18 November 2022

Norwegian trade unions and employers' joint response to the European Commission's call for evidence on the forthcoming European Critical Raw Materials Act

Referring to the call for evidence on the European Critical Raw Materials Act (CRMA), we submit a joint response on behalf of Norway's main confederations of trade unions and businesses (LO and NHO) and the organisations representing workers and companies in Norway's extractive and processing industries (The Norwegian Federation of Industries, Industri Energi, Norwegian Mineral Industry and the Norwegian Union of General Workers).

Our organisations welcome the initiative. The economic impacts of the COVID-19 pandemic and Russia's war in Ukraine have exposed the vulnerability of global and European value chains. At the same time, reaching the targets of the European Green Deal and the accelerated ambitions of REPowerEU will require a significant increase in the use of minerals and metals.[1] Going forward, improving Europe's access to critical minerals and metals will be decisive for securing strategic autonomy and delivering the green transition. The CRMA must address these challenges.

Norway is well positioned to contribute, with experienced extractive and processing industries as well as reserves of metals and minerals which are indispensable to the green transition. In this joint response, we share our views on cooperation between Norway and the EU in the field of critical raw materials and our recommendations for action on the European level.

1. Cooperation between Norway and the EU

Our organisations believe that Norway's mineral policy must be developed in close cooperation with the EU and contribute to securing competitiveness and increased self-sufficiency in Europe.[2] Likewise, the EU can consider Norway among its closest partners in developing its critical raw material policy. Norway and the EU has together announced a Green Alliance[3] and, as part of this, the intention of establishing a strategic partnership on value chains for raw materials and batteries.[4] We welcome and support these initiatives. We highlight two examples of how Norway can contribute to supplying new resources in support of the green transition:

- **Rare earth elements (REE)**: Today, ca. 98% of Europe's demand for REE is supplied by non-EU/EEA countries. China is the world's leading producer of REE, as well as of metals such as copper, nickel, cobalt and lithium. At the same time, REE are considered amongst the most critical raw materials for the European Green Deal.[5, 6] They are used in most of the modern technologies which enable sustainable economic growth, as well as in defense material. Norway may have continental Europe's largest REE deposit in the Fen Complex, a mineral deposit situated 110 kilometers southwest of Oslo in Nome Municipality in Telemark County.[7] Early estimates suggest that the Fen

[1] See e.g. the European Parliament's report on a European strategy for critical raw materials (2021), the IEA's report on the role of critical minerals in clean energy transitions (2021), and Eurometaux' report on metals for clean energy (2021)
[2] The Norwegian government will present a new mineral strategy by the end of 2022. Increased funding for the mapping of mineral resources is already proposed. See press release from the Norwegian Ministry of Trade, Industry and Fisheries (October 2022)
[3] EU-Norway Press Statement on Climate (February 2022)
[4] Joint statement by Vice-President for Interinstitutional Relations and Foresight Maroš Šefčovič, and Jan Christian Vestre, Norway's Minister of Trade and Industry (June 2022)
[5] European Commission (2020): Study on the EU's list of Critical Raw Materials, Final Report
[6] European Commission (2020): Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability
[7] Report from the Geological Advisor to Buskerud, Telemark and Vestfold County Councils (2019): REE mineralization in the Fen Carbonatite Complex, Telemark Norway – A world-class exploration target for the Hi-Tech and "Green-shift" Industry?

Complex could supply up to 30% of Europe's REE demand in 2030.[8] The Fen Complex is well situated as regards access to existing infrastructure, renewable power, industrial processing facilities on Herøya, and sea-based transport to Europe. The development of the Fen Complex could form the basis of an important European REE value chain. *In the context of the forthcoming Norwegian mineral strategy, our organisations have developed a dedicated strategy paper on the ambition of building a European REE value chain based on the Fen Complex (attached in annex).*

- **Deep-sea minerals:** Oceanic ridges host massive sulfide deposits and manganese crusts rich in metals and minerals that are crucial for modern technology. The ridges of the Norwegian Continental Shelf (NCS) can be considered among the world's most attractive for the extraction of deep-sea minerals, with high contents of copper, cobalt, and zinc.[9] Norway is well-positioned for the next steps of making these minerals available. The Norwegian government has initiated an opening process for mineral activities on the NCS, and the Norwegian Petroleum Directorate (NPD) has been tasked to map its most interesting mineral deposits.[10] It is important that exploration and extraction activities do not, unnecessarily or to an unreasonable extent, complicate or impede ship traffic, fishing, aviation or other activity, or cause damage or risk of damage to subsea infrastructure or facilities. Furthermore, all reasonable precautions must be taken to avoid damage to the diversity of nature in the sea, and to avoid pollution. With these considerations, deep-sea mineral deposits will be a great addition to those onshore. Offshore resources on the NCS should be part of the European strategy for securing access to critical metals and minerals. *Further information on the potential for deep-sea mineral exploration and extraction on the NCS, in the context of the CRMA, can be found in the separate consultation response provided by Offshore Norway.*

2. Recommendations for action on the European level

Criteria for third-country partnerships: Europe should promote decent work domestically, in third countries, and in global supply chains. The CRMA should support this cause, given that high supply concentration of raw materials in countries with low standards of governance may exacerbate social and environmental problems.[11] We recommend that the EU establishes criteria for raw material partnerships with third countries. This should include ensuring that ILO Convention 176 on health and safety in mines is respected[12] and avoiding entering into partnerships with authoritarian regimes. Third-country partnerships must be based on mutual respect for democracy, civil and workers' rights, and minimum social and environmental safeguards.

Codification of critical metals and minerals: We understand that the Commission aims to codify the critical metals and minerals Europe will need for the green transition. It is important that this codification is not limited to today's Critical Raw Materials (CRM) list, as the list does not reflect future demand expectations. Aluminium, copper, nickel and high-purity manganese are all examples of metals and minerals which are not included on the CRM-list, as there is no current risk of supply disruption. However, they will all be required in significantly higher volumes for the energy transition and should therefore be considered critical. This should be reflected in the forthcoming codification.

Access to finance and risk sharing: The market risk of mapping, producing and processing mineral resources is high. For REE, this risk is inter alia linked to China's dominant market position. China has previously demonstrated its willingness to leverage its market power and at times dump prices to eliminate competitors. Increased access to finance and risk sharing is therefore important both for the

[8] Assuming European demand for magnet REO of 20 000 tonnes in 2030 (ERMA, 2021)
[9] NPD (2020): Analyses reveal rich seabed minerals
[10] NPD (2021): Deep Sea Minerals on the Norwegian Continental Shelf– Developments in Exploration
[11] As recognised inter alia in the Commission Communication on decent work worldwide (COM (2022) 66 final)
[12] See further information from IndustriALL (2019)

mapping of critical mineral deposits and for investments in industrial production. Finance in the form of loans, grants or public investment can mitigate risk in the early stages of development. State aid flexibility should be ensured. A dedicated IPCEI should be introduced to secure finance for new projects. A dedicated public-private investment fund for raw materials should also be considered on the European level.

Land-use and permitting: Regulatory uncertainty related to land-use and permitting is experienced as a significant barrier for new mineral projects. This uncertainty concerns both the timelines and the results of permit applications, and it represents significant risks and costs for the mineral industry. The CRMA should facilitate accelerated permitting procedures for mining projects. At the same time, European legislation should not undermine the role of national and local authorities in ensuring inclusive processes. New forms for accelerated permitting procedures could be tested in selected prioritised critical raw materials sourcing projects, before being considered for wider application.

Research and development (R&D): Finally, R&D in the field of production and processing of critical raw materials must be increased. As an example, Europe currently has little or no specialised competence within the production and processing of REE. Increased R&D in this area is therefore necessary. Industrial recycling of REE should also form part of a European R&D effort. REE are not recycled to any great extent in Europe today, but recycling should become a supplement to new production in the future. Sufficient volumes of waste would be needed for any investments in recycling capacity to be viable. REE recycling should therefore be seen in a European perspective.

