenue predictability constitutes a key systemic barrier.

This structure has direct implications for which actors are able to carry out investments. In mining, investments are dominated by a limited number of global mining companies and state or state-backed actors. These organisations possess both the financial capacity and the risk tolerance required to manage long timelines and uncertain returns. Smaller companies play an important role in the exploration phase but typically depend on acquisitions or partnerships to realise larger projects.

In processing and refining, barriers are often even higher. These stages require advanced technologies, stable large-scale operations and substantial access to energy. At the same time, qualification requirements in downstream markets are stringent, and it may take considerable time before products are approved for use in applications such as batteries, semiconductors or defence systems. The World Economic Forum emphasises that such qualification processes further delay revenue generation and increase capital risk.

As a result, processing capacity has become highly concentrated among a limited number of actors and jurisdictions. The IEA notes that concentration in processing is often greater than in raw material extraction itself and represents a key source of criticality in value chains.

Financial investors continue to play an important role, but their participation is increasingly conditional on risk-mitigating mechanisms. These include long-term offtake agreements, guaranteed minimum prices, public loan schemes and various forms of public risk-sharing. Without such mechanisms, many projects are unlikely to be considered financially viable, even if they are technically feasible.

This development has contributed to a marked increase in state involvement in the sector. Several countries have introduced active industrial policy instruments to address market failures in capital provision. Australia uses state-backed financing institutions to support critical mineral projects.[66] Canada has established both strategies and financial instruments, including equity and loan schemes, to reduce risk and mobilise private capital.[67] Finland has developed a coordinated model in which geological mapping and public–private collaboration reduce risk in early project phases.[68] Indonesia, for its part, has used export restrictions to promote domestic processing, particularly in nickel, resulting in rapid industrial capacity build-up but also significant market distortions.[69]

These approaches illustrate a broader shift in global industrial policy; whereby critical raw materials are increasingly treated as a strategic domain in which market mechanisms alone are not deemed sufficient. The World Economic Forum concludes that the key constraint is not the availability of capital, but the ability to structure projects such that risk, revenue models and market access make them financeable.

For Norway, this development implies that competition for investment is increasingly taking place between jurisdictions rather than individual projects. The ability to realise projects will therefore depend on framework conditions that influence risk, access to capital and execution capacity. In a global market where value chains are becoming increasingly strategically managed, such execution capacity will in practice determine whether geological and industrial potential can be translated into actual value creation and strategic relevance.

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66 4-3709-export-critical-minerals-final.pdf

67 Canadian Critical Minerals Strategy: A whole-of-government approach

68 National Mineral Strategy of Finland

69 Prohibition of the export of nickel ore – Policies - IEA

3. Norway in a value chain perspective

Norway's role in critical and strategic raw material value chains must be understood in the context of both geological conditions, ongoing mineral extraction and the established process industry that already supplies processed input materials to European and global markets. Following the previous chapters, which have outlined the geopolitical context, key drivers of demand and how international frameworks shape industrial and security policy, this chapter turns attention to Norway's actual position within these value chains. This perspective complements NUPI's analyses of Norway's strategic dependencies in global value chain networks, where Norway's role as both a supplier and a recipient within concentrated trade flows has been analysed using network-based methods.[70]

Norway has a distinctive combination of natural resources, energy-intensive industry, technological expertise and export-oriented value chains. At the same time, Norway's position is complex: some materials are found in Norwegian geology, others are imported and processed by the domestic process industry, and still others form part of intermediate products and inputs that are supplied further into European and global value chains. To identify where Norway holds strategic importance, and where there are untapped opportunities or structural vulnerabilities, it is therefore necessary to analyse the value chain from geological deposits, through mineral extraction and processing, to refined materials and deliveries into industrial applications.

Accordingly, this chapter describes Norway's contributions across several parts of the value chain: (i) relevant geological deposits and their potential, (ii) ongoing mineral extraction, including distinctions between extraction that supplies critical raw materials directly to end uses and extraction that primarily feeds into further processing stages, (iii) processed materials (process industry), including both further refining into strategic materials and upstream material upgrading, (iv) the supply of specialised materials into downstream industrial value chains, and (v) technologies that contribute to the substitution of critical raw materials. In this introductory description, analyses of demand for critical and strategic materials in manufacturing and technology industries have been deliberately excluded.

Similarly, analyses of demand and needs in downstream end-use segments are only included to a limited extent. The primary focus is on mapping how Norwegian deposits, mineral extraction and process industry participate in value chains for critical and strategic raw materials, and how these activities contribute to reducing or reinforcing vulnerabilities in allied value chains.

Overall, the review shows that Norway's strategic importance in critical and strategic raw material value chains cannot be derived directly from formal lists of critical or strategic materials alone. While classifications from the EU, the United States, NATO and the United Kingdom provide an important framework for identifying materials of particular importance, criticality in practice emerges in specific stages of value chains where requirements for quality, processing, security of supply and industrial capacity are decisive. As demonstrated in Chapter 2, vulnerability and strategic importance are increasingly linked to processing and refining stages, as well as to material forms that are directly applicable in sensitive technologies, rather than to raw material availability in a purely geological sense. This implies that Norway's role must be assessed based on how Norwegian deposits, mineral extraction, imported raw materials, process industry, supply capabilities and substitution solutions integrate into allied value chains, and where Norwegian capacity contributes to reducing or reinforcing strategic dependencies.

Figure 3 clarifies the scope of the study and illustrates how activities are distributed along the value chain for critical and strategic raw materials, from geological resources in the ground, via mineral extraction and various forms of processing, to deliveries into downstream value chains.

To illustrate how Norwegian activities are integrated into value chains for critical and strategic raw materials, the actors have been categorised based on the EU's value chain approach in the *Critical Raw Materials Act* (CRMA). CRMA distinguishes between extraction, processing, recycling and substitution. In practice, the processing stage encompasses a wide range of activities, from beneficiation and metallurgical treatment to the production of high-quality materials and near-component products. At the very beginning of the value chain, activities depend on economically viable deposits, where profitability is influenced by a range of factors, but where the size of the deposit and the ore grade constitute key preconditions.

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[70] Norway's strategic dependencies in global supply chain networks | NUPI

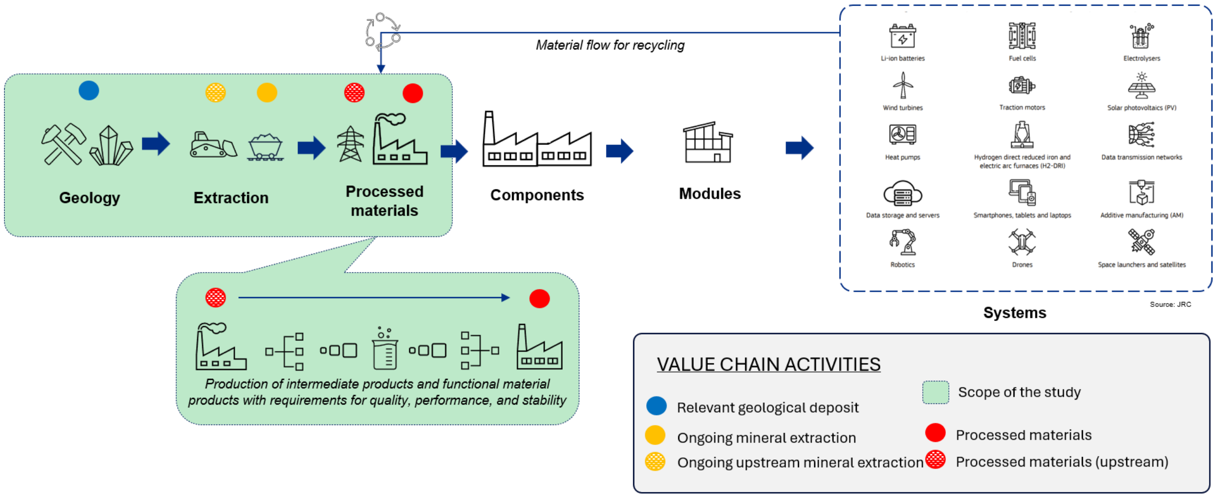

Figure 3 - The study focuses on exploration, development and realisation of deposits, mineral extraction and the production of processed materials, as illustrated by the green shading in the figure. In this context, the term "upstream" refers to activities that supply products which, through further processing, are integrated into subsequent stages of the value chain and thereby acquire increased strategic significance.

To reflect the actual structure of Norwegian value chains and clarify where criticality arises in practice, this overall categorisation has been further operationalised into more granular categories. The figure therefore distinguishes between relevant geological deposits, ongoing mineral extraction and several types of processing activities, including a separate distinction between upstream processing and further material processing. This makes it possible to highlight differences between actors that supply raw material-based intermediate products and those that produce highly refined material qualities considered critical.

3.1 Norwegian geological conditions (mineral deposits)

Norway's mineral resources must be understood in the context of the country's geological setting. Norway lies at the western margin of the Baltic Shield and shares a common geological development history with Sweden, Finland and the north-western parts of Russia (Figure 4). This position is reflected in a resource potential that is distinctive for Norway, but which is also to some extent shared with the other Fennoscandian countries.

In 2022, the geological surveys of the Nordic countries presented a joint assessment of the potential for critical raw materials in the region. The report highlights that Fennoscandia represents one of the most important regions in Europe, both in terms of existing mineral production and its potential to supply European industry with critical and strategic raw materials in the future.[71] An updated report is expected to be published in June 2026.

Mineral resources arise where natural conditions have enabled the accumulation and concentration of metals to levels that can be exploited economically. For such deposits to be economically viable, however, the concentrations and volumes must be sufficient to ensure profitability over time, allowing revenues to cover exploration, investment and operating costs. Resource potential is largely determined by geological history and the interaction of multiple geological processes. The formation of economically viable mineral deposits depends, among other factors, on the presence of fertile mineral systems, effective pathways for melts and hydrothermal fluids, as well as geological traps and processes capable of concentrating metals and minerals, in some cases, enhancing their purity.

Geological processes govern where and how mineral resources are formed. Factors such as age and tectonic history, bedrock composition, degree of metamorphism and the structural evolution of the regional crust are decisive for the occurrence and characteristics of mineral resources. As a result of its varied geological history from north to south, Norway holds potential for new discoveries and for the further development of a wide range of mineral resources.

[71] The Nordic supply potential of critical metals and minerals for a Green Energy Transition

Figure 4 - Map of geological age domains in Fennoscandia, showing selected active and historical deposits.[72]

Knowledge of Norway's resource potential is founded on systematic mapping and provisions of geological data. Responsibility for basic geological mapping of Norway lies with the Geological Survey of Norway (NGU), which collects, processes and disseminates data on bedrock geology, resource potentials and mineral deposits and occurrences. Geological institutes at major universities also contribute to this work.

Norway has a long tradition of mineral extraction, particularly of metals such as copper, zinc, lead, titanium, iron, nickel and silver, as well as gold, chromium, cobalt, vanadium, molybdenum, tungsten and niobium. For many of these metals, a significant potential for new discoveries still exists. Current exploration activity is primarily directed towards base metals such as copper and zinc, as well as nickel and cobalt, precious metals such as gold and platinum, titanium minerals and speciality metals such as niobium and rare earth elements. In addition, interest in uranium has increased in recent years. Parallel to this, investigations are being carried out into critical industrial minerals, including phosphate, graphite and high-purity quartz. Figure 5 shows a map of active mineral extraction sites and a selection of mineral projects under development.

There are a number of mineral projects in Norway that have completed initial scoping and/or pre-feasibility studies and are under development, as well as several projects that are in more advanced stages of development (Figure 5). Two of these are planning to commence mining operations during 2027. Taken together, these projects provide an indication of which parts of Norway's resource potential may be further developed in the short to medium term, and which materials may enter future value chains.

A consolidated overview of selected geological deposits with relevance for critical and strategic raw materials, including compliant resource figures, development status and potential for further value creation, is presented in Appendix 8.1.

[72] Mineral deposits and metallogeny of Fennoscandia

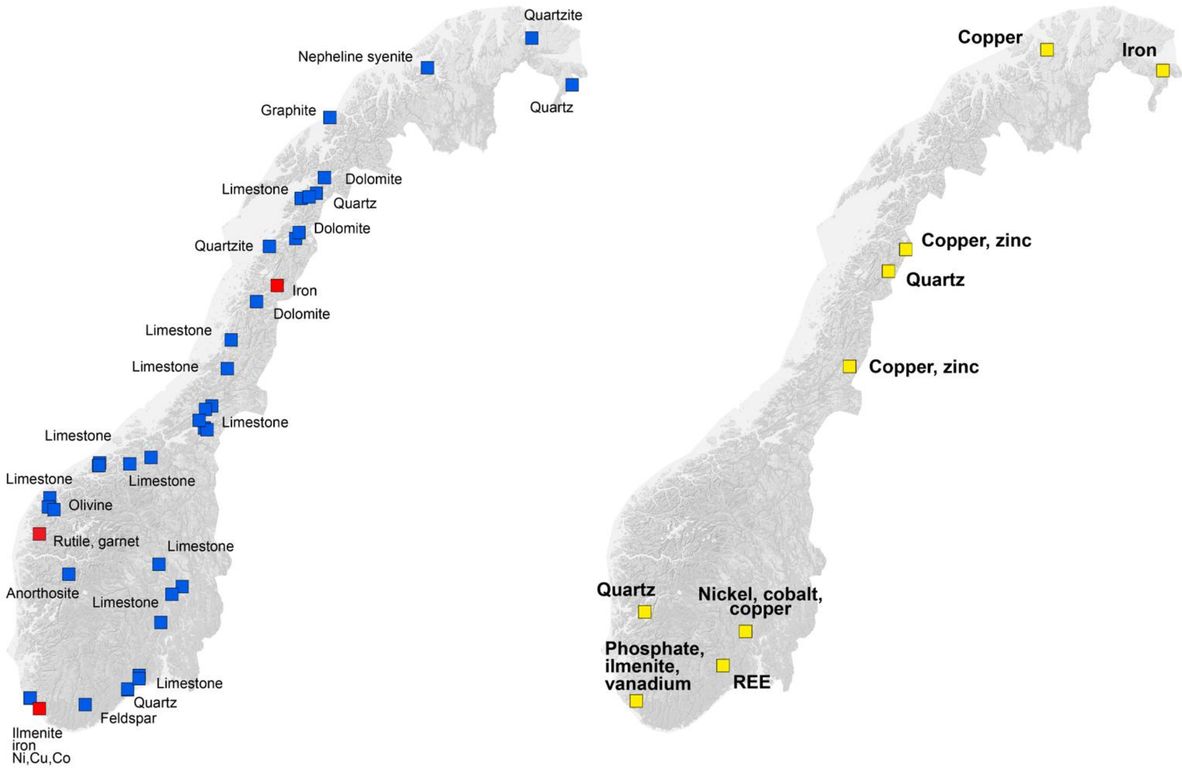

Figure 5 - Map of active mineral extraction sites in Norway; industrial mineral production is indicated in blue, while iron ore and titanium minerals are indicated in red. The figure to the right shows a selection of mineral projects under development, indicated in yellow.

3.2 Ongoing mineral extraction in Norway

Norwegian mineral industry exploits metallic ores, industrial minerals, dimension stone and aggregates (crushed rock and sand and gravel). According to the Directorate of Mining, aggregates account for half of the value of the total Norwegian production (51 %), while metallic ores and industrial minerals account for 24 % and 17 %, respectively. In 2024, the mineral industry employed a total of 4 596 people.[73]

Current production of metals and industrial minerals includes iron ore and titanium minerals, as well as natural graphite, quartz and quartzite, nepheline syenite and other feldspar minerals, olivine, limestone, marble and dolomite. For several of these raw materials, Norway plays a significant role in European production and supply.

Part of this production consists of raw materials classified as critical raw materials by the European Commission already at the extraction stage, such as natural graphite and nepheline syenite. Critical metals such as nickel, cobalt and copper are also produced in smaller quantities as by-products from Titania's production of titanium minerals in Rogaland. Other materials are not necessarily considered critical in their extracted form but may, through further processing, enter value chains for critical primary materials, for example titanium metal and silicon metal. Calcium-rich feldspar in the anorthosite currently extracted in Gudvangen, Vestland, may be suitable as a future feedstock for aluminium production.[74] Some raw materials extracted in Norway are classified as critical in other economies, such as iron ore in the United Kingdom and titanium minerals in the United States.

Both natural and synthetic graphite are included on the EU's lists of critical and strategic raw materials. The Trælen deposit on the island Senja in Troms is the highest-grade operating flake-quality graphite mine in the world, with a graphite content of 23.6 %. With a nominal capacity of around 10 000 tonnes per year, Trælen is the most important

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[73] Harde_fakta_2024.pdf
[74] https://www.heroya-industripark.no/aktuelt/2022/norsk-raastoff-til-aluminium-skaper-stor-interesse

producer of natural crystalline graphite in Europe. The deposit is operated by Skaland Graphite AS, a subsidiary of the Leonhard Nilsen and Sønner (LNS) group.

Feldspar minerals, including nepheline syenite, were designated as critical raw materials in the EU in 2023, and Norway hosts the only significant producing mine of nepheline syenite in Europe. Extraction takes place at the Lillebukt deposit on Stjernøya in Finnmark, owned and operated by the Belgian company Sibelco.[75]

Quartz and quartzite are extracted at several locations in Norway, and part of the production is supplied to domestic process industry, including silicon production, which is classified as a critical raw material in the EU. Norway has been an important supplier of silicon to the EU, and analyses show that Norwegian production accounts for a significant share of European imports of silicon materials.

Norwegian production of titanium minerals accounted for approximately 4 % of the global market in 2025, measured as titanium dioxide.[76] All production in 2025 originated from Titania's mine at Tellnes in Rogaland, where around 2 million tonnes of ore are extracted and processed annually, with an ilmenite content of approximately 28 % ($FeTiO_3$). The mine also produces magnetite and small quantities of nickel-, copper- and cobalt-bearing sulphides as by-products. Titania is owned by the American company Kronos Inc., which also operates the Kronos Titan pigment plant in Fredrikstad and receives part of the production from Tellnes. The output from Titania AS is used primarily for pigment production.

Nordic Mining commenced mining operations at Engebøfjellet in Sunnfjord in late 2024, extracting the titanium mineral rutile (TiO_2) and the industrial mineral garnet. The company produces a rutile concentrate with approximately 95 % titanium dioxide, which is well suited for the production of titanium metal. Part of the production from Engebø is therefore expected to enter international value chains for titanium metal, including in Japan.

An overview of ongoing mineral extraction, including key actors, products and their roles in value chains for critical and strategic raw materials, is presented in Appendix 8.2.

3.3 Processed materials – the Norwegian process industry

Norwegian process industry constitutes a central, and in many respects decisive, stage in value chains for critical and strategic raw materials. While geological deposits represent the potential in the upstream segment, it is largely within the process industry that materials are transformed into products with the quality, purity and performance required to enter strategic applications. As described in Chapter 2.3, criticality often arises precisely in such refining and processing stages, where requirements are technologically demanding and global capacity is concentrated among a limited number of actors.

The Norwegian process industry is diverse and comprises both global industrial groups and specialised standalone facilities. Companies such as Norsk Hydro, Elkem and Yara represent large, integrated value chains with significant industrial and technological capacity. At the same time, individual facilities such as those at Glencore Nikkelverk and Boliden Odda constitute important hubs to produce refined metals with high purity and defined qualities. These companies contribute both to the production of critical and strategic raw materials and to substantial export revenues and thus participate directly in European and global value chains.

A common characteristic of the process industry is that it operates at the interface between upstream and downstream activities. On the one hand, raw materials and concentrates are transformed into industrial intermediate products through metallurgical and chemical processing. On the other hand, these are further refined into functional material products with strict requirements for quality, purity and consistency over time. Such properties are essential for applications in areas including batteries, energy technologies, electronics and defence, where materials must meet specifications such as battery-grade, semiconductor-grade or material standards for defence-related applications. It is in this transition from raw material to functional material that a significant share of industrial and strategic value is created.

In contrast to geological deposits, which are determined by natural conditions, Norway's position in the process industry largely reflects historical access to competitively priced and stable electricity. This has enabled the establishment of an energy-intensive industry with a high technological level and has, over time, made Norway a

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75 Stjernøy

76 Mineral Commodity Summaries 2026

host country for some of the most energy-intensive process industries in Europe. Several of these operations were originally established based on Norwegian raw materials, as in the case of Ineos Tyssedal and Glencore Nikkelverk. Over time, however, an increasing share of the raw material base has been imported, while competitive advantages have become more closely linked to energy, process expertise and industrial scale.

This means that Norwegian process industry is today closely integrated into global raw material flows. Raw materials and concentrates are imported from a wide range of countries and further processed in Norway into high-value products with narrowly defined specifications, which are subsequently exported to European and global markets. Exceptions exist, particularly in silicon and ferrosilicon production, where a significant share of quartz feedstock is sourced from Norwegian mining operations. This results in a higher degree of vertical integration in these value chains compared to other segments of the process industry.

The strategic importance of Norwegian process industry cannot, therefore, be assessed solely based on the production of critical raw materials. The industry also delivers products that function as substitutes, inputs or intermediate products in critical value chains, without the materials themselves necessarily being classified as critical or strategic. Examples include specialised alloys, silicon-based materials and various processed metal products that enter further refining or component manufacturing. These contributions are often essential for the functionality and performance of end products and therefore represent an indirect but significant strategic importance.

Overall, the review shows that the Norwegian process industry is crucial to how critical and strategic raw materials are realised within value chains. While geology and mineral extraction form the foundation, it is through processing that materials acquire the properties that make them usable in technology and industry. This positions the process industry as a central component of Norway’s contribution to allied value chains and as an area where national framework conditions, particularly those related to energy, competence and investment conditions, have direct implications for security of supply and industrial development.

Company descriptions of process industry actors that produce relevant critical and strategic materials, as well as companies supplying substitutes and other inputs to related value chains, are presented in Appendix 8.3.

3.4 Norwegian actors in value chains for critical and strategic raw materials

To illustrate how Norwegian activities are distributed along the value chain, relevant actors have been mapped in Figure 6. The figure links the different stages of the value chain, from geological deposits and mineral extraction to processing, further refining and deliveries into industrial applications, with the actors described in this report.

The overview shows how Norwegian industry collectively covers multiple parts of the value chain, from the upstream resource base to the production of advanced materials used in strategic technologies. It also highlights differences between actors that supply raw material-based intermediate products and those that produce highly refined material qualities.

Descriptions of the individual actors have been prepared by the companies themselves, based on a common template covering their role in the value chain, markets, dependencies, barriers and development opportunities. A consolidated set of company profiles is presented in Appendices 8.1–8.3.

Figure 7 illustrates how selected Norwegian actors can be linked to individual materials, based on which elements they extract, process or further refine. The representation is detailed at the element level and is based on the periodic table, where each element is linked to relevant companies. In addition, the ownership structure of these actors is shown in Figure 8, providing insight into where value creation and control are anchored.

The mapping illustrates that Norwegian actors collectively cover a broad share of the material base for critical and strategic value chains, but with clear concentrations in specific material groups. It also shows that a large share of activities is concentrated in processing and refining stages, where requirements for quality, consistency and performance are decisive for further application.

The geographical distribution of the actors is shown in Figure 9, where companies are positioned on a map of Norway and categorised according to their role in the value chain. The map distinguishes between relevant geological deposits, ongoing mineral extraction, processed materials, as well as supply, substitution and other activities within the value chain.

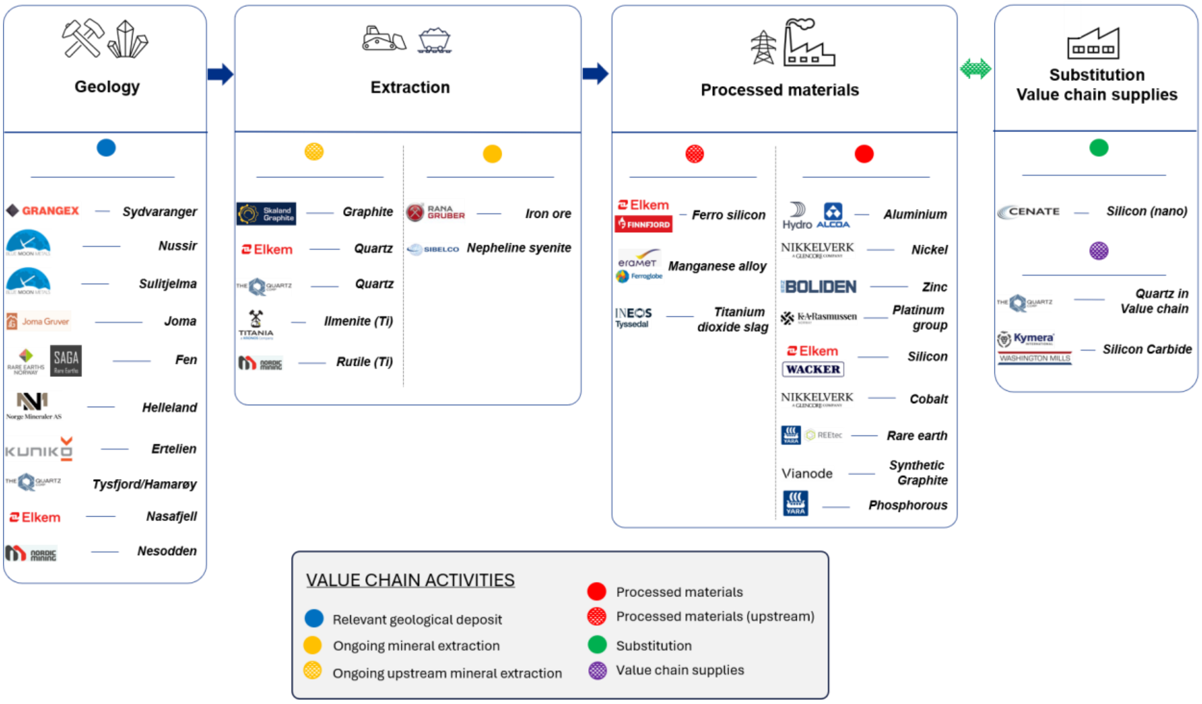

Figure 6 - Actors described in the study. Details for each individual actor are provided in Appendices 8.1–8.3.

The representation shows how Norwegian activities are geographically distributed and how different parts of the value chain are represented across different regions of the country. Geological deposits and parts of mineral extraction are primarily linked to specific geological provinces, whereas activities related to processed materials are more strongly determined by industrial and infrastructural conditions, such as access to electricity and port infrastructure.

The Nussir project is highlighted separately in the map, as it has been designated a strategic project under the EU's *Critical Raw Materials Act* (CRMA). This illustrates how individual projects may acquire particular significance in a European context, both based on their resource base and their role in the value chain.

Overall, the figures provide a comprehensive picture of how Norwegian actors are connected to critical and strategic raw materials, at the material level, across value chains and geographically. This forms an important basis for analysing Norway's overall role and strategic significance in Chapter 4.

	Geology	Extraction	Processed materials
C Karbon		Skaland Graphite	Vianode
Al Aluminium			Hydro, ALCOA
Si Silisium	Elkem, Nordic Mining, The Quartz Corp	Elkem, The Quartz Corp	Elkem, WACKER
P Fosfor	Norge Mineraler AS		YARA
Ti Titan	Norge Mineraler AS	Titania, Nordic Mining	INEOS Tyssedal
V Vanadium	Norge Mineraler AS		
Mn Mangan			eramet, Ferroglobe
Fe Jern	GRANGEX	Rana Gruber	
Co Kobolt	Kuniko, Teako Minerals	Titania	Nikkelverk A Glencore Company
Ni Nikkel	Kuniko	Titania	Nikkelverk A Glencore Company
Cu Kobber	Blue Moon Metals, Joma Gruver, Teako Minerals, Aurum Discovery, Kuniko	Titania	Nikkelverk A Glencore Company
Zn Sink	Blue Moon Metals, Teako Minerals, Aurum Discovery, Joma Gruver		New Boliden
REE	Rare Earths Norway, Saga Rare Earths		REEtec, YARA
PGM			Nikkelverk A Glencore Company, K.A. Rasmussen Norway
Feltspat		Sibelco	
Substitution & Value chain supplies			Cenate, The Quartz Corp, Kymera International, Washington Mills

Figure 7 – The link between critical and strategic raw materials, Norwegian actors and value chain stages. Norwegian actors are associated with individual elements classified as critical and strategic raw materials. The representation is structured according to value chain stages, from geological deposits through mineral extraction to processed materials. The mapping illustrates which materials are handled by Norwegian actors and how activities are distributed across different parts of the value chain.

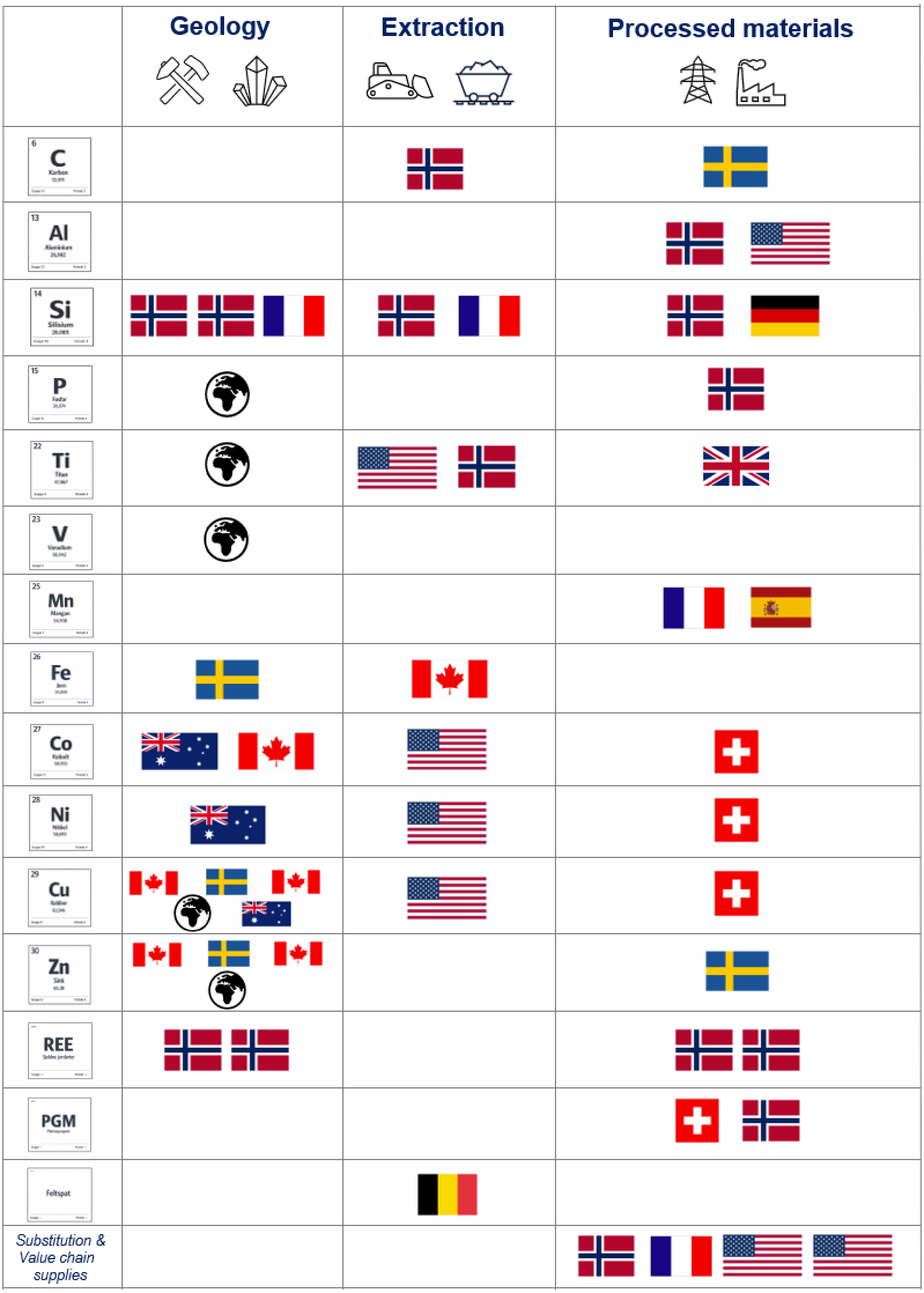

Figure 8 - The figure should be viewed in conjunction with Figure 7 and shows the ownership structures of the companies. This provides insight into how value creation and control are linked to activities along the value chain.

