2023

The green transition starts in the mine

The Swedish mining and mineral industry's contribution to a European low-carbon, resource-efficient and sustainable economy

SveMin

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Svemin, the Swedish Association of Mines, Mineral and Metal Producers, represents around 60 companies with more than 13,000 employees in mining, exploration and technology.

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Foreword

The green transition starts in the mine

In its latest report, the Intergovernmental Panel on Climate Change (IPCC) is clear, the ongoing climate change is both more extensive and faster than the direst projections. How the world acts in the coming years will be crucial to avoid even more catastrophic climate impacts. Wind turbines, solar panels, batteries, and electric cars will play a yet more important role, and they all require access to metals and minerals. In fact, the level of ambition of the climate transition will strongly influence demand for these metals.

Or rather, the availability of raw materials sets the pace of the green transition.

In addition, the dramatic geopolitical changes has highlighted the need for Europe to secure strategic access to raw materials and increased diversification. The newly launched Critical Raw Materials Act can therefore be the paradigm shift that Europe needs. To meet these challenges, the mining in Europe must undoubtedly increase.

Maria Sunér

Hanna Stenegren

As mining only can take place where the mineral resource is located, mining activities comes with a special responsibility. Therefore, the Swedish mining industry has – as the first industry ever – developed a completely new methodology to ensure a strong biodiversity; Mining with Nature. The overall goal is that companies in the mining and minerals industry should make a net positive contribution to biodiversity by 2030 in all areas where they operate.

Sweden is not only the EU's largest mining nation with a great strategic potential, but the Swedish mining industry is also at the global forefront of sustainable mining. The carbon footprint for metals produced in Sweden is already low in a global comparison, and the goal is for the mining to be completely fossil-free by 2035, and the processing climate neutral by 2045.

The green transition starts below ground. In the mine.

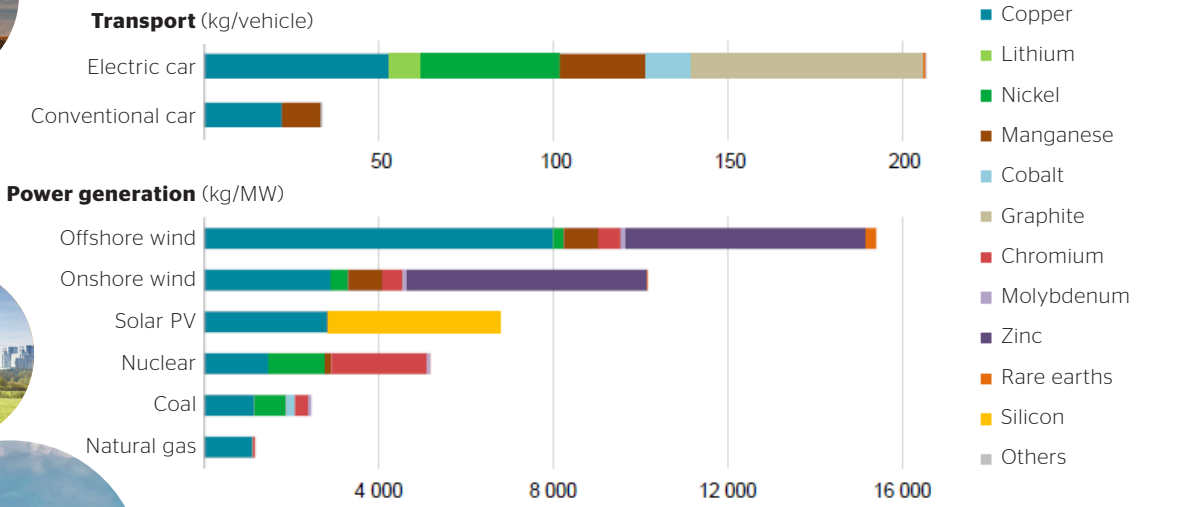
Maria Sunér *CEO, Svemin*
Hanna Stenegren *Director Climate and Energy, Svemin*

The Iron Ore Line is one of the world's oldest railways and crucial for Swedish iron ore exports. It is approximately 500 kilometers long and runs between Luleå in Sweden and Narvik in Norway.