About our organisations:

The Federation of Norwegian Industries (Norsk Industri) represents a diverse membership of around 3000 companies with approximately 127 500 employees, and engages in important industrial and business policy issues.

Industri Energi is a trade union which represents over 56 000 workers in the Norwegian oil, gas and onshore industries. In total, the sectors organised by Industri Energi account for 80% of Norwegian export value.

The Norwegian Confederation of Enterprise (NHO) is the major organisation for employers and the leading voice of business in Norway, with a membership of over 29 000 companies ranging from small family-owned business to multinational companies in most sectors.

The Norwegian Confederation of Trade Unions (LO) is Norway's largest trade union organisation. The 25 national unions affiliated to LO have over 970 000 members, representing a broad range of sectors and occupations.

Norwegian Mineral Industry (Norsk Bergindustri) represents ca. 180 companies within the Norwegian aggregates, minerals and natural stone sectors. The organisation and its members work to create a safe and sustainable mineral industry for the future, with a vision of climate neutrality, complete resource efficiency and zero mineral waste.

The Norwegian Union of General Workers (NAF) is a trade union founded in 1895 by construction workers. NAF now has a membership of 33 000 workers, inter alia within the mining, construction, maintenance, cleaning and janitoring sectors.

ANNEX

Strategy paper

Recommendations for industrial investment in rare earth elements (REEs) as the basis of a complete Norwegian value chain for critically important permanent magnets – a crucial component in the EU's green shift.

The Confederation of Norwegian Enterprises (NHO), the Norwegian Confederation of Trade Unions (LO Norway), the Federation of Norwegian Industries, the Norwegian Workers' Union, and Norwegian Mineral Industry are the organisations behind this report, and recommend that Norway invest in the extraction of rare earth elements and the associated value chain for the production of permanent magnets.

NHO

LO Norge

Forbundet for arbeidsfolk
NORSK ARBEIDSMANDSFORBUND

Norsk Industri

NORSK BERGINDUSTRI

Summary and recommendations

If the economy is to undergo a green transformation, access to minerals and metals is essential. The EU considers rare earth elements (REEs) to be some of the most critical raw materials for *the European Green Deal*. REEs are used in most modern technology that facilitates economic growth, as well as in defence materiel. Permanent magnets (super magnets) are a crucial component in technical solutions used to reduce climate emissions, such as in turbines for wind power and motors for electric cars. Significant amounts of REEs are contained in permanent magnets.

The European Commission (DG GROW), the European Parliament, the European Raw Materials Alliance (ERMA), the International Energy Agency (IEA), and Eurometaux, which represents the non-ferrous metal industry, are among the organisations that have pointed out that a reduction in greenhouse gas emissions, in line with the Paris Agreement, requires a sharp increase in access to metals such as copper, nickel, cobalt, lithium, and not least REEs.[13]

Illustration: REIA

Roughly 98 percent of Europe's REE needs is currently met through extraction in countries outside the EU/EEA, predominantly in China. China is also a leader in the production of metals such as copper, nickel, cobalt, and lithium.[14] [15]As things stand, Europe is completely dependent on its supply of REEs from China in order to meet set climate targets.

Norway's Fens field in Nome municipality in Telemark is likely home to Europe's largest deposit of REEs. Based on the regional geologist's survey from 2016, the deposit is characterised as *"A world class exploration target for REE, and possibly the largest carbonatite-hosted REE deposit in Europe".* The results from the ongoing drilling programme underpin this and provide a basis for continuing the work.

In the Fens deposit, significant amounts of neodymium and praseodymium have been detected, which are types of REEs included in permanent magnets. The Fens field is very favourably located in terms of infrastructure, as well as its access to renewable energy, the processing industry at Herøya, and sea-based transport to Europe. A Norwegian industrial investment in a value chain for REEs and permanent magnets could be based on this mineral deposit.

The Norwegian government has announced that it will present a new minerals strategy in the course of 2022. Among other things, the strategy will facilitate the Norwegian mineral industry's contribution to the UN sustainable development goals through the extraction of minerals necessary for electrification and the green shift in a way that is environmentally, socially, and economically sustainable.[16] According to the government's political platform (the Hurdal platform), the government will step up the surveying of mineral resources both on land and on the continental shelf, with particular emphasis on mineral areas that could play a major role in the green shift, such as rare earth elements.[17] Such positive ambitions are supported by the Norwegian raw materials industry.

[13] See, for example, the report from the European Parliament:https://www.europarl.europa.eu/news/en/press-room/20211118IPR17620/critical-raw-materials-the-eu-should-secure-its-own-supply; the report from the International Energy Agency (IEA): https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions; and the report from Eurometaux: https://eurometaux.eu/media/eoagpalu/metals-for-clean-energy-final.pdf

[14] European Commission: Study on the EU's list of Critical Raw Materials (2020) Final Report. Available from https://rmis.jrc.ec.europa.eu

[15] European Commission, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability, September 2020

[16] Norwegian Ministry of Trade, Industry and Fisheries, 2022: Press release: https://www.regjeringen.no/no/aktuelt/skjerper-miljokravene-i-engebo-saken-og-varsler-ny-mineralstrategi/id2911661/

[17] https://www.regjeringen.no/contentassets/cb0adb6c6fee428caa81bd5b339501b0/no/pdfs/hurdalsplattformen.pdf

In order to unlock the potential for Norwegian jobs and value creation, the government's minerals strategy must:

- Establish a commitment to critical raw materials and the associated value chains together with the EU. The emphasis of the strategy must be on implementing measures and instruments that provide a basis for establishing Norwegian value chains from extraction through to the further processing of minerals and metals. The extraction of REEs on the Fens field and processing at Herøya is an example of a value chain that could be of decisive importance for Norway and the EU.
- Introduce financial incentives both in connection with the surveying of critical mineral deposits and investments in industrial production. Risk relief for surveying must include private initiatives.
- Reduce the processing time for planning permission, discharge permits, and operating licences for minerals projects, including the introduction of co-ordinated licence processing for minerals projects.
- Stimulate increased and focused investment in research and development work for the processing stages within the extraction and further processing of REEs, for which there is currently no or minimal expertise in Europe.

In addition, continuing to have long-term access to renewable energy at competitive prices for Norwegian industry is crucial to being able to establish value chains for the extraction and further processing of REEs in Norway.

With the Fens field as a basis, Norway is in a position to be able to develop a complete value chain from mineral extraction in Nome municipality to the production of permanent magnets at Herøya. In this way, Norway can occupy a central position and serve as a key component in a European value chain for electric motors and turbines for wind power – which will then complement plans for Norwegian battery production. Preliminary estimates indicate that the Fens field can supply up to 25 percent of Europe's REE needs by 2030.

Norwegian competitive advantages for developing a value chain for permanent magnets are: access to the largest European deposit of REEs at the Fens field in Telemark; renewable energy; and the experience of Norwegian industrial companies in mining, mineral processing, and metal production.

Thanks to its size and nature, the Fens deposit can supply a significant proportion of the EU's REE needs for many decades. Furthermore, such a value chain will form the basis for developing research environments in Norway that can take a leading role in European research and development for REEs.

Fact box 1: Norwegian value chain for mineral extraction and the production of permanent magnets

Contents

1 The importance of REE as part of the EU's Green Deal

A modern society is completely dependent on continuous and reliable access to mineral resources and raw materials. The Norwegian Directorate of Mining has estimated that every Norwegian consumes 13 tonnes of Norwegian mineral raw materials per year.[18] Building materials such as crushed stone, gravel, and sand account for the majority of this consumption.[19] In addition there are industrial minerals, metals, natural stone, and energy minerals. Access to minerals is fundamental for our lifestyle and the products we surround ourselves with on a day-to-day basis.