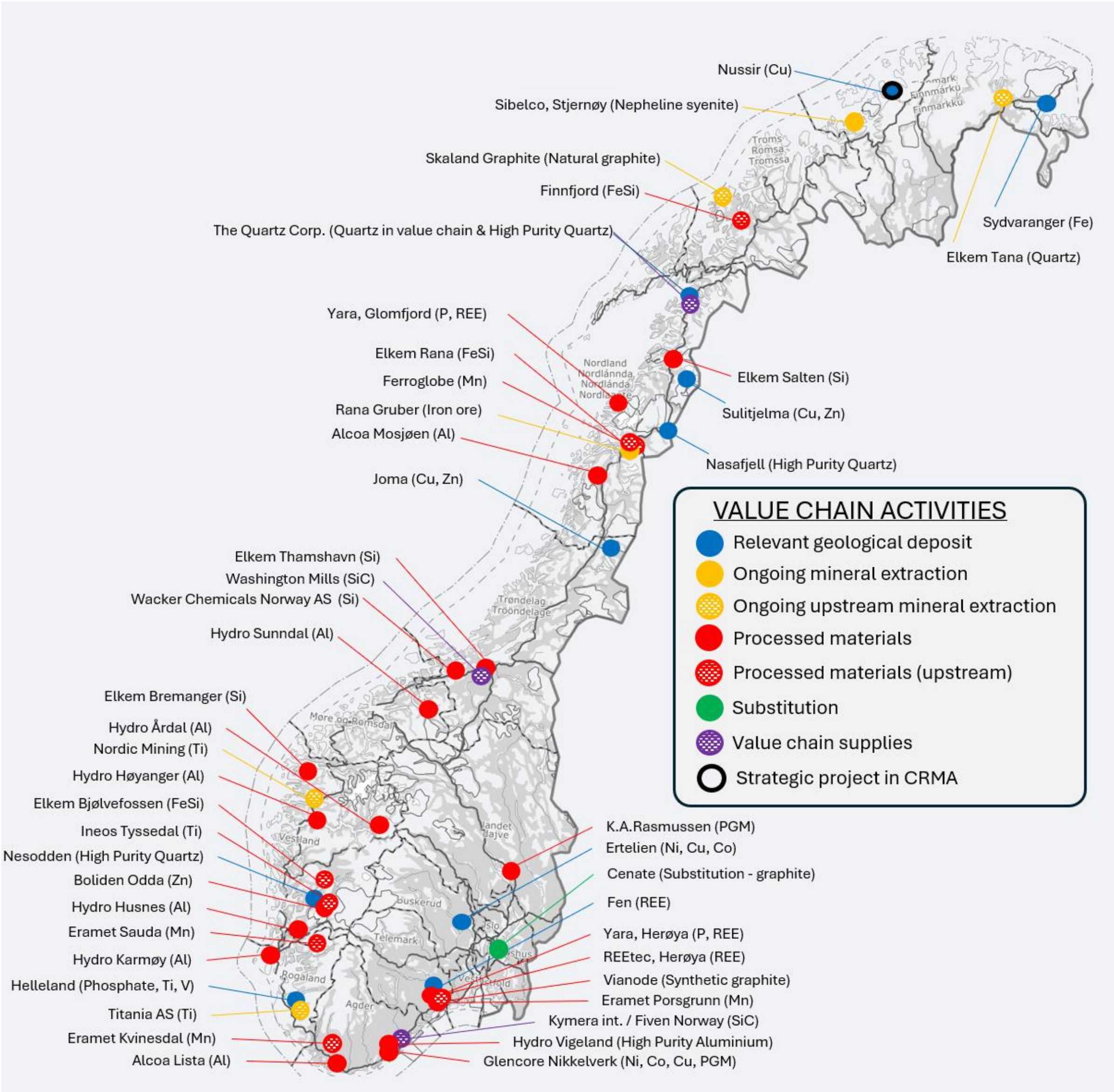

Figure 9 - Geographical distribution of Norwegian actors in value chains for critical and strategic raw materials. The map shows the location of selected Norwegian actors, categorised according to their role in the value chain, including geological deposits, mineral extraction, processed materials, substitution and value chain supplies. The figure illustrates how activities are distributed geographically across Norway and how different parts of the value chain are concentrated in specific industrial regions. The Nussir project is highlighted separately as a strategic project under the EU's Critical Raw Materials Act (CRMA). (Adapted from SSB | Kart | Adaptive)

3.5 By-products, side streams and secondary resources

EU perspective: secondary raw materials and circularity

The EU's *Critical Raw Materials Act* (CRMA) places significant emphasis on the development of secondary raw material streams as a key instrument for strengthening security of supply. The regulation aims to develop robust and integrated value chains for critical raw materials, in which recycling, materials recovery and the use of secondary sources increasingly contribute to overall supply.

The CRMA is followed up through specific capacity targets. By 2030, the ambition is that at least 25 % of the demand for strategic raw materials should be met through recycled or secondary sources. At the same time, the framework seeks to strengthen the entire value chain, from extraction and processing to recovery and material reuse, to reduce dependence on imports from individual countries and increase the resilience of the supply system. The EU highlights recycling as a key instrument for achieving strategic autonomy. The EU Battery Regulation also requires that batteries placed on the market contain a share of recycled materials. In Norway, several actors are already leading in recycling within their respective areas, including Norsk Hydro, Glencore Nikkelverk, Hydrovolt and Vianode.

In this perspective, not only traditional recycling is emphasised, but also the utilisation of industrial side streams and waste as potential sources of critical raw materials. The ambition is to increase overall resource efficiency through improved mapping, technological development and the establishment of new industrial value chains based on secondary material streams.

At company level, the review shows that several Norwegian actors are already actively working to develop circular solutions and utilise industrial side streams as part of their core activities. Examples include the recovery and recycling of metals in closed loops, further processing of by-products from metallurgical processes, utilisation of residual materials from electrolysis and smelting operations, and the development of secondary raw material streams from waste and production residues. For some actors, these streams are integrated directly into production, such that they are not treated as waste but as inputs to new or existing processes. This applies across aluminium, nickel, silicon and graphite-based value chains, where, in several cases, the degree of material utilisation is already high and continues to improve.

At the same time, the review illustrates that the potential for increased utilisation of secondary raw materials is closely linked to further development of process expertise and technology. For many companies, work on circularity is aimed at increasing the recovery of valuable elements from complex material streams, such as slags, dust fractions and other production residues. In addition, new industrial solutions are being developed to integrate recycled materials into the production of materials with high quality requirements, including within battery value chains and specialised metal products. These developments show that circularity is not a separate track, but an integrated part of the continued development of the process industry, where the ability to utilise both primary and secondary raw material streams is becoming increasingly important for competitiveness and strategic relevance.

Resources in historical deposits

In addition to ongoing side streams, secondary resources in the form of historical deposits may represent a potential source of raw materials. Such deposits may contain significant quantities of metals and minerals that were not utilised at the time they were established, either due to lower commodity prices, limited technology, lack of markets for products that are important today, or other priorities prevailing at the time.

The development of new processing and separation technologies, combined with increasing demand for critical raw materials, has strengthened interest in such resources in recent years. At the same time, the potential future utilisation of these deposits raises questions related to environmental considerations, ownership, regulation and economic viability. Figure 10 shows existing deposit sites in Norway.

As part of the follow-up to the government's mineral strategy, the Geological Survey of Norway (NGU) has been tasked with mapping and characterising Norwegian tailings deposits with a view to future utilisation. This includes establishing improved knowledge on composition, volume and the potential for secondary raw materials in both historical and existing deposits.[77]

This initiative reflects a growing recognition that deposits and tailings may constitute a relevant resource base, and similar mapping efforts are currently being carried out across large parts of Europe. However, the work remains primarily focused on mapping and characterisation, and it is yet to be determined to what extent such resources can be utilised on an industrial and commercial basis, and under which conditions this would be economically viable. These studies also have relevance for future reuse and environmental management.

NGU initiated work on the mapping and characterisation of deposits in 2022, including in collaboration with counterpart organisations in Sweden and Finland. In 2024, a Nordic project to develop a database and map selected historical mining deposits was completed with support from Nordic Innovation.[78] The work has subsequently been continued through national mapping activities led by NGU.

[77] NGU - tildelingsbrev for 2026

[78] Secondary Resources and their Critical Raw Material Potential in the Nordic Countries

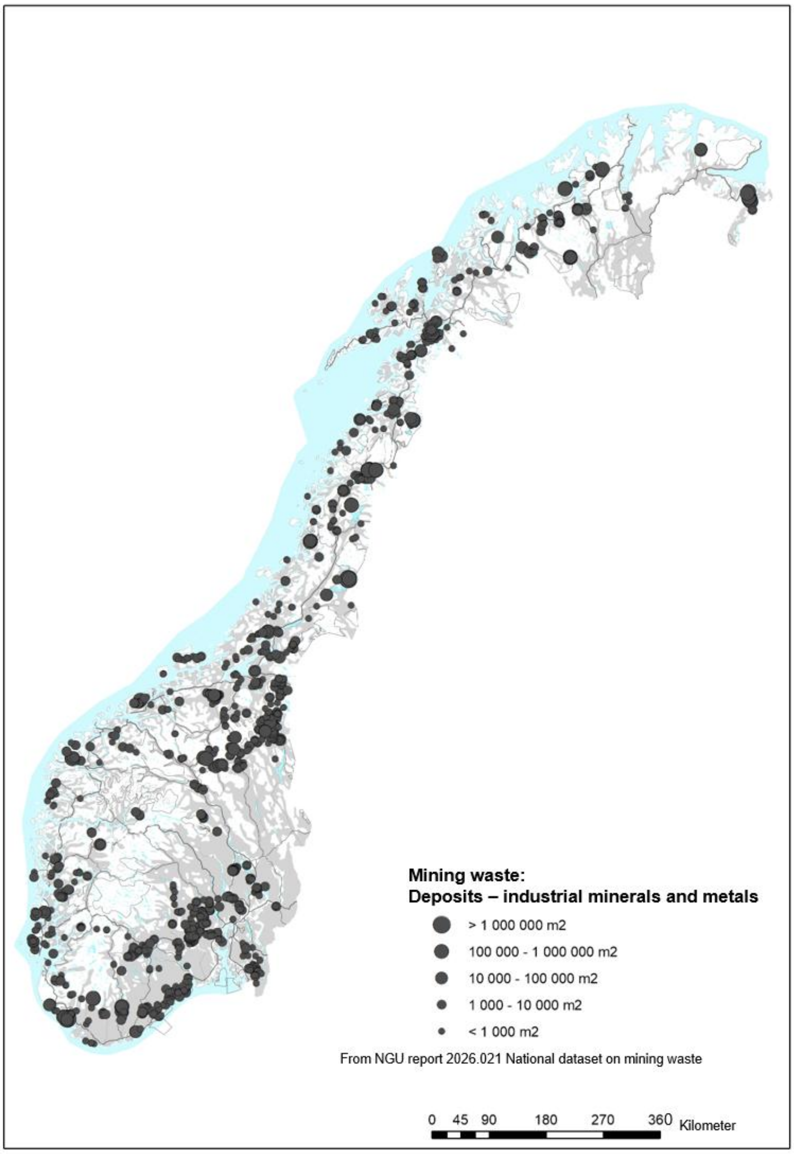

Figure 10 - Map of deposit sites associated with industrial minerals and metals from past mining activity.[79]

As part of this work, LiDAR- and GIS-based analyses have identified more than one thousand deposit sites in Norway associated with both active and abandoned mines and prospects. Most of these are, however, too small to be of commercial interest. An initial screening of the potential relevance of these deposits, particularly about critical raw materials, forms the basis for NGU's further prioritisation of which sites are examined in more detail.

One example of such a prioritised investigation is the tailings deposit at the copper–zinc deposit at Løkken in Orkdal municipality. The investigated deposit shows median concentrations of 2.3 % copper, 2.1 % zinc, 363 g/t cobalt and 18 g/t silver, which must be considered very high levels for a secondary resource. At the same time, the volume is limited, with an estimated total of approximately 3 160 m³. As a result, economically viable extraction of metals from such smaller deposits will in many cases depend on the development of mining of primary resources in the surrounding area.[80]

79 Raaness, A. M., Hibelot, T. & Simoni, M. U. 2026. National dataset on mining waste. NGU report 2026.021.

80 Geochemical and geophysical investigations of the old tailings deposit in Løkken

As a continuation of this work, NGU has, among other activities after 2024, conducted investigations at the Flåt nickel mine in Agder. NGU plans to complete the mapping of the 10–12 most relevant deposits in Norway by 2029, including volume estimates as well as chemical and mineralogical characterisation.

Recent studies show that the potential of historical tailings deposits largely depends on how the materials are present and which processes can be used to recover them. Metals are often bound in complex mineral phases and in finely dispersed fractions, making them more difficult to extract using conventional methods. At the same time, the studies indicate that, in many cases, significant values may remain in such residual materials, particularly for metals such as cobalt, nickel and, in some instances, rare earth elements. This implies that the assessment of these resources will increasingly depend on the development of more tailored processing solutions.[81]

Furthermore, the work indicates that economically viable utilisation can rarely be assessed based on individual deposits in isolation, but must be considered in relation to volume, logistics, processing and potential linkages to existing or planned mining operations. Overall, this implies that the realisation of secondary resources from deposits will depend to a greater extent on industrial and economic conditions than on the resource content alone.

Industrial side streams as a resource base and a database for industrial side streams

Side streams and by-products from industrial processes represent a significant, and in many cases underutilised, resource base. In the process industry, the minerals industry and other material-intensive sectors, material streams are continuously generated that are either disposed of, used for low-value purposes or utilised internally to a limited extent.

Mapping exercises within the Norwegian process industry show that such side streams often contain substantial quantities of metals and minerals, including elements that are part of critical and strategic raw materials. At the same time, the degree of utilisation varies considerably. In many cases, these materials have not been developed into commercial products, either due to technological challenges, economic viability or regulatory constraints.

A key characteristic of industrial side streams is that criticality is rarely linked to volume alone, but rather to the ability to identify relevant materials through chemical analysis, develop processes for concentration and refining, and establish markets for secondary raw materials of sufficient quality. Side streams therefore represent not only a volume of available materials but also a potential for developing new value chains based on existing industrial activity.

To map this potential, the Eyde Cluster was commissioned in 2020 by the Ministry of Climate and Environment to carry out a systematic mapping of side streams from the Norwegian process industry, minerals industry, cement and concrete industry, and pulp and paper industry. The work was carried out in close cooperation with industrial clusters, individual companies and industry organisations, including Norsk Industri (Federation of Norwegian Industries) and Norsk Bergindustri (Norwegian Mining Association).[82]

The mapping has subsequently been developed into a searchable database, where data from companies have been systematised for analysis and the identification of potential industrial applications. The purpose of the database is to make available material streams more visible and to facilitate improved utilisation of side streams through collaboration and knowledge sharing between companies. The work has periodically received support from the Ministry of Climate and Environment, and the database was updated in 2025 in cooperation with participating companies, alongside improvements to its search functionality.

As of May 2026, the database contains information on 230 side streams across 50 companies, with a total annual material volume of approximately 14.7 million tonnes. The dataset primarily covers the process- and minerals industries and reflects ongoing production streams. Information is reported by the companies themselves according to a standardised template. This includes chemical composition, current handling of the material stream, and assessments of its further utilisation potential. Of the registered side streams, 126 are considered to have greater potential than their current use.

Access to the data is differentiated, and ownership of the information remains with the individual companies. Companies determine whether their data are made publicly available. As a result, the database is not fully publicly accessible, and its use in practice depends on facilitated access and collaboration between participants. Most data

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[81] Filter - Nasjonalt vitenarkiv

[82] Sidestrømskartlegging

are shared within the network in connection with collaborative projects, workshops and development activities, while certain information, particularly related to chemical analysis, is typically classified as confidential.

Regarding critical raw materials, the database identifies larger volumes of more established materials such as aluminium, silicon, manganese, chromium and nickel. For rarer or less frequently analysed materials, the available data are more limited, likely because such elements have not always been included in analytical work.

There are, however, exceptions. Significant quantities of arsenic and antimony have been identified, and some side streams contain trace amounts of materials such as scandium, tellurium, thallium, cobalt and gallium. Elkem developed and patented a process for gallium production as early as the 1980s, based on a side stream from aluminium production. Aluminium plants of Elkem were later acquired by Alcoa.

3.6 Historical overview – from diversification to specialisation

The presentation in this chapter is based on a compilation of publicly available sources, including *Store norske leksikon*, open online resources such as Wikipedia, as well as company information and historical overviews. The chapter is not intended as a complete or source-critical account of Norwegian mining and industrial history, but rather provides an overall, synthesised picture of key historical developments.

The history of Norway's mining industry constitutes a central part of the country's broader industrial development and dates back several centuries. Although mining originally formed part of the primary sector, an early and tightly integrated relationship developed with secondary industries such as smelting, chemical production and engineering. Around mining operations, complex industrial environments emerged in which extraction, transport, processing and technological development were closely interconnected, giving these activities a distinct industrial character.

As early as the 17th century, substantial mining operations were established in Norway. The copper works in Trøndelag were particularly important, including Kvikne copper works from 1630, Røros Copper Works from 1644, and later activities at Løkken, Selbu and Folldal. These operations represent early examples of integrated systems in which ore extraction and further processing formed part of the same value chain. In parallel, production of cobalt and later nickel developed, including at Blaafarveverket and through subsequent nickel-bearing ore extraction in areas such as Ringerike, Bamble, Evje and Senja.

From the mid-19th century and particularly towards the end of the century, pyrite became a dominant raw material in the Norwegian mining industry. New mines were developed at Vigsnes, Stord, Sulitjelma, Kjøli and Killingdal, and production increased significantly. By the early 20th century, pyrite had become one of Norway's most important mining products, with output exceeding one million tonnes annually during the interwar period, representing a substantial share of global production. This development laid an important foundation for the emergence of Norwegian industry, which relied heavily on the utilisation of sulphur derived from pyrite.

At the same time, infrastructure developed in parallel with industrial expansion. Railways, aerial ropeways and port facilities, such as the connection between Løkken and Thamshavn, enabled efficient transport of ore to processing facilities and export markets. In several cases, smelters were established close to shipping ports, such as in Thamshavn from 1931, where sulphur was extracted directly from pyrite. This illustrates how Norwegian mining early on developed integrated value chains from extraction to processing.

During the 20th century, the sector underwent further diversification. Large operations such as Sydvaranger in Finnmark developed iron ore production on a global scale, while new minerals gained increasing importance. Titanium-bearing raw materials were introduced early in the century, with a transition from rutile to ilmenite following technological advances and the establishment of Titania at Tellnes from the 1960s, forming the basis for a lasting industrial cluster. At the same time, production of industrial minerals such as olivine, nepheline and later high-purity quartz was established, particularly in Northern Norway and along the coast.

Norwegian process industry has evolved from a phase characterised by broad industrial development, technological experimentation and diversification to a structure that today is far more defined by specialisation in selected materials and value chain segments. In its earlier phase, many of the key companies were not confined to a single material or market but operated across multiple technological domains, input materials and product categories. Over time, global competition, capital intensity and increasingly specialised markets have driven a clearer concentration around core activities.

Norsk Hydro provides a clear example of this development. The company was established in 1905 to produce fertiliser using the Birkeland–Eyde process, based on hydropower and electricity-intensive nitrogen fixation. Hydro also built activities in hydrogen and heavy water at Rjukan and later developed a broad portfolio within the chemical industry, including chlor-alkali products and various specialty chemicals. In the post-war period, magnesium production also became a major business area, with plants at Herøya and later operations in Canada. The company also expanded into aluminium, petrochemicals, and eventually oil and gas.

Today, the company is primarily focused on energy and aluminium and operates as a globally integrated aluminium company, with activities spanning from bauxite and alumina to primary aluminium and downstream products such as castings, rolled products and extrusions. This development illustrates the transition from a broadly diversified industrial conglomerate to a value chain-driven company with a clear strategic focus.

Elkem has undergone a similar transformation. Established in 1904 as a technology company for power-based industry, it played a central role in the development of electrothermal processes and metallurgical technology. Elkem developed, among other innovations, the Söderberg electrode and operated across ferrosilicon, silicon, carbon products and aluminium, while also contributing to the establishment of other industrial companies.

At the same time, the company has developed new products based on by-products and side streams from existing production. A key example is microsilica, which is generated as a by-product from silicon production and has subsequently been developed into a high-value material used in high-performance concrete and specialised applications. This illustrates how technological opportunities and material flows within diversified industrial structures can give rise to new niche products over time. Following periods as part of Orkla and later the Chinese Bluestar group, Elkem today has a clear profile as a producer of silicon, silicon-based advanced materials, ferrosilicon and carbon solutions—again reflecting the shift from diversification to specialisation.

The development of Eramet in Norway illustrates how today's specialised structure has also been shaped by acquisitions and consolidation of existing Norwegian industry. Eramet Norway was established in 1999 when the French group acquired smelters in Sauda and Porsgrunn from Elkem. In 2008, Eramet also acquired Tinfos' plants in Kvinesdal and Tyssedal. Today, operations in Sauda, Porsgrunn and Kvinesdal are concentrated on manganese alloys, while Tyssedal focuses on production based on titanium-bearing raw materials. This illustrates how a previously broader and more fragmented smelting industry has been consolidated into fewer companies with clearer product specialisation.

Tyssedal itself provides a clear example of such structural shifts. After the aluminium plant in Tyssedal was closed in 1980, a smelter was established in the early 1980s to utilise ilmenite resources and available electricity and labour. The plant subsequently became part of Tinfos and later Eramet, before being acquired by INEOS in 2023 and renamed INEOS Tyssedal. Today, it produces titanium slag with high TiO_2 content for the pigment industry and high-purity pig iron for European foundries. The site illustrates how a single industrial location has transitioned from aluminium to titanium raw materials and further into specialised metallurgical products.

Orkla Exolon, now Washington Mills in Orkland, illustrates another dimension of this development. Established in 1962 by Orkla, Christiania Spigerverk and the American company Exolon, production was based on silicon carbide, initially as a relatively broad industrial mineral product. Over time, the company became increasingly specialised in finer grades and micro-powders for a growing range of applications. It was eventually acquired by Washington Mills and is today part of an international structure focused on high-value silicon carbide products.

Fesil provides another example. The company had roots in the Ila and Lilleby smelting works in Trondheim and was involved over time in a wide range of activities, including carbides, zinc refining, ferrochrome, manganese alloys, ferrosilicon, iron foundry furnaces, silicon metal and later solar-grade silicon. Operations were in Lilleby, Holla and Mo i Rana, before being gradually consolidated through closures, divestments and acquisitions. Holla was sold to Wacker, while Rana Metall later became part of Elkem.

Overall, the picture is therefore not only one of increasing internationalisation of Norwegian industry, but also one of a clear transition from diversification to specialisation. Many of the companies that today appear as dedicated aluminium, manganese, titanium or silicon producers historically operated across a much broader range of technologies, products and markets. At the same time, many have developed specialised materials for demanding applications, contributing to sustained relevance, stable cash flows and international competitiveness.

4. Analysis of Norway's role in critical and strategic value chains

This chapter provides a consolidated, quantitative overview of Norway's role in selected parts of the value chain for critical and strategic raw materials. The purpose is to highlight Norwegian mineral extraction and processing capacity in a European and global context, and to provide a comparable picture of where Norway has tangible relevance for allied partners. The analysis is based on production volume, value and geographical distribution and seeks to link these dimensions to the structure and development of the value chains. At the same time, it is important to emphasise that such representations necessarily involve simplifications, as they combine data across different materials, processing stages and statistical frameworks. The overview presented should therefore be understood as an analytical tool for assessing relative scale and position, rather than as a precise and fully consistent statistical basis.

4.1 Overview of Norway's market position

Table 1 – Overview of selected critical and strategic materials, either as processed products or mineral deposits, in which Norway holds a relatively significant position in a European context. Sources are based on the British Geological Survey, the U.S. Geological Survey, EU RMIS and SCRREEN, and have subsequently been adjusted based on company data.

Processes Materials				Global value	Global production	European production capacity production	Norwgian production capacity volume	Norwegian share of European production volume	Norwegian share of global production volume	2025 Norwgian exports value [2]
Critical Raw Material	**Definition**	**Companies**	**Description**	(bn. NOK)	(1000 tons)	(1000 tons)	(1000 tons)	Percent (%)	Percent (%)	(bn. NOK)
Aluminium	Al	Norsk Hydro, Alcoa	Primary aluminium	2 500	73 000	3 500	1 400	40 %	2 %	54,9
Nickel	Ni	Glencore Nikkelverk	Rafined Nickel metal (Class 1)	185	1 138	180	100	56 %	9 %	16,1
Zinc [1]	Zn	Boliden Odda	Raffined zinc metal	330	14 000	1 884	350	19 %	2 %	5,4
Silicon	Si	Elkem, Wacker	Silicon metal	73	4 686	310	220	71 %	4 %	5,2
Ferro silicon	FeSi	Elkem, Finnfjord	Ferro silicon	101	7 800	425	185	44 %	2 %	3,9
Manganese alloys	FeMn	Eramet, Ferroglobe	Ferro-/Siliko-manganese	250	22 900	910	640	70 %	3 %	3,8
Cobalt	Co	Glencore Nikkelverk	Raffined cobalt metal	20	56	6	3	50 %	5 %	1,0
Rare Earths Elements	REE	REEtec	NdPr-oxides	80	78	3	1	25 %	1 %	0,2
Graphite (battery quality)	C	Vianode	Anode-graphite	175	2 661	4	2	50 %	0 %	0,1

[1] Norwegian capacity expansion in operation in 2026

[2] Source: SSB, tabell 08801

Extraction				Global value	Global production	European production capacity production	Norwgian production capacity volume	Norwegian share of European production volume	Norwegian share of global production volume	2025 Norsk eksport verdi [4]
Kritisk/strategisk råmateriale	**Definition**	**Companies**	**Beskrivelse**	(bn. NOK)	(1000 tons)	(1000 tons)	(1000 tons)	Percent (%)	Percent (%)	(bn. NOK)
Titanium-bearing ore	Ilmenite	Titania	Extraction	30	10 900	700	700	100 %	6 %	1,1
Nepheline syenite	Feldspar	Sibelco	Extraction	13	5 700	300	300	100 %	5 %	0,43
Graphite (natural concentrate)	Graphite	Skaland Graphite	Graphite concentrate	15	1 750	7	7	95 %	0,4 %	0,06
Titanium-bearing ore [3]	Rutile	Norge Mining	Expected extraction	6	550	35	35	100 %	6 %	0

Nordic Mining opened rutile extraction and processing in 2024 og volume expectation valid for 2027

[4] Export value estimated by NGU baserd on SSB, producers and UN trade data

For the process industry, which constitutes the upper part of the table, the materials are ranked according to actual export value for 2025. The overview clearly shows that aluminium is the dominant activity by a wide margin, both in terms of value and volume. This reflects an industry characterised by both breadth and maturity, with seven plants producing primary aluminium and one facility refining high-purity aluminium. Also included in the export data are cast and extruded products. Refined nickel (*high grade*), associated with Glencore Nikkelverk in Kristiansand, follows as the second most significant activity, giving Norway a clear position in a market characterised by stringent requirements for purity and quality. The table further highlights the importance of Norwegian process activities in silicon, ferrosilicon and manganese alloys, all of which are key inputs in industrial value chains. In addition, cobalt appears as a by-product of nickel refining, illustrating how several critical and strategic materials are embedded within the same industrial processes. In emerging material segments, the overview also shows activities related to rare earth elements and synthetic graphite, represented by industrial facilities operated by REEtec and Vianode. Overall, this underlines that the Norwegian process industry covers both established and emerging parts of the value chain, with a clear emphasis on processing and refining stages.

For mineral extraction, the table reflects a different structural pattern, where geological conditions play a more prominent role than export values. A characteristic feature is that Norway holds a dominant position in Europe for certain raw materials. This applies to titanium-bearing deposits and nepheline syenite, where Norwegian production effectively constitutes the entire European supply. Skaland Graphite also stands out as a unique deposit, hosting the active mine with the highest known content of coarse crystalline graphite globally. At the same time, it is more challenging to establish comparable export values for mineral extraction than for processed products. This is partly due to confidentiality constraints in official statistics, particularly where production is dominated by a small number of actors or where individual companies may be identifiable. NGU has therefore prepared estimates based on data from Statistics Norway (SSB), company information and UN trade statistics.[83] The table should therefore be understood as an indicative representation of activity and significance, rather than a complete quantification of economic value. Overall, the overview shows that Norwegian mineral extraction is particularly significant either where it accounts for all or large parts of European production, or where deposits possess distinct qualities that provide a strategic position in downstream value chains.

This relationship is further illustrated in Figure 11, where the activities presented in Table 1 are displayed as a bubble chart combining market value and market position. The figure shows Norwegian actors' share of global capacity along the x-axis and share of European production along the y-axis, while the size of the bubbles represents the global market value of the respective materials. Market shares are calculated within segments of comparable products and qualities.

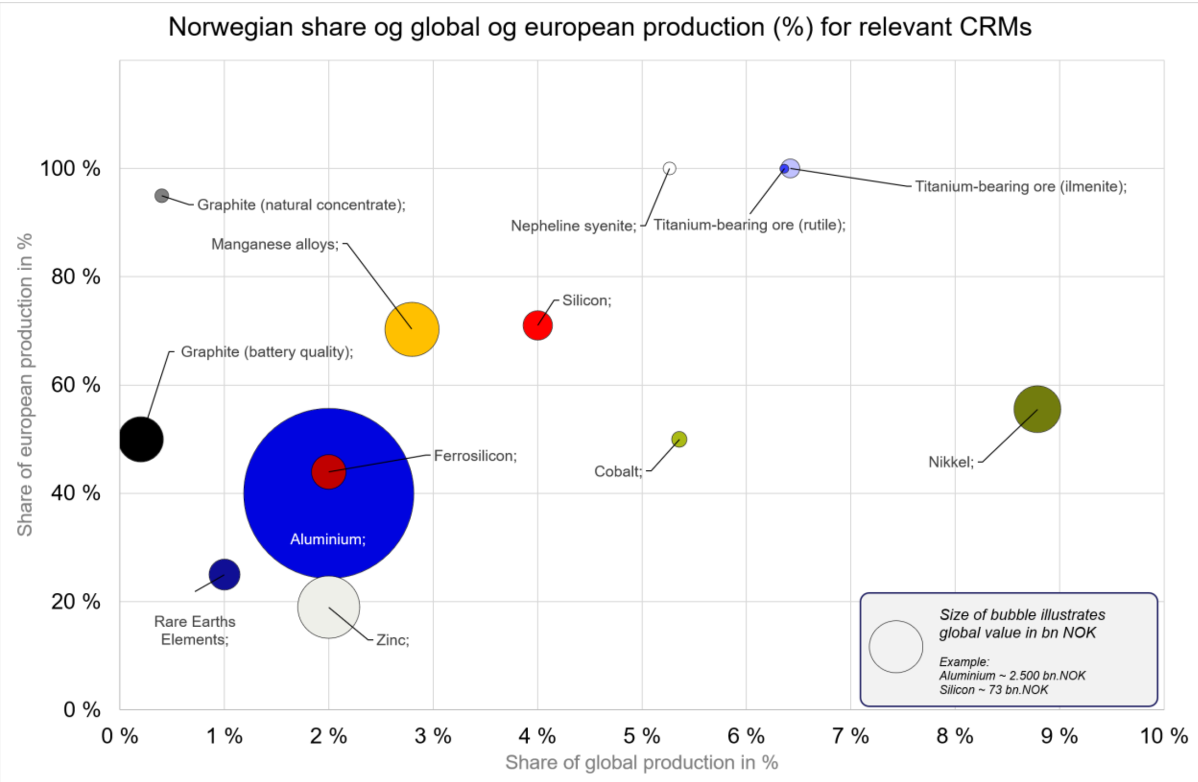


Figure 11 - Visualisation of Norwegian actors' share of global and European production capacity, with bubble size indicating the global market value of the corresponding products.

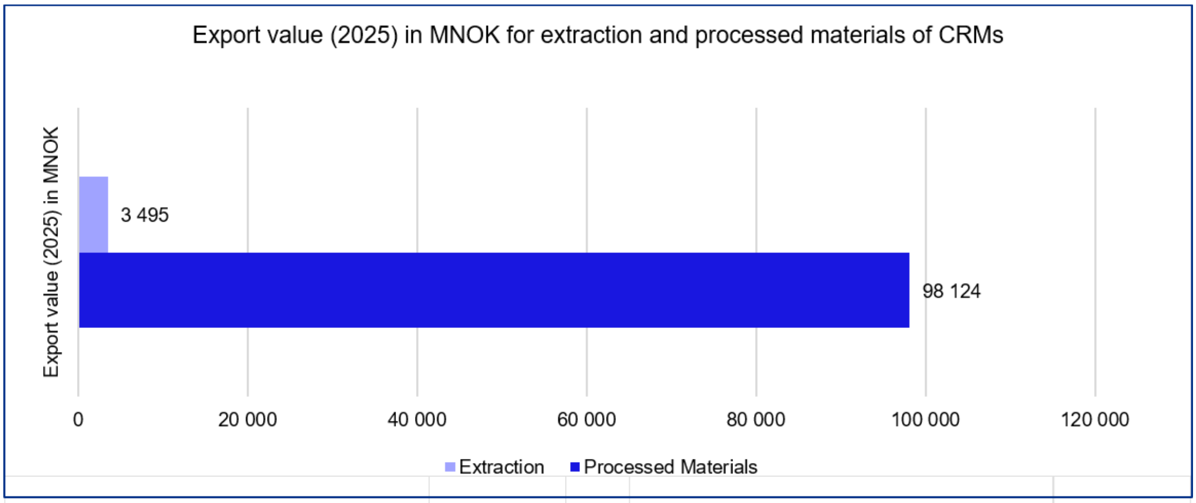
[83] *Neeb og Simoni, NGU (2026),*

The consolidated overview provides an overall picture of Norwegian mineral extraction and processing capacity in a European and global context. Table 1 is based on a synthesis of multiple data sources and should be understood as an indicative representation of orders of magnitude, rather than as a consistent statistical basis in the traditional sense. This is largely because the analysis is based on a value chain perspective and on materials refined to a specified quality at a defined processing stage.

Figure 12 shows the export value of Norwegian mineral extraction and processed materials related to critical raw materials. It illustrates a clear distinction between upstream activities associated with raw material extraction and downstream activities in the process industry, where materials are further processed and significantly increased in value.

The total export value from the extraction of critical raw materials is estimated at approximately NOK 3.5 billion in 2025. This value is distributed across a limited number of products, with iron ore and ilmenite representing the largest individual items, at approximately NOK 1.4 billion and NOK 1.1 billion respectively.

By comparison, the figure shows that the export value for processed materials amounts to close to NOK 100 billion. This value is dominated by aluminium, which alone accounts for nearly NOK 55 billion and thus represents a substantial share of Norway's total exports of critical and strategic materials. Additional significant contributions come from nickel (approximately NOK 16 billion), ferroalloys (approximately NOK 7.7 billion), as well as zinc and silicon, each at around NOK 5 billion. Platinum group metals, copper and cobalt also contribute substantial export values.