A sustainable green transition requires sustainable metals and minerals

To meet the goal of net-zero emissions globally, six times more metals and minerals will be needed compared with today – and many times more for some specific metals critical to the clean energy supply. Many factors affect the demand for metals, such as economic development, urbanisation, the metal intensity of our economy, and the recycling rate, to name a few.[1]

Metals and minerals used in transition-related technologies

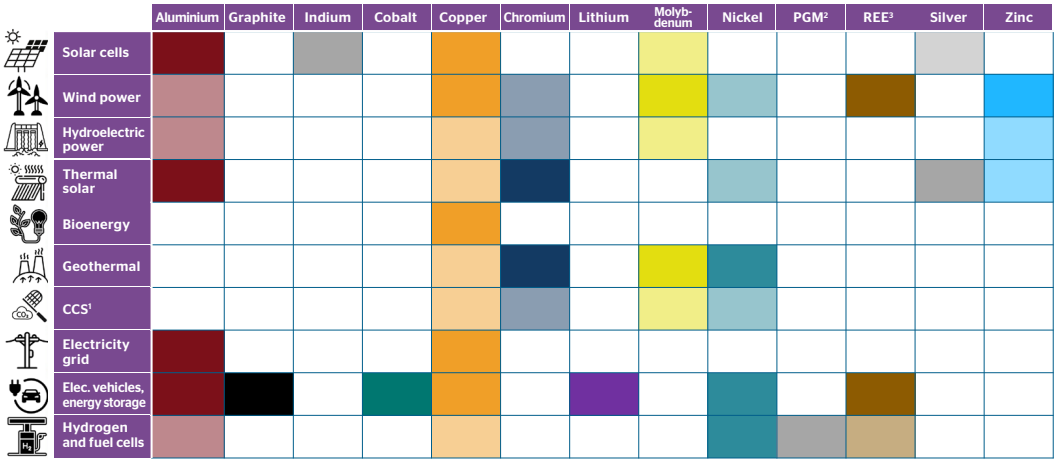


The shift from coal and gas to renewable energy sources increases the requirement for metals by 10–50 times to produce the same amount of electricity. An offshore wind plant requires thirteen times more metals and minerals than a similarly sized gas-fired power plant. The requirement for metals in an electric car is six times greater compared to a conventional car.[2]

1 IEA (2021); Svemin (2021a).
2 IEA (2021); Svemin (2021a).

Relative importance of metals for different climate technologies

Some metals have a fairly narrow area of use but can be critical for these technologies. The list is not exhaustive and excludes iron, for example, which is used in more or less all technologies.



[1] Carbon capture and storage. [2] Platinum group metals. [3] Rare earth elements. Note: Not exhaustive list of metals.

The darker the colour, the more important the metal is for the technology

Source: IEA, World Bank

A faster transition to a net-zero society means an increased demand for metals.

Higher climate ambitions increase the need for metals

For many metals, the most critical driver behind increasing demand up to 2050 will be the climate transition. Three changes linked to the green transition will have a particularly large impact on the demand for metal: the shift to electric battery-powered vehicles, the expansion of renewable electricity (especially solar cells and wind power), and the expansion of the electricity grid, which is a result of the fact that many parts of the economy need to be electrified as fossil fuels are phased out.

These so-called energy-critical metals include lithium, cobalt, nickel, indium, and rare earth metals. Lithium, cobalt, and nickel are metals needed to make batteries for electric vehicles and energy storage. Solar cells use indium while, for example, wind turbines and electric motors use rare earth metals. For these metals, more than half of the future demand will come from climate technologies. Thus, the level of ambition in the climate transition will affect demand significantly – a faster transition to a net-zero society means an increased demand for metals.[3]

3 Svemin (2021a); Svemin (2022).

> Improved recycling could reduce the need for primary metals by 15–26% up to 2050.