Europe aims to be a global leader in the green transition, with the goal of being climate neutral by 2050. The EU's green growth strategy, the Green Deal, is the European Commission's strategy for achieving this objective, while also ensuring that the strategy is a driver for further economic development in Europe. To make this transition a success, there is a huge need for the minerals that are the building blocks of green technology. This is expressed in the EU's Green Deal, which among other things states that:[20]

"Access to resources is a strategic security question for Europe's ambition to deliver the Green Deal. Ensuring the supply of sustainable raw materials, in particular of critical raw materials necessary for clean technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources, is therefore one of the pre-requisites to make this transition happen."

REEs – a collective term for 17 different elements – are considered by the EU to be among the most critical minerals[21] and absolutely essential raw materials for Europe's economy and political agenda.[22] In a survey of 25 critical raw materials for strategically important products and sectors, the European Commission considers that the supply risk associated with REEs is the highest (that is, the risk that the EU's access to raw materials may be interrupted or disrupted).[23] In the UK, too, access to REEs is deemed to be very critical, based on assessments of supply risk and economic significance should access to raw materials be disrupted.[24]

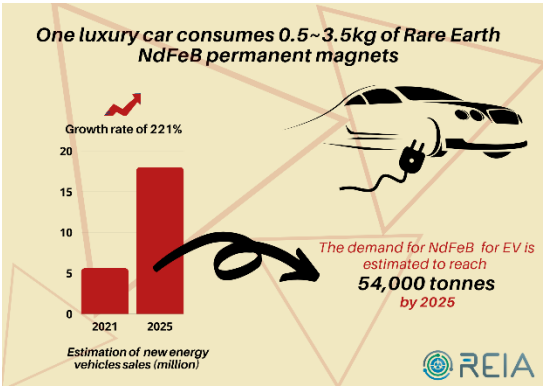

Illustration: REIA

REEs are used in most modern technology. Examples include electric cars, wind turbines, robotics, data storage, and medical technology. A particularly important application area for REEs is permanent magnets, which play a key role in electric cars and wind turbines, among other things. The EU expects demand for REEs for use in permanent magnets to increase tenfold by 2050.[25] An increase in mineral extraction, in addition to increased recycling and a focus on a circular economy, will therefore be essential.

It is estimated that Europe imports roughly 98 percent of the REEs it consumes from China.[26] No REEs are currently extracted in Europe, and there are very few current projects outside of the Fens field.[27] Consequently, the EU has a considerable need to

[18] https://dirmin.no/mineralnaeringen
[19] Norwegian Directorate of Mining, 2021: *Hard facts about the minerals industry 2020*. https://dirmin.no/sites/default/files/hf20-rapport_web.pdf
[20] European Commission, The European Green Deal, COM (2019) 640 final, December 2019. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF
[21] European Commission, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability, September 2020
[22] European Raw Materials Alliance, Rare Earth Magnets and Motors: A European Call for Action – September 2021
[23] EU Commission, 2020: *Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study*. https://ec.europa.eu/docsroom/documents/42881
[24] Lustry, P A J, Shaw, R A, Gunn, A G, AND Idoine N E. 2021. *UK criticality assessment of technology critical minerals and metals*. *British Geological Survey Commissioned Report*, CR/21/120. https://www.bgs.ac.uk/download/uk-criticality-assessment-of-technology-critical-minerals-and-metals/
[25] European Commission, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability, September 2020
[26] European Commission, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability, September 2020
[27] European Raw Materials Alliance, Rare Earth Magnets and Motors: A European Call for Action – September 2021

strengthen its own security of supply for these minerals. There exists a clear objective for achieving a greater degree of self-sufficiency when it comes to strategically important raw materials, as well as developing European industrial production that is more robust – politically referred to as "European resilience" or "European autonomy".

Three important reasons for this are:

- Europe must have sufficient access to minerals and metals in order to realise the green transition and to achieve the objectives set out in the Paris Agreement and the EU's Green Deal.
- It is strategically important that Europe become less dependent on China, both for security policy reasons and in terms of the need for secure supply chains.
- To ensure the more environmentally friendly production of strategically important minerals, such as REEs, in accordance with European requirements.

In the autumn of 2020, the European Commission launched an action plan to make Europe's access to raw materials more secure and more sustainable.[28] The first step in this action plan was to establish the European Raw Materials Alliance (ERMA) to propel minerals policy in general, and in particular with a view to securing access to critical raw materials such as REEs and permanent magnets.[29] The EU and Norway are seeking to strengthen and expand their co-operation on access to strategic raw materials and value chains for batteries, such as by entering into industrial partnerships.[30]

One of the goals of ERMA is to identify projects for the extraction of critical raw materials that can be in operation by 2025. Although the aim of a start-up in 2025 is unrealistic with regard to technology development and permit processes, this goal has been set to emphasise the importance and criticality of greater self-sufficiency in REEs for Europe. In the autumn of 2021, ERMA presented a report with 12 proposed measures to improve Europe's access to REEs and its degree of self-sufficiency.[31] ERMA's recommendations include regulatory simplifications and the need for state risk relief in the early stages.

In light of the importance of the Fens field, ERMA has asked the Norwegian authorities to support the extraction of REEs with the Fens field as a basis.[32] The companies Rare Earths Norway and REE Minerals have, over time, examined REE deposits in the Fens field and have ambitions to commence extraction. This will thus provide opportunities for the production of permanent magnets in Norway. The company REEtec is in the process of obtaining funding for the first industrial production facility for the separation and processing of REEs into magnetic metal oxides. This facility will be located at Herøya Industripark in Porsgrunn. There are other stakeholders who may be relevant in connection with the further separation of REEs.

Norway has a solid, well-established, and strong smelting industry which should have the best conditions for establishing new ventures for metal production based on oxides from REEs. With regard to magnet production, there is hardly any transferable expertise from other industries in Norway. However, the industrial environment at Herøya Industripark – located 35 kilometres from the Fens field

[28] European Commission, Commission announces actions to make Europe's raw materials supply more secure and sustainable, September 2020
[29] Cf. European Commission, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability from September 2020, which states that the supply of REEs and magnets is deemed essential for industrial value chains in the EU: "*Focus on the most pressing needs, which is to increase EU resilience in the rare earths and magnets value chain, as this is vital to most EU industrial ecosystems.*"
[30] https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_4150
[31] European Raw Materials Alliance, Rare Earth Magnets and Motors: A European Call for Action – September 2021. https://eitrawmaterials.eu/wp-content/uploads/2021/09/ERMA-Action-Plan-2021-A-European-Call-for-Action.pdf
[32] Letter dated 04.03.2021 from ERMA by CEO Bernd Schäfer of EIT RawMaterials to the then Minister of Trade, Industry and Fisheries Iselin Nybø, in which it is stated, among other things, that: *"On behalf of ERMA we strongly support the development of the Fen-deposit and the activities of Norsk Mineral, which we also understand abide by the highest ethical and environmental standards available. The development of the Fen-deposit could substantially contribute to the development of a European supply chain for e-motors, thus addressing both the issues that ERMA was set up to tackle. Here, we will also point to other initiatives in Norway, such as the REETec refining operations, which will create further value in the Norwegian economy. We emphasise the need to increase recycling and build a more circular economy. However, in the case of rare earths, exploiting virgin resources will be necessary. Accordingly, we urge the Norwegian government to look closely and favourably on the strengthening of European supply chains through mining in Norway, and specifically to support the development of the Fen-deposit."*

– may provide good conditions for the successful establishment of such a venture. Initiatives should be taken to investigate these opportunities, with the aim of establishing a complete Norwegian value chain from mineral extraction to the production of permanent magnets.