	Export value MNOK 2025
Iron ore (Fe)	1 374
Ilmenite (Ti)	1 100
Quartz (SiO2)	516
Nepheline syenite	426
Graphite (C)	61
Nickel (Ni)	16
Feldspar	1
Copper (Cu)	1
TOTAL extraction CRM	**3 495**

Export value estimated by NGU based on SSB, producers and UN trade data

	Export value MNOK 2025
Aluminium (Al)	54 934
Nickel (Ni)	16 129
Ferro Alloys (Si/Mn)	7 688
Zinc (Zn)	5 367
Silicon (Si)	5 191
Platinum Group Metals	3 898
Copper (Cu)	3 633
Cobalt (Co)	975
Rare Earth Elements (REE)	226
Synthetic graphite (C)	84
TOTAL processed materials CRM	**98 124**

Source: SSB, tabell 08801

Figure 12 - Export value from Norwegian mineral extraction and processed materials related to critical raw materials (2025). Sources: Statistics Norway (SSB), table 08801 and NGU estimates based on SSB data, company information and UN trade statistics.

The difference between these two levels, around NOK 3.5 billion in extraction and close to NOK 100 billion in processed materials, illustrates a fundamental value chain dynamic in which value creation occurs primarily in processing, refining and material upgrading rather than in raw material extraction alone. This reflects both higher prices for finished or semi-finished materials and the technological and industrial capabilities required to produce them. Not least, it highlights the potential associated with establishing additional stages in the value chains based on geological deposits and mineral extraction.

4.2 Data basis and methodological considerations

For many of the materials included in the overview, there is no single, unambiguous statistical definition of what constitutes "production". Data may be reported as extraction, refined metals, alloys or specialised material products, depending on the source and statistical framework. This implies that both volumes and values vary significantly depending on which stage of the value chain is considered. Direct comparison across materials will therefore necessarily involve a certain degree of methodological inconsistency, particularly when combining materials that form part of different processing chains and end markets.

The data base is primarily derived from the British Geological Survey (BGS) publication *World Mineral Production*[84], which provides consistent and comparable production statistics across countries, with 2024 as the most recent complete reporting year. This source has been used as the main reference for global volumes and production data for European countries. To supplement and validate this picture, data have also been drawn from *USGS Mineral Commodity Summaries 2026*[85] and the EUs Raw Materials Information System (RMIS)[86], which is based on the analytical framework developed through the SCRREEN project[87]. For certain materials, particularly where public statistics are limited, specialised market analyses have also been used, including data from Benchmark Mineral Intelligence[88] for synthetic graphite.

To ensure relevance and up-to-date information, the data has also been verified or updated against available information from the companies concerned. In some cases, adjustments have been made to reflect new or updated production capacity not captured in the international statistical sources. Estimates of market value are partly based on available price data from market indices (LME)[89] , and partly on industry information where such data are not available in open sources.

Despite this approach, it is important to emphasise that no single consistent and complete data set exists that covers all relevant materials, value chain stages and geographical boundaries. Different sources apply different definitions, time series, units and methodological assumptions. In addition, factors such as co-production, by-products and the degree of downstream processing influence how production is attributed to different material streams. This is particularly relevant for metals and minerals that form part of complex alloys or are further processed into specialised material qualities.

Table 1 should therefore be understood as a synthesis of available knowledge, with the primary objective of providing a comparable picture of Norway's relative role in selected material streams. While the absolute figures are subject to uncertainty, the overview provides a robust basis for assessing where Norway has significance in European and global value chains, and how this significance varies across different materials and stages of processing.

4.3 Data basis for assessing Norway's market position in EU

A key question in assessing Norway's role is the actual market share held by Norwegian actors, particularly in the European market, which is Norway's most important. However, it has not been within the scope of this study to carry out a systematic mapping of Norwegian market shares compared with those of other countries in the EU.

An indication of such market shares can nevertheless be derived through the EU's Raw Materials Information System (RMIS), which is based on data developed, among other sources, through the SCRREEN project. RMIS

84 World mineral production 2020-24 - NERC Open Research Archive
85 Mineral Commodity Summaries 2026
86 RMIS - Raw materials' profiles
87 Flexx SCRREEN 3 -
88 Battery & Critical Minerals Intelligence | Benchmark
89 Home | London Metal Exchange

provides an overview of the EU's supply structure for selected materials, including contributions from third countries such as Norway, and shows both relative market shares and the countries from which the EU imports.

The data is primarily based on 2023, with some updates through to 2025 for selected materials, and the system remains under further development by the European Commission. Despite these limitations, RMIS provides a useful picture of Norway's position in the European market.

For several materials, Norway emerges as a significant supplier, particularly in aluminium, silicon, ferrosilicon, manganese alloys and nickel. At the same time, RMIS illustrates how these materials form part of broader import flows into the EU, where deliveries from Norway must be understood in the context of competing and complementary supplies from other regions. This highlights both Norway's relative strengths in selected materials and the structural dependence on global value chains that characterises European raw material supply.

4.4 Delimitation – assessment of value potential for deposits

It has also been assessed to what extent it is appropriate to convert resource estimates for selected deposits into estimated annual revenues based on current price levels. While such calculations may provide an intuitive illustration of potential values, they are subject to considerable uncertainty. This is due, among other factors, to variations in ore grade, recovery rates, processing yields, product quality and market prices, as well as the fact that different projects are at different stages of development.

Furthermore, value creation in many cases is largely linked to further processing and integration into value chains rather than to the value of the raw material alone. On this basis, it has been decided not to present aggregated estimates of potential annual revenues for the deposits.

4.5 Market developments for materials where Norway holds positions

Aluminium

The European aluminium industry has faced significant challenges, particularly following the energy price crisis in 2022. At the same time, the industry represents an established and relatively complete value chain, with more than 600 production facilities across Europe covering the entire spectrum from bauxite extraction to recycling. However, the market is characterised by a structural imbalance between demand and domestic production capacity for primary aluminium. Demand has been relatively stable since the financial crisis, but with an increasing share of recycled aluminium. At the same time, European primary production has been stable, and in recent years declining, because of high energy costs and weaker competitive conditions compared with other regions.[90]

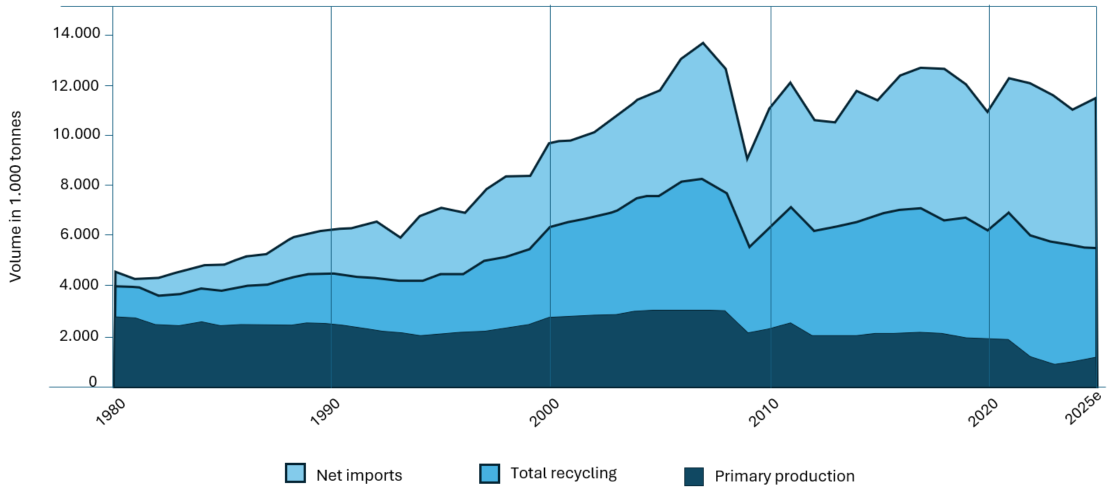


Figure 13 - Overview of primary aluminium production in Europe. The estimate for EU-27 in 2025 was 1,167 thousand tonnes. This excludes Norway, Iceland and other non-EU countries. Data cover EU-15 up to 1999, EU-25 for the period 2000–2004, EU-27 for 2005–2013, EU-28 for 2014–2019 and EU-27 from 2021 onwards. (Figure reconstructed; source: European Aluminium)

90 https://european-aluminium.eu/about-aluminium/aluminium-industry/

This has led to an increasing share of demand being met through imports from third countries. Iceland and Norway are important supplier countries to the EU, but the Union also imports primary metal from, among others, Turkey and Saudi Arabia, India and China. Figure 13 illustrates the EU market supply through an overview of primary metal production, recycled volumes and imports, where imports also include deliveries from Norway and Iceland.

Nickel (and cobalt as a co-product)

The nickel market has in recent years been characterised by persistent oversupply and declining prices. In 2025, prices fell for the third consecutive year, to an average of around USD 15,000 per tonne, in a market where global production increased by approximately 7 percent. Supply growth has largely been driven by the production of *nickel pig iron* (NPI) in Indonesia, which alone accounted for a significant share of global nickel units. High-grade nickel (*Class 1*), as shown in Table 1, represents a volume of approximately 1.1 million tonnes and accounts for around 30 percent of total global nickel production, including ferronickel. Demand for nickel continues to be dominated by stainless steel, with moderate global growth, while demand from the battery sector has developed more slowly than previously expected due to a shift towards less nickel-intensive battery chemistries.

The structural development of the market is closely linked to the build-out of integrated value chains in Indonesia, where Chinese actors have invested heavily in mining, processing facilities and downstream production. This also follows from Indonesian policy requiring domestic processing of ore prior to export, which has contributed to the establishment of large, vertically integrated industrial complexes. Over time, these investments have created significant global overcapacity, and production growth is expected to continue, with an increasing share of global nickel units linked to Indonesian supply streams. At the same time, the linkage between lower-refined products such as NPI and ferronickel and high-purity nickel has strengthened, partly through the development of processes that enable conversion into battery-grade materials.

Cobalt is primarily produced as a by-product of nickel and copper mining, and developments in the cobalt market are therefore closely linked to the increase in nickel production. Increased output from new nickel projects has contributed to growth in cobalt supply and thereby to oversupply and downward price pressure, despite rising demand from the battery market.

Overall, both the nickel and cobalt markets are increasingly characterised by concentration in production and processing, a high degree of vertical integration and persistent overcapacity, all of which influence global price levels and the profitability of new projects in other regions.

Silicon (silicon metal)

Silicon metal is a key input factor in several industrial value chains, including aluminium alloys, the chemical industry (siloxanes), electronics, and increasingly solar power production through further processing into polysilicon. Production of silicon metal in Norway is based on access to quartz and renewable energy, and the Norwegian silicon industry has over time developed a strong international position, both in terms of technological capabilities and carbon-efficient production.

At the same time, the market is characterised by increasing global competition, particularly from China, which has built up substantial capacity both in the production of silicon metal and in downstream processing into products such as polysilicon and solar components. This implies that the competitive landscape is increasingly shaped by cost levels, access to energy and industrial framework conditions, while demand is driven by both traditional industries and green technologies.

Silicon thus illustrates a market in which European/Norwegian industry still holds a significant position in upstream production, while value creation is increasingly concentrated in downstream value chains dominated by actors outside Europe.

Ferroalloys (ferrosilicon and manganese alloys)

Ferroalloys comprise several products and product qualities, of which ferrosilicon, ferromanganese and silicomanganese are the alloys produced in Norway. However, market conditions have changed following the introduction by the EU of a safeguard mechanism for ferroalloys effective from 19 November 2025. The measure covers ferrosilicon, ferromanganese, silicomanganese and ferrosilicomagnesium and is designed as a tariff rate quota system, where the import quota is set at 75 percent of historical import levels, combined with minimum prices for imports exceeding the quota.

Norway is included in the measure, which limits market access to its most important export market. The following companies are directly affected: Elkem, Finnfjord, Eramet, Ferroglobe and Hafsil. Considering the increased use of trade defence measures in the EU, including safeguard duties, the precedent set by the ferroalloy case has contributed to significant uncertainty also for other sectors. There is uncertainty as to whether free market access to the EU will be maintained going forward. At the same time, increasing protectionism in the United States reinforces the trend towards more fragmented markets. Market access thus emerges as a key risk factor for Norwegian export-oriented ferroalloy industries, and this uncertainty is likely to be increasingly reflected in decisions on future investments and capacity expansions.

The market for manganese alloys has also been affected by geopolitical developments following Russia's full-scale invasion of Ukraine in 2022. Prior to the war, Ukraine was one of the most important producers of manganese alloys in Europe, both in terms of production and installed capacity. Reduced output because of the war has contributed to lower European supply and increased dependence on imports from other regions. At the same time, several European smelters have in periods operated at reduced capacity due to high energy costs and weakened competitiveness. Together, these developments have contributed to a tighter and more volatile market in Europe, where availability, price levels and market structure are increasingly influenced by factors outside traditional market mechanisms.

Rare earth elements (REE)

The term rare earth elements (REE) encompass 17 individual elements, including the 15 lanthanides as well as scandium and yttrium, with significant variation in occurrence, chemical properties and applications. This is reflected in the market, where both demand and value vary considerably between the individual elements. In a typical deposit, neodymium and praseodymium (NdPr) account for more than 75 percent of the total value. NdPr is used in permanent magnets for electric vehicles, wind power, robotics and electronics, applications that are all characterised by strong growth. For this reason, it is appropriate to limit the market description to NdPr oxides, which constitute the most central and value-driving part of the rare earths market.

Global demand for NdPr oxides in 2024 was around 78,000 tonnes, and the market was largely balanced, with a limited surplus.[91] This implies that available processing capacity broadly corresponds to demand.[92] At the same time, global capacity is highly concentrated in China, which accounts for more than 85 percent of existing processing capacity. In Europe, only a limited number of actors have capacity for the separation of NdPr oxides, including REEtec in Norway, Solvay in France, Silmet in Estonia and Carester, which is currently developing a plant in France. However, there is uncertainty related to access to feedstock, actual production levels and the timing of scale-up to full capacity.

Overall, this means that the rare earths market is characterised by a high degree of concentration in the value chain, limited European capacity and uncertainty related to the actual availability of raw materials and production. See also the description of the Fen field in Chapter 3.1.

Graphite (natural, synthetic and battery-grade)

Natural graphite is extracted from geological deposits and processed into graphite concentrate, which can be used in a wide range of industrial applications. It can also be further upgraded to battery grade through purification, spheroidization and surface treatment. Synthetic graphite is produced industrially from carbon-rich raw materials such as petroleum coke through energy-intensive processes at high temperatures. The material can be used in various industrial applications and can similarly be further processed into battery-grade material through the adjustment of structural and surface properties.

Battery-grade graphite therefore represents a distinct and critical segment of the market, regardless of whether the raw material is natural or synthetic. It is this stage that links raw material production to battery cell manufacturing, and where most of the value creation and strategic control in the value chain is concentrated.

Market developments are shaped by structural factors on the supply side. In recent years, China has built up substantial overcapacity in battery graphite (both natural and synthetic), which has contributed to sustained price

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91 https://www.iluka.com/media/xyfjf0fr/iluka-investor-briefing.pdf (side 36)

92 World Scrambles for Rare Earths to Erode China's Dominance from 90% to 69% Market Share and Gain Pricing Power, According to Bloomberg Intelligence | Press | Bloomberg LP

pressure.[93] At times, market prices have been below production costs for new entrants. Chinese producers have nevertheless maintained production, supported by access to financing and various policy instruments, and these low prices are effectively exported to Western markets.[94]

This creates a highly challenging competitive environment for new projects in Europe and North America and contributes to delays in the development of new capacity. The result is that graphite stands out as a clear example of a material where criticality is only to a limited extent related to geological availability, and to a much greater extent linked to control over processing, material quality and integration into the battery value chain. At present, European production capacity for battery graphite remains very limited. The two existing facilities, Vianode's plant at Herøya and Tokai Cobex's plant in France, have a combined capacity of approximately 4,000 tonnes per year, corresponding to around 2 percent of European demand. Several projects have been announced, but few have been realised. At the same time, low-priced exports from China continue to affect European markets, weakening the competitiveness of Western producers that are still in a scale-up phase and further slowing the development of new capacity.

Ilmenite and rutile (titanium feedstocks)

Ilmenite and rutile are key raw materials in the production of titanium dioxide (TiO_2), which is used as a pigment in applications such as paints, plastics and paper. The market is primarily driven by demand from traditional industry and the construction sector and therefore differs from several other critical raw materials in being less directly linked to the energy transition and emerging technologies. At the same time, there is a clear value chain structure in which raw material production has a relatively low value per tonne, while substantial value creation occurs in chemical processing into pigment products.

Production of ilmenite is geographically concentrated in a limited number of countries, in which Norway is an important actor. At the same time, downstream processing is more internationalised, and the market is characterised by global value chains in which raw materials are exported to processing facilities. In a European context, there has been increasing attention to access to titanium dioxide as an input factor, particularly related to competitive conditions in the pigment market. The EU has introduced trade measures targeting imports of titanium dioxide from China to counter price pressure and contribute to more level playing field conditions for the European pigment industry.[95]

This reflects a market where strategic considerations are increasingly related to downstream processing and competitiveness in the chemical industry, rather than to raw material access alone. For raw material producers, this means that market developments are largely influenced by conditions in downstream value chains, including trade policy measures and developments in European industrial production.

At the same time, there is a more specialised but strategically important market for titanium metal, in which rutile, as well as high-quality titanium concentrates, are used as input factors. Titanium metal is applied in areas with high requirements for strength, low weight and corrosion resistance, including aerospace, defence and certain advanced industrial applications. This market is smaller than the pigment market but is characterised by higher value creation and a stronger linkage to strategic technologies. The development of downstream processing from titanium feedstocks to titanium metal in a European context has therefore received increasing attention, both from a supply security perspective and as part of efforts to increase value creation within the value chain.

93 Cleantech: Reducing Europe's Strategic Dependence on China | Institut Montaigne

94 The China Model's Fatal Flaw | Lizzi C. Lee

95 EU acts to counter dumping of titanium dioxide from China - Trade and Economic Security

5. Overall analysis of the mapping

5.1 Key observations

The mapping provides a comprehensive picture of how Norway's geological resources, mineral extraction and process industry are integrated into value chains for critical and strategic raw materials. In line with the analysis in Chapter 2, criticality must be understood in a value chain perspective, where the strategic importance of a raw material is not determined solely by its occurrence, but by the stages at which it is extracted, processed and incorporated into industrial applications. The relationship between critical raw materials and critical value chains implies that vulnerability and strategic importance are largely determined by concentration, control and capacity in these stages, rather than by raw material availability alone.

In accordance with the framework set out in *White Paper No. 16 (2024–2025) - Industry: competitiveness for a new era*, the role of Norwegian industry is analysed in both national and allied value chains, considering international frameworks, including the EU's initiatives under the *Critical Raw Materials Act* (CRMA) and corresponding strategies in other allied countries. The mapping reflects a growing recognition of the need for resilience and strategic autonomy in an increasingly uncertain geopolitical and market environment, where secure access to critical inputs is becoming both a political and industrial priority.

A central finding is that Norway's most established role in these value chains is only to a limited extent linked to primary raw material extraction, and to a greater extent to processing and further refining of materials. Norwegian process industry covers several of the most capital-intensive and technologically advanced stages, particularly within energy-intensive metallurgical and chemical processing, where both Norwegian and imported raw materials are transformed into materials with high requirements for purity, specification and performance. Overall, this results in a clearly defined industrial role based on processing and material quality, rather than on raw material extraction alone.

At the same time, Norway's role is complex. The mapping identifies a significant geological resource base and several relatively mature development projects, including within copper, rare earth elements and high-purity quartz. These represent a potential for increased mineral extraction in the medium term, but realisation depends on appropriate framework conditions, access to capital and sufficient execution capacity. In this context, the process industry appears as an established and operational capacity, whereas the geological resource base represents a longer-term opportunity space.

The mapping does not provide a basis for definitive conclusions regarding vulnerability in Norwegian value chains. Several companies depend on imported raw materials and inputs, while analyses from Statistics Norway indicate that such import flows may in some cases be associated with high vulnerability, including due to limited substitution options and exposure to suppliers outside Europe. Set in the context of the industrial structure described in this report, this implies that the same value chains may both be exposed to such dependencies and simultaneously constitute key stages in the further processing of critical inputs. Several actors also point to a significant capacity potential beyond current levels.

A recurring challenge in this context is the combination of higher cost levels and increasing global competition from actors operating under different regulatory and economic conditions. Several value chains are characterised by production concentration and, in some cases, by non-market measures that influence price formation and profitability. This makes investment challenging, despite high levels of technological maturity.

Overall, the mapping points towards a development trajectory in which Norway's role is not static, but can be further strengthened through increased specialisation, material upgrading and further processing within existing and new value chains. This forms the basis for the subsequent analyses of barriers and development opportunities.

5.2 Barriers to development and realisation

The development of geological deposits and the establishment of integrated value chains for critical and strategic raw materials are shaped by a range of barriers that vary across different stages of the value chain. These range from early-stage challenges related to regulation, land use and social acceptance, to capital and cost drivers in industrial scale-up, and further to market-related conditions in downstream segments. Overall, this reflects that different phases of the value chain are characterised by different types of risk and decision-making criteria, where certain barriers in practice function as thresholds that determine whether projects can be realised. Figure 14 illustrates the main barriers across the different parts of the value chain.

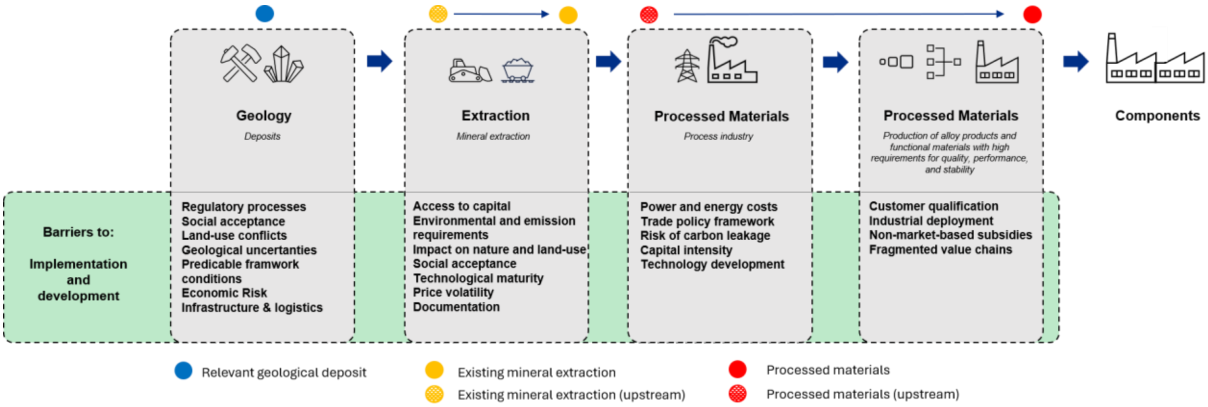

Figure 14 - Barriers to realising and developing activities across different stages of the value chain.

In the early phase, related to the identification and development of deposits into mines or open-pit operations, regulatory processes emerge as the most decisive barrier. Lengthy and complex permitting procedures, combined with requirements for environmental impact assessments and land-use planning, contribute to significant time delays and uncertainty. Social acceptance is closely linked to this, and a lack of local or regional support can in halt projects, regardless of the resource base. Competing land-use interests and conflicts with other societal objectives, including environmental protection and other land uses, further reinforce this challenge. Geological uncertainty is an inherent factor in the early phase but is often managed through incremental knowledge development. Overall, investment willingness is strongly influenced by the predictability of framework conditions, while economic risk and access to infrastructure and logistics constitute important, but more manageable, factors in later stages of project development.

During the realisation of mineral extraction, where projects move from planning to construction and operation, access to capital emerges as the most critical single factor. Such projects are capital-intensive, and investment decisions are directly influenced by both technological maturity and market expectations. At the same time, environmental and emissions requirements represent key framework conditions, particularly related to the handling of waste material and impacts on the natural environment. Land use and physical intervention, combined with stricter environmental requirements, add complexity to project implementation. Social acceptance remains an important factor also in this phase, especially in relation to concrete impacts and local conditions. Technological maturity affects execution capability and cost levels, while price volatility in raw material markets can influence profitability and investment appetite. Documentation and reporting requirements further add to administrative and operational complexity.

In upstream process industry, including beneficiation, high-temperature processing and refining, competitiveness is largely determined by structural cost factors. Power and energy costs are the dominant factor, particularly in a European context characterised by relatively high energy prices. Trade policy conditions, including tariffs, quotas and subsidies in other regions, also affect market access and the competitive landscape. The risk of carbon leakage illustrates the link between climate policy and industrial policy, where stricter climate requirements in one region may lead to production being relocated to regions with less stringent regulation. The capital intensity of process plants entails a need for long-term investments with significant risk, while technological requirements and development are necessary to handle more complex raw material streams and stricter environmental standards over time.

In downstream process industry and further processing, barriers are more closely related to market access and industrialisation. Customer qualification constitutes a key threshold, particularly in demanding applications where materials must be tested and approved before use. Technological development and scale-up from pilot to industrial production involve significant risks, both technical and commercial. At the same time, non-market-based subsidies in other regions affect the competitiveness of European actors. Fragmented value chains in Europe, with limited integration between stages, may further constrain the development of robust industrial ecosystems.

Overall, this overview shows that barriers change character along the value chain, from regulatory and societal factors in the early phase, via capital and cost drivers in industrial development, to market- and scale-up-related challenges in downstream segments. This implies that measures to strengthen the development of critical raw materials must be differentiated and adapted to the different phases, while also being considered in an integrated manner to ensure that value chains can develop coherently.

5.3 Development opportunities

Despite the clear barriers identified across different parts of the value chain, Norway and, in extension, the Nordic region emerge as an area with strong prerequisites for the development of competitive value chains for critical and strategic raw materials. The region has a solid geological foundation, with known deposits of several relevant raw materials and significant potential for further exploration and development. Viewed together with Sweden and Finland, it represents one of the most stable and resource-rich regions in Europe.

This must also be considered considering Europe's growing need for security of supply for critical raw materials. In a context characterised by geopolitical uncertainty and high concentration in global value chains, Norway appears as a stable and reliable supplier of both raw materials and processed materials. This provides a concrete basis for deeper integration into European value chains, both through raw material supply and further processing, and strengthens Norway's role as a potential strategic partner in the development of robust and more autonomous European and allied value chains.

At the same time, Norway occupies a distinct industrial position through a process industry built up over more than a century, based on access to renewable hydropower. This is an industry that has maintained competitive production due to access to relatively low-cost electricity. Norway is therefore also an important host country for some of the most energy-intensive industries in Europe. This industry has developed highly energy-efficient production and a comparatively low emissions profile relative to global competitors. In most cases, production in Norway has a carbon footprint of approximately one third of that in alternative production locations.[96] A reduction in this industrial base could therefore lead to carbon leakage, whereby production shifts to regions with higher emissions, resulting in increased global emissions overall. This makes existing industrial capacity a key foundation for future development, both from a competitiveness and a climate perspective.

Development opportunities vary across the different parts of the value chain. In mineral extraction, the potential lies in further development of known deposits and the realisation of new projects, particularly within graphite, titanium feedstock, rare earth elements and industrial minerals. Increased exploration, improved utilisation of existing deposits and the development of more complex resources may contribute to higher production. At the same time, this part of the value chain is strongly influenced by regulatory conditions, land-use interests and social acceptance. Where mineral extraction is realised, significant process expertise already exists in Norway, enabling increased national value creation.

In the process industry, a key development opportunity lies in further strengthening existing production of metals and materials. Norway holds a strong European position in aluminium, ferro-alloys, silicon and nickel, where companies operate in global, highly competitive markets. The industry is largely based on imported raw materials, but has developed high levels of expertise, efficient processes and relatively low emissions. The opportunity lies in maintaining and strengthening production in Norway, while enabling further processing and specialisation based on established industrial competence environments. Norway continues to host leading industrial and research environments that are developing next-generation processes, including solutions that enable both specialised material qualities and emissions reductions, often in combination. However, without access to competitively priced electricity, investment will decline, and the potential to strengthen Norway's role in supporting allied value chains will be weakened.

A particularly important development pathway is the strengthening the link between upstream process industry and downstream further processing. Several Norwegian actors illustrate concrete opportunities in this regard: Vianode in synthetic graphite and battery anode materials, Cenate in silicon-based materials that can replace carbon-based alternatives, REEtec in the separation of rare earth elements, and K.A. Rasmussen in the recycling and refining of precious and platinum group metals. These activities build on process expertise developed over a long industrial history and demonstrate how existing industrial capacity can form the basis for new, more advanced value chains.

[96] P21 Dekarbonisering i industrien v2

Such links also provide a foundation for developing robust and resilient value chains in cooperation with allied countries.

In circular value chains, there are also potential development pathways. Norwegian process industry and associated recycling actors have developed significant expertise in the recycling and alternative utilisation of metals from secondary material streams. At the same time, there is uncertainty regarding the extent to which this capacity can be expanded to include a broader range of materials and more complex feedstock streams. This applies, among other things, to the treatment of electronic waste, industrial waste streams and internal side streams, where technological, economic and regulatory factors will be decisive for further development. Such developments could increase resource efficiency and reduce import dependence. However, the scale and pace of progress will depend on framework conditions, economic viability and access to relevant feedstock. At the same time, these efforts build on existing industrial infrastructure, which provides a basis for further development, provided enabling conditions are in place.

Existing tailings deposits may also represent a potential resource base. Studies indicate that valuable materials often remain in such residuals. However, these materials are typically bound in complex mineral phases and finely dispersed fractions, making extraction technically challenging. Economically viable utilisation will therefore depend on the development of tailored processing solutions and, in some cases, on integration with existing or planned mining operations.

Another important development pathway relates to scaling up new technologies from the pilot and demonstration phase to industrial production. Several of the identified projects in Norway are currently at this stage, particularly within materials for battery value chains and advanced processing. This represents a critical step in the value chain, characterised by high risk and strong dependence on access to capital, predictable framework conditions and stable market expectations. At the same time, it is precisely at this stage that new industrial activities can emerge and form the basis for long-term value creation.

Overall, this points to a development potential that is not primarily linked to individual materials, but to the ability to build coherent value chains. This requires mineral extraction, process industry, further processing and circular solutions to be developed in an integrated manner, with more systematic use of existing competencies, infrastructure and industrial environments. Realising this potential will depend on framework conditions that reduce risk and support long-term investment, particularly in the transition from technology development to industrial production.

This development also reflects a more fundamental shift in how small, open economies such as Norway must position themselves in global value chains. Historically, access to raw materials and inputs has largely been based on efficient markets and relatively frictionless trade, where cost efficiency and specialisation have been the dominant principles. In a more fragmented and geopolitically shaped system, it is increasingly insufficient to rely on imports from the most cost-effective suppliers, particularly where these dominate key stages of the value chain. Instead, integration with allied markets and participation in strategically prioritised value chains becomes more important, both to secure market access for domestic industry and to reduce vulnerability in access to critical and strategic materials.

For Norway, this implies that the development of mineral extraction and process industry must increasingly be viewed in the context of partnerships and institutional frameworks, particularly those linked to the EU and transatlantic cooperation. This applies both to the realisation of new projects and to the further development of existing industry, where access to capital, technology, markets and regulatory frameworks is increasingly embedded in such cooperation structures. A strategy based solely on cost optimisation is therefore becoming insufficient and is gradually being replaced by an approach that places greater emphasis on security of supply, industrial capacity and strategic positioning within value chains.

6. Competence and R&D needs

Competence is a fundamental prerequisite for both the development and continuation of activity within mineral extraction, processing and materials production. The activities forming part of these value chains are technologically demanding and often tailored to specific deposits, raw materials and processes. Consequently, a large share of the competence required is highly specialised and directly linked to the solutions developed and applied within individual companies. Within exploration, extraction and beneficiation of mineral deposits, there is a need for engineering expertise with specialisation in resource geology, mining engineering and mineral processing. Access to such competence is currently limited in Norway, both in terms of newly graduated candidates and professionals with relevant industrial experience. Similar challenges are evident in other European countries and in parts of North America. If activity levels in mineral extraction increase, it will therefore be necessary to recruit expertise from the international labour market, as is already the case in parts of the industry.

The same applies to vocational skills. The operation of mines and beneficiation plants requires an operational workforce with practical experience and technical competence in production, maintenance and industrial operations. The availability of such skills appears limited in several areas and will be an important factor for the further development of the sector.

At the same time, competence needs must be viewed in the context of developments in value chains. An increasing share of industrial activity related to critical and strategic raw materials is located further downstream, including in process industry, metallurgy, materials development and further processing. This implies growing demand for expertise in process engineering, materials science, metallurgy and the scaling up of industrial processes, in addition to specialised competence related to mineral extraction and beneficiation.

To develop and realise this potential, a more long-term and integrated approach to competence development will be required. This includes not only education and skills development, but also closer collaboration between industry, research environments and educational institutions. Such an approach will be important to ensure that competence evolves in line with industry needs and technological developments in value chains.

Research and development will play a central role in this context. The development of more efficient extraction methods, improved resource utilisation and more advanced solutions for beneficiation and further processing is essential to strengthen both profitability and sustainability in the sector. This also includes the development of solutions to reduce environmental impact, including improved management of waste materials, reduced energy use and more efficient utilisation of input factors.

Furthermore, there is a need for research and development related to flexible handling of raw materials and the utilisation of different types of feedstocks, including secondary resources and side streams. Increased circularity and higher resource efficiency are key development trends, but they depend on both technological progress and access to relevant competence.

There is also a need for further development of processes and solutions that enable a higher degree of further processing, as well as the production of climate-neutral or low-carbon materials with more specialised properties. This includes, among other things, material qualities and alloys tailored to demanding applications in renewable energy, electronics and other high-technology industries. In addition, digitalisation and automation of production processes will be important drivers for both efficiency and operational safety. These topics have previously been highlighted in the work of Prosess21. [97] [98] [99] Within this area, there are also good examples of how collaboration between R&D environments and industry contributes to competence development and the training of specialised expertise required by industry, both today and in the future, including through initiatives such as SFI Metal Production and FME ZeMe (*Zero Emission Metal Production*).[100]

Overall, competence and R&D emerge as a critical enabler for the development of Norway's mineral and process-based industries. The ability to develop, apply and retain relevant expertise will be decisive both for the realisation of new projects and for the further development of existing industrial capacity.