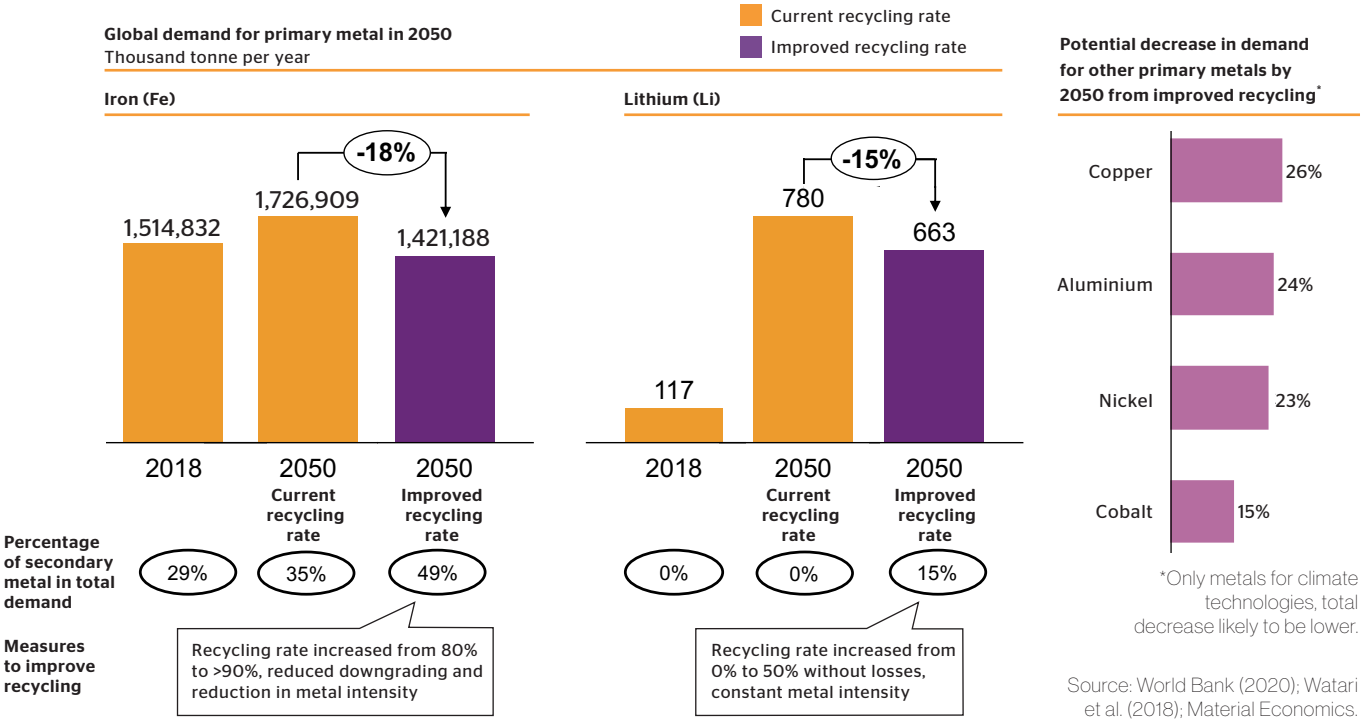
Increased recycling and extraction must go together to meet demand

An essential source of metals is from products that have reached their end-of life. A significant proportion of the iron, copper, aluminium and other base metals used today comes from recycled scrap. Recycling metals has many advantages – it is often more energy-efficient than primary production, in some cases cheaper, and it also reduces the amount of material sent to landfills. So can society meet its use of metals solely by recycling what we already have extracted? Unfortunately, this is not possible, although there is potential for improvements compared to today. Improved recycling could reduce the need for primary metals by 15–26 per cent at most in the period up to 2050.

Increasing the recycling rate is challenging and sometimes requires new technologies and processes for collecting and transforming the scrap to new material. Many metals exist in small quantities along with other metals and other materials, such as plastics. This mix means that there are technical and economic challenges associated with increased recycling that need to be solved. While this ought to have a high priority, as it would result in substantial gains for our society, there remains a significant need for continued mining.[4]

4 Svemin (2021a); The World Bank (2020).

Effect of increased recycling rate on demand for iron and lithium



The figure shows the effects of improved recycling and other circular measures for iron and lithium – two metals that will develop in different directions up to 2050.

Iron is the metal used most, primarily in the form of steel, in everything from cars to bridges to cutlery. Since it is widespread and has a long history of use, 80 per cent of all steel is recycled. However, only about 29 per cent of all newly produced steel comes from secondary metal (scrap). This is because steel products' life often is long, and the global economy is still going through a phase of increased demand for steel. An improved recycling rate could decrease global demand for steel by 18 per cent by 2050. However, more than half of all the iron needed would still come from mining.

Lithium has begun to be used on a larger scale only in recent years, with the technological breakthrough involving lithium-ion batteries. Today practically no lithium is recycled, and the proportion of secondary metal is therefore also zero. Much research is taking place into recycling lithium-ion batteries, and a lithium-recycling industry is being built. However, the share of lithium that will be recycled by 2050 is very uncertain today. If the recycling rate were to reach 50 per cent, the demand for primary lithium would decrease by around 15 per cent by 2050.

The World Bank has carried out a similar analysis for copper, aluminium, nickel and cobalt and the result is similar in all cases. Even if the recycling rate can be maximised, demand for primary metals up to 2050 will only decrease by around 15–26 per cent.[5]

5 Svemin (2021a); The World Bank (2020).

Europe consumes around a quarter of the world's raw materials but produces only 3%.

The EU's heavy import dependency of metals and minerals is a vulnerability

The EU has set one of the world's most ambitious targets for the climate transition. This high ambition means that the EU's need for metals for the climate transition will be relatively higher than other parts of the world.