Piece of the drill cores from the Fens field with bastnäsite (brown mineral) and carbonates (dolomite/ankerite; white minerals) containing REEs. Photo: Sven Dahlgren

The Fens field in Telemark is the remains of a 580-million-year-old volcano with carbonate-rich magma, known as carbonatite. The volcano itself has long since eroded away, and only the volcanic conduit remains. The field is roughly circular with a diameter of between 2 and 2.5 kilometres, and consists of carbonatites of varying geochemical and mineralogical compositions. Iron ore operations took place in the eastern part of the field between 1657 and 1927. This area consists of rødberg (hematitised carbonatite). Niobium ore operations took place in the western part between 1953 and 1965. The rock type here is sovite (limestone carbonatite). In particular, REEs are found in the central eastern part of the field, which is dominated by iron-dolomite carbonatite (rauhaugite). This rock type contains REEs bound in bastnäsite, parisite, and monazite, and has a grain size and texture that makes it possible to extract these minerals.

The part of the Fens field which consists of iron dolomite carbonatite covers an area of around 1.4 km^2 and has recently been mapped by the Geological Survey of Norway (NGU) and the regional geologist. Drilling shows that the field extends vertically by at least one kilometre. The average content of REEs in the cores was 1.2 and 1.8 percent respectively. Neodymium and praseodymium – which are used in permanent magnets – make up about 20 percent of this.

The Fens field is probably the largest carbonatite-type REE deposit in Europe. For example, the international consultancy company Golder has defined Rare Earth Norway's deposit in the Fens field as a so-called exploration target of around 1.4 to 3.3 billion tonnes, with between 0.4 and 2 percent rare earth oxides (REO). However, significant investigations in the form of core drilling and analysis must be carried out to define these resources in accordance with international standards. Several private companies are in the process of drilling which will increase our knowledge of the Fen deposit.

The most important REE deposits in the world consist of the same type of rock as the Fens field. Consequently, although there is an established global supplier industry with suitable technology, as no two deposits are identical, specific methods must be developed for each deposit. The exploitation of REEs in the Fens field will require the development of more environmentally friendly and sustainable solutions and processes, which will deviate significantly from the methodology and standards used by China, for example.

Fact box 2: The Fens field[33,34,35,36]

[33] Dahlgren, S. 2019: *REE Mineralization in the Fen Carbonatite Complex, Telemark, Norway – A world-class exploration target for the Hi-Tech and "Green-shift" industry?* Report from the Geological Advisor 1-2019, Buskerud Vestfold Telemark County Councils. 86 pp.
[34] Coint, N. & Dahlgren, S. 2019: 2019: Rare earth elements (REE) in two long drill-cores from the Fen Carbonatite Complex, Telemark Norway. Geological Survey of Norway, Report 2019.008, 36 pp.
[35] Golder Associates (UK) Ltd, 2021: Fen REE Project, Pre-Scoping Study.
[36] Kalvig, P. 2021: *Sjældne jordartsmetaller (REE). Forekomster, forarbejdning, forbrug, forsyning og forventninger.* MiMa rapport 2021/2, ISBN: 978-87-7871-552-2.

2 Permanent magnets and their critical role in the green shift

Magnets, and especially permanent magnets (super magnets), are important in modern technology. Magnet-based technology is crucial for the ongoing shift from fossil fuels to renewable energy sources.

Permanent magnets are considerably stronger and lighter than traditional magnets, and can remain magnetised without the influence of nearby magnetic fields. They have a very good ability to convert electrical power into mechanical power and vice versa. The strongest permanent magnets by weight contain neodymium, which is a rare earth element (REE). The properties mentioned above are particularly important in applications where space and weight are decisive factors. One example is electric cars, where weight and the efficient transfer of electric power to mechanical power are important when it comes to energy efficiency.[37]

Illustration: REIA

Permanent magnets are essential for the construction of large wind turbines with greater longevity. This is because they are significantly more efficient and eliminate the need for gearboxes which are subject to considerable wear and tear given the sizeable dimensions of the largest turbines combined with harsh weather conditions.

The ability of permanent magnets to transfer mechanical power to electrical power more efficiently than traditional magnets is also important in other applications, for example in medical equipment such as MRI machinery, as well as in digitalisation where permanent magnets can give rise to more energy-efficient solutions for things such as data storage.

Table 1 shows examples of some rare earth elements (REEs) and their associated applications.

Element	Examples of applications
Scandium	Advanced lasers, X-ray tubes, and powerful magnets
Yttrium	Television and computer screens
Lanthanum	Glass for optics in expensive cameras
Europium	Makes Euro notes fluorescent
Samarium	Captures neutrons in nuclear reactors
Gadolinium	Contrast fluid for MRIs
Neodymium	Wind turbines, permanent magnets, hard drives
Cerium	Catalysts and sea- and temperature-resistant aluminium

Table 1: Examples of REEs and associated applications

[37] European Raw Materials Alliance, Rare Earth Magnets and Motors: A European Call for Action - September 2021

Permanent magnets are a critical component in technology such as electric cars and wind turbines. Around 2 kilos of REEs are needed in an electric car, and up to 2,000 kilos are needed in a large wind turbine. Consequently, REEs and permanent magnets are essential for accelerating the green transformation of the economy. This also gives rise to greater opportunities. Europe's electric car industry alone is expected to generate sales of EUR 400 billion and employ some 6 million people by 2030. Consequently, being part of the European value chain for electric motors provides Norway with considerable industrial opportunities. Inclusion in other industrial European value chains that depend on permanent magnets and REEs will bring about similar industrial opportunities.

Fact box 3: Industrial opportunities in new European value chains

3 Norwegian advantages in respect of the development of a value chain for permanent magnets

Historically, Norway has taken a leading role in the development of hydropower, the power refining industry, the petroleum industry, and materials technology. There are now similar opportunities to take a leading role in the industrial green shift in Europe by investing in the extraction of critical raw materials such as REEs and establishing a complete value chain for permanent magnets. Norway has competitive advantages in its ability to develop sustainable industrial value chains based on REEs thanks to the country's renewable energy, innovative manufacturing processes and, not least, its comprehensive resource utilisation, among other things.

As mentioned above, the Fens field is likely home to Europe's largest deposit of REEs. The deposit contains critically important minerals for the production of permanent magnets. The Fens field in Nome municipality is only 35 kilometres from Herøya Industripark in the neighbouring municipality of Porsgrunn. Norway is therefore in a position to develop a compact value chain with a small CO_2 footprint for the extraction of REEs, further separation and processing, the production of REE oxides, and the production of metals and magnets. A compact value chain for the production of permanent magnets in Norway will also supplement the investment in Norwegian battery production.

Below are examples of advantages that make Norwegian industrial ventures successful.

3.1 Stability, predictability, and tripartite co-operation

Predictable framework conditions, stability, and effective tripartite co-operation are examples of decisive factors for Norway being perceived as an attractive host nation for such an industry.[38] Investments in industrial facilities for the extraction and further processing of REEs and metal and magnet production are extensive, both in terms of time and money. This requires consistently stable and predictable framework conditions that remain in place regardless of political majorities. As cost levels generally challenge industrial production in Norway, it is important that we maintain a competitive tax and duty regime in relation to other European industry nations. This includes corporation tax, capital depreciation rules, excise duties, and European climate-related duties linked to quota prices.