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97 p21_rapport_ny-prosessteknologi_web-1.pdf

98 Produktutvikling i prosessindustrien

99 250318-digitalisering-i-prosessindustrien-2025-hovedrapport.pdf

100 FME ZeMe - Zero Emissions Metal Production - NTNU

7. Need for further analyses and follow-up studies

The work presented in this report establishes an initial knowledge base on Norway's positions and potential within critical and strategic raw materials. To translate this foundation into concrete priorities and operational recommendations, two targeted follow-up studies have been initiated under the auspices of Prosess21 and the Research Council of Norway. These follow-up studies also form part of the Research Council's mandate to follow up the recommendations from the report on future R&D investment in land-based minerals (June 2025), as well as to contribute to the Government's objective of conducting a comprehensive mapping of Norwegian industry's role in national and allied strategic and critical value chains. Furthermore, the Research Council will manage the national co-funding for Norway's participation in the EU partnership on raw materials (*Raw Materials for the Green and Digital Transition*) under Horizon Europe and ensure that Norwegian analyses and priorities are aligned with European processes and needs. Taken together, these studies will provide a basis for how Norway can shape its policies, mapping efforts and industrial initiatives considering the rapid changes in European and allied framework conditions.

7.1 Future competence ecosystem – a Norwegian model for critical and strategic raw materials

The mapping presented in this report has been carried out as part of the follow-up to *White Paper No. 16 (2024–2025) – Industry: competitiveness for a new era*, in which it was decided to conduct a comprehensive analysis of Norwegian industry's role in national and allied strategic value chains. At the same time, the work should be seen in the context of increased political attention to critical minerals in Norway, including several parliamentary proposals (*Dok. 8*) and the Storting's deliberations in spring 2026.[101] In this context, the Standing Committee on Business and Industry has, among other things, requested that the Government undertake a comprehensive mapping of the value chain for critical minerals, from research and development through extraction, processing, mass handling and recycling, with the aim of identifying bottlenecks and possible measures.

The analysis shows that Norway's current strategic role in value chains for critical and strategic raw materials is largely linked to the process industry, materials competence and the ability to supply high-quality, reliable products to European and global markets. At the same time, Norway has a substantial geological resource base and clear potential for increased mineral development over time. This implies that a narrow focus on either the mining sector or the process industry alone provides an incomplete picture of Norway's actual significance and opportunities in these value chains.

The Norwegian mining sector is smaller in scale and characterised by a different risk profile and development trajectory than the process industry but nonetheless represents an important foundation for future value creation. The process industry, by contrast, is significantly larger, more capital- and research-intensive, and closely integrated into the research and innovation system, including through participation in schemes such as *Centres for Research-based Innovation* (SFI), *Centres for Environment-friendly Energy Research* (FME) and emerging national AI research centres. The interaction between process industry, universities and research institutes is extensive and constitutes a central part of Norway's knowledge base.

From a value chain perspective, the actors are nevertheless closely interconnected, although they operate at different stages. This implies that analysing individual segments in isolation does not capture the overall potential for value creation. In this sense, the report primarily highlights the downstream stages related to processing and material production, while also pointing to opportunities for increased value creation through the development of geological resources in combination with existing industrial capacity.

In this context, and as reflected in the mapping carried out by Prosess21, it is relevant to consider the development of a more **integrated competence ecosystem** that encompasses the entire value chain, from resource mapping to finished material products and circular solutions. The core of such a system consists of industrial actors operating at different stages of the value chain, from mineral extraction to processing and further refining, and driving value creation through their activities, expertise and market linkages.

101 Innst. 376 S (2025-2026) - stortinget.no

On the public side, an important starting point is that many of the necessary functions are already in place. The Geological Survey of Norway (NGU) and the Directorate of Mining with the Commissioner of Mines for Svalbard (DMF) have clear roles related to resource mapping, data and governance, while policy instrument actors such as the Research Council of Norway, Innovation Norway, Siva and Eksfin contribute to research, commercialisation, industrial development and financing. At the same time, it is less clear how these roles collectively form part of a coherent value chain perspective for critical and strategic raw materials.

Considering geopolitical developments and increasing concentration in global value chains, such an ecosystem may also have implications for national preparedness and resilience. Mapping and analysis, as represented by this report, can in this context be viewed as a contribution to the knowledge base for further prioritisation, both nationally and in cooperation with European and allied actors.

To take a clearer position in these value chains, the analysis points to several key development directions. These include the need for stronger linkages between education, research and industry, improved conditions for scaling up from pilot and demonstration phases to industrial production, and increased integration into European and allied frameworks. How these priorities are followed up will largely determine Norway's future role.

The overall system of policy instruments will be an important part of this, both through support for knowledge development, financing and facilitation of collaboration. At the same time, the interaction between different instruments and actors will be decisive for whether a more integrated approach can be realised in practice.

Overall, this points to the conclusion that Norway's strategic importance is not primarily linked to individual deposits or projects, but to how different parts of the system interact. The extent to which this can be developed into a more coherent model is likely to be decisive for Norway's role in European and allied value chains going forward.

The European Union has adopted the *Critical Raw Materials Act* (CRMA), which operationalises policy on critical and strategic raw materials through, among other measures, the prioritisation of strategic projects, capacity targets for extraction, processing and recycling, and the establishment of new governance mechanisms and institutions. For Norway, incorporation of the CRMA into the EEA Agreement implies that it is not sufficient merely to adapt to existing market and regulatory conditions. It also requires the development of professional, technical and institutional capacity comparable to that of EU Member States, including in areas such as resource mapping, value chain monitoring, reporting and participation in European mechanisms. In practice, this raises the question of how Norway organises national functions and representation in a way that enables it to act as a relevant and reliable partner in this cooperation.

7.2 Upcoming studies

Prosess21 and the Research Council of Norway have initiated, or plan to initiate, two studies relevant to the future development of a competence ecosystem linked to critical and strategic value chains.

Study on Norwegian critical and strategic raw materials in global and allied value chains

The purpose of this study is to analyse Norway's current and potential role as a supplier in strategic value chains for critical and strategic raw materials, with particular emphasis on markets in Europe, the United States and other allied countries. The work adopts a demand-driven perspective, in which needs in allied markets, vulnerabilities in value chains, and requirements related to quality, volume and security of supply are central. The analysis will link these factors to Norway's resource base, industrial capacity and opportunities for further processing and value creation.

The assignment involves mapping selected materials across the entire value chain, from extraction to end use, as well as identifying where Norway has, or can develop, competitive advantages. It will also include assessments of barriers, market conditions and relevant policy and regulatory frameworks, including developments in international regulations and policy instruments. The study will result in a prioritised and decision-oriented knowledge base, with recommendations on how Norway can strengthen its position in allied value chains. The work will be carried out during the project period in 2026, with completion expected by the end of the year.

Study on Norway's implementation needs under the EU Critical Raw Materials Act (CRMA)

Through the *Critical Raw Materials Act* (CRMA), the European Union has established a comprehensive framework to strengthen security of supply for critical and strategic raw materials. In the event of incorporation into the EEA

Agreement, Norway will need to establish the necessary professional, technical and institutional capacity to participate on a par with EU Member States. This is not only a matter of formal compliance, but also of positioning Norway as a reliable and predictable partner in European value chains.

The study, carried out on behalf of the Research Council of Norway, will assess the non-legal implementation requirements associated with this, including the organisation of national functions and participation in EU cooperation structures. Emphasis will be placed on clarifying the role of the Research Council in facilitating Norwegian contributions to joint European initiatives and partnerships. The study will also examine how these processes may contribute to the development of a more integrated competence ecosystem, thereby strengthening Norway's ability to participate in and supply strategic value chains in allied markets.

8. Appendix – Company profiles

8.1 Activities in mature geological deposits

Sydvaranger (iron ore)

An operating licence has been granted for the reopening of the Sydvaranger iron ore mine near Kirkenes. The project is being developed by the Swedish company Grangex, with start-up planned in the near term.[102] The deposit has a total resource base of 511 million tonnes of ore, and annual production is planned at around 3.5 million tonnes of magnetite concentrate.[103] The product is tailored for use in direct reduction steelmaking processes, which are a key technology in the transition to low-emission steel production. The company has entered into a long-term offtake agreement with Anglo American covering production over the full life of the mine.[104]

Iron ore is not classified as a critical raw material under the EU framework, but it is considered critical in certain national assessments, including in the United Kingdom, due to its importance for industrial value creation and security of supply in the steel value chain. The project is therefore particularly relevant in light of the growing need for secure access to input materials for European steel production.

Nussir (copper)

The Nussir copper project, located south of Hammerfest in Finnmark, is under development, with production scheduled to commence in the third quarter of 2027. The project is being developed by Nussir ASA, which was acquired in 2025 by the Canadian mining company Blue Moon Metals Inc.[105]

The deposit has a total resource base of approximately 60.7 million tonnes of ore, with average grades of 1% copper, 13 g/t silver and 0.13 g/t gold.[106] Annual ore production is planned at around 2 million tonnes. Geological studies indicate potential for further resources towards depth.

Copper is a key input material in electrification, energy infrastructure and digital technology, and is classified as a critical raw material both in the EU and under several allied frameworks. The project is therefore relevant in a value chain context marked by growing demand, while the pipeline of new projects globally remains limited and characterised by long lead times. The project has been designated a strategic project under the EU Critical Raw Materials Act (CRMA).[107]

Sulitjelma (copper, zinc)

Several initiatives are under way in the Sulitjelma district in Nordland to re-establish copper and zinc mining, following the closure of operations in 1991. The activity is led by the companies Nye Sulitjelma Gruver AS and VMS Explorations AS, which in spring 2026 signed a letter of intent on merging their activities to support further exploration and project development.[108]

The companies are subsidiaries of, respectively, the Canadian mining company Blue Moon Metals Inc. and the Luxembourg-based investment company Alpha Future Funds. Nye Sulitjelma Gruver has reported a mineral resource estimate of approximately 17 million tonnes of ore with an average copper grade of 1.06%, based mainly on historical data, while work is ongoing to expand and update the resource base.[109]

The project is aimed at the production of copper and zinc, both of which are used in important industrial value chains. Copper is of particular importance in electrification, energy infrastructure and digital technology, while zinc

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102 Completion of a Definitive Feasibility Study for the restart of operations at the Sydvaranger Mine – Grangex
103 The Project – Sydvaranger
104 GRANGEX secures strategic commercial partnership with Anglo American to support the restart of operations at Sydvaranger – Grangex
105 Blue Moon Metals Closes Norwegian Acquisitions, and Announces the Appointment of Skott Mealer as President and COO and Theodore Veligrakis as VP Exploration - Blue Moon Metals Inc.
106 Blue Moon Announces Results of Nussir Project Feasibility Study - Blue Moon Metals Inc.
107 Blue Moon Metals Nussir Copper Project Receives Special Strategic Project Status from the European Union - Blue Moon Metals Inc.
108 Blue Moon Metals and Alpha Future Funds S.C.S. Announce Non-Binding Agreement to Combine Holdings in the Sulitjelma Mining District, Norway - Blue Moon Metals Inc.
109 Blue Moon Announces Maiden NI 43-101 Sulitjelma Resource of 17 Mt @ 1.06% Cu & 0.21% Zn in the Inferred Category Supporting VMS District Growth Potential - Blue Moon Metals Inc.

is used primarily for galvanising and in construction materials. Although the project remains at an earlier stage of development than the most mature projects, Sulitjelma illustrates the potential for reactivating historic mining areas that may contribute to increased European raw material supply over time.

Joma (copper, zinc)

Joma is a former copper and zinc mine in the municipality of Røyrvik in Trøndelag, which remained in operation until 1998. Joma Gruver AS is working to re-establish mining activities, and the project is being developed as part of the portfolio of the Swedish company Bluelake Mineral AB.[110] The project is currently in the development and permitting phase.

An extensive drilling programme is planned for 2026, with the aim of updating the resource estimates for Joma on the Norwegian side and Stekenjokk on the Swedish side of the border, and of providing a basis for further assessments of the project's economics and feasibility. At present, the resource base at Joma is estimated at around 7.2 million tonnes of ore with an average copper grade of approximately 1.03%, based on existing and historical data.[111]

Bluelake Mineral is planning an integrated development of the deposits on both sides of the border, with a shared processing plant in the municipality of Røyrvik. The project is aimed at the production of copper and zinc, both of which are important input materials in industrial value chains. Copper is of particular importance in electrification, energy infrastructure and metal-based manufacturing, while zinc is used primarily for galvanising and in construction materials. As a former mining area now undergoing renewed development, Joma illustrates the potential for reactivating historic mines that may contribute to increased European raw material supply over time.

Fen (rare earth elements – REE)

The Fen field near Ulefoss in Telemark is one of Europe's most significant development projects for rare earth elements (REE) and represents the largest documented deposit of such metals in Europe. Several companies hold rights in and around the area, with Rare Earths Norway as the dominant operator, controlling approximately 90% of the licence area.[112]

In spring 2026, Rare Earths Norway completed a pre-feasibility study (PFS) with an updated resource estimate of 1,206 million tonnes of ore at an average grade of 1.31% total rare earth oxides (TREO), with NdPr accounting for an estimated 17–19% of the total rare earth content.[113] NdPr (neodymium and praseodymium) typically accounts for more than 75% of the total value in carbonatite-hosted light rare earth element dominated deposits. In addition, Saga Rare Earths has published a resource estimate of 95 million tonnes of ore at 1.28% TREO.[114] Taken together, this corresponds to a known resource base of just under 17 million tonnes of total rare earth oxides (TREO), based on the reported ore volumes and average grades.

Rare earth elements are classified as critical and strategic raw materials in the EU, the United States, the United Kingdom and NATO, and are part of some of the most concentrated and geopolitically sensitive value chains globally. The project therefore has the potential to make a major strategic contribution to European security of supply.

In April 2026, responsibility for the spatial planning process was transferred from the municipal to the national level, reflecting both the national importance of the project and the complexity associated with its further development and realisation.[115]

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[110] Update on the status of the Joma mining project

[111] JOMA Project MRE

[112] REE | Europe's largest deposit of rare earth elements discovered at…

[113] Rare Earths Norway med oppdatert ressursestimat for Fensfeltet: Nær dobling av Europas største dokumenterte forekomst av sjeldne jordarter | Rare Earths Norway

[114] The Fen field — Saga Rare Earths

[115] Statlig reguleringsplan for Fensfeltet - regjeringen.no

Helleland (phosphate, titanium and vanadium)

In the Eigersund area of Rogaland, approximately 20 km east of Egersund, Norge Mineraler is developing a project for the extraction of apatite, ilmenite and vanadium-bearing magnetite. The project forms part of the large Bjerkreim–Sokndal intrusion and is among the most extensive mineral deposits currently under development in Europe.[116]

Extensive exploration activity since 2020, including nearly 90 km of core drilling, has confirmed a very substantial resource base. The company reports total resources of around 4.5 billion tonnes of mineralised rock across three sub-areas within the deposit. Grades are generally moderate, and the project's economics are therefore likely to depend on large-scale operations and the concurrent extraction of several valuable minerals.

A pre-feasibility study (PFS) for the first development phase was completed in 2024 and concluded that the project could be economically viable with planned production of 20 million tonnes of ore per year. The resources base include a higher-value segment in the Storeknuten area comprising 200 million tonnes, with reported phosphate grades of 3.5% P_2O_5 and additional values in titanium minerals and vanadium-bearing magnetite.[117]

The project is aimed at the production of phosphate, titanium products and vanadium, which are used in value chains linked to food production, energy storage, advanced materials and high-technology industry. Phosphate is classified as a critical raw material in the EU, and the project is therefore relevant as a potential future European source of a key input material.

Ertelien (nickel, copper and cobalt)

Ertelien is a nickel–copper–cobalt deposit in Ringerike municipality, Buskerud. The deposit was in operation until 1920, with nickel extraction, but in recent years has been the subject of extensive exploration activity led by the Australian company Kuniko Ltd.[118]

Kuniko has carried out several drilling programmes and resource estimates and, as of 2024, reports a total mineral resource of 40 million tonnes of ore with average grades of 0.18% nickel, 0.12% copper and 0.014% cobalt. Of this, around 22 million tonnes are classified as indicated resources, while the remainder is classified as inferred resources. The resource remains open both towards depth and along strike, and further exploration is under way to assess the potential for further resources.

The project is aimed at the production of nickel, copper and cobalt, which are key input materials in batteries, electrification and high-technology industry. Several of these metals are classified as critical raw materials in the EU, and the project therefore forms part of a market where demand is increasing, while few new production projects are being realised in Europe.

Tysfjord/Hamarøy, Nesodden og Nasafjell (high-purity quartz)

High-purity quartz is an important input material in the production of silicon metal and advanced silicon-based products for, among other things, electronics, solar cells and various high-technology industries. Norway is already a significant producer of quartz for a range of industrial applications, but the development of deposits with very high purity is essential to meet demand from more advanced market segments.[119]

At Drag in Tysfjord/Hamarøy, feldspar has been mined since 1908, while quartz extraction began only in the mid-1970s. The quartz occurs as lenses in pegmatites located within the Tysfjord granite. The deposits in Tysfjord and Hamarøy were developed as a source of high-purity quartz from 1985, initially by Elkem and Norcem, and later by Norwegian Crystallites and The Quartz Corp. Operations have been suspended during certain periods. Detailed zoning plans are now being prepared for the Håkonhals quartz quarry to facilitate continued operations by making new areas available for extraction, based on updated resource estimates and plans for the mine. At the same time, the underground mine at lower and outer Øyvollen is being prepared for a resumption of operations, so that production from this area can form part of The Quartz Corp's future output.

In addition, two other high-purity quartz projects are under development in Norway. The Nasafjell deposit in Nordland is being developed by Elkem, while the Nesodden deposit in Kvinnherad, Vestland, is being developed

[116] Eigersund-prosjektet – Norge Mineraler
[117] MINERAL RESOURCE ESTIMATE FOR THE STOREKNUTEN PROJECT, EIGERSUND, NORWAY
[118] Ertelien | Kuniko
[119] Quartz resources in Norway | NGU

by Nordic Quartz, a subsidiary of Nordic Mining. Both are hydrothermal vein quartz deposits, which are among the most important sources of very high-purity quartz. Nordic Quartz completed a resource estimate for the Nesodden deposit in 2016, indicating a resource base of 4.26 million tonnes of ore containing approximately 2.8 million tonnes of quartz. For the Nasafjell project, Elkem reports a resource base of around 6 million tonnes. The strategic importance of these deposits lies in their material quality and their relevance to high-technology value chains, rather than in tonnage alone.

8.2 Ongoing mineral extraction – critical and strategic raw materials

Rana Gruber (iron ore)

Rana Gruber ASA is a Norwegian producer of iron ore, with operations located in Mo i Rana in Nordland. The company operates both open-pit and underground mines in the Dunderland Valley, together with a beneficiation plant at Gullsmedvik with direct access to a shipping terminal. The business builds on a long industrial tradition, with continuous operations since the 1960s and a resource base that has been known and exploited for more than a century.

Rana Gruber operates in the upstream part of the value chain for metal-based materials, where iron ore is extracted, beneficiated and further processed into concentrates tailored to industrial use. Annual extraction amounts to around 5 million tonnes of crude ore, which is processed into approximately 1.8 million tonnes of iron oxide concentrate. The product portfolio consists mainly of hematite concentrate for use in steel production, as well as magnetite for applications including the chemical industry and water treatment.

The business is integrated throughout the process from mining to finished concentrate, with rail transport and a port terminal as key components of the logistics chain. The company therefore represents an important primary stage in the supply of iron-based input materials to European industry.

Relevance to critical and strategic raw materials

Iron ore is not classified as a critical raw material under the EU framework, but it is a fundamental input in steel production, which in turn underpins a wide range of industrial and societally important applications. These include power infrastructure, transport, construction and defence-related systems. At the same time, the United Kingdom included iron (Fe) in its 2024 criticality assessment, making it one of the first countries to classify iron as a critical raw material. The material should therefore be understood as system-critical, in the sense that it forms part of value chains that are essential for industrial activity and key societal functions, even if classification differs between jurisdictions and it is not included on the EU's formal criticality lists.

Rana Gruber's production of high-quality iron ore concentrate is directed primarily towards European steel producers and thereby contributes to value chains that are increasingly relevant to the transition towards low-emission solutions, including the development of steelmaking routes with a lower carbon footprint. At the same time, the company has developed products with higher purity and iron content, tailored to more specialised applications and capable of commanding a market premium.

Markets, dependencies and competitive conditions

Rana Gruber is an export-oriented producer, with Europe as its main market, where customers consist primarily of steel producers and companies in the chemical industry. Its products form part of global value chains, but the competitive landscape is shaped to a large extent by European demand for iron ore with specific quality characteristics and a low carbon footprint.

Competition is global and is dominated by large-scale producers in Australia, Brazil and other regions, which benefit from substantial economies of scale. At the same time, there is a distinct market segment for high-quality iron ore products with higher iron content and lower impurity levels, where European and Nordic producers hold a position.

Rana Gruber benefits from geographical proximity to European customers and access to renewable power, which results in a relatively low carbon footprint per tonne produced compared with global supply. This may represent a competitive advantage in a market characterised by growing requirements for sustainability and traceability. At the same time, the business remains exposed to fluctuations in global iron ore prices, which have a significant impact on profitability.

Barriers, investment needs and opportunities in Norway

Rana Gruber operates in a capital-intensive industry in which investments in mining, beneficiation and logistics all have long time horizons. Further development therefore depends on stable and predictable framework conditions, including access to capital, energy and the necessary permits.

A key challenge is competition from large international producers, particularly in the low-cost segment. Maintaining competitiveness requires continuous improvements in product quality, efficiency and cost levels. This also entails investment in new mining areas and upgrades to existing operations, including the development of deposits with a higher magnetite share and higher iron content.

At the same time, there is significant scope for further development. Demand for high-quality iron ore is expected to increase as the steel industry shifts towards more energy-efficient and low-emission production routes. Rana Gruber has positioned itself to respond to this development through a stronger focus on product quality and differentiation.

Circularity, side streams and secondary raw materials

The business is based primarily on the primary extraction of iron ore, but production also includes speciality products and by-products used in other industrial applications, including the chemical industry and water treatment. Rana Gruber has also worked to reduce the environmental impact of its operations and improve resource efficiency through technological measures and process improvements. Iron ore production is largely based on electricity from renewable sources, and extensive measures have been initiated to electrify machinery and reduce the use of fossil fuels. The company also aims to reduce or eliminate direct CO_2 emissions from mining through electrification and the use of new technologies.

Overall message

Rana Gruber represents a central upstream stage in Norway's mineral-based value chain, producing iron ore concentrate that feeds into fundamental industrial value chains. The United Kingdom has classified iron as a critical raw material in its criticality assessment, which underlines the company's strategic importance through its supply of input materials to steel production and wider industrial activity.

The company's position is linked to the production of high-quality iron ore with a relatively low carbon footprint and close access to European markets. Further development will depend on its ability to remain competitive in a global market characterised by price volatility, while also capturing growing demand for materials suited to low-emission production and more specialised industrial applications.

Rana Gruber was listed on the Oslo Stock Exchange in March 2021. In April 2026, the company was delisted following the acquisition of 100% of its shares by the Canadian company Champion Iron. Rana Gruber is therefore now a subsidiary of Champion Iron, which is listed in Sydney and Toronto.

Skaland Graphite (natural graphite)

Skaland Graphite AS is a mining and processing company located at Skaland in Senja municipality. Its operations are based on the production, distribution, marketing and further development of natural crystalline graphite. The business is centred on underground mining at the Trælen deposit, where graphite ore is extracted and subsequently processed at the beneficiation plant at Skaland. The company is currently the only producer of natural graphite of significant scale in Europe and therefore represents an established industrial capacity in an otherwise highly import-dependent European value chain.

Skaland Graphite operates in the upstream part of the graphite value chain through an integrated business model spanning mineral extraction to marketable graphite concentrate. The process includes mechanical beneficiation followed by multi-stage flotation, purification and separation into different fractions based on flake size and purity. Mining and beneficiation are largely based on standard mineral processing methods but are specifically adapted for the efficient recovery of flake graphite, where both flake structure and carbon content are decisive for end use.

Relevance to critical and strategic raw materials

Graphite is classified as both a critical and a strategic raw material under international frameworks, including those of the EU, the United States, the United Kingdom and NATO. This is largely linked to growing demand arising from the material's role in battery technology and defence-related applications. Skaland Graphite produces natural flake graphite in the form of graphite concentrate, which is an upstream raw material and an input into several value chains. These include batteries for electric vehicles and energy storage, as well as applications in electronics, advanced industry and defence-related products.

The company represents a European production capacity in a value chain that is otherwise heavily dominated by China, both in extraction and in downstream processing. Access to traceable European graphite is considered increasingly important in light of growing attention to security of supply and resilient value chains. In addition to battery-related applications, graphite from Skaland is used in several established market segments, including refractories, foundry applications, lubricants and specialised carbon products.

Markets, dependencies and competitive conditions

Skaland Graphite supplies markets in Europe and the United States, with total annual production of up to 10,000 tonnes of natural flake graphite concentrate. A significant share of production is delivered into the downstream battery value chain, while lower grades are used more extensively in the process and metals industries.

The graphite market is highly segmented by purity and flake size, and competition is therefore influenced to a considerable extent by product specifications and quality, not only by volume and price. Skaland operates in segments where stable quality and consistent material properties are central competitive parameters. Globally, the graphite market is dominated by producers in Asia, particularly China, which combines extensive upstream production with, in many cases, vertically integrated downstream processing into spherical graphite and anode materials for lithium-ion batteries.

Competition is also increasingly shaped by non-market factors, including industrial policy measures, subsidies and trade-related regulation. At the same time, demand for traceable, European-produced graphite in strategic applications is rising, driven in part by requirements related to origin and security of supply, which may strengthen the competitive position of producers such as Skaland. The business is based on extraction from its own deposit at Trælen and therefore has limited dependence on imported raw materials. The main input factors are electricity, diesel and gas, where no major supply risks are currently reported.

Barriers, investment needs and opportunities in Norway

The business is influenced by key framework conditions for the minerals industry, including access to capital, permitting and market developments. For an established but relatively small producer, access to capital for modernisation, capacity expansion and quality improvements is particularly important.

Current production is constrained mainly by the size of the deposit, existing environmental permits and, to some extent, access to capital. Over the longer term, access to ore and the development of additional deposits will be the main limiting factor for continued operations. There is significant potential to increase production through upgrades to the beneficiation plant and expansion of the ore resource base through further exploration and development of new areas. With the necessary investments and expanded framework conditions, including environmental permits, production is estimated to be capable of increasing to as much as 25,000 tonnes per year.

An increase in production capacity would contribute directly to greater graphite availability in Europe and potentially also in the United States, thereby strengthening security of supply. There is also strategic potential in further downstream processing of graphite in Norway or Europe, particularly towards the production of anode materials for batteries. This would require investment in new downstream processing stages such as purification and spheroidisation, as well as access to relevant expertise and markets.

Circularity, side streams and secondary raw materials

Circularity and the utilisation of side streams are of limited relevance to Skaland Graphite's current operations. Production is based primarily on the extraction and beneficiation of graphite ore into concentrate, without significant commercially utilised by-product streams.

Overall message

Skaland Graphite represents the only operating graphite extraction of significance in Europe and constitutes a stable and strategically important source of natural graphite in a global value chain dominated by Asian actors. The business is particularly relevant to battery value chains, energy storage and defence-related applications, where access to European, traceable graphite can reduce supply vulnerability.

Further value creation in Norway is closely linked to the potential for increased production and the establishment of downstream processing, particularly towards anode materials for battery production. At the same time, long-term access to ore and market conditions will be decisive for future development.

Sibelco – Stjernøy (nepheline syenite/feldspar)

Sibelco Nordic AS, the Norwegian subsidiary of Sibelco, extracts and processes industrial minerals in Norway, including at Stjernøy in Alta municipality. At Stjernøy, nepheline syenite is extracted from the Nabbaren open pit and processed into feldspar–nepheline concentrates for use in glass, ceramics and filler applications. The operation is based on seasonal open-pit mining from June to December and is shaped by Arctic conditions, including challenging weather, polar night and logistical constraints associated with a coastal Arctic location. The raw material is transported to the processing plant, where it undergoes dry, mechanical and chemical-free beneficiation before shipment via the company's own port terminal.

Figure 15 - Sibelco's facility at Stjernøy. Nepheline syenite is extracted from the Nabbaren open pit and processed into feldspar–nepheline concentrates used in glass, ceramics and filler applications. (Photo: Sibelco)

The company operates in the primary part of the value chain, covering mineral extraction and first-stage processing. The processing route includes crushing, drying, screening and magnetic separation, resulting in a finished mineral concentrate tailored to customer requirements. Further refining and chemical processing take place in downstream stages, for example in glass and ceramics production. The operation is based on specialised expertise in geology, process mineralogy and mineral processing.

Relevance to critical and strategic raw materials

Feldspar was classified as a critical raw material in the EU in 2023, partly because of increasing import dependence and the concentration of supply in a limited number of countries. Nepheline syenite is functionally equivalent to feldspar and can substitute for it in key applications and is therefore considered part of the same critical raw material base in an EU context.

Nepheline syenite from Stjernøy, with annual production in the range of 250,000–320,000 tonnes of finished product, is used mainly in the glass industry, which accounts for around 75% of demand, while approximately 20% is used in ceramics and around 5% in coatings, paints and plastics. As a high-purity, quartz-free raw material, nepheline syenite is particularly well suited to applications where stable chemistry and consistent material quality are essential.

Although the material is not generally used directly in high-technology applications, it is an important input in value chains that support them. This includes glass production for solar panels, insulation materials and components used in electrical infrastructure. Nepheline syenite may also serve as an alternative source of alumina and thereby enter the aluminium value chain indirectly, which could increase its strategic relevance over the longer term.

Markets, dependencies and competitive conditions

Sibelco's production in Norway is overwhelmingly export oriented. Around 98% of output from Stjernøy is delivered to international markets, primarily in Europe, with some shipments to the United States, the Middle East and Asia. The products form part of established industrial value chains, especially in the glass, construction and ceramics industries.

Nepheline syenite and feldspar are fundamental industrial minerals with a wide range of applications, and demand is closely linked to activity in construction, packaging and industrial production more broadly. Expectations of increasing demand for glass, ceramics and insulation materials suggest that demand is likely to remain stable or increase over time. The feldspar market is characterised by a high degree of concentration, with Turkey accounting for more than 50% of EU supply. This is an important reason why feldspar has been classified as a critical raw material, and at the same time it strengthens the strategic relevance of European production of alternative raw materials such as nepheline syenite.

Production at Stjernøy is largely based on the company's own mineral resource and is not exposed to imported mineral raw materials. The key input factors are energy, explosives and fuel for operations and logistics. Access to electricity is particularly important, as the processing operation is energy-intensive and local grid capacity is limited.

The competitive landscape for nepheline syenite is relatively concentrated, with Canada as the principal competitor in the same market segment. For feldspar, competition is broader, with significant production in Turkey, Italy and Spain. Norwegian production stands out through high quality, stable delivery performance and a low carbon footprint, but operates at a higher cost level than several competing regions.

Barriers, investment needs and opportunities in Norway

The further development of the business is influenced by several structural factors. Access to electricity and grid capacity represents a potential bottleneck in the event of plans to expand production. Permits and regulatory conditions are also important. Expansion of operations and changes in the operating pattern are shaped by licensing requirements, including considerations relating to land use and reindeer husbandry, which may constrain both the operating season and production volumes. In addition, the Arctic coastal location creates operational challenges linked to weather conditions, snow, wind and periods of polar night, all of which affect operations and maintenance. Recruitment and access to skilled labour are a further challenge, particularly given the location and the need for specialised expertise in mineral extraction and processing.

At the same time, there is significant potential for further development. The resource base at Stjernøy is substantial, with an estimated operating horizon of several decades. Plans to modernise the processing plant could increase capacity and improve efficiency, if electricity supply and investment capital are available.

Circularity, side streams and secondary raw materials

The business is based primarily on primary raw materials, but with a growing focus on the utilisation of side streams and on reducing the need for disposal. At present, around 220,000 tonnes of tailings are deposited each year from the processing of the main product, nepheline syenite, largely because markets for the side streams have not yet been developed.

Current uses include the use of parts of the side streams in foam glass and glass products with a higher iron content, as well as the development of the soil improvement product *Soilfeed*. Work is also under way to assess the use of nepheline syenite tailings as an input in low-carbon concrete, which could create new market opportunities. Over the longer term, further technological development and the creation of markets for secondary materials could improve resource efficiency, reduce the environmental footprint and provide a basis for additional value creation.

Overall message

Sibelco represents an important primary-stage supplier of industrial minerals to European industry, producing nepheline syenite that forms part of the same raw material base as critically classified feldspar. The operation is supported by a robust resource base and holds a clear position in a market with a limited number of suppliers, but further development will depend on access to electricity, predictable framework conditions and the ability to develop new applications for both the main products and the side streams. Stable production and expanded capacity could help strengthen European security of supply for critical industrial minerals.

Titania AS (titanium/ilmenite)

Titania AS is a mining company in Sokndal in Rogaland that extracts and beneficiates ilmenite from the open pits at Tellnes and, historically, from Sandbekk. The company is part of the Kronos group and builds on a long industrial history in the area, based on the local ore deposits, with mining operations having commenced in 1916. Current operations are based on a licence granted in 1994, and the present open-pit plan provides reserves for production until around 2080, with additional identified resources beyond this. Titania is a significant supplier of titanium minerals to the global market and is also the only producer of such ilmenite minerals in Europe.