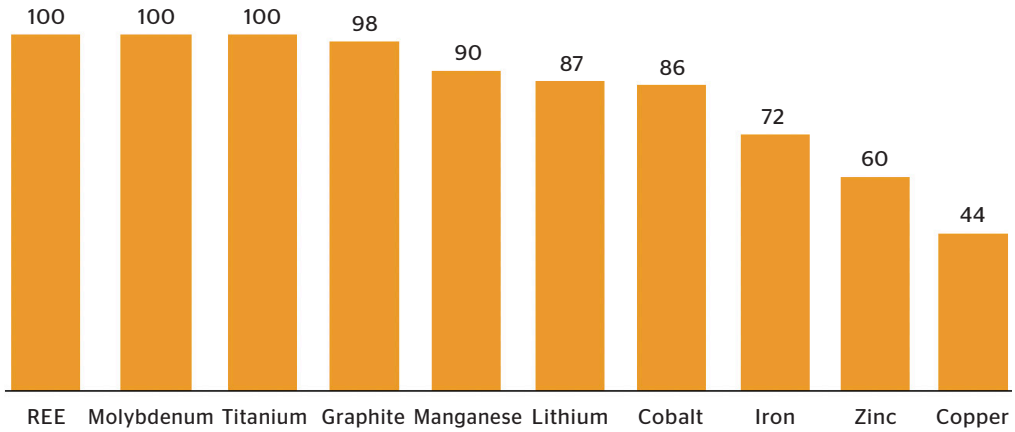
Europe consumes around a quarter of the world's raw materials but only produces three per cent. The metal market is fully globalized and the EU is highly dependent on imports of many metals and minerals from Asia, Africa, and South America. At present, the EU imports 100 per cent of the demand for rare earth elements, molybdenum, titanium, and nearly all of the need for graphite, manganese, lithium, and cobalt – critical metals used for electric cars, batteries, and wind turbines.[6]

Import dependency of selected metals and minerals

Europe imports a majority of the metals it requires. For some metals the EU is completely dependent on imports.

Level of dependency on imports per metal

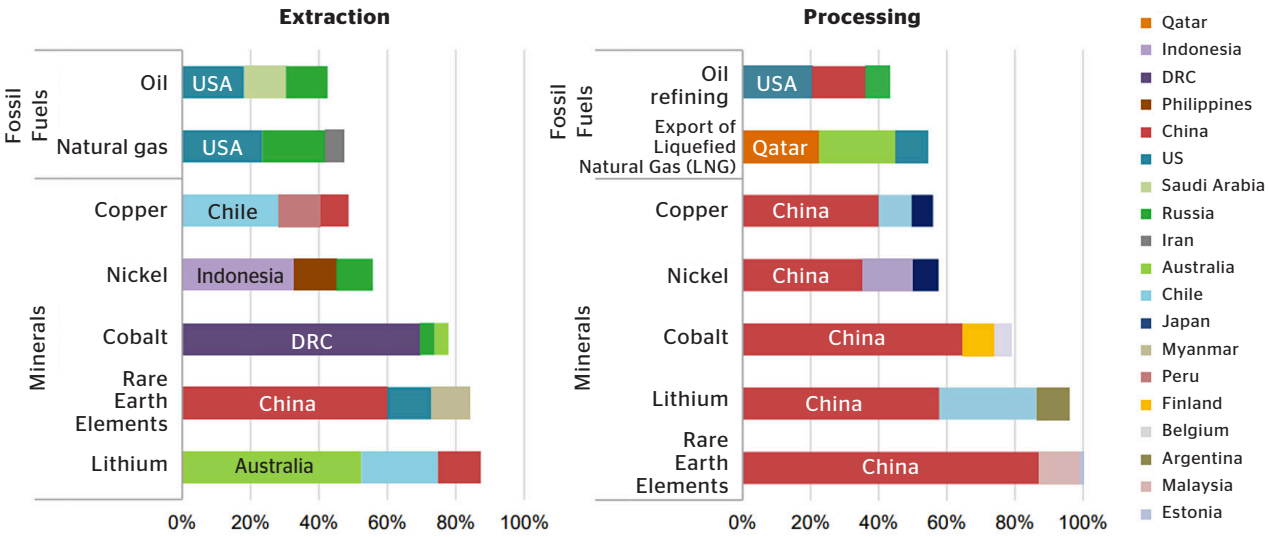
Per cent



Note: Import dependence on extraction (non-processing)
Source: Study on the EU's list of Critical Raw Materials (2020)

6 SGU (2021a); Svemin (2021).

At present, the production of many minerals critical to the energy production and supply needed in the transition to a climate-neutral society is more geographically concentrated than oil and gas.
The chart shows the share of production of certain minerals and fossil fuels in the top three countries produced.



Extraction refers to the process of obtaining (extracting) raw materials from our environment and is also referred to as the mining or harvesting stage. Processing refers to a series of operations and treatments that transform raw materials from a raw-material state into substances which are then used to make semifinished and finished products. Also referred to as the post-mining or postharvesting stage.