3.2 Renewable energy at competitive prices

Norwegian industry has historically had access to renewable energy at competitive prices. This has been a leading competitive advantage of Norwegian industry. Our emission-free energy system gives industry a unique opportunity to be carbon-neutral. A continued power surplus in Norway is crucial for ensuring the competitiveness of industry in Norway and makes it possible to host new green value chains. Swathes of Norway are now to be electrified, while new industries are to be established that

[38] The Federation of Norwegian Industries, 2016: Roadmap for the processing industry. https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/veikart-for-prosessindustrien_web.pdf

are hungry for renewable energy. Arrangements must therefore be made for the further development of hydropower and wind power. Offshore wind power will make a significant contribution to ensuring a continued power surplus. In addition, significantly faster licence processing times for key power and network projects, investment in the upgrading of existing hydropower plants, increased solar energy production, as well as investment in energy efficiency in industry and construction are all vital.[39]

3.3 Expertise and industrial tradition

Norwegian industry has expertise in mineral extraction, processing, separation, and metal production. Norwegian businesses and research environments are also leaders in materials technology. Available expertise at all levels is a key prerequisite for the competitiveness of Norwegian industry across global markets. There is a tradition of close collaboration between research and industry, and Norway enjoys effective participation in international research projects. Furthermore, Norwegian industry has a well-educated workforce in terms of both operators and engineers, as well as well-developed collaboration within companies between management and employees. This contributes to the success of Norwegian industry in terms of both improvement and innovation.[40]

3.4 Good environments for research and development

The development of a value chain for permanent magnets in Norway, based on the deposit at Fen, requires research and development in several fields, including resource mapping and process mineralogy, mining, mineral separation (screening), hydrometallurgy, and materials technology. In addition to the production and utilisation of REEs, research must be done on the resource-efficient utilisation of surplus masses, as well as the proper management of potentially environmentally harmful and radioactive elements. The processes developed through this must have the lowest possible environmental footprint. Relevant Norwegian research environments in these fields include NTNU, SINTEF, the Institute of Energy Technology (IFE), the Geological Survey of Norway (NGU), and MiMac (The Norwegian Laboratory for Minerals and Materials Characterization). These are research and development heavyweights that can be scaled up to become leaders in Europe within the field of REEs and magnets. This will further contribute to the development of a competitive Norwegian mineral and processing industry through a combination of basic research in academic environments and more applied research in collaborative projects between academia and industry.

4 Barriers

Consequently, Norway has several advantages that help to make new industrial ventures in the country a success. There are, however, barriers that stand in the way of establishing a value chain for permanent magnets based on REEs.

4.1 Economic barriers

A lack of relevant arrangements for risk relief presents an economic barrier. This applies at all stages, from the surveying of mineral resources to investments in industrial facilities for their extraction, separation, and further processing. Geological surveys and core drilling to obtain sample material and build knowledge of mineral deposits are both very costly. Such surveys are necessary for obtaining detailed knowledge of a mineral deposit (distribution, concentrations, mineral composition, etc.), and form the basis for being able to develop processes and plan a sustainable operation with a high

[39] The Federation of Norwegian Industries, 2022: *Input to the Energy Commission*. https://www.norskindustri.no/dette-jobber-vi-med/energi-og-klima/aktuelt/utbygging-av-ny-fornybar-kraft-ma-folge-ambisjonene-for-industriutvikling/
[40] Prosess 21's expert group for expertise, 2020: Expert group on expertise. https://www.prosess21.no/om-prosess-21/ekspertgrupper-og-workshops/kompetanse/

extraction rate. Yet no public funding is given to private initiatives for surveying mineral resources.[41] The Geological Survey of Norway (NGU) conducts surveys and provides research-based knowledge about areas with key mineral resources in Norway.[42] Supporting NGU's surveying activities will improve knowledge about mineral deposits in Norway.

There are currently no public funding schemes providing risk relief for industrial facilities for the extraction, separation, and further processing of minerals, including REEs. The extensive investments needed in connection with increasing production capacity pose a significant economic risk. This is reinforced by the fact that the financial markets consider the risks associated with permit processes in Norway to be high.

As an example, the Fens field represents an opportunity for large-scale mineral extraction, hopefully for centuries, yet the uncertainty poses a considerable economic risk. It could cost several hundreds of millions of kroner before sufficient knowledge and facts are in place for a decision to be made on investment. This includes a detailed survey of the deposit. Viable REE deposits are a scarce resource worldwide, and so a high extraction rate for the deposit is essential for responsible management. The development of mining and processing facilities for extraction on the Fens field could amount to an estimated NOK 8 to 10 billion.

The EU's need for REEs is increasing rapidly, as is the desire for far greater self-sufficiency for Europe. It is therefore extremely desirable that the various processes run in parallel. This increases the financial exposure for the initiators. Risk mitigation measures are therefore crucial.

4.2 Market barriers

There is a high level of market risk in the extraction and further processing of minerals. For REEs, this risk is linked to China using its dominant position as a producer, among other things. China has previously demonstrated its willingness to leverage its market power and at times dump prices to eliminate competitors.

4.3 Regulatory barriers

In order to commence mineral extraction, legislation requires the preparation of an impact assessment and approval of 1) a development plan, 2) a discharge permit, and 3) an operating licence. These plans/permits are processed by three different authorities under three different ministries and according to three different laws (see appendix 2). Multiple topics are also dealt with in several of these processes. A lack of co-ordination results in an unnecessarily long and expensive process before all the permits are in place. Traditionally, the permit process (development plan, discharge permit, and operating licence) for minerals projects can take between 10 and 20 years in Norway. Furthermore, outcomes in connection with the processing of the necessary plans and permits will always be subject to a certain degree of uncertainty. Regulatory uncertainties related to both timing and outcomes therefore represent in themselves a significant risk and cost for the minerals industry.

Effective and predictable land use planning is a prerequisite for the establishment of new minerals projects. At the same time, land use and land regulation is an area where state, county, and municipal bodies have adjacent or overlapping authority, and where there is a need for co-ordination between the different levels of administration and sectoral authorities. Land use regulation is time-consuming and is perceived as being unpredictable. Changes in planning and building legislation that simplify municipal planning processes should therefore be considered. In addition, consideration should be given to putting national guidelines in place that protect strategically important mineral resources that are of international importance against downscaling and sequestration for other uses. For example,

[41] This may be related to the fact that mapping of mineral deposits is not considered to be research and development, but an economic activity; see the OECD and the Research Council of Norway, 2015: *The Frascati manual, 2015. Guidelines for gathering and reporting data on research and experimental development.* https://www.forskningsradet.no/contentassets/4aba99235386471d87122bc4206e335b/frascati-2015-norsk.pdf
[42] https://www.ngu.no/emne/kartlegging-og-prospektering

consideration should be given to drawing up national guidelines that ensure that access to strategically important minerals is given weight in connection with impact assessments of potential minerals projects. It is also seen as highly unreasonable that municipalities can decide to stop a private planning initiative even after they have held a start-up meeting, that is to say before the consequences of a measure have even been clarified.[43]

4.4 Technological barriers

The development of processes for the separation of REEs from ore requires new mining work in Europe. To date, it has been Chinese environments in particular that have built up knowledge about the further processing and screening of REEs. At the same time, we can build on the extensive experience of companies within the Norwegian minerals industry. As mentioned in section 3, several Norwegian companies already have expertise in mineral extraction, processing, separation, and metal production. Norwegian businesses and research environments are also leaders in materials technology.