Titania operates as a dedicated mining company and produces ilmenite concentrate through the extensive use of physical separation methods, developed and refined over more than 100 years of operation. The ilmenite from Tellnes is particularly suited to the sulphate process, in which ilmenite is dissolved chemically to produce titanium dioxide, and which was historically developed to utilise ore with a high ilmenite content from Sokndal. In its current form, the product cannot be used in the chloride process, which is based on chlorination of feedstock with a higher titanium content and is the globally dominant route for the production of titanium dioxide pigment (TiO_2), without further upgrading.

Titania therefore forms part of the value chain supplying feedstock for sulphate-based pigment production, including through deliveries to its sister company Kronos Titan in Fredrikstad. There, titanium dioxide pigments are produced for surface treatment applications, together with by-products such as ferrous sulphate for water treatment and spent acid for waste and environmental applications, based on process side streams.

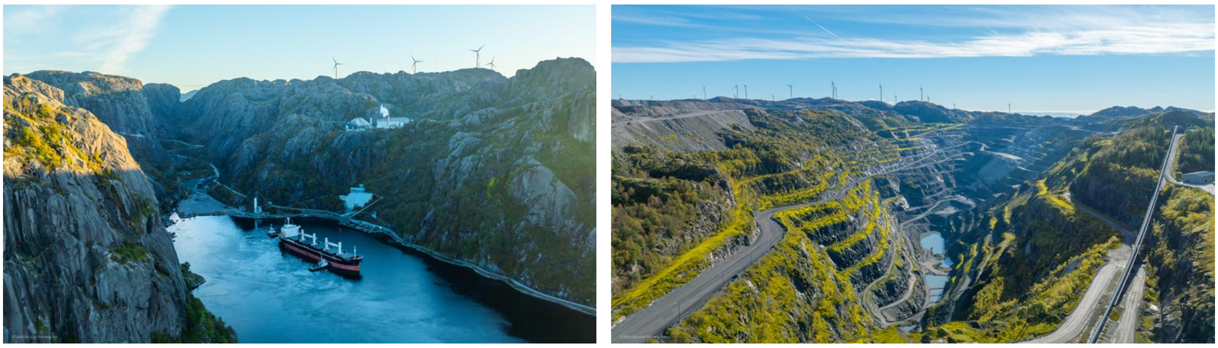

Figure 16 - Titania AS is a mining company in Sokndal in Rogaland that extracts and beneficiates ilmenite from the open pits at Tellnes. (Photo: Spectacular Norway)

Relevance to critical and strategic raw materials

Titania produces ilmenite, which is an important raw material for the production of both titanium dioxide pigment and titanium metal. The company is highlighted in the report *Critical metals and minerals in the Nordic Countries of Europe* (Jonsson et al.)[120] as a significant producer in a value chain of strategic importance. Ilmenite is not itself classified as a critical raw material, but it forms part of value chains in which certain downstream products and applications may be considered strategic or critical.

Ilmenite has been used as a feedstock for titanium metal production in Europe, including in Ukraine, and continues to be used globally for this purpose. Titanium metal has important applications in aerospace, defence and space technologies, and is classified as strategic in the EU, the United States and NATO. Titania therefore represents a potential raw material base for a European titanium metal value chain.

In addition to its main product, Titania produces several concentrates from side streams, including products containing copper, nickel and cobalt, as well as a magnetite concentrate containing vanadium, which may represent alternative sources of critical raw materials.

Markets, dependencies and competitive conditions

Until 2019, Titania's principal market was the European pigment industry. As a result of reduced industrial production and fewer customers in Europe, the company has adapted to a changing market and now exports around 50% of its output to Asia, with China as the largest single market through a trading company that distributes the products further along the value chain. Titania's competitive advantages are linked to the size of the deposit, the absence of radioactive elements in the ore, and more than 100 years of documented and reliable deliveries with consistent specifications.

The competitive landscape includes both other ilmenite suppliers and producers of titanium slag. The Kronos group is the largest producer of pigment based on ilmenite or ilmenite-based slag in Europe. The European pigment industry has declined over time, combined with increasing imports of pigment from Asia, particularly China. Tariff barriers have been introduced against Chinese pigment in order to protect European industry and contribute to more level competitive conditions.

On the input side, the business is exposed to several forms of dependency. Access to explosives is critical for ore extraction and has been affected by international instability. Operations also depend on complex supply chains for spare parts, chemicals and processing equipment.

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Barriers, investment needs and opportunities in Norway

A key barrier for Titania is the development of the pigment market in Europe, where reduced capacity and increasing competition from imports have weakened the market for ilmenite for the sulphate process. Over time, a continued shift from the sulphate to the chloride process represents a structural challenge, given that Titania's product is currently tailored to the sulphate route. Increased demand would require either new sulphate-based pigment capacity or the development of commercially viable solutions for the production of synthetic rutile that could be used in the chloride process. The competitive balance between the two process routes is influenced by the cost of feedstocks, energy, chemicals and waste treatment.

Titania has spare capacity at its plant and could increase output through additional staffing and longer operating hours. One possible development path is linked to the potential establishment of titanium metal production in Europe, including on the basis of technology developed in Ukraine, where Titania could serve as a natural supplier of raw material. Realisation of such a development would require access to capital, expertise, customers and power.

Circularity, side streams and secondary raw materials

Titania has developed several value streams based on by-products and tailings from ilmenite production. These include a metal concentrate containing copper, nickel and cobalt, as well as a magnetite concentrate containing vanadium. Titania is participating in the Horizon Europe project AVANTIS, which among other things is assessing alternative vanadium resources in Europe.

Potential has also been identified in relation to scandium, which is present in the ore and in residual streams from downstream processing at Kronos Titan. Analyses show that a significant share of the scandium content follows acid streams in pigment production, together with, among other things, vanadium, and an early-stage assessment is under way regarding the possible utilisation of these resources. The ore also contains apatite, the extraction of which has previously been assessed but was not found to be economically viable.

The waste rock from operations consists largely of anorthosite, which contains significant quantities of aluminium. Large volumes have been deposited over time and represent a potential secondary raw material source. Surplus masses of anorthosite and norite are also being assessed as input materials in cement production, where demand is increasing as a result of the need for lower CO_2 emissions. Work is also under way on the utilisation of historic material from the Sandbekk mine, as well as the possible use of nickel-bearing sludge from the treatment plant downstream of the tailings dam at Tellnes.

Overall message

Titania's operations have over time been affected by a structural shift from the sulphate to the chloride process in global pigment production, combined with reduced industrial capacity in Europe and increasing imports from Asia. A continued development in this direction may weaken the market base unless new applications or processing routes are established for ilmenite from Sokndal.

The contraction of European industry also represents a continuing market risk, even though Titania has developed a more global market position as a supplier. This makes the business dependent on competitive logistics and framework conditions.

Titanium metal is not currently produced in Europe, primarily as a result of limited processing capacity and low market prices, rather than a lack of raw material. In this context, Titania represents an established and reliable source of feedstock and could form part of a future European value chain if strategic importance and commercial viability are given greater weight.

Nordic Mining (titanium/rutile and quartz)

Nordic Mining is a Norwegian mining company engaged in the exploration, development and production of industrial minerals relevant to strategic and critical value chains. The company aims to become a leading player in the development of new mining projects in the Nordic region. Its operational activity is centred on Engebø Rutile and Garnet AS (ERG), a subsidiary of Nordic Mining, with mineral extraction and processing at Engebø in Sunnfjord municipality. The operation comprises an open pit, a processing plant and shipping infrastructure for the production and export of mineral concentrates. Commercial-scale production commenced in 2024.

The main products are rutile (TiO_2) and garnet. Garnet is produced as a finished industrial product for direct use in applications such as waterjet cutting and surface treatment. Rutile is produced as a mineral concentrate and exported as an input material to international titanium value chains.

Figure 17 - Nordic Mining has established Engebø Rutile and Garnet AS, which comprises an open pit, a processing plant and shipping infrastructure. (Photo: Jostein Vedvik)

Engebø operates in the early stages of the value chain, with mineral extraction and mechanical processing as its core activities. The process route includes crushing, grinding and separation of ore to produce rutile and garnet concentrates. The plant has been designed for large-scale production, with a high degree of integration and automation across the process lines.

In addition, the company is developing a high-purity quartz (HPQ) project in Kvinnherad, targeting very high-purity silica products for use in semiconductors, fibre-optic cables and solar energy applications. HPQ is a raw material with very limited global availability, and the deposit in Kvinnherad has demonstrated high purity and favourable test results for advanced applications, including the semiconductor industry (see also the description under Nesodden in Chapter 3.1).

Relevance to critical and strategic raw materials

Rutile from Engebø is an important source of titanium feedstock, which enters value chains linked to pigment production, titanium metal production and advanced industrial applications. Titanium and titanium-based materials are central to strategic sectors such as defence, aerospace, aviation and high-technology industry, and are regarded as strategically important under several international frameworks. Engebø represents a European source of titanium feedstock outside the dominant supplier countries and may therefore contribute to more diversified and resilient supply chains.

Figure 18 - Processing plant including crushing, grinding and separation of rutile and garnet concentrates. (Photo: Jostein Vedvik)

Garnet from Engebø is an industrial end product used in applications such as waterjet cutting, sandblasting and surface treatment, and can in several cases substitute for more environmentally burdensome materials. Engebø is a long-term industrial project with potential for further optimisation and increased production. The deposit is currently estimated to support 39 years of operation, with scope for significant expansion through further drilling. Over time, more extensive downstream processing in Norway may also become relevant.

Taken together, Nordic Mining's products are linked indirectly to value chains associated with the energy transition, industrial production, defence and European raw material supply. Key customer segments include process industries, titanium value chains and industrial mineral markets.

Markets, dependencies and competitive conditions

Nordic Mining is an export-oriented company, and products from Engebø are supplied to international markets in Europe, North America and Asia. Rutile enters global titanium value chains, while garnet is sold as an industrial end product. At design capacity, annual production is around 35,000 tonnes of rutile and 200,000 tonnes of garnet.

The operation is based on local mineral resources and has limited dependence on imported raw materials. At the same time, it depends on input factors such as chemicals, process reagents, spare parts, fuel, stable power supply and maritime logistics. International conditions, including geopolitical instability, logistical disruptions and price volatility, may affect both availability and cost levels for these inputs. As an export-oriented business, the company is also dependent on stable trade and transport conditions.

From a competitive perspective, Nordic Mining operates in a global market with producers in Africa, Australia and Asia. In several cases, these markets are characterised by higher geopolitical risk, weaker environmental standards and less predictable framework conditions. Norway, by contrast, benefits from political stability, stringent regulation, high environmental standards and access to renewable energy. This provides a stronger position in markets where sustainability, traceability and responsible production are becoming increasingly important.

Barriers, investment needs and opportunities in Norway

The mining and process industries are characterised by long development cycles, high capital intensity and the need for stable and predictable framework conditions. Lengthy and complex permitting processes can affect both the pace of investment and the competitiveness of new projects. Access to expertise and specialised labour is another important constraint, particularly in process industry, automation and technical disciplines. Competitive access to power, infrastructure and reliable logistics is also essential for both current operations and further development. International market conditions, including price volatility, geopolitical uncertainty and competition from low-cost regions or subsidised producers, also influence investment appetite and profitability.

A particular challenge is limited access to capital for mining projects, both nationally and internationally. There is a general shortage of both Norwegian capital and investment appetite, as well as limited access to international investors with a long-term perspective, reflecting the long-term horizons and high risks associated with the sector. This creates a risk that developed projects may be wholly or partly acquired by foreign actors with lower costs of capital. Nordic Mining has stated an ambition to develop additional mining projects in the Nordic region, with the quartz project in Kvinnherad currently the highest priority. New project opportunities are also being assessed on an ongoing basis.

Circularity, side streams and secondary raw materials

The Engebø operation is based on the utilisation of several mineral fractions from the same deposit, with the aim of achieving high resource efficiency and reduced waste. The production of both rutile and garnet from the same resource base illustrates an integrated and efficient use of the deposit. There is potential for further development of side streams and new mineral products over time, depending on market conditions and technological progress. Growing emphasis on resource efficiency, circularity and sustainable value chains is expected to become increasingly important for both the mining and process industries and may broaden the economic basis for further resource utilisation.

Overall message

Nordic Mining aims to help develop a strong Nordic minerals industry and to contribute to increased availability of strategic raw materials from a stable European context. Engebø represents a new industrial operation that strengthens the supply base for titanium-related value chains. The main challenges relate to lengthy and unpredictable framework conditions, limited access to capital and weak domestic investment appetite. At the same time, the pool of both national and international investors remains limited, increasing the risk of foreign acquisition of developed projects. More efficient permitting processes, stronger investment appetite and improved framework conditions will be essential to unlock further value creation, strengthen security of supply and support the development of a stronger Norwegian minerals industry.

8.3 Process industries handling critical and strategic raw materials

Norsk Hydro (aluminium)

Norsk Hydro ASA is a fully integrated aluminium and energy company and one of Norway's largest and most strategically important industrial groups. Hydro's operations in Norway are centred on the production of aluminium, renewable energy, and advanced technology and process development. The company forms a central pillar of Norway's power-intensive industry and plays a key role in European and global value chains for materials that are essential to industrial competitiveness, the energy transition and defence.

Hydro's Norwegian production structure encompasses the entire energy-intensive part of the aluminium value chain. Primary aluminium is produced by electrolysis and further processed in foundries at the plants in Karmøy, Sunndal, Årdal, Høyanger and Husnes. Anode production, which is a critical input to the electrolysis process, takes place mainly at the plants in Årdal and Sunndal. In addition, aluminium with a purity exceeding 99.999% is refined at Hydro Vigeland Brug in Vennesla. Hydro also manages substantial hydropower resources through power plants located across large parts of Norway, which both supply its own operations and contribute to the stability of the Norwegian power system.

Figure 19 - Europe's largest aluminium plant, Hydro Sunndal. (Photo: Norsk Hydro)

Hydro also has an extensive apparatus for research, technology and process development, with key centres in Porsgrunn (Herøya), Årdal, Karmøy and Sunndal. These environments work on continuous improvements to existing production technology, digitalisation, process control and the development of carbon capture and storage (CCS) from existing plants, as well as next-generation zero-emission aluminium technology through the HalZero programme. Taken together, this gives Hydro a combination of industrial scale, technological maturity and innovation capacity that is unique in the Norwegian context.

Hydro produces a broad range of products, including primary aluminium, low-carbon and recycled aluminium, cast and semi-finished aluminium products, and electrical power. These products feed into a wide range of strategic downstream value chains in transport, construction, power infrastructure, packaging, renewable energy and defence-related industry.

Position in the value chain and strategic relevance

Hydro spans the full global aluminium value chain, from bauxite mining and alumina refining in Brazil, via primary production in Norway, Brazil, Qatar, Slovakia, Canada and Australia, to recycling, casting and extrusion in an extensive international network. The Norwegian part of the business is particularly concentrated in energy-intensive primary production and forms the basis of Hydro's position as a supplier of low-carbon aluminium to the European market.

Aluminium is classified as a critical and strategic raw material under several international frameworks and is placed at the top of NATO's list of materials of particular importance to the defence industry. The metal is used in a broad range of military and civilian applications, including aircraft, vehicles, maritime structures, energy infrastructure and advanced technical components. Aluminium combines low weight with high strength and corrosion resistance, and is therefore difficult to replace in many strategic applications.

Aluminium is also central to the energy transition. The metal enables weight reduction in the transport sector through substitution for heavier materials such as steel, thereby contributing to lower emissions. In addition, aluminium has good electrical conductivity and is used on a large scale in power grids, transformers and other electrical infrastructure required for the expansion of renewable energy and the electrification of society.

Figure 20 - Hydro's activities in the aluminium value chain. (Source: Norsk Hydro)

Hydro's main market segments reflect this broad range of uses. Transport, construction, and power transmission are the largest application areas, but aluminium is also used in packaging and in the solar industry, including in structures and support systems for solar panels.

In addition to large-scale primary production, Hydro also has more specialised activities directed towards materials with particularly demanding quality and performance requirements. At Hydro Vigeland Brug, high-purity aluminium (HPA) is produced through the further refining of primary aluminium to very high purity levels (above 99.999%). Such materials are used in technologically advanced applications, including electronics, the semiconductor industry, battery technology and specialised energy infrastructure. This production represents a global niche position with few alternative suppliers, and the material has, in practice, limited possibilities for substitution. This gives high-purity aluminium strategic importance in critical and strategic value chains.

The activity at Vigeland Brug is based on advanced process expertise, specialised technology and access to renewable energy, enabling deliveries with both high quality and a low carbon footprint. Taken together, this extends Hydro's role from that of a large-scale supplier of primary aluminium to also include highly specialised materials of direct relevance to emerging strategic technology value chains.

Markets, dependencies and competitive conditions

Hydro operates in a global market, but Norwegian production is primarily directed towards Europe. More than 90% of the aluminium produced in Norway is delivered to European customers. Norway produces a total of around 1.4 million tonnes of primary aluminium per year, of which Hydro accounts for approximately 1.2 million tonnes. This corresponds to around 40% of total European production, and around 30% through Hydro's operations alone.

This position makes both Norway and Hydro central suppliers in European value chains. At the same time, it means that the competitiveness of the Norwegian aluminium industry is largely determined by developments in European framework conditions for energy, climate and trade.

Primary aluminium production depends on several critical input factors. Aluminium oxide (alumina) is supplied mainly from Hydro's own plants in Brazil but is also purchased on the open market from suppliers in Europe, Australia and elsewhere in the world. Petroleum coke is used in the production of anodes and is sourced mainly from refineries in Norway and Europe. Finished anodes are also purchased from China. In addition, Hydro's products depend on alloying elements such as magnesium and silicon, where magnesium in practice is available almost exclusively from Chinese producers, while global silicon production is also heavily dominated by China.

Without access to these input materials, it would not be possible to produce a large share of Hydro's aluminium products. At the same time, aluminium production is highly electricity-intensive, and access to sufficient volumes of stable, competitively priced and low-carbon electricity is a prerequisite for the Norwegian aluminium industry.

Hydro competes only to a limited extent with individual companies, and primarily with regions operating under fundamentally different framework conditions. China is by far the dominant global producer, with heavily state-supported and vertically integrated industrial chains, often based on coal-fired power with low cost and high CO_2

intensity. In the Middle East, several Gulf states have built large export-oriented smelters based on very low energy costs through state-priced gas. Eastern Europe and parts of Eurasia have historically had significant primary production, but with a more variable power mix and increasing geopolitical and trade-related risk. In North America, Hydro competes mainly in extruded and further-processed products, where production, cost structures and market access are more regionally based and are therefore not directly comparable with Norwegian primary aluminium production.

Norway differs from these regions through a power mix that is almost entirely based on renewable hydropower, stable electricity supply and very low CO_2 intensity. Electricity accounts for roughly one third of the cost structure in aluminium production and is therefore the single most important factor for competitiveness. Norwegian aluminium has a carbon footprint of around one quarter of the global average, which gives it a particular advantage in markets where customers impose strict requirements for sustainability and traceability.

At the same time, European aluminium production is affected by several non-market factors. The carbon pricing system creates price spillovers even for renewable Norwegian electricity, and while the Carbon Border Adjustment Mechanism (CBAM) is intended to protect European industry against imports of high-carbon products, the scheme has methodological weaknesses and loopholes. Hydro therefore regards the CO_2 compensation scheme as a more effective instrument for countering carbon leakage than the current design of CBAM.

Barriers, investment needs and opportunities in Norway

The principal barrier to maintaining a strong aluminium industry in Norway is uncertainty relating to electricity prices and power availability. Predictable, long-term and competitive electricity supply is the most important prerequisite for further investment in both existing plants and any new capacity. Aluminium production is among the most capital-intensive of industrial processes, and even relatively small changes in framework conditions can have major effects on investment decisions.

Hydro has expanded capacity at several Norwegian plants in recent years, and demand for low-carbon products, combined with delivery reliability and political predictability, suggests that Norway is in principle well positioned for further development. At the same time, new investments require stable and long-term framework conditions, particularly in relation to energy, market access and regulation.

Circularity, side streams and secondary raw materials

Hydro is a leading player in aluminium recycling. Aluminium is highly suited to material recovery, and products made from recycled metal have the same quality as products made from primary metal. Demand for recycled aluminium is high, and the constraint lies in the availability of used metal rather than in demand.

At present, a significant share of used aluminium leaks out of Europe, mainly to Asia but also to the United States. Increased import tariffs on primary metal in the United States also create a higher willingness to pay for used metal, which is not subject to equivalent tariffs, and thereby contribute to considerable price pressure in the market for scrap metal.

Overall message

Hydro constitutes a critical part of European aluminium value chains, for a material that is essential to defence, transport, power infrastructure and the energy transition. Norwegian aluminium production combines industrial scale with a very low carbon footprint and high delivery reliability and therefore plays a unique role in European security of supply.

At the same time, the Norwegian and European aluminium industries are exposed to structural competition from regions with lower energy costs and weaker climate and environmental requirements. Uncertainty related to electricity prices, power availability and regulatory framework conditions represents the greatest risk to further investment and capacity development in Norway.

To unlock further value creation in the Norwegian aluminium industry, it is essential to secure stable, long-term and competitive framework conditions, particularly in relation to energy. Predictable access to electricity is the key prerequisite for Hydro and the wider Norwegian aluminium industry to continue contributing as pillars of European and allied value chains.

Alcoa Norway (aluminium)

Figure 21 - Alcoa's smelter in Mosjøen (Foto: Alcoa)

Alcoa Norway operates primary aluminium production at two smelters in Norway, located in Mosjøen and at Lista. Both plants produce low-carbon primary aluminium based on renewable wind and hydropower and form part of Alcoa's global production and supply structure. The operations are based on modern prebake technology and Søderberg technology in aluminium electrolysis, combined with energy-efficient casting solutions and continuous process optimisation.

Alcoa's Norwegian operations form part of the upstream section of the aluminium value chain, where alumina is converted into primary aluminium through electrolysis and subsequently cast into products adapted to industrial applications. The production at Mosjøen and Lista is directed primarily towards standardised primary aluminium products, including foundry alloys and other cast products for downstream processing in European and international markets.

Position in the value chain and strategic relevance

Alcoa Norway operates in the smelting and materials stage of the aluminium value chain, where alumina is converted through electrolysis into primary aluminium, which is then further processed into alloy products with specific properties. The business covers this entire production stage, from electrolysis to casting and alloy production, before the products are supplied to global industry as input materials for a wide range of applications.

Aluminium is defined as a strategic raw material in the EU, the United States and NATO, and forms part of several critical value chains. The material is strategic and gains additional importance through further processing into components used in end applications of high societal importance. These include, among other things, applications in battery systems, solar energy, electronics, defence and aerospace. Aluminium is used, for example, in structures and casings for battery systems, in load-bearing structures in solar installations, in thermally demanding components in electronics, and in light, high-strength alloys for defence and aerospace applications.

Figure 22 - Aluminium slabs at Alcoa Mosjøren (Foto: Alcoa)

The competence profile at the plants includes metallurgy, process engineering, energy optimisation, emissions reduction and the operation of electrolysis cells. Production is highly complex and requires a strong understanding of process conditions, materials technology, operations and maintenance, as well as health, safety and environmental management. At the same time, the business is characterised by a systematic approach to energy efficiency and emissions reduction, in line with the groups and the national objectives for the transformation of the process industries.

Markets, dependencies and competitive conditions

Alcoa Norway supplies primary aluminium to international markets, with a particular focus on Europe and the United Kingdom. Between 80 and 90% of production is exported, and total output from the two plants is approximately 300,000 tonnes per year. The products enter several key end markets, with the transport sector, including electric vehicles, accounting for around 20–30% of volumes, followed by building and construction at 20–25%. A further

10–15% is used in energy and electronics applications, while 5–10% enters defence- and aerospace-related applications through further processing.

The supply chain is global and depends on stable deliveries of several input materials. These include alumina, carbon-based anodes produced from coal and petroleum coke, electrolysis chemicals such as cryolite, and alloying elements such as magnesium, silicon, copper and manganese. Alumina is imported mainly from Australia, Brazil and Guinea, while anode materials are supplied from, among other places, China, the United States and Europe. Alloying elements are sourced through global market systems, with exposure to both European and Asian suppliers.

This structure entails several types of risk. These relate to geopolitical risk associated with supplies from China, especially for anodes and certain alloying elements, as well as price volatility in the markets for alumina and carbon products. In addition, there are logistical risks in global supply chains. Power prices and grid access in Norway also constitute a decisive, but often underestimated, factor in the competitiveness of the business.

The global competitive landscape is characterised by significant differences in cost levels, framework conditions and emissions requirements. Key competitors include producers in the Middle East, which benefit from low energy and labour costs; China, with large production capacity and state support schemes; Canada, with access to renewable power and modern plants; and Russia, which has historically been an important exporter to the European market. Competition is also shaped by non-market factors, including subsidies, export controls and regulatory measures. For European producers, the further development of the EU Emissions Trading System (ETS) and the introduction of CBAM are therefore key framework conditions.

In this context, Alcoa Norway benefits from access to renewable power, high process competence and stable deliveries, combined with documented sustainability and traceability. Production is subject to extensive certification and qualification requirements, including the ASI Performance Standard and Chain of Custody for sustainable aluminium, as well as industry-specific standards such as IATF 16949 for the automotive industry and alloy-quality requirements for aerospace applications.

Barriers, investment needs and opportunities in Norway

Primary aluminium production is highly energy-intensive and closely dependent on the availability of competitively priced electricity. Uncertainty relating to power prices and future framework conditions therefore represents a major barrier to investment and further development of the business. In addition, limitations in grid capacity may reduce the scope for capacity expansion or modernisation.

The business is also exposed through import dependence on critical input materials such as alumina, anodes and alloying elements, as well as through lengthy permitting processes for any industrial upgrades. Global competition from producers that benefit from subsidies or lower cost levels reinforces these challenges, while access to qualified labour in metallurgy and process engineering may also be a limiting factor.

At the same time, there is potential for increased capacity through the modernisation of electrolysis cells, estimated at around 10–20% for existing plants. Realising this potential will require long-term power contracts and predictable regulatory frameworks, including the future development of CBAM and the CO_2 compensation scheme. If such framework conditions are in place, there may also be a basis for investment in both capacity expansion and low-carbon technology. Improved access to raw materials and more robust logistics solutions will also be important prerequisites.

In this context, strengthening Norwegian capacity for primary aluminium would help improve Europe's access to low-carbon metals that are essential to the energy transition, the defence industry and emerging battery value chains.

Circularity, side streams and secondary raw materials

Aluminium production provides a strong basis for circularity in a value chain perspective, as the material can be recycled repeatedly without any significant loss of properties. Alcoa Norway forms part of a value chain in which both primary production and recycling play a role in the flow of materials.

The business works continuously to improve resource efficiency in its own processes, including the optimisation of material flows, the reduction of losses and the utilisation of by-products where this is technically and economically feasible. At the same time, the most important circular effect is linked to aluminium's role in downstream applications, where low weight, corrosion resistance and long service life contribute to more energy-efficient products and systems.

Access to low-carbon aluminium with documented traceability is also of growing importance in international markets were environmental performance and sustainability form part of supplier qualification requirements.

Overall message

Alcoa Norway produces low-carbon primary aluminium that forms part of strategic value chains linked to the energy transition, industry and defence. The business represents a central processing stage in the aluminium value chain, where access to renewable energy and advanced process technology enables the production of materials with high quality and a low carbon footprint. At the same time, the further development of operations is closely linked to framework conditions for power, access to input materials and competition in a global market shaped by both market and non-market factors.

Glencore Nikkelverk AS (nickel, cobalt, copper and platinum group metals)

Glencore Nikkelverk AS is one of Norway's most central and technologically advanced refineries for non-ferrous metals and forms an integrated part of the global Glencore group. The group has operations in more than 35 countries and employs a total of around 135,000 employees and contractors. The Nikkelverk plant in Kristiansand has around 550 employees and represents one of the world's leading facilities for the refining of high-purity nickel and cobalt, based on proprietary technology and a long industrial tradition.

Figure 23 - Glencore Nikkelverk in Kristiansand (Photo: Anders Martinsen for Glencore Nikkelverk)

The operations in Kristiansand comprise the refining and further processing of nickel, cobalt, copper and platinum group metals, as well as the production of sulphuric acid and a bismuth concentrate. Production is directed towards markets with very strict requirements for metal quality, purity and traceability, and the products are used in value chains that are strategically important for the energy transition, digital infrastructure, aerospace and the defence industry. Nikkelverk's products are marketed and supplied globally, and the plant plays a central role as a supplier of refined metals to European and transatlantic end users.

Position in the value chain and strategic relevance

Glencore Nikkelverk operates in the midstream and downstream stages of the value chain for metallic raw materials. The feedstock received consists mainly of concentrates and intermediate products with a metal content of approximately 20 to 80 per cent. These undergo a combination of hydrometallurgical and roasting processes before pure metals are produced through electrolysis. This combination of processes provides considerable flexibility in the handling of different feedstock types and enables the production of metals of very high and consistent quality.

The products refined at Nikkelverk are all included on lists of critical and strategic raw materials in the EU, the United States, the United Kingdom and NATO. Nickel, cobalt and copper are defined as critical materials, while platinum group metals are strategic for advanced technologies including catalysts, hydrogen technologies and specialised defence applications. The bismuth concentrate requires further processing before reaching the end market, but also forms part of value chains of strategic importance. Taken together, Glencore Nikkelverk therefore constitutes an important European hub for the production of refined metals of high strategic relevance.

Figure 24 - Refined nickel metal from Glencore Nikkelverk. (Photo: Glencore Nikkelverk)

Markets, dependencies and competitive conditions

Glencore Nikkelverk supplies products to customers across large parts of the world. Around 50 per cent of nickel production and approximately 95 per cent of copper production are delivered to markets in the EU, while a significant share of cobalt production is supplied to the United States. These deliveries enter key end-user segments such as batteries, renewable energy, the semiconductor industry, aerospace and defence, where the requirements for purity, stable quality and security of supply are particularly high.

The company's raw material input consists mainly of metal-bearing concentrates and intermediate products, in addition to a range of chemicals that are important for process control and the quality of the end products. Among the most important input factors are soda ash (sodium carbonate) and hydrochloric acid. A large share of the feedstock comes from Glencore's own mines and smelters in Canada, particularly in the Sudbury area, supplemented by deliveries from Finland and other parts of the world. This access to integrated raw material flows provides a degree of robustness, but the business is at the same time exposed to global commodity markets and geopolitical developments.

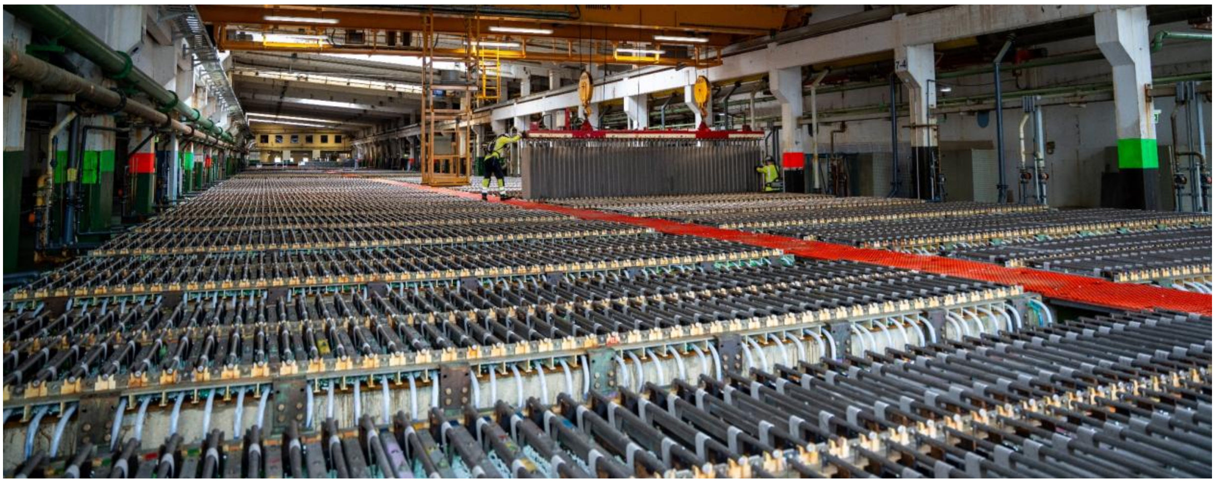


Figure 25 - The electrolysis hall where High Grade (HG) nickel metal is produced (Photo: Glencore Nikkelverk)

The nickel market is characterised by a significant structural imbalance. Production of nickel, particularly in Indonesia, has increased sharply in recent years, and Indonesia is to a large extent controlled by Chinese capital. It is estimated that, during 2026, Indonesia will account for around 70 per cent of total global nickel production. This overcapacity has led to persistently low prices, which have weakened the competitiveness of Western producers.

Within the category of "Class 1 nickel", which is required for advanced battery and industrial applications, global production has increased significantly over the past 10 years. However, if Russia, China and Indonesia are excluded, production in the rest of the world has declined markedly. This indicates a strategic development in which China is seeking to achieve a dominant position across large parts of the nickel value chain, with parallels to the historical development in magnesium and other metal markets.

Energy is a critical input factor in Nikkelverk's production, particularly in the electrolysis process where the metals are produced. Uncertainty relating to power availability, price levels and taxation, including CO_2 charges, affects both operating costs and investment decisions. Compared with many international competitors, Nikkelverk operates under stricter environmental requirements, a higher regulatory burden and with less subsidised access to power. Regulations such as the EU REACH Regulation entail increased costs that many competitors outside Europe are not subject to. Taken together, this contributes to a competitive environment in which European production faces structural cost disadvantages, despite high environmental standards and lower carbon intensity.

Barriers, investment needs and opportunities in Norway

The dominant market position that Indonesia, in practice owned by Chinese interests, has built up in nickel production constitutes the most important structural barrier to the further development of European nickel refining. Persistently low prices reduce profitability and make access to capital challenging, particularly for larger investment projects and capacity expansions. This affects not only Glencore Nikkelverk, but also the broader European value chain for energy-intensive industries and the production of advanced materials.