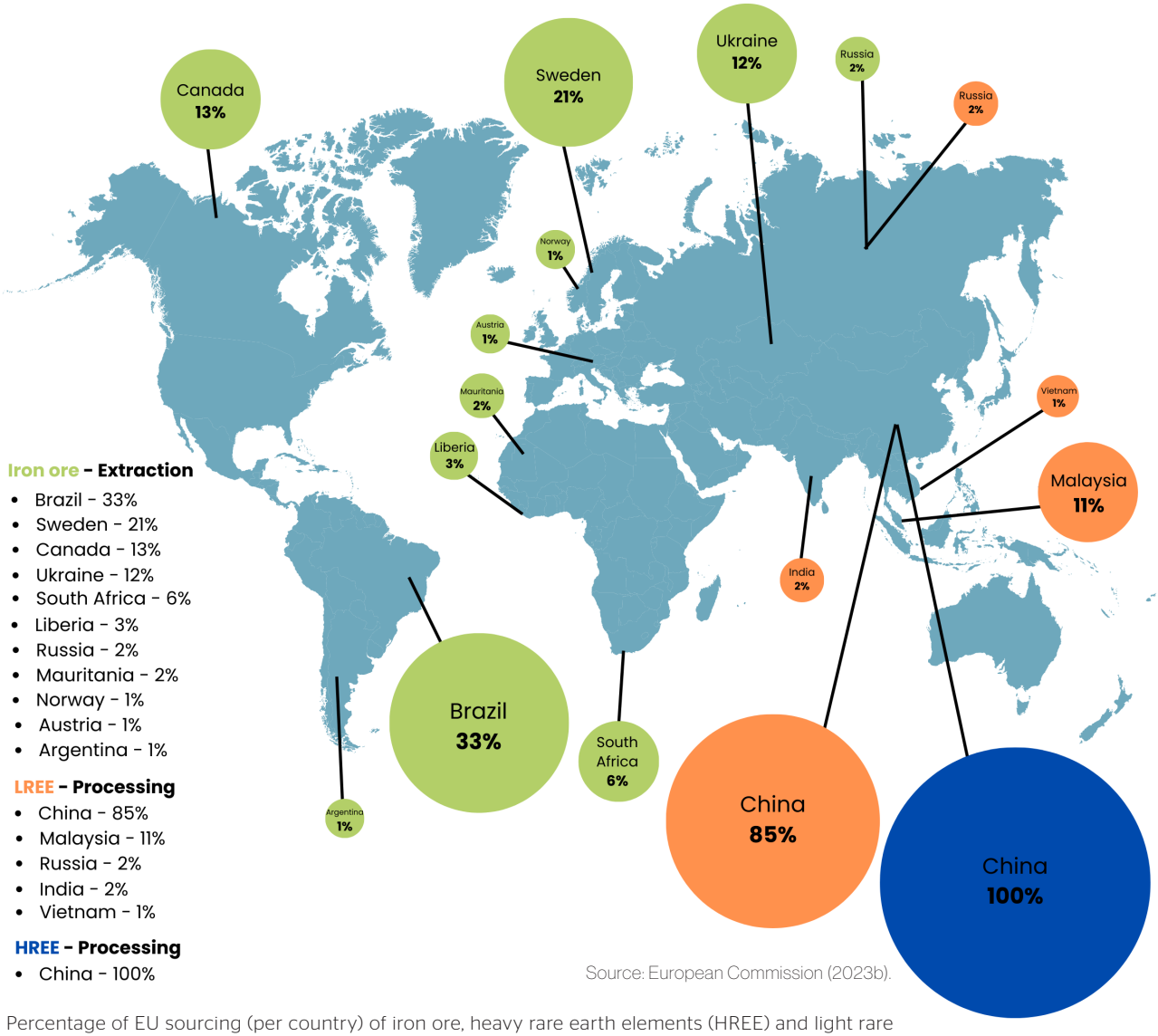
Image source: IEA (2021) The Role of Critical Minerals in Clean Energy Transitions

How and where minerals and metals are produced matter

Many of these critical metals and minerals are currently produced in countries with low environmental standards, a high climate footprint, and poor working conditions. Moreover, import dependency, especially where a substantial proportion of the supply comes from one or a few countries, creates great uncertainty in terms of security of supply, transparency in the value chain, and geopolitical risks.[7]

7 Copenhagen Economics (2021).

Major EU sourcing countries of – **Iron ore**, **HREE**, **LREE**



Iron ore – Extraction

- Brazil – 33%
- Sweden – 21%
- Canada – 13%
- Ukraine – 12%
- South Africa – 6%
- Liberia – 3%
- Russia – 2%
- Mauritania – 2%
- Norway – 1%
- Austria – 1%
- Argentina – 1%

LREE – Processing

- China – 85%
- Malaysia – 11%
- Russia – 2%
- India – 2%
- Vietnam – 1%

HREE – Processing

- China – 100%

Source: European Commission (2023b).