4.5 Barriers related to infrastructure for renewable energy

There is a rapidly increasing demand for power grids that can provide sufficient capacity for both existing and new industry players, on top of the electrification measures being implemented throughout Norway. New industrial ventures such as battery production and hydrogen production will require access to robust power grids and new industrial areas.[44] The same can be said for the expansion of the existing power refining industry, industrial facilities for the separation and processing of REEs, and the production of metals and magnets. Norway must therefore have an energy market and energy balance that can provide ample access to renewable energy at reasonable prices. A continued structural energy surplus in Norway is also a prerequisite for the successful establishment of a value chain for permanent magnets, in the same way as for other major industrial ventures.[45]

5 Concrete recommendations for what is needed to succeed

The Norwegian government has announced that it will present a new minerals strategy in the course of 2022. Among other things, the strategy will facilitate the Norwegian mineral industry's contribution to the UN sustainable development goals through the extraction of minerals necessary for electrification and the green shift in a way that is environmentally, socially, and economically sustainable.[46] In regard to the Hurdal platform, the government will step up the surveying of mineral resources both on land and on the continental shelf, with particular emphasis on mineral areas that could play a major role in the green shift, such as rare earth elements.[47] Such positive ambitions are supported by the Norwegian minerals industry.

The minerals industry is characterised by particularly long timeframes, both before extraction begins and during production. It is therefore crucial that changes are made to legislation and other framework

[43] Cf. § 12-8 of the Norwegian Planning and Building Act.
[44] The Federation of Norwegian Industries, among others, 2021: *Letter to the Storting's energy and environment committee with a proposal to support Norway as a host nation for green industry*. https://www.norskindustri.no/siteassets/dokumenter/horinger-og-notater/2021-06-14-forslag-for-a-styrke-norge-som-vertskapsnasjon-for-gronn-industri.pdf
[45] The Federation of Norwegian Industries, 2022: *Input to the Energy Commission*. https://www.norskindustri.no/dette-jobber-vi-med/energi-og-klima/aktuelt/utbygging-av-ny-fornybar-kraft-ma-folge-ambisjonene-for-industriutvikling/
[46] Norwegian Ministry of Trade, Industry and Fisheries, 2022: Press release: https://www.regjeringen.no/no/aktuelt/skjerper-miljokravene-i-engebo-saken-og-varsler-ny-mineralstrategi/id2911661/
[47] https://www.regjeringen.no/contentassets/cb0adb6c6fee428caa81bd5b339501b0/no/pdfs/hurdalsplattformen.pdf

conditions so that society and the industry have predictability and thus confidence in the situation over a longer timeframe.

The definition of which minerals are defined as critical and strategically important is related to developments in technology and society, and will change over time. This implies that measures to stimulate the establishment of value chains for REEs in Norway should, to the greatest extent possible, be general measures that can also benefit other minerals. New measures to ensure improved access to REEs will also be necessary to ensure access to other mineral resources and raw materials that modern society depends on.

In order to unlock the potential for Norwegian jobs and value creation, the government's minerals strategy must:

Measure 1: Establish a commitment to critical raw materials and associated value chains together with the EU.

The Norwegian government will present a new minerals strategy in the course of 2022. This strategy must also address the need for access to strategically important minerals and raw materials. In addition, the emphasis of the strategy must be on instruments that will provide a basis for establishing Norwegian value chains from extraction through to the further processing of minerals and metals. The extraction of REEs on the Fens field and processing at Herøya is an example of such a value chain that is of decisive importance for Norway and the EU. Authorities and industry must have joint objectives that ensure the necessary pace, co-ordination with international partners/alliances, and promote Norwegian minerals projects with associated value chains in order to attract investment funds.

A new strategy for the minerals industry must outline how Norway can collaborate with countries in Europe and beyond, such as the US and Canada, in order to procure raw materials that are strategically important for a green transformation of the economy. The European Commission has announced that it will present a "raw materials package".[48] There is reason to believe that such a package could consist of a statement addressing the European Commission's raw materials policy, proposals for new EU legislation, and an updated list of critical raw materials. A central objective is to facilitate new minerals projects that improve European access to strategically important minerals and metals that are crucial for a green and climate-friendly restructuring of the economy. In addition to increasing extraction and processing in the EEA, the European Commission wants to enter into strategic partnerships to improve access to strategically important raw materials with third countries such as the US and Canada.

A Norwegian minerals policy must therefore be developed in close co-operation with the EU and must contribute to the safeguarding of European competitiveness and improving its self-sufficiency in critical raw materials. An example of such co-operation is entering into strategic partnerships to improve access to strategically important minerals with the EU and other countries.

What is needed to achieve success:

- The Norwegian government's strategy for the minerals industry must facilitate the extraction of REEs in Norway and the establishment of industrial value chains based on critical and strategically important raw materials. New measures for the industry must help to improve competitiveness and self-sufficiency in the minerals needed in a green transformation of the economy, cf. the EU's targets to reduce greenhouse gas emissions, etc.
- Norway must be an active contributor and co-player in the preparation of the European Commission's new "raw materials package" and associated measures. Norway should enter

[48] See, for example https://www.euractiv.com/section/economy-jobs/news/eu-ramping-up-efforts-for-strategic-autonomy-in-raw-materials/

into strategic partnerships with the EU and other countries to increase access to strategically important raw materials in connection with a green restructuring of the economy.

The European Commission's fourth study of critical raw material resources was published in 2020. Previous studies were published in 2017, 2014, and 2011. The European Commission has now defined 30 raw materials as critical, including heavy rare earth elements (HREE) and light rare earth elements (LREE). The two main criteria of the European Commission for assessing whether a raw material should be defined as critical are:

- **Economic importance**, i.e. the importance of the raw material for the EU economy with regard to value creation in the sectors that use the raw material. The technical and economic impact of using other types of raw materials (substitution) is included in assessments of economic importance.
- **Supply risk**, i.e. the risk of the interruption of or disruption to the EU's access to the raw material. The supplying countries' governance and trade policy are among the aspects assessed. Substitution potential and recycling are included in the assessments and can mitigate supply risk.

In connection with the announcement of the European Commission's "raw material package", the list of critical raw materials will be updated. In addition, new instruments will be introduced to improve European access to other raw materials that are strategically important in connection with the green transition. These include metals such as magnesium, aluminium, copper, and nickel. An element's status as a strategic raw material could help to facilitate the financing of projects for their extraction, processing, or recycling.

Fact box 4: Critical raw materials and strategically important minerals in relation to the green shift[49,50]

Measure 2: Funding schemes and economic risk relief

Early-phase risk relief is important for realising minerals projects. This relates to the surveying, extraction, and further processing of minerals. Current funding schemes, such as the green platform and Innovation Norway's scheme for innovation projects in business (IPN), are not suitable for the minerals industry and its associated Norwegian value chains. Risk relief measures are needed for both the surveying of critical mineral deposits and investments in industrial production. Additionally, state funds should be made available to ensure that NGU can continue to step up the necessary surveys and investigations of critical mineral resources in Norway, as a basis for new projects.

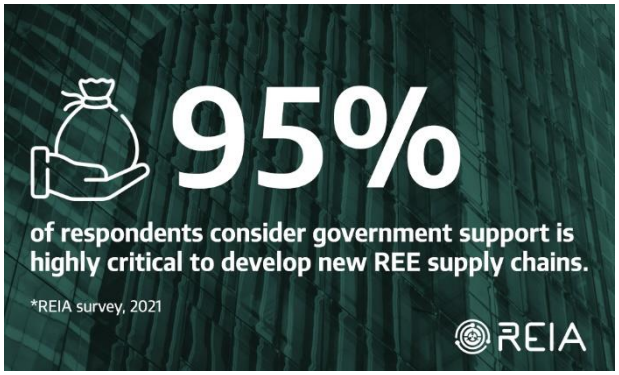

Illustration: REIA

Investments in the industrial production and processing of REEs are very costly. The establishment of a value chain for the extraction, separation, and processing of REEs and the production of metals and magnets will depend on state risk relief. There are several possible instruments that could contribute to this. One example is innovation loans or guarantees. Conditions such as interest rates and repayments, if the project is successful, must be defined[51]. Another example could be the establishment of a state company whose purpose is to offer risk capital to minerals projects in the start-up phase. In Finland, the state has established the investment company Finnish Minerals Group, which invests in the establishment of industrial capacity for the extraction of critical minerals and for establishing the production of lithium batteries. A third option could be the establishment of a state commodity fund. Although the EU has

[49] https://ec.europa.eu/growth/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en
[50] European Commission, 2020: *Methodology for establishing the EU list of critical raw materials – Guidelines*. https://op.europa.eu/en/publication-detail/-/publication/2d43b7e2-66ac-11e7-b2f2-01aa75ed71a1/language-en/format-PDF/source-32064602
[51] For example, Rare Earths Norway has recently been granted NOK 45 million in innovation loans for process development by way of the KAVA scheme for EIT RawMaterials, see https://eit.europa.eu/our-activities/opportunities/eit-rawmaterials-opens-call-projects-2022-kava-9

indicated that it will consider a proposal for such an investment fund, it is unclear whether, and how, this could be relevant for Norway.