At the same time, the feedstock landscape is changing. Forecasts show that future nickel feedstocks will increasingly be available in alternative formats, particularly so-called MHP products (mixed hydroxide precipitate) and other wet concentrates. Such feedstocks arise both in primary production and in several recycling processes. Glencore Nikkelverk currently has limited capacity to handle feedstocks with high moisture content, which represents a bottleneck to increased flexibility and future access to raw materials.

Framework conditions related to power prices in the NO2 area, CO_2 charges and general regulatory uncertainty affect investment appetite. The combination of high operating costs and price pressure from global markets makes it difficult to realise new, capital-intensive measures without greater predictability in market and framework conditions.

Despite these challenges, Glencore Nikkelverk has identified significant potential for further development, particularly in flexible feedstock handling and the recycling of nickel and cobalt. A phased investment plan is on the drawing board. The first phase comprises the establishment of a new intake station for wet feedstocks delivered in bulk bags, with an estimated cost of around NOK 250 million and a target for commissioning in 2029. This will provide the basis for increased receipt of alternative and recycled feedstock streams.

The next phase involves the construction of a pre-treatment plant to remove unwanted contaminants before integration into existing process lines. The plant will require further research and development, and rough cost estimates indicate investments in the order of NOK 3 billion, with possible completion around 2032. In addition, replacement and capacity expansion of the existing liquid-liquid extraction plant is being considered, as it has now reached its maximum capacity. A new plant with a 50 per cent increase in capacity is estimated to cost around NOK 1 billion.

Taken together, these investments, along with the expansion of bottlenecks, could enable an increase in production of between 20,000 and 50,000 tonnes of refined metals, with total investment needs in the order of NOK 4 to 8 billion. Such an expansion would provide a significant strengthening of Europe's capacity for the refining and recycling of nickel and cobalt and would contribute directly to the EU's objectives under the Critical Raw Materials Act to increase European processing and recycling.

Circularity, side streams and secondary raw materials

Glencore Nikkelverk has for several decades been involved in the recycling of metals such as nickel, cobalt and copper. A share of recycled material streams is already included as part of the feedstock mix, either via intermediate products from Glencore's smelters in Sudbury or through direct receipt at Nikkelverk. Going forward, the ambition is to increase the share of recycled material taken directly into Kristiansand, in line with the investment plans for greater feedstock flexibility.

The production processes also generate various types of sludges and waste streams. Nikkelverk is actively working to develop solutions to convert these into useful products through a "waste-to-value" approach. This work is an important contribution to increased circularity and reduced resource waste and may, over time, provide new secondary raw materials of strategic importance.

Overall message

Glencore Nikkelverk constitutes a central European hub for the refining of high-purity nickel, cobalt, copper and platinum group metals and already plays an important role in value chains that are strategically relevant to the energy transition, digital infrastructure and defence. With its technological expertise and existing process capacity, the plant has the potential to contribute much more significantly to European and transatlantic security of supply, particularly through increased processing and recycling of critical metals in Europe.

At the same time, the business is exposed to considerable structural risks linked to global commodity markets characterised by strong concentration and persistent price pressure. China's dominant position in the nickel value chain, via extensive production in Indonesia, has led to low prices that weaken the investment basis for market-based producers in Europe. Combined with high power costs, CO_2 charges and stricter regulatory requirements than those faced by many global competitors, this means that capital-intensive projects in Norway face significantly higher risk than corresponding investments in other regions.

To realise the identified potential in Glencore Nikkelverk and contribute to the EU's objectives under the Critical Raw Materials Act, there is therefore a need for more predictable and supportive market and framework conditions. Long-term offtake agreements, risk-sharing through public policy instruments and access to targeted investment schemes will be decisive in unlocking the necessary investments in increased feedstock flexibility, recycling and capacity expansion. A precondition for this is that the CRMA is incorporated into the EEA Agreement, so that Norwegian actors can participate on equal terms with European projects of strategic importance.

Boliden Odda (zinc)

Boliden Odda is part of the Swedish mining and smelting group Boliden AB and is the group's only production facility in Norway. The plant is in Odda and is one of Europe's largest and most modern zinc refineries. It produces refined zinc products, zinc alloys and sulphuric acid, with an annual production capacity of around 350,000 tonnes of zinc following completion of the Green Zinc Odda 4.0 expansion project.

Position in the value chain and strategic relevance

Boliden Odda operates in the midstream and downstream stages of the zinc value chain and receives zinc concentrates in the form of zinc sulphide (ZnS) from mines in Europe and other parts of the world. The concentrates are further processed into zinc metal and zinc alloys through a fully integrated process chain comprising roasting and hydrometallurgical processes. Finished products are delivered in various commercial formats to European customers, primarily in construction, transport, infrastructure and industrial production.

Figure 26 - Transport of cast products at a fully automated zinc foundry at Boliden Odda. (Photo: Thor Brødreskrift)

The production process can in principle be divided into four main stages. First, the zinc concentrate undergoes a roasting process, in which the zinc sulphide is burned at high temperature and converted into zinc oxide (ZnO) and sulphur dioxide. The sulphur dioxide is further processed into sulphuric acid, which is either used internally or sold to external customers. This is followed by leaching and purification in a wet-chemical process, in which zinc is dissolved, and impurities are removed through advanced separation and purification stages. In the third stage, zinc is reduced from the electrolyte to metal by electrolysis, forming so-called zinc cathodes. Finally, the zinc cathodes are melted in the foundry, alloyed with other metals according to customer specifications and cast into saleable products.

Through the Green Zinc Odda 4.0 expansion project, Boliden Odda has carried out one of the largest single investments in Norwegian process industry in recent years. The investment, decided in 2021 and completed in 2026, has increased production capacity from around 200,000 to 350,000 tonnes of zinc per year. The increase in capacity has been realised through the construction of a new roasting and sulphuric acid plant, expansion of leaching and purification capacity, establishment of a new electrolysis hall, a fully automated zinc foundry and a new quay facility. The entire plant is integrated through a high degree of digitalisation and automation, which provides increased energy efficiency, better process control and greater operational flexibility.

The new expansion has also made it possible to use more complex raw materials and recover more metals through by-products. A key example is the establishment of Odda Leach Product, which enables the recovery of metals that were previously deposited as waste. Boliden Odda aims to be among the world's most modern and sustainable zinc producers, and Green Zinc Odda 4.0 represents a decisive technological step in that direction.

Markets, dependencies and competitive conditions

Boliden Odda supplies primarily zinc and zinc alloys to the European market. The products are used mainly in the galvanising of steel, die casting, the production of brass and chemical applications. The distribution of end uses shows that around 49 per cent of volumes go to construction, 22 per cent to transport, 17 per cent to infrastructure, 6 per cent to consumer goods and a smaller share to other segments.

Zinc is classified as a critical raw material by both the United States and the United Kingdom and is considered strategically important in light of its broad use in societally critical infrastructure, climate-relevant industry and civil preparedness. Corrosion protection of steel through galvanising is important for the service life and robustness of buildings, transport and energy infrastructure, and zinc therefore plays an indirect but system-critical role in the energy transition and in society's physical foundation.

Boliden Odda's raw material input consists mainly of zinc concentrates from mines in Sweden, Ireland and Portugal, supplemented by deliveries from other regions through the global commodity market. In addition, a range of input materials is used, including alloying metals such as aluminium, nickel, magnesium, copper and bismuth, as well as electrodes and speciality chemicals. Some of these input factors are produced only to a limited extent in Europe and must be imported from markets such as South Africa, Australia and China.

The business is exposed to risks related to global logistics and geopolitical tensions, particularly for chemicals and other input materials imported from outside Europe. Ongoing conflicts and trade disruptions have contributed to increased uncertainty in supply chains, and some critical input materials are not currently produced in Europe. This reinforces vulnerability in the value chain, even though the zinc concentrate itself is traded mainly in a relatively liquid global market.

In competitive terms, Boliden Odda mainly faces other European zinc producers. Raw materials are traded globally but finished zinc products compete primarily within a European market with relatively similar technical specifications and quality requirements. At the same time, competitive conditions are affected by structural differences in framework conditions. Norwegian and European producers operate under stricter environmental requirements, higher energy and CO_2 costs, and more extensive regulatory requirements than some producers outside Europe.

Boliden Odda stands out positively through its high technological maturity, large-scale production, advanced automation and ability to process complex concentrates. Access to renewable power provides a basis to produce zinc with a low carbon footprint. Boliden Odda produces zinc with a documented CO_2 intensity of below 1.0 kg CO_2 equivalent per kg of zinc, compared with a global average of around 3.6 kg CO_2 equivalent. Emissions are calculated in accordance with the Greenhouse Gas Protocol for scopes 1, 2 and 3 and provide a significant competitive advantage in markets with increasing emphasis on carbon footprint and sustainability.

Barriers, investment needs and opportunities in Norway

The decision to invest in Green Zinc Odda 4.0 illustrates both the opportunities and the barriers for capital-intensive industrial projects in Norway. The investment was conditional on several prerequisites, including access to renewable power, grid capacity, stable framework conditions and the necessary permits under the Pollution Control Act, including solutions for the disposal of waste in rock chambers.

A key lesson from the project is the importance of predictable and sufficiently efficient public processes. The ability of authorities and state actors to process “shovel-ready” projects within expected timelines was decisive for the investment decision. For large, complex industrial projects, it is essential that all main prerequisites have clear and coordinated lead times. A lack of predictability in case handling, grid access or support schemes increases risk and may in practice move investments to other countries.

Over the longer term, Boliden Odda represents potential for further capacity development and increased value creation, particularly related to circularity and more efficient utilisation of secondary raw materials. The existing plant already has high technological maturity, and further investments will largely depend on market signals, stable framework conditions and access to competitive terms for electric power.

Circularity, side streams and secondary raw materials

Circularity is an integral part of Boliden Odda’s operations. The raw material base for zinc production consists both of primary zinc concentrate and zinc that has been recycled through recovery, including from steel scrap and electronic products. At present, recycled raw materials account for around 17 per cent of input materials.

The production process also generates several by-products that enter further material recovery. These include cadmium metal, copper cement and Odda Leach Product, which contains metals such as lead, silver and gold. These streams represent valuable secondary raw materials and contribute to higher overall resource efficiency and reduced waste.

Overall message

Boliden Odda plays a central role in European value chains for zinc and related materials and contributes to securing access to critical metals that are necessary for construction, transport, infrastructure and climate-relevant industry. Production in Europe, based on renewable power and low emissions, provides greater robustness and reduces dependence on less sustainable suppliers outside the region.

At the same time, the business is exposed to structural risk related to global market conditions and differences in regulatory framework conditions. Turbulence in global markets, stricter European regulations and limited predictability in national arrangements, such as CO_2 compensation and grid access, may weaken competitiveness and investment willingness over time.

To realise further potential in the value chains from mine to finished product, political and administrative recognition of the importance of critical minerals produced in Europe is essential. Predictable framework conditions, efficient case handling and stable energy solutions are key instruments for unlocking further investment and strengthening the strategic position of Norway and Europe.

K.A. Rasmussen (precious metals and platinum group metals)

K.A. Rasmussen AS is a Norwegian industrial company with headquarters and production facilities in Hamar. The company operates an integrated business within the recycling, refining and further processing of precious metals. Its activities include the treatment of metal-bearing material streams, refining into pure metals, and the production of industrial products and investment metals. The business includes chemical processing, metallurgical operations and mechanical working. Through this integration, the company covers several process stages, from the treatment of secondary raw materials to finished products.

The company’s main products include refined precious metals (gold, silver and platinum group metals), industrial catalysts, semi-finished products for industry and goldsmithing, as well as investment products such as bars and coins. The recycling and refining business is based on a combination of hydrometallurgical and electrochemical processes. Blanks of pure metals or alloys are then cast and mechanically processed into finished products, which are used in the production of new catalysts, semi-finished products and investment products.

K.A. Rasmussen operates primarily in the midstream and downstream parts of the value chain through recycling, refining of end-of-life products with significant precious metal content, and advanced processing. The company receives, among other things, catalysts based on silver and platinum group metals, as well as gold- and silver-bearing materials from jewellery, silverware and industrial waste. These materials are processed into pure metals that are incorporated into new products. The company has strong expertise in handling complex and composite raw material streams, as well as in developing efficient process solutions for recycling and material upgrading.

Relevance to critical and strategic raw materials

Figur 27 - K.A. Rasmussen Viking Eirik Bloodaxe 1 kg silver coin bar. (Photo: K.A. Rasmussen)

K.A. Rasmussen handles several metals that are defined as critical or strategic in international frameworks, including silver and the platinum group metals platinum, palladium, rhodium, iridium and ruthenium. These metals are of major strategic importance in a range of industrial applications.

The metals are in themselves classified as strategic raw materials, and their importance is further reinforced through their use in high-technology products and industrial processes. They are used, among other things, in catalytic processes in the chemical industry that contribute to the reduction of greenhouse gas emissions, as well as in the production of advanced components. The business is particularly relevant in that the company contributes to the recycling of such metals from secondary raw material streams. This increases resource efficiency and reduces the need for primary extraction and represents an important contribution to security of supply for materials with limited global availability.

The most important market segments are the chemical process industry using precious-metal-based catalysts, as well as actors involved in the refining of precious-metal-bearing material streams. In addition, the investment market for precious metals and producers of precious-metal-based products, including goldsmiths, are important customer segments.

Markets, dependencies and competitive conditions

K.A. Rasmussen operates in several markets, depending on product category. Investment metals and semi-finished products are sold primarily in the Nordic region, while materials for industrial catalysts are supplied to a global market. For catalysts, there is often an integrated relationship, whereby the same customer both supplies used catalysts for recycling and receives new products.

The most important input factors are metal-bearing material streams for recycling, including gold, silver and platinum group metals, as well as inputs such as hydrochloric acid, nitric acid and sodium hydroxide. The supply of raw materials is based mainly on deliveries from the Nordic region and Northern Europe, with some input from other European markets. Technical equipment and operating materials are supplied largely from Europe.

The business is moderately exposed to market and logistics risk, particularly related to access to raw materials and price volatility in the metals markets. Access to capital in the supply chains may be a limiting factor in periods of sharply rising metal prices. At the same time, standard input factors with several alternative suppliers are mainly used, which reduces vulnerability. The company operates with relatively moderate volumes across several markets, which helps to dampen the effects of market volatility.

Competition comes mainly from larger European actors in refining and recycling, particularly in Germany, the United Kingdom, Switzerland and Italy. No significant competitive advantages or disadvantages have been identified in relation to subsidies, export controls or other non-market factors.

Barriers, investment needs and opportunities in Norway

A key barrier is access to relevant competence. The business is highly specialised, and access to labour with the necessary experience is limited in the Nordic region. Recruitment from abroad is relevant but is challenged by language requirements and the need for Norwegian as the working language in day-to-day operations.

Incoming material streams are often classified as waste, which entails extensive regulatory requirements and documentation needs. This results in increased costs and more complex logistics, even though the materials function as raw materials in further processing. The business is also affected by price developments in the metals markets. Sharp price increases can create liquidity challenges in the supply chains, which may in periods limit access to raw materials and business activity. In addition, the export of precious-metal-bearing waste streams out of the Nordic region and Europe may reduce access to raw materials for regional recycling and further processing.

There is potential for capacity expansion in silver refining, both in terms of volume and flexibility towards different types of input streams. This will require investment in process equipment and infrastructure, as well as stable access to raw materials. Investment needs will vary depending on the choice of technology and project design. Development work is also under way relating to the recovery of metals from printed circuit boards in electronic waste, which represents a potential new business area.

Existing process plants can be adapted to new material streams, including raw materials with lower metal content and materials containing other valuable metals. Examples that have been assessed include the recovery of yttrium from fluorescent tube waste. Such initiatives are, however, dependent on risk-reducing measures, particularly in relation to investment and market risk. The lack of support schemes directed at material recycling, compared with energy transition projects, appears to be a limitation on the realisation of new industrial initiatives.

Circularity, side streams and secondary raw materials

The business is largely based on secondary raw materials and represents an established circular model in which precious metals are recycled and returned to the market. There is potential to expand recycling to include more metals from existing material streams, as well as to increase the utilisation of more complex raw materials with lower metal content, particularly in electronic waste. The company has process expertise that can be applied to several types of material stream, both for metals that are already refined and for metals with similar processing properties.

Overall message

K.A. Rasmussen has specialised competence and process facilities for the recycling and refining of precious and strategic metals from secondary raw material streams, while also contributing to the production of catalysts for the chemical industry. The greatest risks relate to access to competence, generational change and limited resources for technology development compared with larger international actors, as well as market volatility in metal prices. Increased support for the scaling-up of technology for material recycling, from laboratory and pilot level to industrial scale, appears to be a key measure for reducing risk and facilitating the development of new circular value chains in Norway.

Elkem (silicon, ferrosilicon)

Elkem ASA is a global industrial company with Norwegian roots and headquarters in Oslo and is a leading producer of silicon-based and carbon-based materials for international industry. The company has more than 120 years of industrial history and constitutes a central part of Norway's power-intensive industry. Elkem has developed into a strategic supplier of materials that form part of a wide range of critical technologies and infrastructures, both in Europe and globally.

Elkem has a broad and solid industrial base in Norway, with six production plants, two quartz mines and two research and technology centres, in addition to the group's headquarters. The Norwegian operations employ a total of around 1,500 people and serve as cornerstone enterprises in several local communities. The production plants include the silicon plants at Salten (Straumen), Thamshavn (Orkanger) and Bremanger (Svelgen), the ferrosilicon plants at Rana (Mo i Rana), Bjølvefossen (Ålvik) and Bremanger, as well as the production of carbon-based materials at Fiskaa in Kristiansand. In addition, Elkem owns quartz mines in Tana and Mårnes, which supply high-

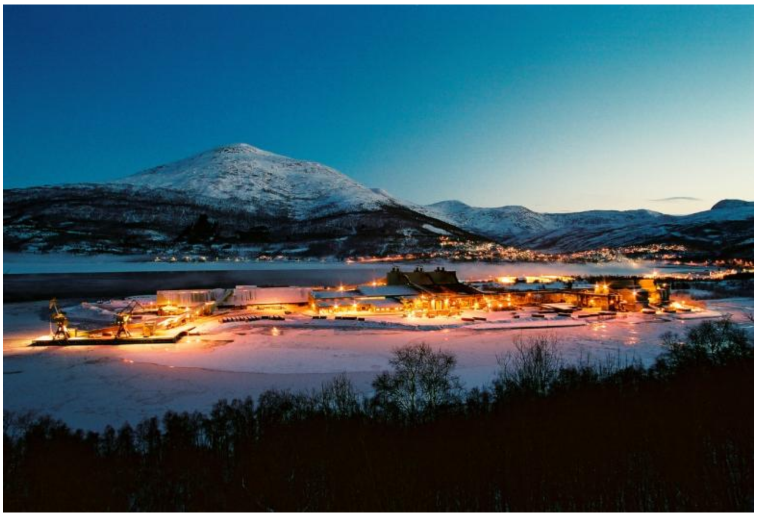


Figure 28 - Elkem's silicon metal plant at Salten. (Photo: Elkem)

quality raw materials to the smelters. Research and technology development is supported through R&D environments in Kristiansand and Trondheim.

The Norwegian operations constitute the centre of gravity in Elkem's global value chain. Norway supplies a total of more than 40 per cent of all silicon and around 30 per cent of the ferrosilicon consumed in Europe, making both Norway and Elkem strategically important suppliers to European industry. Elkem's materials form part of value chains for, among other things, transport, construction, renewable energy, electronics and defence, and thereby contribute directly to both industrial competitiveness and societally critical security of supply in allied markets.

Elkem's operations are situated in the energy- and capital-intensive part of the value chains for silicon-based and carbon-based materials, and the company covers a broad range of value chain stages. The activities range from mineral extraction to smelting, refining, advanced material processing and by-product utilisation. This vertical integration gives Elkem control over the quality, processing and security of supply of critical input materials that are used further in downstream industry.

The value chain first comprises the extraction of quartz raw material, where Elkem, through its own mines, secures access to raw materials with the necessary quality and traceability. This is followed by smelting and metallurgical reduction in electric furnaces, based on quartz, carbon materials and renewable power. These are the core processes at Elkem's Norwegian plants and represent high-technology and energy-intensive industry in which Norway has particular advantages. Refining and advanced processing then take place through metallurgical purification, alloying and specialised treatment into high-purity silicon, ferrosilicon and foundry alloys. Proprietary technologies, such as Silgrain®, make it possible to supply materials for demanding applications with stricter specifications than standard products.

An important part of the value creation also takes place through the utilisation of by-products. Microsilica®, which is formed from fine SiO_2 particles in the off gas from the smelting furnaces, is collected and further processed into products used in construction, the oil and gas industry and refractory materials technology. This systematic utilisation of side streams contributes both to increased resource efficiency and to reducing the environmental footprint of production.

Relevance to critical and strategic raw materials

Elkem produces silicon, ferrosilicon and foundry alloys in Norway that are either directly classified as critical or strategic raw materials, or that form indispensable input factors in value chains that are assessed as critical by the EU, the United States and NATO.

Figure 29 - Slide from Elkem showing raw materials for silicon (Si) and ferrosilicon (FeSi) production. Si and FeSi form part of alloys in various semi-finished products such as aluminium profiles or electrical steel. (Source: Elkem)

Silicon is defined as both critical and strategic in the EU Critical Raw Materials Act and is also included on the USGS list of critical minerals as well as on the US Department of Energy's list of critical materials for energy technologies. The reason for this classification is silicon's central role in the production of solar panels, electronics, battery technology, aluminium and silicones, which are in turn used in sectors including defence and aerospace. Although Elkem does not produce electronics-grade or solar-grade silicon directly, the company supplies high-quality metallurgical silicon, which is a necessary input factor in these value chains.

Ferrosilicon is not explicitly listed as a critical raw material in the EU or the United States, but it is an entirely central input factor in the production of electrical steel (often referred to as electric steel). Electrical steel is classified as a critical material in the United States, among other things because of its importance for power grids, transformers, electric motors and defence-related applications. Ferrosilicon must therefore be understood as indirectly critical through its role in the production of materials that are included on formal criticality lists.

Foundry alloys, which consist of ferrosilicon with smaller additions of rare earth elements, are similarly not classified as critical raw materials in themselves. Nevertheless, they are indispensable in the production of cast iron, which constitutes a fundamental material for vehicles, infrastructure, machinery, wind power, robotics and defence materiel. Rare earth elements used in certain foundry alloys are themselves classified as critical and strategic raw materials in both the EU and the United States, although this applies to the raw materials and not to the alloy product. These alloys are therefore system-critical materials.

Silicon and several downstream products based on ferrosilicon are also included on NATO's list of "defence critical raw materials" published in December 2024. This underlines Elkem's strategic relevance in value chains that are decisive for allied defence capability and industrial preparedness.

Markets, dependencies and competitive conditions

Elkem's Norwegian plants have a combined production capacity of around 150,000 tonnes of silicon, 200,000 tonnes of ferrosilicon and foundry alloys, and more than 100,000 tonnes of carbon-based products. Sales from the Norwegian plants are mainly export-oriented: around 70 per cent go to the EU market, around 10 per cent to the United States and around 20 per cent to Asian markets.

The products form part of a broad portfolio of critical downstream applications, including power generation and transmission, renewable energy, electronics, aerospace, batteries, infrastructure and military materiel. Elkem is therefore an indirect, but central, supplier to several value chains that are at the core of both the green transition, digitalisation and security policy in Europe and North America.

Production depends on significant quantities of electricity and raw materials such as quartz, coal, coke, charcoal, wood chips and electrodes. Ferrosilicon production also uses iron pellets. Quartz is supplied mainly from Norwegian deposits, including from Elkem's subsidiary Elkem Tana, which produces high-purity quartz. Carbon-based reducing materials, iron pellets and certain alloying elements are imported, and foundry alloys additionally require the import of rare earth elements.

The competitive landscape is global and characterised by a significant concentration of production. China is by far the largest producer of both silicon and ferrosilicon, with other important producing countries including Brazil, France, Spain, the United States, Malaysia, Kazakhstan and Poland. Competitiveness depends largely on access to and the price of electricity, technological efficiency and the ability to supply speciality products to demanding markets.

Norway has historically had comparative advantages as a producing country through access to renewable power, high technological competence and energy-efficient operations. At the same time, Norwegian industry faces higher electricity prices and stricter environmental and climate regulations than many competitors globally. Elkem has therefore chosen to develop a product portfolio aimed at more demanding applications, where stricter specifications and stable quality provide better margins than standard products.

Barriers, investment needs and opportunities in Norway

Elkem points to several structural barriers to further growth in Norway. Uncertainty related to market access, including as a result of trade protection measures on ferro-alloys, represents a significant risk for capital-intensive industrial projects. High electricity prices and the prospect of increased costs through the EU Emissions Trading System (EU ETS) further reinforce this risk.

At the same time, the opportunities for further capacity development and value creation are closely linked to developments in the EU, which is Elkem's most important market. Predictable and free market access to the EU, and preferably also the United States, is a prerequisite for full utilisation of existing production capacity and for further growth in volume or value. Security of market access is regarded as decisive for all major, capital-intensive investments.

Elkem also points to significant potential related to further specialisation and the production of more technologically demanding products, for example through fine crushing and classification, blending of pre- and post-consumer scrap, and the development of special alloys. Although such investments do not necessarily provide volume growth, they may provide significant value growth through higher product prices and a stronger position in critical value chains.

Over the longer term, increased Norwegian and European mineral extraction, including rare earth elements, represents a strategic scope for action for the further development of the smelting and refining industry in Norway. Local access to raw materials provides a comparative advantage in value chains where quality, traceability and security of supply are becoming increasingly important.

Circularity, side streams and secondary raw materials

Elkem has established a practice in which all side streams from its own production are reused, and the company currently deposits no metal-bearing waste streams. Work is under way to increase recycling further, including through the blending of post-consumer materials and the recycling of side streams from downstream customers in the value chain. This strengthens both resource utilisation and Elkem's position in circular value chains.

Overall message

Elkem plays a key role in value chains that support the energy transition, infrastructure, electronics and defence, through the supply of silicon-based and carbon-based materials that are critical or system-critical for modern industry. The Norwegian plants constitute a strategic foundation for European security of supply in these areas.

At the same time, the business is exposed to risks related to limited market access, rising electricity prices and environmental costs in Norway and Europe, combined with global competition from actors operating under significantly different framework conditions.

To unlock more value creation and further develop Norway's strategic position in these value chains, it is essential to secure predictable market access and competitive framework conditions for energy-intensive industry, particularly with regard to electricity prices and climate and environmental regulation.

Wacker Chemicals Norway AS (silicon)

Wacker Chemicals Norway AS operates the WACKER Group's silicon metal plant at Holla in Heim municipality in Trøndelag. The plant is the group's only production unit for silicon metal and constitutes a central upstream production stage in a globally integrated value chain for silicon-based materials and chemicals.

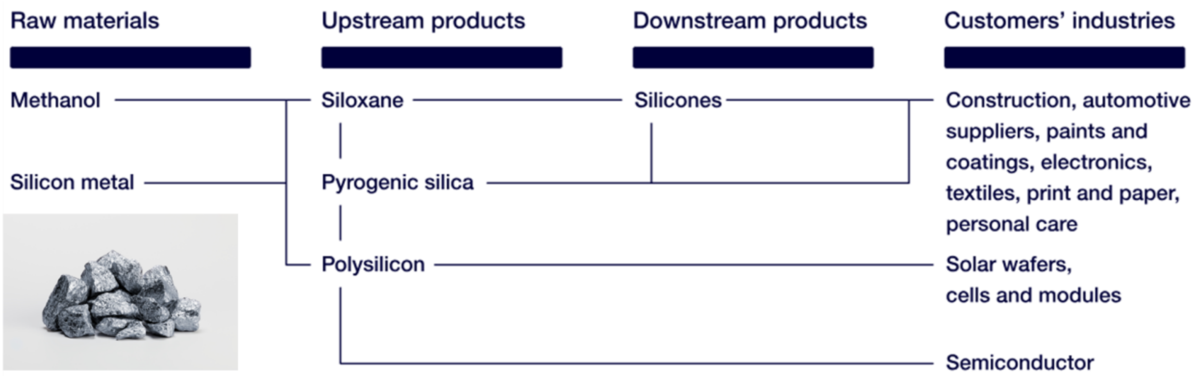
Figure 30 - Wacker Chemicals Norway's silicon metal plant at Holla. (Photo: Wacker)

Production is based on the reduction of quartz with carbonaceous reducing agents in electric arc furnaces at temperatures above 2,000°C. The plant is technologically advanced and consists of modern furnace lines with high energy efficiency, long service life and a stable production profile. In 2019, Wacker commissioned the world's largest silicon furnace at Holla, increasing the plant's total capacity by more than 40% and strengthening its role as a strategic production unit within the group. The installed capacity at the plant is around 80,000 tonnes of metallurgical silicon per year, in addition to around 40,000 tonnes of micro silica. The plant is logistically integrated with its own quay for direct shipment of production to the group's downstream processing plants, particularly in Burghausen and Nünchritz in Germany.

Wacker Chemicals Norway AS thus functions as a specialised and integrated upstream supplier of silicon metal to the group's global value chains, which are largely directed towards advanced chemical products and materials.

Position in the value chain and strategic relevance

Wacker Chemicals Norway operates in the metallurgical materials stage of the silicon value chain, which represents a critical transition point between raw material and highly processed materials. The silicon metal produced at Holla is transported to Germany, where it is further refined into hyper-pure polysilicon – the basic material for the production of solar cells and semiconductor components.



***Metallurgical-grade silicon**, produced through the chemical reduction of quartz and carbon. It is required for the production of high-purity polysilicon for microchips, solar modules, and the entire range of silicones (source: WACKER)*

Figure 31 - Wacker Group activities from silicon metal production through to end-user markets, illustrated by, among other things, solar cells and semiconductors. (Source: Wacker Chemicals)

Production at Holla covers approximately 25–33% of the WACKER Group's total need for silicon metal. This internal supply is a central part of the group's strategy to ensure stable access to input materials and reduce exposure to volatile raw material markets. The plant therefore functions as an integrated and strategic production stage in the group's overall value chain and contributes to security of supply in several downstream material and chemical streams.

Silicon forms part of a number of strategically important value chains. Through further processing into polysilicon, production at Holla becomes an integrated part of the solar energy value chain. Through the production of silicones, it is also incorporated into materials used in electrical insulation, sealing systems and components in wind power and power grids. In this way, the business contributes to technologies that are necessary for both energy systems and digital infrastructure.

Silicon metal is classified as both a critical and a strategic raw material in the EU, and corresponding assessments exist in the United States, the United Kingdom and in security policy analyses linked to NATO. Its criticality is associated with applications in semiconductors, electronics, solar cells and chemical products. Wacker Chemicals Norway AS is therefore a central actor in such value chains through its role as a supplier of input materials for further processing.

Markets, dependencies and competitive conditions

Production is based on input factors such as quartz as the main raw material, carbon-based reducing agents that are gradually being replaced by biogenic carbon, and electric power as a central production factor. In addition, electrodes and refractory materials are necessary input factors in the furnace processes. The markets for the materials include, among other things, electronics and electrical engineering, consumer products and health applications, transport and mobility, and building and construction. In these applications, silicon-based materials are used in, among other things, electrical insulation, encapsulation materials and thermal solutions, as well as in sealing systems and adhesives. The combination of chemical stability, temperature resistance and electrical properties is decisive for the function of the materials in such applications.

The value chain for silicon metal is global and characterised by significant production capacity and high concentration, particularly in China. At the same time, new actors are in the process of entering the market, including production linked to new resource bases such as in Angola. This affects price levels and competitive conditions in the market and has led to the establishment of trade policy measures in both the EU and the United States. At the same time, there is increasing regulatory and strategic attention to security of supply for input materials to critical value chains.

Wacker's business model, based on vertical integration from silicon metal to advanced materials, provides a significant degree of robustness against such market conditions. At the same time, the business depends on stable deliveries of quartz of the right quality, access to carbon-based reducing agents and competitive energy costs.

Barriers, investment needs and opportunities in Norway

The further development of production at Holla is closely linked to framework conditions for energy, raw materials and industrial operations. Production is highly energy-intensive, and competitiveness is directly affected by power prices and regulatory conditions. At the same time, the plant represents an advanced technological environment with potential for the further development of low-emission production solutions. The plant is well positioned to function as a pilot and learning plant within the Wacker Group. The technological maturity and size of the plant also make it a relevant platform for the further development of low-carbon production in the global silicon industry.

An important area of development is the transition from fossil-based reducing agents to biogenic carbon based on renewable raw materials. This is a central part of the work to reduce the climate footprint of production and forms part of the group's long-term strategy for low-emission materials.

Circularity, side streams and secondary raw materials

Production at Holla generates significant side streams, particularly in the form of micro silica, which has established applications in, among other things, concrete and special materials. This contributes to a high utilisation rate of the input factors and reduces waste from production. At the same time, the company is working to reduce its climate footprint through increased use of renewable and biogenic input factors, as well as through improved energy utilisation. Solutions for the capture and further use of CO_2 from process gases may potentially become important in the future.

Overall message

Wacker Chemicals Norway AS is a central upstream production stage for silicon metal in a globally integrated value chain for silicon-based materials. Through deliveries to the group's downstream processing, production enters directly into value chains for solar energy, semiconductors, electronics and advanced chemicals, where silicon is classified as a critical and strategic raw material. The business thereby contributes to security of supply in industrial and technological systems that are of major importance to both the energy transition and digital development. At the same time, competitiveness is affected by global market conditions and national framework conditions, particularly related to energy and cost levels.