Percentage of EU sourcing (per country) of iron ore, heavy rare earth elements (HREE) and light rare earth elements (LREE). Even for important metals like iron, the EU is dependent on a few high-producing countries. Disruptions in the production chain in individual countries can therefore have a major impact on supply. Maintaining and strengthening competitive iron ore production in the EU is therefore crucial. The iron ore in Kiruna also contains REE and is planned to be extracted as a by-product of the iron ore, which in turn can reduce dependency on China if the processing stage can be located in the EU.

Access to metals and minerals expected to become scarce

In the short term, the supply of certain metals and minerals necessary for the green transition is expected to become scarce as demand increases. In the medium term, this will apply to most metals and minerals, as the expected demand exceeds the expected supply from existing mines and projects underway.

This means that significant investments will be required both within the EU and globally to meet this increasing demand. Due to the often long lead times for new projects, there is a clear risk that the green transition will both slow down and become more expensive due to shortages of metals and minerals.[8]

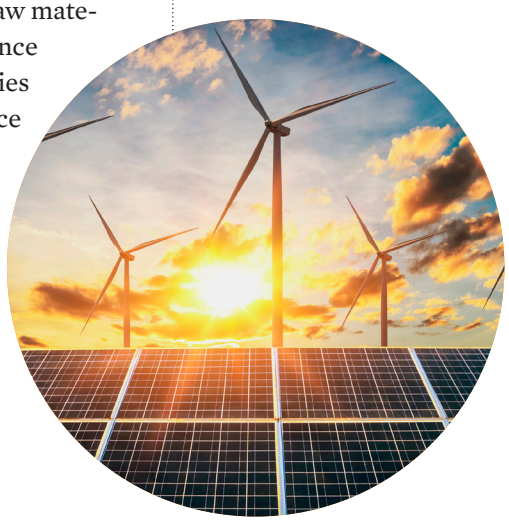
Expanding domestic production is a means of improving the security of supply and ensuring the metals and minerals are produced in sound working conditions, in compliance with tough environmental regulations, and with a low climate impact from an international perspective.

> There is a clear risk that the green transition will both slow down and become more expensive due to shortages of metals and minerals.

Ensuring EU's access to critical raw materials

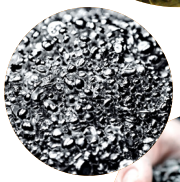
The EU has taken action to ensure the availability of crucial metals and minerals. Since 2014, the EU-commission has established a list of identified critical raw materials as a priority action of the EU Raw Materials Initiative of 2008. The list is updated every four years.

In 2023, along with the CRMA proposals, the list was updated to include 34 different critical raw materials, some of which are designated as strategic. Critical raw materials are selected according to the two main parameters economic importance and supply risk. Strategic raw materials are defined as crucial to technologies important to Europe's green and digital ambitions and for defence and space applications, while being subject to potential supply risks in the future. A critical raw materials act proposes a comprehensive set of actions to ensure the EU's access to a secure, diversified, affordable and sustainable supply of critical raw materials.[9]



8 IEA (2021).

9 European Commission (2008); (2020); (2023b).



Sweden – Europe's major mining nation

Sweden has a long history of mining and metal refining stretching back more than a thousand years. Today, Sweden is a leading mining producer in a global metal market, and a crucial part of EU's supply of metals such as iron, zinc, copper and lead. Sweden accounts for more than 90 per cent of the EU's production of iron and more than a third of the production of lead and zinc. Sweden is also the EU's sole mining producer of tellurium.

Over the years, Sweden has developed an internationally leading business, in which not only mining companies are at the forefront. Sweden has also built industries around the mines, such as world-leading technology companies specialising in mining equipment and engineering.[10]

10 Svemin (2021a).

Metals mined in Sweden

Fe **Iron** is the main ingredient in steel, which is a real community builder. We use it almost everywhere; in bridges, walls, floors, roofs, trains, cars and not least in machines and tools that in turn make other products. Steel is the most widely used metallic raw material in the world, used more than 20 times as much as all other metals combined.

Cu **Copper** is used to conduct heat and electricity and connects our world in many ways. Copper is also bactericidal and can be used in, for example, door handles. You can find copper in electronics that are in your computer, mobile phone and TV. Copper is the world's third most widely used metal after iron and aluminum.

Zn **Zinc** is used in, among other things, surface treatments by galvanizing and hot-dip galvanizing to prevent corrosion. It is also used in batteries where the most common use is as a negative pole in alkaline batteries. Zinc is also found in a variety of medical and cosmetic products.

Au **Gold** works well as a conductor of electricity and is therefore used in telephones, computers, hi-fi products and other electrical appliances. In addition to its presence as a component in the electronics, space, and pharmaceutical industries, the jewelry industry is still the largest user of this precious metal.