In addition to being an active contributor of the mining industry, a state investment fund would be able to take an active role in the creation of a Norwegian value chain, including the production of metals and permanent magnets.

What is needed to achieve success:

- Stepping up of surveying activities for minerals, including REEs, under the auspices of NGU.
- Establishment of state funding schemes for the obtaining of samples and the surveying of critical mineral deposits aimed at private actors, as a continuation of NGU's activities.
- Establishment of new risk relief schemes in the case of investments relating to the extraction, separation, or processing of raw materials that are assessed as critical or strategically important in connection with the green shift.
- Examples of risk relief instruments for minerals projects in the start-up phase are:
    - New schemes for innovation loans or guarantees
    - Establishment of a state company whose purpose is to offer risk capital to new minerals projects
    - Establishment of a separate investment fund, which can be an active financial contributor

Finnish Minerals Group has been established by the Finnish state to develop the country's battery value chain and to safeguard state investments in the minerals industry. The company's purpose is to maximise the value of Finnish minerals in a way that is sustainable. As of 31 December 2021, the company had shares in the companies Terrafame Oy (67.1 percent), Keliber Oy (20.4 percent), and Skoli Oy (100 percent). The most important holding is in the company Terrafame Oy, which produces nickel, zinc, cobalt, and copper from a mineral deposit in Sotkamo. In 2021, the company established the production of nickel and cobalt sulphate, which are used in the production of batteries for electric cars. A feasibility study was also conducted for the establishment of materials for battery production in the Kymenlaakso region.

Fact box 5: Finnish Minerals Group[52]

Measure 3 – Good land use planning and co-ordinated licence processing for minerals projects

As mentioned in section 4, regulatory uncertainty related to the approval of planning permission, discharge permits, and operating licences is perceived as a significant barrier to the establishment of new minerals projects in Norway. Uncertainties related to both timing and outcomes therefore represent a significant risk and cost for the minerals industry. It is therefore proposed that work related to planning processes and permits be co-ordinated by a single specialist body. It is natural that the Norwegian Directorate of Mining be given this role. The expectation of good co-ordination in regard to planning and permit processes in the establishment of new minerals projects should be clearly expressed in the Norwegian Minerals Act. A model for co-ordinated licence processing for minerals projects is outlined in appendix 2.

What is needed to achieve success:

- Implement co-ordinated licence processing for minerals projects.
- A model of co-ordinated licence processing should be tested in selected pilot projects. A potential pilot project could be implemented in connection with planning and permit processes relating to the Fens field.

[52] https://www.mineralsgroup.fi/

- Consider simplifications to the Norwegian Planning and Building Act that make planning processes faster and more predictable and that protect strategically important mineral resources against downscaling and sequestration for other uses.

Measure 4: Step up investment in research and development within the extraction and processing of mineral resources

In order to succeed in establishing new mineral extraction projects which attract capital in a competitive global arena, the industry is dependent on access to public funding for research and development. Such funding should come from regional and national implementation systems, in addition to funding opportunities available in the EU system. The last dedicated research programme aimed at the minerals industry (NORMIN) ended in 1996. In a strategy paper from 2011, SINTEF, NGU, and NTNU advocated for the establishment of a new research and development programme for the minerals industry under the auspices of the Research Council of Norway (MINFORSK). An objective of the programme was that it should last eight to ten years with public investment in the region of NOK 100 million per year.[53] Another important objective was to strengthen links with EU framework programmes in research. Increased and focused investment in research and development work for the processing stages within the extraction and further processing of REEs, for which there is currently no or minimal expertise in Europe, must be part of the stepping up of research and development for the minerals industry.

Several products contain small amounts of REEs. For example, electrical and electronic products that we surround ourselves with on a day-to-day basis contain REEs. As things stand, REEs are recycled only to a very limited extent. In the future, however, REEs could be recycled from electrical and electronic waste to supplement extraction and meet market demand. Industrial recycling of REEs should therefore be part of any investment in research and development. In addition, access to sufficient volumes of waste will be crucial for the viability of investments in recycling capacity. The recycling of REEs should then be seen in a European perspective.

Fact box 6: Recycling of REEs

What is needed to achieve success:

- Increased commitment to funding research and development in the minerals industry, preferably by way of establishing a dedicated programme for research and development targeted at the extraction and processing of minerals in Norway.
- Research and development work for the processing stages within the extraction and further processing of REEs, for which there is no or minimal expertise in Europe, must be part of the stepping up of research and development. The same applies to research aimed at industrial possibilities for recycling REEs.

[53] https://www.sintef.no/projectweb/minforsk/

Appendix 1: Detailed description of process steps in a value chain for the production of REEs at the Fens field and magnet production at Herøya

Step 1: Mineral extraction (mining)

Extraction will take place underground with a low environmental footprint. The aim is to use methods that allow for a high degree of automation and autonomy, and which are suitable for backfilling residual masses from mineral separation. The stakeholders in the Fens field have several decades of experience with mineral extraction, both in open pits and in underground operations. The companies' experience and development projects can be leveraged in operations at the Fens field and form the basis for adopting new solutions.

Step 2: Mineral separation

Mineral separation separates minerals that contain REEs from other minerals in the ore. NTNU's rock lab has commenced research and development work to develop this process using environmentally friendly chemicals. Active efforts are underway to identify alternative applications and new products that use the residual material. The stakeholders in the Fens field have solid and extensive experience in minerals separation. They have, for example, helped to develop world-leading operations in lime-based pigments for the paper industry, and super-pure quartz products for the high-tech industry.

Step 3: Hydrometallurgical processing

In the hydrometallurgical process, the minerals are dissolved so that the REEs can be precipitated as a mixed rare earth concentrate (MREC). The advantage is that this can be done at existing industrial parks, such as Herøya, where the conditions are in place for such a processing industry.

Step 4: Separation of REE concentrate

Over the course of 13 years, REEtec has built up considerable expertise in the separation and processing of REEs. The company has developed technology that can efficiently separate these minerals using just a few processing steps, resulting in a high level of purity, low resource input, and low emissions. REEtec is currently obtaining funding for the first industrial production facility. A decision has been made to locate the facility at Herøya. If funding is available, it will be established in an existing industrial building. To start with, the raw materials must be sourced from abroad, but the Fens field will be the key for REEtec in ensuring sufficient access to raw materials for a planned production facility at Herøya. There are other stakeholders who may be relevant in connection with establishing facilities for the separation of REEs in Norway.

Step 5: Metal and magnet production

Norway has a solid, established, and strong smelting industry which should have the best conditions

for establishing new ventures for metal production from REE oxides. Norway's established smelting industry will be able to take an interest in this new business area and acquire the necessary expertise. With regard to magnet production, there is currently hardly any transferable expertise from other industries in Norway. Furthermore, there is also limited activity and expertise in Europe within this link in the value chain. Initiatives should be taken to investigate these opportunities, with the aim of establishing a complete Norwegian value chain from mineral extraction to the production of permanent magnets. Access to renewable energy and clean water are key factors that underpin the argument for locating these activities at Norway's existing industrial parks, such as Herøya.