Yara Norway (phosphorus and the potential for rare earth elements)

Yara International ASA is a Norwegian company headquartered in Oslo, established as a separate listed company in 2004 through a spin-off from Norsk Hydro, with roots going back to Hydro's fertiliser business in the early 20th century. Yara is a central actor in Norwegian process industry and has some of the group's most strategically important production plants located in Norway. The company is a major global producer and distributor of ammonia, the world's largest producer of NPK fertiliser, and a leading supplier of nitrates and nitrogen-based industrial chemicals. Yara's Norwegian operations form a central part of the group's global value chain and are of great importance both for Nordic and European food security and for the supply of strategic chemicals to industry and preparedness.

The Norwegian production plants are Yara's nitrophosphate-based factories in Porsgrunn and Glomfjord. In 2025, these plants had a combined production of approximately 3.1 million tonnes of NPK fertiliser and 1.6 million tonnes of calcium nitrate (CN).

The domestic market accounts for only a limited share of the volumes produced in Norway. Total Norwegian consumption in the period 2023–2024 was estimated at around 285,000 tonnes of NPK and 110,000 tonnes of nitrogen fertiliser, mainly ammonium nitrate with sulphur. The main share of production is therefore exported to the global market, primarily to Europe. The Norwegian plants thus play an important role for Nordic and European food security, particularly in light of increased geopolitical uncertainty and growing focus on robustness in supply chains for food and agricultural inputs.

In addition to fertiliser products, Yara's Norwegian factories produce several chemicals that are critical input factors for both civilian industry and national preparedness. These include AdBlue, which is crucial for emissions reduction in the transport sector and for compliance with environmental and climate regulations, as well as nitric acid, which is a necessary input in the production of explosives. Domestic capacity for such chemicals used in explosives production is considered strategically important, particularly for infrastructure development, mining activity and defence-related purposes.

Position in the value chain and technological profile

Yara's Norwegian plants are chemical process factories situated in the capital- and energy-intensive part of the value chain for nitrogen-, phosphorus- and potassium-based products. Production is based on the use of mineral raw materials such as apatite (phosphate concentrate), potassium chloride and potassium sulphate, combined with large amounts of energy and natural gas, as well as the production and further processing of ammonia and nitric acid.

The nitrophosphate process used at Yara's Norwegian plants is characterised by high utilisation of the raw material and substantially lower waste generation than alternative production routes. The process does not give rise to gypsum and is therefore associated with a significantly lower need for disposal of solid waste. At present, only a limited number of fertiliser producers globally use this process route, mainly because it places very strict requirements on the quality of the apatite concentrate. These quality requirements mean that only a limited share of global phosphate production is suitable as feedstock for the process.

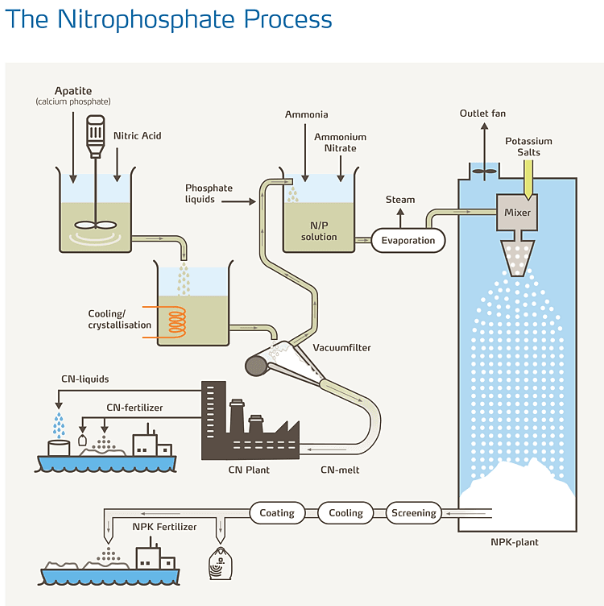


Figure 32 - Yara's nitrophosphate process to produce NPK fertiliser and calcium nitrate (CN). (Source: Yara)

The dominant alternative production route internationally is the phosphoric acid process, in which apatite concentrate is dissolved in sulphuric acid. This process gives rise to significant quantities of gypsum that must be handled and deposited. Globally, large volumes of gypsum are produced each year, and the long-term storage and environmental management of this by-product represents a persistent environmental and land-use problem.

Worldwide, only a small number of producers have mastered and operate this process route on an industrial scale. The high technological threshold means that Yara's Norwegian plants represent a unique and difficult-to-replace production capacity within the fertiliser industry, with significance far beyond the Norwegian market.

Relevance to critical and strategic raw materials

Yara's Norwegian value chain is strongly exposed to raw materials that are classified as critical or strategic in the EU, the United States, Canada and the United Kingdom. This applies to phosphate concentrate, potassium-based raw materials and rare earth elements (REE) that can be extracted as a by-product from igneous apatite concentrate.

Phosphate concentrate is included on lists of critical raw materials in several jurisdictions, but the term covers a broad range of qualities with very different supply situations. Around 90 per cent of global phosphate production is of sedimentary origin and is produced on a large scale, mainly in North Africa, the Middle East and the United States, with relatively good global security of supply. China also has significant domestic phosphate production but exports only a limited share of these volumes.

At the other end of the spectrum is phosphate concentrate of very high purity, which is a prerequisite for use in the nitrophosphate process. This quality occurs only in a limited number of deposits globally, either as special sedimentary qualities or as igneous (magmatic) phosphate.

Potassium chloride and potassium sulphate are both included on the United States' and Canada's lists of critical raw materials. Although potassium is a globally traded product, the market is characterised by few supplier countries and geopolitical sensitivity. The experience following the loss of supplies from Belarus has made clear the importance of diversified access to potassium-based raw materials

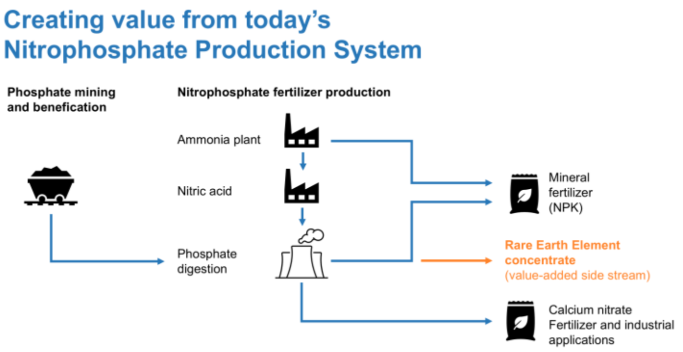


Figure 33 - Igneous apatite concentrate has an additional dimension in that it may contain commercially interesting concentrations of rare earth elements. In the 1990s, Yara produced rare earth concentrate as a by-product at the plant in Glomfjord. (Source: Yara)

Igneous apatite concentrate also has a distinct strategic dimension in that it may contain commercially interesting concentrations of rare earth elements. In the 1990s, Yara produced rare earth elements (REE) as a by-product at the plant in Glomfjord, but the activity was discontinued as a result of strong price pressure from Chinese actors. In the early 2020s, Yara participated in a European research and demonstration project together with REEtec, LMC and Vacuumschmelze, in which a complete and integrated value chain for rare earth elements was demonstrated both technically and industrially.[121]

Rough calculations indicate that there is significant untapped potential for rare earth elements at Yara's Norwegian plants, and that a further development of this production could in time cover a substantial share of the EU's current demand for rare earth elements. Rare earth elements are classified as critical and strategic raw materials in all major allied frameworks and are crucial input factors for energy technology, electrification, the green transition, defence and high-technology industry.

Markets, dependencies and competitive conditions

Yara's deliveries from Norway are mainly global and are directed primarily towards food production, but also towards a range of industrial applications. NPK and CN products are essential for maintaining Nordic, European and global food production and constitute a fundamental prerequisite for stable access to food.

As a result of the war in Ukraine, Yara's Norwegian production plants have had to undertake an extensive reorganisation of raw material flows. The plants in Porsgrunn and Glomfjord were originally developed with igneous apatite from the Kola Peninsula as the primary phosphate source, and this raw material was used for several decades, including during the Cold War. After 2022, this supply was interrupted as a result of sanctions and political restrictions. In parallel, access to potassium chloride from Belarus was lost even before the outbreak of the war.

[121] Building a European value chain for rare earth elements | SecREEts Project | Results in Brief | H2020 | CORDIS | European Commission

Today, sedimentary and igneous phosphate is purchased from Africa, supplemented by smaller volumes from Yara's own mine in Finland. Potassium is now procured from a broader range of suppliers in Europe, North America and the Middle East. This reorganisation has been crucial for maintaining operations but has at the same time highlighted the underlying strategic vulnerability associated with certain input factors.

The fertiliser market is global, but Yara's premium nitrate-based NPK products and calcium nitrate compete primarily with finished products from Russian nitrophosphate plants. Following reduced Russian gas exports to Europe, the Russian fertiliser industry has had access to large volumes of inexpensive gas, which has given it highly favourable production costs and strong competitiveness. This illustrates how non-market factors can significantly affect competitive conditions.

Barriers, investment needs and opportunities in Norway

A key barrier to the further development of rare earth element production at Yara's Norwegian plants is access to a long-term and stable supply of igneous phosphate. Several Nordic and Canadian phosphate projects are under development and may in time provide a relevant basis for securing such access. Without long-term raw material contracts, however, there is no basis for making investment decisions related to the production of rare earth elements.

Yara considers the separation of rare earth elements from the existing fertiliser process to represent a particularly attractive example of circular value creation. Unlike dedicated mining and hydrometallurgical processing of rare earth elements, this can be carried out without significant new land disturbance, with low environmental impact and limited investment costs. At the same time, the market for rare earth elements is strongly characterised by state control, subsidies and export controls, particularly in China, which dominates large parts of the global value chain.

To realise this potential, public-private cooperation, long-term offtake agreements and market mechanisms that can reduce price risk and investment uncertainty, including minimum prices or similar arrangements, will probably be necessary.

Circularity, side streams and secondary raw materials

Overall, Yara's Norwegian operations are crucial for Nordic and European food security through the production of fertiliser that is fundamental for agriculture. In addition, the plants supply strategic industrial chemicals such as AdBlue and nitrates, which are critical input factors for the transport sector and for defence-related explosives production. At the same time, the business represents a significant, but conditional, potential for future production of rare earth elements in Europe.

The separation of rare earth elements from existing nitrophosphate-based fertiliser production represents a clear example of the circular economy. A material stream that today follows the fertiliser product can be utilised to produce critical raw materials without new mining operations and with very limited environmental impact. This gives Yara's Norwegian plants a particular strategic potential in a European perspective.

The greatest risk is linked to the loss of long-term access to critical raw materials, in particular igneous phosphate, which is a prerequisite both for operation of the nitrophosphate plants and for the development of rare earth element production. Long-term raw material contracts with new phosphate projects in the Nordic region or Canada will be decisive in securing such access. To realise the potential for rare earth element production, public-private cooperation will also be required.

Overall message

Yara's Norwegian production plants constitute a central part of Europe's supply base for nitrogen- and phosphorus-based fertiliser and are therefore critical infrastructure for Nordic and European food security. The high export share and the concentration of production capacity in Norway mean that the plants are significant far beyond national needs, particularly in a geopolitical situation characterised by trade disruptions and uncertain access to agricultural inputs.

At the same time, Yara's nitrophosphate-based production represents a unique and little-discussed potential for the circular extraction of rare earth elements in Europe. The possibility of separating rare earth elements as a by-product from existing fertiliser production provides a rare combination of industrial scale, low environmental impact and rapid realisation compared with new mining. This technological and structural starting position makes Yara a possible key actor in the establishment of allied value chains for rare earth elements.

The decisive limitation on realising this potential is not technology or process expertise, but long-term and predictable access to igneous phosphate of the right quality. Without long-term raw material contracts, it will not be possible to make investment decisions to produce rare earth elements. To unlock this potential, there will therefore be a need for targeted public-private cooperation, including long-term offtake agreements, risk-sharing and possible pricing mechanisms that can reduce exposure to a market strongly shaped by geopolitical and non-market factors.

REEtec (rare earth elements)

REEtec AS is a Norwegian industrial company engaged in the processing of rare earth elements. The company has developed its technology over more than 18 years, from laboratory and pilot scale to demonstration plants and further to industrial production. Its first industrial plant has been established at Herøya Industrial Park in Porsgrunn and represents one of the few processing plants for rare earth elements outside China. Among the company's largest shareholders are the Swedish state-owned mining company LKAB, Scatec Innovation, TechMet and Nysnø.

The company's technology constitutes an alternative to conventional solvent extraction (SX), which is currently the dominant processing method globally, and is the only known industrial process solution that is not based on this technology. REEtec's process is based on high-performance liquid chromatography (HPLC) and is characterised by fewer process steps, a closed circuit without the use of organic compounds, and full recovery of process chemicals. This results in a lower environmental footprint and reduced health, safety and environmental exposure compared with traditional solutions, while the technology also offers high flexibility with regards to feedstock composition. Taken together, this gives an estimated CO_2 footprint that is around 90% lower than conventional processes.

Figure 34 - REEtec's rare earth processing plant at Herøya Industrial Park. (Photo: REEtec)

The plant is designed to be able to produce around one per cent of global demand for neodymium and praseodymium oxides (NdPr), which are used in permanent magnets. At the same time, the technology is flexible and can, with adaptations, be used for the separation of all 17 rare earth elements. The company has entered into sales agreements and is engaged in ongoing commercial discussions with leading industrial actors in, among other things, electric vehicles and high-technology defence industry.

Rare earth elements are classified as critical and strategic raw materials in several jurisdictions, including the EU, the United States, the United Kingdom and NATO. These materials are crucial for a wide range of high-technology applications, and their criticality is largely linked to high concentration in the value chain and a lack of alternative suppliers.

Position in the value chain and strategic relevance

The value chain for rare earth elements consists of several distinct stages, from mineral deposits and extraction to processing and end applications. Although rare earth elements are relatively common in the earth's crust, they rarely occur in concentrations that are economically extractable. The largest deposits are found in China, Brazil, India, Australia and Russia, while Europe's most important resources are located, among other places, in Norway and Sweden.

After extraction, the ore must be processed into a rare earth concentrate consisting of a mixture of the various elements. This concentrate must then be separated into individual oxides, which is the form in which the materials are used industrially. This separation stage is technologically demanding because of the chemical similarities between the elements and constitutes one of the most complex and critical stages in the value chain.

REEtec operates in this separation stage, where the concentrate is split into individual oxides of high purity. Globally, this stage is dominated by China, which accounts for around 85% of capacity. In the subsequent refining stage, where oxides are further processed into metals, alloys or other materials, China's share is even higher, at around 90% of capacity.

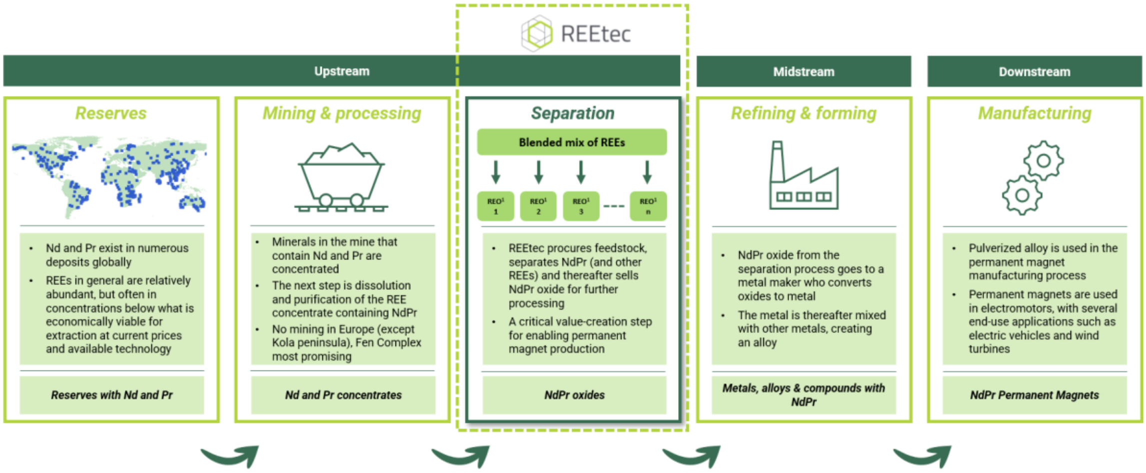


Figure 35 - Illustration showing REEtec's activities in the permanent magnet value chain. (Source: REEtec)

REEtec produces oxides that are either used directly in industrial applications or further processed into metal. Examples of direct applications include yttrium oxide for ceramic applications, lasers and heat-resistant materials, as well as gadolinium oxide for medical diagnostics, nuclear power and advanced materials. Other materials, such as NdPr oxide, must be further processed into metal and are used in the production of permanent magnets, which are essential for electric vehicles and wind turbines. Terbium and dysprosium are used in high-temperature magnets with applications in demanding technological systems.

The strategic significance of REEtec therefore lies in its ability to supply separated oxides in a stage of the value chain that is currently highly concentrated and characterised by geopolitical risk.

Markets, dependencies and competitive conditions

REEtec's production is mainly directed towards markets linked to permanent magnets, where demand is driven by electric vehicles, wind turbines and electronics. Around 40% of demand for NdPr-based materials is linked to electric vehicles, around 25% to electronics and around 14% to wind turbines. In addition, increasing demand is expected from new applications, including robotics and automated systems. At the same time, there are more specialised markets for other rare earth elements, including in the defence and aerospace industries, where volumes are lower but importance is high as a result of technological requirements.

China's dominant position in the value chain is the result of several decades of targeted industrial development, with the state supporting this development through subsidies, low energy costs, financing and a high tolerance for environmental impact. During 2025, export restrictions were introduced on both certain rare earth minerals and processing technology, which further reinforced uncertainty in global markets. As a result of this structure, prices for certain rare earth oxides have been significantly higher in Europe than in China, in some cases with differences of more than thirty times. This illustrates both market distortions and dependence on Chinese capacity.

REEtec's most important input factor is rare earth concentrates from extraction companies. Access to feedstock represents the greatest challenge for the business. Extraction outside China and Russia is limited, and existing actors, such as MP Materials in the United States and Lynas in Australia, are vertically integrated and largely have limited incentives to sell feedstock to independent processing actors. Furthermore, state involvement in the United States, including investments, offtake agreements and price guarantees, has helped to tie available feedstock streams more closely to national industrial strategies. This may result in reduced access to feedstock for European actors.

At the same time, Norway has potential in the value chain through large deposits, particularly in the Fen field, as well as relevant expertise in process industry and metallurgy. This provides a basis for the further development of a European value chain.

Barriers, investment needs and opportunities in Norway

The greatest barrier for REEtec is access to feedstock for the plant at Herøya. Limited extraction outside China and Russia, combined with vertical integration and state control over alternative sources, makes access to feedstock challenging in both the short and medium term. The development of new mining projects is capital-intensive and time-consuming, and few projects are expected to provide significantly increased capacity soon. For an actor operating in a single stage of the value chain, without its own access to raw materials, this entails a particularly challenging commercial situation.

At the same time, REEtec has identified several growth opportunities in Norway. These include the establishment of new separation plants based on feedstock from the Fen field or from LKAB's project in Kiruna, as well as possible downstream expansion into the metallisation stage. Norway has competitive advantages at this stage through access to renewable power and strong metallurgical expertise. If such initiatives are realised, they could contribute to a significant strengthening of European security of supply for rare earth elements.

Circularity, side streams and secondary raw materials

Recycling of rare earth elements is currently limited, partly because the materials are often present in small quantities in complex products. This makes recovery technically demanding and often costly, with limited yield.

REEtec has nevertheless identified concrete opportunities within circularity. In the production of permanent magnets, material losses of around 20% typically arise, which could potentially be recovered and reintroduced into the value chain through the company's processes. In addition, there are opportunities to process concentrates from the recycling of used magnets.

The company has also investigated opportunities to extract rare earth elements as a side stream from existing industrial processes, including in cooperation with Yara. This points towards a broader approach to resource utilisation, where primary production is supplemented by secondary sources.

Overall message

REEtec is one of the few actors outside China that can separate rare earth elements on an industrial scale and represents a critical processing stage in a value chain characterised by high concentration and geopolitical risk. The company's technology offers a lower environmental footprint and high flexibility, but the realisation of its potential depends on access to feedstock. The development of new feedstock sources in Norway and Europe, particularly in the Fen field and Kiruna, will be crucial for establishing a more robust and independent European value chain for rare earth elements.

Vianode (synthetic graphite)

Vianode is a Norwegian-based industrial company that produces anode materials for batteries based on synthetic and recycled graphite. The company was established in 2020 with origins in Elkem and is today mainly owned by Altor Equity Partners. Vianode is among the few industrial actors in Europe that have established production of battery graphite outside China, and in recent years the company has built up both production capacity and market position in allied markets.

Figure 36 - Vianode's Via ONE plant at Herøya Industrial Park. (Photo: Vianode)

In 2024, Vianode opened its first full-scale factory, Via ONE, at Herøya. The plant has a capacity of around 2,000 tonnes per year and currently represents around 50 per cent of total production capacity for battery graphite in Europe, with the potential to expand capacity significantly within the same building. Production from Via ONE is supplied to customers in Europe and North America. In addition, Vianode has a research and pilot plant in

Kristiansand, which is used for the further development of production processes and the scaling-up of new technologies, including within recycled graphite.

In 2025, Vianode announced the construction of Via TWO in Ontario, Canada. The project is linked to a commercial agreement with General Motors and LG Energy Solution and constitutes Canada's largest contribution to the G7 Critical Minerals Production Alliance. The plant is planned to be built in stages and will, at full build-out, have a capacity of up to 150,000 tonnes per year, with planned start-up around 2030. At the same time, Vianode has received support from the EU Innovation Fund for the development of a further full-scale factory in Europe with a planned capacity of 65,000 tonnes per year, where the final location is still under consideration.

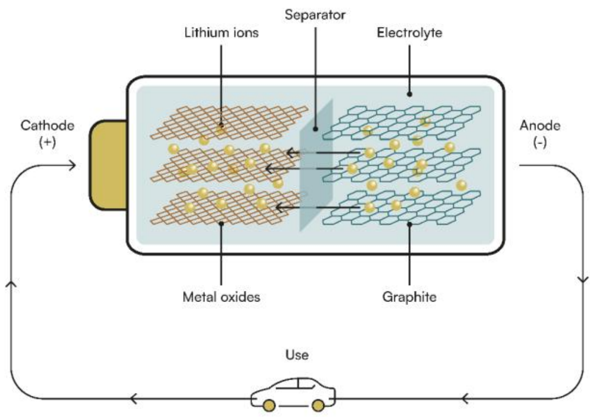


Figure 37 - Illustration showing how a lithium-ion battery function. Synthetic graphite is used as an anode material in batteries. (Source: Vianode)

Vianode currently has around 250 employees, the majority of whom are in Norway. The business is situated in the energy- and capital-intensive part of the value chain for battery materials, at the intersection of process industry, materials technology and strategic value chains for energy storage, electrification and defence-related applications.

Position in the value chain and technological profile

Vianode produces anode materials based on either synthetic graphite or recycled graphite. Anode materials represent an advanced production stage in the battery value chain, involving significant further processing and strict requirements for material properties. For battery applications, there are requirements relating to particle size, purity, crystal structure and surface properties that only a limited number of actors globally can supply on an industrial scale.

For synthetic graphite, the most important input factor is coke, which is mainly a by-product from oil refineries. Access to coke is therefore linked both to the refineries' production priorities and to general market conditions in the petroleum sector. To produce synthetic battery graphite, the coke must first be crushed and purified of unwanted constituents. The material then undergoes a graphitisation process at temperatures of around 3,000 °C, before surface treatment is used to adjust electrode quality and performance in the battery.

Production of recycled graphite is based on graphite concentrates extracted from used batteries or from electrode scrap in battery production, often through the treatment of so-called black mass. At present, there is in practice no commercial recycling of battery graphite on a large scale globally. Vianode has developed its own thermal process for recycled graphite, which largely uses the same type of equipment as in synthetic graphite production. The company is among the actors that have progressed furthest in the industrial scaling-up of this technology.

Both synthetic and recycled graphite produced by Vianode can replace natural graphite from mining as an input material in batteries and thereby contribute to reducing exposure to raw material access and processing outside Europe and North America.

Relevance to critical and strategic raw materials

Vianode produces battery graphite, which is the largest single material component by weight in a lithium-ion battery cell. On the order of one kilogram of graphite is required per kilowatt-hour of battery capacity, which makes graphite a necessary input factor in all commercial battery technologies in use today. The material is used in batteries for electric vehicles, stationary energy storage systems and, increasingly, in defence-related applications.

Graphite is therefore classified as critical or strategic in all major allied frameworks. NATO has defined graphite as one of twelve defence-critical materials and considers the material to be associated with particularly high supply risk. The EU has, in the Critical Raw Materials Act, classified battery graphite as a strategic raw material within a prioritised subgroup of critical raw materials. In the Net Zero Industry Act, anode materials are defined as strategic components, while synthetic graphite in the upcoming Industrial Accelerator Act is classified as a strategic energy-intensive industry. The United States and several other countries have corresponding classifications for synthetic graphite. The Via TWO project in Canada is explicitly included in the G7 Critical Minerals Production Alliance.

Vianode supplies or qualifies products for several segments, including electric vehicle batteries, stationary energy storage systems and defence-related applications, through multiple binding and non-binding partnerships.

Markets, dependencies and competitive conditions

Vianode currently supplies anode materials to customers in Europe and North America, based on production in Norway and planned production in Canada. Via ONE at Herøya has an annual capacity of 2,000 tonnes and is planned to be expanded to approximately 5,000 tonnes per year, with the earliest completion around 2029. Via TWO in Canada will, at full build-out, be able to supply up to 150,000 tonnes per year, while a further European factory of 65,000 tonnes is being considered if market conditions so warrant. Overall, Vianode aims to supply 10–20 per cent of Europe's demand for battery graphite in the period 2030–2035 from facilities in Norway and Canada.

On the raw materials side, Vianode depends on coke to produce synthetic graphite, as well as graphite concentrate to produce recycled graphite. To secure market access in Europe and North America, the raw materials are sourced from suppliers in these regions. Access to coke nevertheless entails a certain commercial risk, as the material is a by-product that is not always prioritised by the refineries. Vianode's strategy is therefore to increase the share of recycled graphite in order gradually to reduce this exposure. Production is also energy-intensive, and both energy costs and access to grid capacity are decisive factors for competitiveness and further investment.

The international competitive landscape is characterised by a very high degree of concentration. More than 95 per cent of the world's production of battery graphite takes place in China today. In recent years, the Chinese authorities have introduced controls on graphite, including bans, which have affected security of supply for actors outside China. At the same time, Chinese producers have built up significant overcapacity, with price levels that at times have been below the cost level for new Western projects in the scaling-up phase. This market structure makes it challenging for new actors outside China to conclude long-term supply agreements and secure financing, despite technological maturity.

Barriers, investment needs and opportunities in Norway

The most important barrier for Vianode is the structural conditions in the market for battery graphite. Price pressure and competitive conditions in a market dominated by Chinese actors make it difficult to conclude contracts with customers, which in turn affects financing opportunities. In the scale-up phase, Vianode is therefore dependent on regulatory frameworks that contribute to levelling the competitive playing field, including through requirements relating to origin, sustainability and security of supply, as reflected in American and European policies for critical raw materials.

Geopolitical uncertainty and increased risk aversion in the capital markets also affect access to investment capital. Vianode is in an intermediate phase in which the technology has been demonstrated at industrial scale, but where market and price uncertainty remains significant.

For further investment in Norway, predictable access to the European market is crucial. The risk of trade protection measures relating to battery graphite, and uncertainty surrounding EEA-related market access, reduce the attractiveness of Norway as a location for new capacity. In addition, access to sufficient grid capacity for energy-intensive processes is an important framework condition.

On the recycling side, there is risk associated with access to graphite concentrate from black mass. At present, significant volumes are exported to Asia, among other things because of the higher willingness to pay among Chinese actors, which limits access to raw materials for European recycling projects.

Circularity, side streams and overall message

Vianode already offers recycled graphite and aims to increase this share over time. Recycled graphite is expected to become more important in the period 2030–2040, both regarding environmental footprint and security of supply. Compared with other actors outside China, the company has progressed far in the commercial scaling-up of recycled battery graphite.

Overall, Vianode represents one of the few industrial initiatives in Europe contributing to the establishment of production capacity for battery graphite outside China. Via ONE in Norway already constitutes a significant part of European capacity, and the company has the potential to play a central role in allied value chains for energy storage and electrification.

The greatest risk to further development is linked to persistent competitive conditions and framework conditions that make it difficult for new Western actors to achieve commercial scale. To unlock further investment in Norway, stable market access to the EU will be crucial, together with consistent implementation of regulatory frameworks and demand-side measures that reduce investment risk in strategic material value chains.

Overall message

Vianode represents one of the few industrial production capacities in Europe for battery graphite outside China, in a context where European capacity is very limited compared with Chinese dominance. The company supplies a central input material for batteries used in electrification, energy storage and defence-related applications. Graphite is the largest material component in lithium-ion batteries and is classified as critical and strategic in the EU, NATO and the United States. The Via ONE plant in Norway already constitutes a significant share of European production capacity and makes a concrete contribution to reducing Europe's dependence on Chinese supplies in a particularly vulnerable stage of the value chain.

At the same time, Vianode is exposed to a value chain characterised by strong global concentration and significant disparities in competitive conditions. China's dominant position in battery graphite, underpinned by state support measures, overcapacity and export restrictions, has contributed to price levels and competitive conditions that make it difficult for new actors outside China to achieve commercial scale. This limits the ability to conclude long-term supply agreements and secure private financing, despite technology demonstrated at industrial scale and demand in allied markets.

To unlock further investment and scale-up in Norway, predictable and full market access to the EU is essential, together with consistent implementation of European frameworks for critical raw materials and battery value chains, including the Critical Raw Materials Act, the Net Zero Industry Act and the Industrial Accelerator Act. Demand-side measures and initiatives that reduce investment risk in the scaling-up phase will be central to ensuring that production of battery graphite in Norway and Europe can develop in parallel with the expansion of battery cell production and electrified transport solutions.

Cenate (substitution of graphite)

Cenate AS is a Norwegian company that develops and industrialises silicon-based nanocomposite materials for use as anode materials in lithium-ion batteries. The company's technology is aimed at replacing a substantial share of the graphite used in today's battery cells, particularly in applications related to electric vehicles and drones.

The material developed by Cenate does not represent an alternative type of graphite, but a silicon-based composite material with significantly higher performance. One kilogram of the material can replace approximately 5–7 kg of graphite in a battery anode. This increases the energy density of the battery, and the weight and volume of the battery cell can be reduced considerably. This means that the technology can provide both longer range and more compact battery solutions.

Figure 38 - Cenate's production facilities for silicon-based nanocomposite materials at Holtskogen in Tomter. (Photo: Cenate)

The company has its headquarters and pilot plant at Holtskogen in Tomter, as well as research and business development activities in Oslo. The business builds on Norwegian expertise in silicon and materials technology, with backgrounds including Dynatec, REC and IFE, and the company works closely with international battery cell manufacturers in development and qualification processes.

Position in the value chain and strategic relevance

Cenate operates in the advanced materials stage of the battery value chain, closely linked to the production of battery cells. This stage is characterised by high requirements for material properties, quality and reproducibility, and represents a critical interface between raw materials and finished energy storage systems.

In today's lithium-ion batteries, graphite constitutes the largest single material in the anode and is at the same time classified as a critical and strategic raw material in several allied frameworks (the EU, the United States, the United Kingdom and NATO). Cenate's technology represents an alternative approach by reducing the actual need for graphite through the use of silicon-based materials with higher capacity per unit of weight.

Figure 39 - Silicon-based nanocomposite powder produced by Cenate. (Photo: Cenate)

The company's strategic relevance therefore lies not in the production of a critical raw material, but in its ability to **substitute** such a material in a central part of the value chain. This means that the criticality of the graphite value chain can be reduced through material efficiency and technological substitution, rather than through increased production of the same raw material. The material developed by Cenate can therefore be incorporated into battery solutions for electric vehicles, drones, robotics and other high-performance applications, where energy density, weight and service life are decisive.

The company has also been admitted as an associated partner in a European IPCEI battery project, which reflects its relevance in a European industrial policy context.

Markets, dependencies and competitive conditions

Production of battery graphite is currently highly concentrated, with estimates of more than 90–95% of global capacity linked to China. Export restrictions and control over supplies have in recent years made the vulnerability of this structure clear, including through restrictions on deliveries of graphite to certain Asian battery manufacturers in 2026.

Cenate's competitive landscape includes both established producers of graphite-based anodes and other companies developing silicon-based material solutions. The company's competitive advantages are linked to the properties of the materials being developed, including high energy density, reduced material consumption per kWh, potential for a lower cost per unit of performance, and significantly lower production-related emissions compared with conventional anode materials. Cenate states that it has more than 93% lower direct CO_2 emissions from production compared with conventional anode materials.

For applications in defence- and preparedness-related systems, particularly drones, access to high-performance battery materials within European value chains may be of particular importance, both about performance and security of supply. In addition to electric vehicles and drones, the material is also relevant to other high-performance applications, including robotics, portable electronics, aerospace and specialised batteries for defence-related systems, where requirements relating to energy density, weight and performance are decisive.

Barriers, investment needs and opportunities in Norway

The most important barrier for Cenate is related to the qualification of new materials in a conservative and safety-critical industry. Battery cell manufacturers impose extensive requirements for testing, stability and documented performance over time before new materials are taken into commercial production, particularly in vehicles with long warranty periods. The company has, however, reached important milestones in the industrialisation of the technology. In 2024, the production process was scaled up to the first commercial level, and the company is delivering industrial test volumes to several customers. Work continues on qualification in cooperation with leading international actors. At the same time, increasing interest is being reported in applications within drone technology, where implementation timelines may be shorter and the requirements for energy density particularly high. First commercial deliveries are possible from 2026.

From a Norwegian perspective, Cenate represents an opportunity to develop a new position in the battery value chain based on technology and materials expertise, rather than traditional raw material extraction. This implies a potential strengthening of Norway's role through the development of new material types that reduce dependence on established, concentrated raw material value chains.