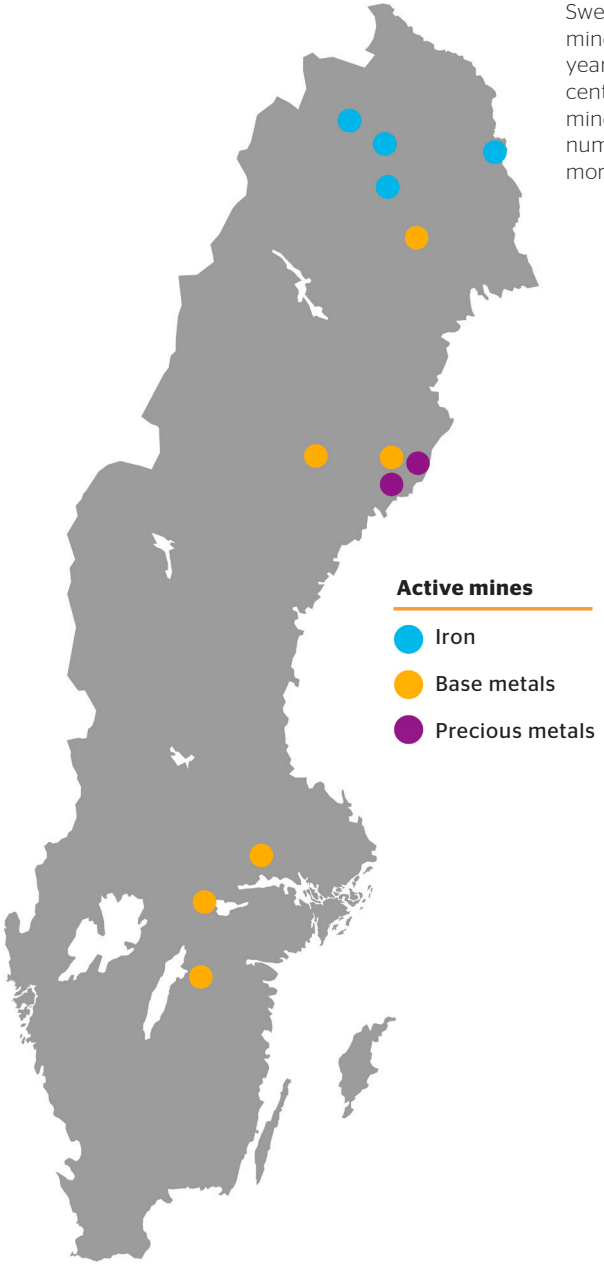
Ag **Silver** conducts heat and electricity best of all metals and is used in batteries, connectors and circuit boards in electronics such as mobile phones and computers. It is also used in solar cells, aircraft and satellites as well as in healthcare because it is antibacterial.

Pb **Lead** is important in healthcare where it is used in protective equipment, as it protects against ionizing radiation used in X-rays. The metal is also an important part of larger batteries such as car batteries and at reserve power plants. Because lead provides good and long-lasting moisture protection, it is used in cables and wires, especially underground or in water.

Te **Tellurium** is an important component in the transition to fossil-free electrical power production, and it's used as a semiconductor in the manufacture of solar panels. Tellurium can also be found in alloys together with other metals, since it makes stainless steel and copper easier to work, for example.

Source: Svemin (retrieved 2023b).

Active mines in Sweden 2022



Sweden currently has twelve active mines – half of them are more than 50 years old. At the beginning of the 20th century, Sweden had around 250 active mines, yet despite the decrease in the number of mines, total production has more than doubled.

Sweden's mining production 2021 in relation to the EU

Gold:	**17%**
Silver:	**19%**
Copper:	**11%**
Zinc:	**31%**
Lead:	**32%**
Iron:	**93%**
Tellurium:	**100%**

Source: SGU (2022b).

> Sweden has a long history of mining and metal refining stretching back more than a thousand years.

Water sampling. The total discharge of metals to water from Swedish mines in operation was 2,079 kg in 2019. In comparison, the country's largest water treatment plant, Henriksdal in Stockholm, released 3,845 kg of metals to water during the same time period.[11]

The life of a mine

Sweden, and Europe, has some of the highest environmental standards in the world. This includes the standards for mining. The life of a mine can be divided into three main phases – exploration, production and remediation.

The permit granting process is extensive and usually takes more than a decade. The process can be divided into several phases.