By-products and residues

Residual material will be generated both from mineral processing and from hydrometallurgical processing. The ore contains small amounts of other potentially interesting minerals such as fluorspar, apatite (phosphate), and barite. The minerals of primary interest, however, are the carbonates calcspar, dolomite, and ankerite. One objective is to develop saleable by-products from the residual material from mineral screening, both as part of the economically responsible utilisation of raw materials, and to reduce the environmental footprint. Essentially, around 90 percent of what is taken out ends up as residue material, while around 10 percent is REE-containing concentrate that must be processed further. Provision will be made for the backfilling of residue material in the underground mines. However, because the material expands when crushed and ground down, there will not be room for more than 60 to 70 percent of the material. Efforts to develop commercial by-products from the residual/surplus material are therefore vital in helping to reduce or eliminate the need for landfill solutions beyond backfilling.

The ore contains around 200 ppm of thorium. This presents a challenge due to radioactivity. Thorium accompanies the REEs in the mineral separation process, and must undergo a separate separation process in the subsequent hydrometallurgical process. However, there is interest from Norwegian stakeholders (Thor Medical AS and Oncoinvent AS) in using natural thorium as a raw material for the production of radiopharmaceuticals for cancer treatment. In addition to this, thorium must be stored properly so that it is available for future energy utilisation. Research is being conducted on thorium reactors, which have advantages over traditional reactors that use uranium. Estimates have been made indicating that the Fens field may have an energy content in the form of thorium that is a hundred times greater than all the oil and gas on the Norwegian continental shelf.[54] This may be significant at some point in the future.

[54] Berg, Ø., Bjørnstad, T., Dahlgren, S., Nøvik, S., Rondeel, W. and Totland, A., 2012: *Thorium - En framtidsressurs i Oslofjordregionen? Thorium Think Tank report to the Oslofjord fund.* Report No. 2-2012, Regional Geologist, County Administrations of Buskerud, Telemark, and Vestfold. 24 pp.

Appendix 2: Co-ordinated licence processing for minerals projects

In order to commence mineral extraction, legislation requires the preparation of an impact assessment and approval of 1) a development plan, 2) a discharge permit, and 3) an operating licence. These plans/permits are processed by three different authorities under three different ministries and according to three different laws (see the table below). Multiple topics are also dealt with in several of these processes.

Permit	Act	Authority	Superior authority
Development plan	Norwegian Planning and Building Act	Municipality	Norwegian Ministry of Local Government and Regional Development
Discharge permit	Norwegian Pollution Control Act	County Governor / Norwegian Environment Agency	Norwegian Ministry of Climate and Environment
Operating licence	Norwegian Minerals Act	Norwegian Directorate of Mining	Norwegian Ministry of Trade, Industry and Fisheries

The work is currently carried out sequentially, not concurrently. A lack of co-ordination results in an unnecessarily long and expensive process before all the permits are in place. This is illustrated in Figure 1 below. Considerable time will be saved by the work being co-ordinated by a single specialist body and by being pursued concurrently. It is natural that the Norwegian Directorate of Mining be given this role. The desired model for a co-ordinated process is illustrated in Figure 2 below.

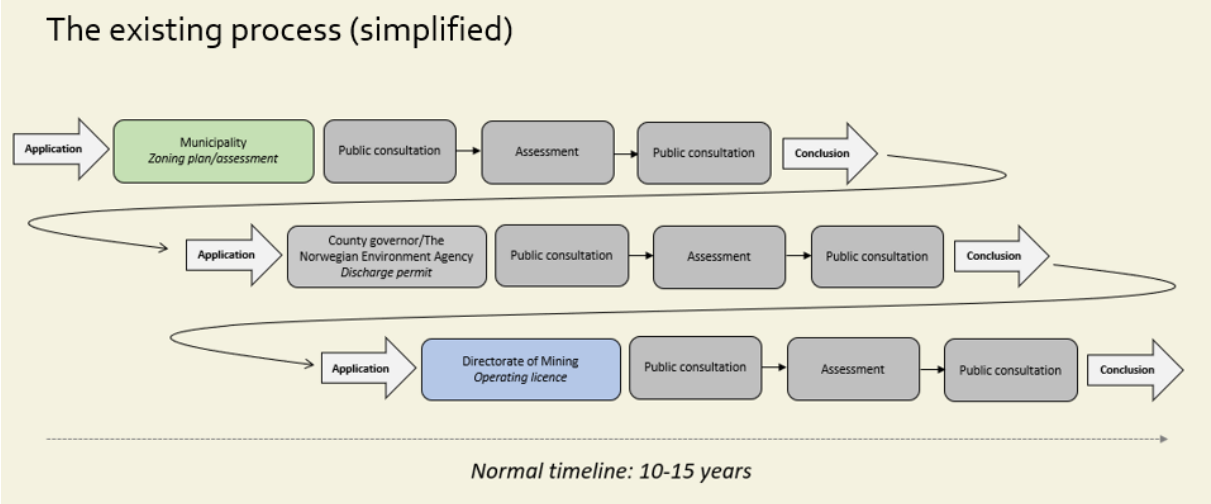

Figure 1: Current process for processing the development plan and necessary permits

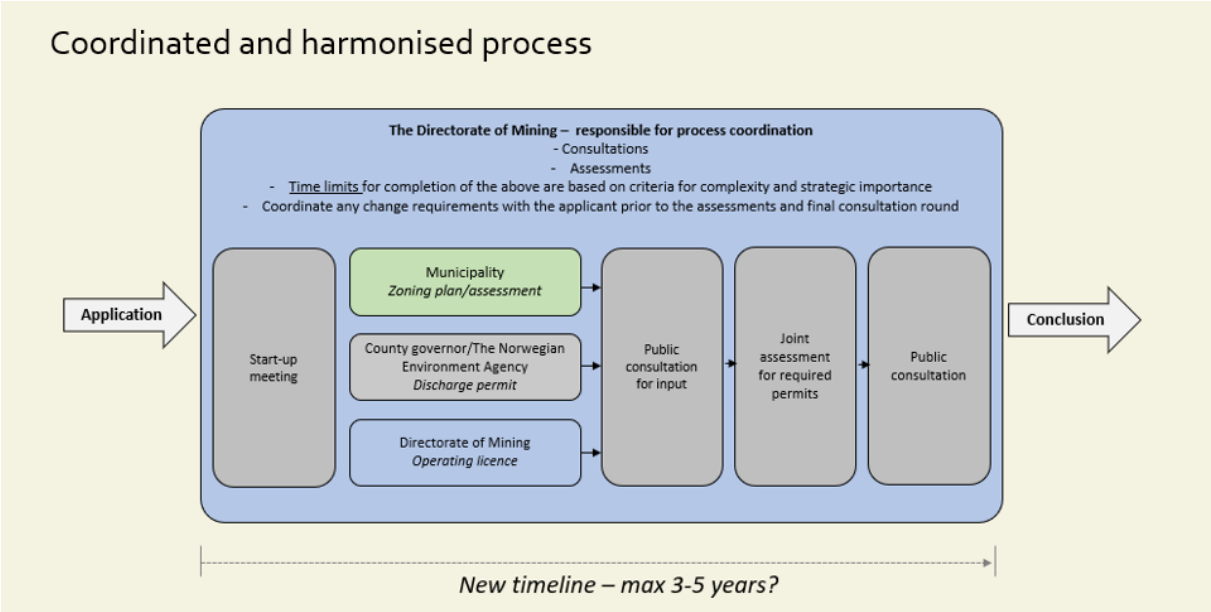

Figure 2: Desired model for a co-ordinated process