Circularity, side streams and secondary raw materials

Cenate's technology is relevant to circularity primarily through material efficiency. By reducing the need for graphite per battery unit, the overall material intensity in battery production can be reduced significantly. In addition, the company points to possibilities for recycling the material at end of life. From a critical raw materials perspective, however, it is substitution and reduced material use that represent the most important effect. By replacing large quantities of graphite with smaller quantities of high-performance material, pressure on a geopolitically concentrated raw material value chain can be reduced.

Overall message

Cenate AS represents a technology-based approach to critical raw materials through substitution rather than increased production. By developing silicon-based anode materials that can replace significant amounts of graphite, the company can contribute to reducing dependence on one of the most concentrated and vulnerable material value chains in the battery sector. At the same time, the realisation of this potential depends on successful qualification, access to capital and scaling in a market dominated by established actors.

Eramet Norway (upstream refining of manganese)

Eramet Norway AS is part of the French mining and metallurgical group Eramet and constitutes the group's main activity in the production of manganese alloys. The company operates three smelters in Norway, located in Porsgrunn, Sauda and Kvinesdal, as well as research and development activities at NTNU in Trondheim. With a combined production capacity of around 580,000 tonnes of ferromanganese and silicomanganese per year, the business is among the world's leading producers of these materials. The company holds a strong market position in refined manganese alloys, with significant market shares in Europe and North America, and functions as a central supplier to the steel industry in these markets.

Figure 40 - Eramet's plant in Kvinesdal, where silicomanganese is produced. (Photo: Eramet)

Production is based on the metallurgical reduction of manganese ore in electric furnaces at temperatures of around 1,600°C, where manganese oxides are reduced using carbon-based reducing agents, typically metallurgical coke.

Production is energy-intensive and in Norway is based on access to renewable power, which is a central part of the company's industrial competitiveness.

Manganese alloys are used primarily as an input factor in steel production. Manganese is necessary in order to give steel desired mechanical properties such as strength, toughness and wear resistance, and is thus an indispensable component in all steel production. As the fourth most widely used metal globally, after iron, aluminium and copper, manganese forms a fundamental input factor in a range of industrial value chains.

Position in the value chain and strategic relevance

Eramet Norway operates in the metallurgical materials stage of the steel value chain, where manganese ore is refined into alloys that are used directly in steel production. It is important to distinguish this role from the production of manganese metal for battery applications, which is the part of the manganese value chain that is explicitly classified as critical and strategic in the EU. Eramet Norway does not produce manganese metal for batteries, but manganese alloys for steel. The company's strategic importance therefore lies in the steel value chain, not in the battery value chain.

Figure 41 - Molten manganese-containing metal. (Photo: Eramet)

This role is nevertheless of considerable strategic importance. Steel is a fundamental material in modern infrastructure and industrial systems and is used in everything from energy and transport infrastructure to advanced industrial solutions. Manganese alloys are therefore a prerequisite to produce steel that can meet requirements relating to durability, strength and resilience. This also applies in a security policy context. Metallic materials and manganese-containing alloys are crucial for defence materiel, including structural components, armour and load-bearing structures in vehicles, vessels and other systems. Manganese's contribution is indirect, but critical, through its role in ensuring the necessary material properties in steel.

Markets, dependencies and competitive conditions

Around 90% of global manganese consumption goes to steel production, and manganese alloys are therefore closely linked to activity in the steel industry. Eramet Norway supplies such alloys to steelworks in Europe and North America and is integrated into industrial value chains in these regions, where demand is largely driven by sectors such as construction, energy, transport, industry and defence. Around 20% of production in Norway is sold to other regions, including Africa and Latin America.

The raw material base is globally concentrated. A large share of the world's known manganese resources is found in South Africa and Ukraine, which gives a clear geographical concentration in the value chain. The Eramet group's own mining activities in Gabon, combined with deliveries from, among other places, South Africa, help to secure access to raw materials and reduce exposure to market volatility.

Competition in the market for Norwegian manganese alloys is primarily linked to producers in India and Brazil, which are key actors globally. Although China is a major producer of manganese, exports of such products are limited because of domestic priorities and export restrictions, which affects global trade patterns.

The European market is also affected by trade policy measures. The introduction of safeguard measures in the EU from 2025, justified by the limited number of remaining producers in Europe, has contributed to changing competitive conditions in the European market for manganese alloys, including through effects on import volumes and price formation. This may indirectly affect the position of producers located in Europe, including Eramet Norway, through changed market conditions in their core markets. In addition, trade disruptions and geopolitical conditions have contributed to increased uncertainty and volatility in the market, making the planning of production and new investment more challenging.

Barriers, investment needs and opportunities in Norway

Production of manganese alloys is energy-intensive, and access to competitively priced power is a decisive factor for profitability and further development. Costs in Norway, particularly energy costs, therefore directly affect the company's competitiveness. At the same time, the company faces increasing regulatory requirements, both in the fields of climate and trade policy. This includes European climate regulations, a tighter emissions trading system and measures affecting imports and exports. The absence of, or insufficient, compensatory arrangements for export-oriented industry may reinforce these challenges, particularly for companies that also serve markets outside Europe to a large extent.

On the positive side, the business has an advanced technological and industrial foundation, with expertise and experience that provide a basis for further development. This includes work on energy optimisation, improved resource utilisation and the development of lower-emission production processes.

Circularity, side streams and secondary raw materials

Manganese is used in steel, which is a material that is recycled to a high degree. Steel can be recycled repeatedly without significant loss of properties, which makes manganese part of an established circular material flow. Circularity in production is largely linked to the internal utilisation of side streams. Slag from ferromanganese production is used as an input factor in the production of silicomanganese, which contributes to better utilisation of the raw materials. Dust and fine fractions from production and refining processes are collected and returned either internally in production or used in other industrial contexts. In addition, briquetting is used to utilise fine fractions from material handling.

Several development projects are also under way with the aim of further increasing the utilisation of side streams. This includes work to identify new applications and develop processes that may enable the extraction of materials from streams that are not currently fully utilised.

Overall message

Eramet Norway is a central producer of manganese alloys used in steel production, and thus in value chains that are fundamental to industrial activity, infrastructure and defence capability in Europe. The company does not produce manganese metal for battery applications, but its business has strategic importance through its role in the steel value chain and as a supplier to applications where the material properties of steel are decisive.

Through access to raw materials, advanced production capacity and deliveries to key markets, the company contributes to reducing vulnerability in a value chain characterised by concentration and geopolitical risk. At the same time, competitiveness is affected by global market conditions, trade policy measures and national framework conditions, particularly related to energy and exports.

Ineos Tyssedal (upstream refining of titanium)

INEOS Tyssedal operates an ilmenite smelter in Tyssedal in Ullensvang municipality and has around 200 employees. It is Europe's only producer of titanium slag. The main products are high-purity pig iron and titanium slag. Production is based on a process originally developed using technology from Elkem and later further developed at INEOS Tyssedal.

Production is based on ilmenite ($FeTiO_3$), which is pelletised and pre-reduced at high temperature before the material is smelted in an electric furnace. In the latter process, the iron is reduced to metal and separated from the titanium slag. The iron is refined and alloyed, while the titanium slag is further processed into a product with a high content of titanium dioxide – TiO_2. Historically, the plant has used ilmenite from both Norwegian deposits, including Titania, but now receives raw material from international suppliers.

Figur 42 - INEOS Tyssedal, which produces pig iron and titanium slag. (Photo: INEOS Tyssedal)

In principle, there are two process technologies for upgrading products from ilmenite. One method, known as "synthetic rutile", does not utilise the iron content and deposits it as a waste product. The other method, known as slag production, utilises the iron content to produce pig iron. INEOS Tyssedal uses the latter method, which means that both the titanium and iron fractions of the feedstock are utilised in further industrial value chains.

The titanium slag produced at the plant has a relatively high TiO_2 content (above 85%) and a high degree of purity regarding other trace elements. This provides an upgraded titanium dioxide product that is suitable as a feedstock both to produce TiO_2 pigment and for further processing into titanium metal.

Production depends on input factors such as electric energy, ilmenite ore and carbonaceous materials such as coal and coke, as well as electrode materials. Over time, the company has developed a stable and diversified supplier base and has considerable flexibility in the use of feedstock from different suppliers. This provides the competence to upgrade ilmenite of varying composition into products with specific properties.

Position in the value chain and strategic relevance

INEOS Tyssedal operates in an upstream and midstream stage of the titanium value chain, where ilmenite is upgraded into titanium slag and high-purity pig iron through energy-intensive processes. This stage is decisive in converting mineral resources into technical materials with properties that make them suitable for further industrial use.

Titanium feedstocks, including titanium slag, naturally contain titanium, which is classified as a critical raw material in several international frameworks, including in the United States, the United Kingdom and NATO. Titanium slag can be further processed into titanium metal, which is classified as a critical raw material in the EU. Although titanium slag itself is not classified as critical in the EU, it is a prerequisite to produce titanium metal and therefore forms a central input factor in a critical value chain. At present, there is no primary production of titanium metal in Europe, although some actors are working on the recycling of titanium metal. Access to high-value titanium-bearing raw materials is therefore a fundamental prerequisite for establishing a European value chain for titanium metal.

Pig iron from INEOS Tyssedal is used in the foundry industry, where it is indispensable in the production of foundry iron in special qualities. This in turn is a prerequisite to produce components for, among other things, vehicles, infrastructure, machinery, wind power, robotics and defence materiel.

The business therefore represents a central processing stage in two parallel value chains, one titanium-based and one iron-based, where material quality and process capacity are decisive for further industrial production.

Markets, dependencies and competitive conditions

INEOS Tyssedal supplies its products to international markets. Titanium slag is exported globally and is used mainly as a feedstock in the production of TiO_2 pigments but can also be used in the manufacture of titanium metal. The titanium slag from INEOS Tyssedal has a high TiO_2 content and low levels of trace elements, which makes it well suited to demanding industrial applications, both in pigment production and as an input factor in titanium metal production. The market for titanium dioxide-based pigments is global, with significant actors in the United States, China, the United Kingdom and the EU. Production of titanium metal, by contrast, is concentrated in a limited number of countries, including Japan, China, Kazakhstan, Saudi Arabia and Russia. This means that the subsequent downstream stages in the titanium value chain are largely located outside Europe. The iron product is supplied mainly to the European foundry industry, with a smaller share exported to Asia.

The competitive landscape is global and characterised by significant production concentration, particularly in China, Australia and South Africa. The competitiveness of European actors is largely dependent on long-term and competitively priced power and stable framework conditions.

Barriers, investment needs and opportunities in Norway

Europe currently has no primary production of titanium metal, despite demand from, among others, the aviation, aerospace, defence and medical industries. If such an industry is to be established in Europe, this will depend on access to high-value titanium feedstocks. European pigment production has seen a negative development in recent years, which affects demand for upgraded titanium dioxide feedstocks. This points to the need to strengthen and further develop industrial value chains in Europe.

INEOS Tyssedal carried out a capacity expansion of around 20% in 2015–2016. The company has since examined several alternatives for further expansions, with potential for capacity increases in the order of 50–150%, depending on technology and market developments. The realisation of such projects depends on competitive framework conditions, particularly related to electric power. Long-term and stable energy costs, predictable regulatory conditions and measures to counter carbon leakage will be decisive in unlocking new investments.

Circularity, side streams and secondary raw materials

Production at INEOS Tyssedal utilises both the titanium and iron fractions in ilmenite, in contrast to alternative methods in which the iron component is not utilised. Ilmenite contains on the order of 50% iron oxides, and the utilisation of this fraction to produce high-purity pig iron represents an important contribution to efficient resource utilisation. In this form of production, nearly all of the feedstock is utilised in end products, which gives a high degree of resource efficiency and reduces waste compared with alternative processes.

At the same time, there is a long-term development in the raw material base, whereby available ilmenite resources are gradually acquiring higher iron content and lower TiO_2 content. Through long operation, INEOS Tyssedal has developed significant competence in handling variations in feedstock composition and is therefore well positioned to utilise a more complex future raw material base.

Overall message

INEOS Tyssedal is Europe's only producer of titanium slag and represents a central processing stage in the value chain for upgrading titanium feedstocks. Through the production of titanium slag, the business operates upstream in industrial value chains. Its strategic significance lies in its ability to convert mineral resources into technical materials with properties that are decisive for further industrial production. At the same time, the further development of the business is closely linked to competitive conditions, especially for power and emissions, and to developments in European value chains for titanium and related materials.

Finnfjord (ferrosilicon)

Finnfjord AS is a family-owned Norwegian producer of ferrosilicon, microsilica and power, located in Finnsnes on Senja in Troms. The company operates an integrated smelter and is one of the few independent, non-group-affiliated ferroalloy producers in Europe. The business employs around 200 people and constitutes a central industrial and competence actor in Northern Norway.

The company operates in an energy- and capital-intensive metallurgical stage of the value chain for silicon-based materials. Its main activity is the carbothermic reduction of quartz using carbon-based reducing agents in electric arc furnaces. The plant consists of three furnaces with a combined production capacity of around 100,000 tonnes of ferrosilicon per year, together with the production of around 20,000 tonnes of microsilica as a by-product from the off gas. Raw materials are received and finished products are distributed via the company's own quay, with primary emphasis on exports to European markets.

Figure 43 - Finnfjord's plant in Finnsnes, where ferrosilicon is produced. (Photo: Finnfjord)

Finnfjord has developed significant capacity for energy recovery. Off gas from the furnaces is utilised for power generation in an integrated facility based on steam turbine technology, which annually produces around 200 GWh of electricity. In addition, the plant participates in Statnett's market for special regulation and thereby contributes flexibility to the power system.

Relevance to critical and strategic raw materials

Ferrosilicon is not explicitly classified as a critical raw material in the EU or the United States, but it constitutes a central input factor in the production of electrical steel, which is classified as critical in the American context because of its importance for power grids, transformers, electric motors and defence-related applications. The material must therefore be understood as indirectly critical through its role in the production of materials that form part of central technological and societally critical value chains.

Silicon metal is at the same time included on NATO's list of "defence-critical raw materials", and ferrosilicon is indirectly relevant in this context through its applications in steel production and other metal-based value chains. Microsilica represents a high-quality by-product used as an additive in concrete, refractory materials and other technical applications, and has both commercial and climate-related significance.

Finnfjord's products form part of value chains for the European steel, cast iron and construction industries, and are thereby indirectly linked to key applications in the energy transition, transport, construction, infrastructure and defence.

Figure 44 - Pouring of ferrosilicon metal at the Finnfjord smelter. (Photo: Finnfjord)

Markets, dependencies and competitive conditions

Finnfjord is largely export-oriented, with historically around 80% of sales directed towards the EU market. The remaining volumes go to the United Kingdom, other European markets and certain overseas destinations. The main customer segment is producers of carbon steel, stainless steel and speciality steel. Microsilica is marketed mainly to the construction and concrete industries and the refractory industry, primarily in the Nordic region and Europe.

Production depends on access to quartz, carbon-based reducing agents such as coal and coke, wood chips, as well as electrodes and large amounts of electric power. Quartz is supplied mainly by European suppliers, while coal and coke are imported from several international markets. The company is working to secure stable and long-term deliveries.

The competitive situation is global and is characterised by significant production capacity, particularly in China, but also in Russia, Kazakhstan, Brazil, Malaysia, Norway and certain EU countries. Competitiveness is determined to a large extent by access to power, power prices, raw material costs and carbon profile. Norwegian producers operate under stricter climate regulations than many of their global competitors and without equivalent subsidised power arrangements. At the same time, production at Finnfjord has a significantly lower CO_2 footprint than the global average, which gives a potential competitive advantage in markets with increasing requirements for low-emission materials. At the same time, the willingness to pay in the market for low-carbon ferrosilicon remains limited, which reduces the incentives for investment based on carbon advantage alone.

Barriers, investment needs and opportunities in Norway

A central barrier to further development is linked to market access to the EU. The European Commission's safeguard measures on ferroalloys create uncertainty for capital-intensive investments and affect predictability in export markets.

The company is subject to the EU Emissions Trading System (ETS), which also applies in Norway. The introduction of CBAM currently applies to selected sectors and materials and does not for the time being include ferrosilicon. At the same time, discussions are under way within the European Commission on the further development and possible expansion of the scheme, including how carbon leakage and competitive conditions for additional material categories are to be handled. At present, however, there are no mechanisms that compensate producers for exports out of the EU/EEA. Norwegian producers may therefore be exposed to carbon costs through the harmonised emissions trading system, without corresponding protection or compensation in markets outside the EU, while at the same time facing constraints related to market access in Europe.

Power prices represent a further uncertainty factor. This applies to access to long-term power contracts and expectations regarding price developments in Northern Norway, which have direct significance for both operating costs and investment decisions.

At the same time, there is significant potential for further value creation. This includes the further development of solutions for carbon capture and the utilisation of CO_2, increased use of microsilica in new applications, and the development of more specialised ferrosilicon grades. The conditions for realising this potential are linked to three factors: stable and predictable market access to the EU, competitive conditions related to power, and a regulatory framework that to a greater extent reflects differences in climate footprint between producers.

Circularity, side streams and secondary raw materials

Finnfjord has developed an integrated approach to the utilisation of side streams. Microsilica is captured from the off-gas and further processed as a commercial product, while the heat content of the off-gas is utilised for power generation. This provides both increased energy efficiency and reduced emissions per unit produced.

The company also participates in the development of solutions for the industrial utilisation of CO_2. In cooperation with The Arctic University of Norway (UiT), a pilot facility is being developed for the use of CO_2 from furnace off gas in the production of microalgae. These are intended to be used as an input factor in feed for the aquaculture industry and represent a link between land-based process industry and marine value chains. The project is in the pilot phase and illustrates a possible development path for integrated, circular solutions of relevance to both climate and resource utilisation.

Overall message

Finnfjord is a central supplier of ferrosilicon and microsilica to European industry, with production based on a low carbon footprint and a high degree of integrated energy recovery. The business represents an important processing stage in silicon-based value chains, with indirect importance for a range of critical applications. Further development depends on three factors: access to the European market, competitive power conditions, and an emissions regulatory framework that ensures a level playing field.

The Quartz Corp (quartz in value chains)

The Quartz Corp (TQC) produces high-purity quartz for use in high-technology industries. The company extracts and processes quartz raw materials of particularly high purity and offers products that are used in materials with very stringent requirements for chemical composition and process quality. TQC is owned by the French company Imerys and the Norwegian company Norsk Mineral and was established in 2011 through a merger of operations in

Figure 45 - The Quartz Corp at Drag in Nordland. (Photo: The Quartz Corp)

Norway and the United States. The company operates with a raw material base in both Spruce Pine in North Carolina and Drag in Nordland, with processing and further refining in both regions.

The raw material from Spruce Pine is extracted from alaskite, a light granitic rock with a very low content of impurities and is regarded as a global “gold standard” for quartz used in technological applications. This provides a raw material that is particularly well suited for further processing into high-purity quartz quality. The quartz deposits at Drag in Nordland have different geological characteristics but are also suitable for selected technological applications. Further development of the Norwegian resource’s forms part of the company’s strategy.

Production forms part of an integrated value chain in which the quartz is extracted in the United States, separated in processing plants through grinding and mineral separation, and transported to Norway. The product then undergoes further purification at the plant in Drag. Through a range of advanced processing and purification operations, a material purity of around 99.998% SiO_2 is achieved, which is necessary for use in the most demanding technological applications.

The product, that is, the high-purity quartz, is used in the production of semiconductors, solar energy and optics, for example in crucibles for producing monocrystalline silicon for semiconductors or solar energy. These crystals are cut and polished into wafers that form the basis for semiconductor components and solar cells. TQC’s products are also used in fibre-optic cables and other technical glass products necessary for the semiconductor and solar industries.

Position in the value chain and strategic relevance

TQC operates in a specialised materials stage of the silicon and electronics value chain, where quartz is extracted and, through advanced production processes, converted into high-purity input material for further use in electronics and energy value chains. This stage extends from raw material extraction and includes the manufacture of high-technology products used in production stages for end products in semiconductors and solar energy and is characterised by strict requirements for purity and material quality.

Although high-purity quartz is not in itself classified as a critical or strategic raw material, it is a necessary input factor to produce materials that form part of such value chains. This applies to the production of high-purity silicon for semiconductors and solar cells, where quartz glass is used in central process stages. Without access to quartz of sufficient quality, it would not be possible to produce these materials.

Figure 46 - Preparation of high-purity quartz for analysis. (Photo: The Quartz Corp)

Markets, dependencies and competitive conditions

The market for high-purity quartz is characterised by a high degree of concentration, with only a limited number of producers globally able to supply materials of sufficient purity and quality to the electronics and semiconductor industries, and even fewer actors able to meet the requirements of the most advanced applications at industrial scale.

TQC is therefore an indirect, but important, supplier into value chains that are defined as critical in both European and allied frameworks. The company’s products are used, among other things, in production equipment and processes that are decisive for the manufacture of advanced electronics, energy technology and communications infrastructure.

Production therefore has strategic relevance through its role in enabling downstream value chains, rather than through direct classification of the raw material. This applies in a situation where access to high-quality input materials may be a limiting factor for the development of European capacity within semiconductor and solar energy value chains.

Barriers, investment needs and opportunities in Norway

For several years, the company has faced increasing demand for high-purity quartz because of developments in the semiconductor and solar energy markets. To meet this, significant capacity expansions have been invested in both in Norway and internationally. New production capacity is now under completion at Drag. As a result of a weaker market over the past year, capacity will be brought into use in stages.

Access to energy is a central prerequisite for the company's development. Current power demand at the plant is around 7 MW, while the requirement following planned expansions is estimated at around 15 MW. Access to sufficient power and the necessary grid infrastructure is therefore decisive to carry out the investments and further develop production.

The development of new raw material areas in this context is linked primarily to the realisation of mineral resources from local deposits and, together with the expansion of production capacity, depends on efficient planning and permitting processes.

At the same time, TQC's position represents an opportunity for Norway to strengthen its role as a supplier of specialised input materials to global and European technology value chains.

Circularity, side streams and secondary raw materials

Production of high-purity quartz is largely based on the selective extraction and further processing of high-quality raw material. Resource utilisation is therefore significantly influenced by the ability to classify and produce raw materials to the desired qualities. The company is working on the further utilisation of various side streams from production, including the use of by-products in less demanding applications. From a value chain perspective, however, the most important effect is linked to the fact that high-purity quartz enables the production of materials with long service life and high functionality in downstream applications.

Overall message

The Quartz Corp is a supplier of high-purity quartz used in critical value chains for semiconductors, solar energy and optics. Although the raw material is not defined as critical, it has strategic importance through its role as an input factor in central process stages in these value chains. The company, which operates from raw material extraction and mineral processing, therefore constitutes an important starting point for advanced materials production in global and allied technology value chains.

Kymera International / Fiven Norway AS (silicon carbide in value chains)

Fiven Norway AS, part of Kymera International, produces silicon carbide (SiC) and boron carbide (B_4C) in the form of powders, grains and specialised material grades for industrial and technological applications. The company has production plants in Lillesand and Arendal and forms part of Kymera's global structure for advanced materials and speciality powders.

Silicon carbide (SiC) is included in this overview because the material has gained increasing importance in power electronics, where it enables more compact and energy-efficient solutions in, among other things, energy systems and mobility. SiC is also used in defence-critical applications.

The business has more than one hundred years of industrial history in silicon carbide and was originally established by Sam Eyde (Arendal Smelteverk). The company supplies both standard and high-purity material grades, including customer-adapted powders. Production comprises refining and classification processes in which the materials are purified, sorted by particle size and further processed for specific applications. This also includes granulation and the production of so-called "ready-to-press" materials, which are pre-adapted for further forming into ceramic components by customers.

Production is based on the further processing of raw materials, where silicon carbide and boron carbide are largely supplied as crude primary material, combined with the group's own silicon carbide produced in Brazil. In Norway, there are also existing, but currently inactive, smelting facilities for SiC crude that can be brought back into operation if framework conditions make this commercially attractive, which could provide flexibility in raw material supply. The main share of value creation takes place in Norway through advanced processing, material adaptation and quality control, and the company's core competence lies in materials technology and process development. Criticality is therefore mainly linked to processing capacity and material quality, rather than to raw material access alone.

Figure 47 - Silicon carbide plant in Lillesand, Kymera International. (Photo: Kymera International)

Position in the value chain and strategic relevance

Kymera/Fiven operates in a specialised midstream to downstream materials stage, where raw materials are further processed into functional materials with precise properties. This stage is decisive in applications where performance, purity and consistency are critical factors.

Silicon carbide is particularly relevant in power electronics, that is, components that control and convert electrical energy in systems such as power grids, charging solutions and industrial drive systems. The material enables higher power density, better efficiency and greater temperature tolerance than traditional silicon-based solutions. Demand is driven, among other things, by electrification, energy infrastructure, e-mobility, data centres and defence-related applications. Criticality here is linked to access to high-purity material grades and production capacity.

Figure 48 - Kymera's silicon carbide and boron carbide in the value chain for ballistic systems. (Source: Kymera International)

Boron carbide, for its part, is a central material in defence- and security-related applications, particularly in ceramic ballistic protection, such as armour in vehicles, systems and personal protective equipment. Access to such materials from suppliers outside China and Russia is of increasing strategic importance in allied value chains.

Although silicon carbide and boron carbide are not necessarily explicitly classified as critical raw materials, they form part of technological value chains where access to advanced material grades is regarded as strategic. Both American and European analyses highlight the need for supply chains for such materials that are not dependent on China and Russia.

Markets, dependencies and competitive conditions

Kymera/Fiven is an export-oriented business with its main markets in the EU, the United States and selected Asian markets. The products are used in several industrial segments, including the semiconductor and electronics industries, energy systems and energy-efficiency solutions, as well as mechanical and defence-related applications that include wear-resistant components and ceramic protection (armour).

The market for high-value SiC and B_4C materials is global, but concentrated. For both materials, production is to a significant extent dominated by actors in China, in addition to certain other regions. This gives rise to a market structure characterised by high concentration and exposure to non-market-based measures, including subsidies and price pressure.

European and American analyses point to the need to establish alternative supply chains for such materials, particularly in applications related to semiconductors, energy systems and defence. In this context, Kymera/Fiven represents part of the limited processing capacity that exists in European and allied value chains. The company depends on stable deliveries of primary materials, while competitiveness is determined largely by quality, process competence and the ability to deliver specialised materials adapted to customers' needs.

Barriers, investment needs and opportunities in Norway

Production of advanced ceramic materials is demanding in terms of both technology and capital, and further development depends on investment in both processing capacity and competence. At the same time, the activity is energy-intensive, which makes cost levels and framework conditions important for competitiveness.

A central strategic opportunity lies in the potential to integrate the value chain further upstream. The resumption of primary SiC production in Norway would represent a strategic shift from pure downstream processing to more complete value chain integration. This could strengthen security of supply and reduce dependence on imports at a central stage of the value chain. A similar rationale could in time apply to boron carbide.

Increasing demand for materials for power electronics and defence-related applications at the same time provides a basis for the further development of the business in Norway.

Circularity, side streams and secondary raw materials

The company has strong R&D capacity in materials technology and process development, which provides a good basis for the further development of more circular solutions. This includes, among other things, the reuse of internal process materials and the utilisation of side streams where this is technically, economically and qualitatively possible.

Further work is being undertaken on the use of secondary raw materials in production and the development of material grades adapted to recycling and reuse solutions in downstream value chains. In this context, the most important effect lies in developing material solutions that enable more robust and longer-lasting products, as well as in reducing the need for primary raw materials through higher utilisation rates and better functional properties per unit of material.

Overall message

Kymera/Fiven Norway is a specialised producer of silicon carbide and boron carbide used in technological value chains with high performance requirements, particularly in power electronics and defence-related applications. The company's strategic importance lies in processing capacity and material quality in a global market characterised by concentration and limited supply outside China and Russia. Through its role, the business contributes to strengthening alternative supply chains for advanced materials in allied markets.

Washington Mills (silicon carbide in value chains)

Washington Mills AS produces and processes silicon carbide (SiC) at its plant in Orkanger in Trøndelag. The activity comprises both primary production of silicon carbide based on quartz and carbon-based raw materials, as well as refining and further processing into products with specific chemical and physical properties.

Silicon carbide (SiC) is included in this overview because the material has gained increasing importance in power electronics, where it enables more compact and energy-efficient solutions in, among other things, energy systems and mobility. SiC is also used in defence-critical applications.

Production is based on high-temperature processes in which silicon carbide is formed through the reaction between quartz and carbon-based inputs. The material is then further processed in several stages, including crushing, milling, sieving and classification, to achieve product qualities with controlled chemical composition and particle size distribution tailored to different industrial applications. The activity is based on a combination of in-house smelting (primary production) and further processing of silicon carbide produced within the group, particularly from the United States, which provides flexibility in raw material supply while the main share of value creation takes place through processing and material adaptation in Norway.

The facility at Orkanger forms part of Washington Mills' international group structure, in which raw material production, refining and market deliveries are integrated across regions. The central value creation in Norway lies in processing, material adaptation and quality control.

Position in the value chain and strategic relevance

Washington Mills operates in a combined upstream and midstream stage of the silicon carbide value chain, through both primary production of silicon carbide and further refining and processing. This position makes the company a supplier of functional materials for applications with high requirements for performance and material properties. The company's role must therefore be understood as a supplier into value chains where material performance and process quality are decisive for the function of the final product.

Figure 49 - Silicon carbide primary material, submicron powder and example of a product for use in filtration. (Photo: Washington Mills)

Silicon carbide is not in itself necessarily classified as a critical raw material in established frameworks. The strategic relevance instead arises in the processing and materials stage, where access to high-purity grades and production capacity is decisive. The production of silicon carbide for advanced applications is technologically demanding, capital-intensive and globally concentrated, resulting in a structure where vulnerability lies in processing capacity and material quality rather than in raw material access.

Washington Mills' products are used in value chains related to power electronics, that is, components that control and convert electrical energy in systems such as power grids, charging solutions and industrial drive systems, semiconductors, electronics and defence-related applications. In such applications, the material's combination of high hardness, temperature resistance and electrical properties is utilised, making it suitable both for wear-resistant components and for systems that handle high temperatures and electrical loads. In addition, silicon carbide is used in wear-resistant components and protective materials, including in contexts relevant to the defence industry.

Markets, dependencies and competitive conditions

Washington Mills supplies products to international markets, with customers in Europe, North America and Asia. The products are used in several industrial segments, including the semiconductor industry, power electronics, electronics, the ceramics industry and defence-related applications. Production at the plant is in the order of around 10,000 tonnes annually.

The power and power electronics market is particularly important, and this segment is characterised by strong global competition and significant Chinese dominance. At the same time, the markets for semiconductors, electronics and specialised applications are more differentiated, with higher requirements for quality and technical performance. The market for silicon carbide is global, including Asia, Europe and the Americas, with particularly strong competition from producers in China, but also from actors in, among other places, India, Vietnam and South America. Competition takes place both on price and quality and is influenced by differences in energy costs, subsidies and industrial framework conditions.

The business depends on stable deliveries of input factors such as quartz, carbon-based raw materials, energy and various process materials. Although parts of the raw material supply are integrated within the group, the use of imported silicon carbide and other inputs implies some exposure to international supply chains.

Barriers, investment needs and opportunities in Norway

The production of silicon carbide is energy-intensive and depends on stable access to competitively priced electric power. Energy costs are therefore a key factor for profitability and further development of the business. In addition, the activity is affected by factors such as grid capacity, access to inputs, logistics and international trade conditions. Geopolitical developments and price volatility in raw material and energy markets can create uncertainty for production planning and investment.

At the same time, there is potential for further development of the business, particularly within increased downstream processing and production towards higher-value segments. Existing industrial competence and technological capacity provide a basis for strengthening the position as a supplier to specialised value chains. Given stable framework conditions and access to competence and capital, the company may increase its production capacity and contribute to strengthening the supply of high-value SiC products in international markets.

Circularity, side streams and secondary raw materials

The production of silicon carbide offers opportunities for increased circularity through better utilisation of material streams and by-products. This includes the reuse of process materials, the utilisation of side streams from refining, and the development of solutions for the recycling of SiC-based materials.

From a value chain perspective, the most important effect lies in the fact that the material enables solutions with high wear resistance and long service life in downstream applications. This may contribute to reduced material consumption over time and more efficient industrial systems.

Overall message

Washington Mills AS is a producer of silicon carbide that, through both primary production and further processing, supplies input materials to value chains with high requirements for material performance. Although silicon carbide is not classified as a critical raw material, the business has strategic importance through its role in the processing and materials stage, where access to high-value qualities is decisive. The company therefore forms part of value chains related to semiconductors, power electronics and defence-related applications, where vulnerability lies in production capacity and competence rather than in raw material access.

9. Appendix – Contributors

This report has been compiled by **Lars Petter Maltby**, Director of Prosess21. Significant contributions on mineral-related topics have been provided by **Henrik Schiellerup** of the Geological Survey of Norway (NGU).

In addition, valuable input and contributions have been provided by the **expert group** established by Prosess21, represented by:

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- Gunnar Grini, The Federation of Norwegian Industries (to February 2026)
- Kjersti Hartvig Larsen, The Federation of Norwegian Industries (from March 2026)
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- Pål Grimsrud & Petter Barkost, REEtec
- Ole Svorkdal & Bård Smehagen, Washington Mills
- Christoph Jacobitz, Wacker Chemical Norway
- Ole Leren Moen, Cenate
- Grethe Hindersland & Arooj Iftekar, Alcoa Norway
- Fredrica Mudu, K.A. Rasmussen
- Marte Kristine Tøgersen, The Quartz Corp.
- Trygve Eidet, Kymera Int. / Fiven Norway
- Knut Petter Netland, Titania AS
- Harald Hansen, Skaland Graphite & LNS
- Roar Sandøy, Sibelco
- Andreas Davidsen, Nordic Mining
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