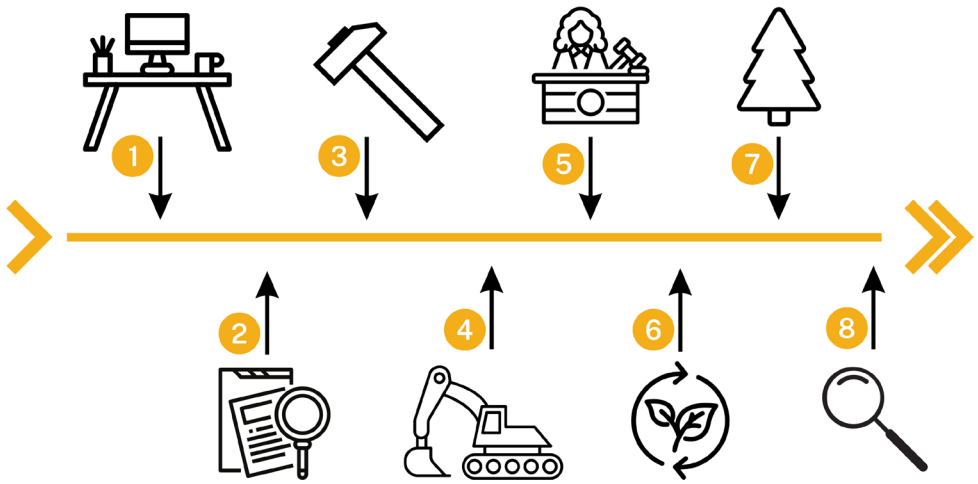
Sweden's mining and mineral companies surpasses the legislative demands with their own far-reaching environmental objectives, implementation of environmental management systems, and technological development efforts. The Swedish mining sector and Sweden's suppliers are world leaders and international role models, which benefits the environment and the development of society globally. What's more, growth in production from Sweden's climate-smart businesses could lead to a reduction in emissions globally.[12]

11 Svemin (2020b)

12 Svemin (retrieved 2023a); SGU (2018); Svemin (2021b); Den Svenska Gruvan (retrieved 2023b).

From exploration to mine

Somewhat simplified, this is how the legislative process works:



Now mining can begin!

1. Studies of available data and maps in order to locate a possible deposit.

2. An application for an exploration permit according to the Minerals Act is to be submitted to the Mining inspectorate of Sweden.

3. A work plan, containing how the exploration operations are to be carried out, is to be submitted and communicated to stakeholders.

4. The Mining inspectorate grants an exploitation concession according to the Minerals Act if the mining is considered appropriate.

5. The Land Environment Court considers applications for environmental permits under the Environmental Code. Permits are granted on condition that the applicant puts up a bond to cover clean-up costs.

6. The Mining Inspectorate allocates land for mining purposes under the Minerals Act.

7. The Municipality grants building and land permits under the Planning and Building Act.

8. Mining can begin.

Source: SGU (2018); Svemin (2021b).

Thanks for the loan – remediation of mines

According to the law, open pit and underground mines must undergo land reclamation and remediation by the mining operator post-mining activities, for the purpose of protecting nature and environment.

Remediation involves several steps, including cleaning up and decommissioning the mining area or taking care of waste to minimize discharges over time. Different techniques and technologies are used to mitigate discharges of metals or substances that may pose a risk for environment. These are described in a land reclamation and remediation plan developed by the mining operator in collaboration with the supervisory authority. Among other things, the nature of the waste, the appearance of the area, infiltration, watercourses or groundwater levels impact the choice of method.

The objective of land reclamation and remediation is to create a long-term stable solution that will avoid exposing nature or humans to environmental risks. The aim is to restore the area so that it can become part of the surrounding landscape once more and be used for other purposes, such as reindeer husbandry or biodiversity. In some cases, land reclamation can be done with a focus on the goal of re-establishing the original condition (pre-mining), such as a forest. If possible, the operator can setup a facility that will have some value for the local community, such as a park, if the geology allows this.

To ensure that there is sufficient money for the land reclamation and remediation work, the mining operator provides a financial security bond that is managed by the supervisory authority[13].

Pulsatilla patens.

13 SGU (2022a); Boliden (retrieved 2023a).

Kiirunavaara mining area.

Land restauration vision for the Kiirunavaara mining area.

> The aim of remediation is to restore the area so that it can become part of the surrounding landscape once more.

LKAB's land restauration vision for the Kiirunavaara mining area

As a voluntary commitment based on the company's guidelines for sustainable land use, LKAB has developed a vision for how the mining area in Kiruna should be restored and developed after the mining operations have been discontinued. When the mine closes, a technical rehabilitation will be carried out to make the area safe for the environment, people and animals. This will be followed by ecological landscaping. "With this vision, we can create great natural and social benefits when ecosystems can be restored and developed. This in turn benefits biodiversity, improves water treatment and allows the land to be used for grazing and rest areas for reindeer husbandry", says Emma Nyberg, development engineer project manager, LKAB.[14]

14 Ecogain (retrieved 2023b).

Production of ore and metals in Sweden is 60–90% less emissions intensive than equivalent production internationally.

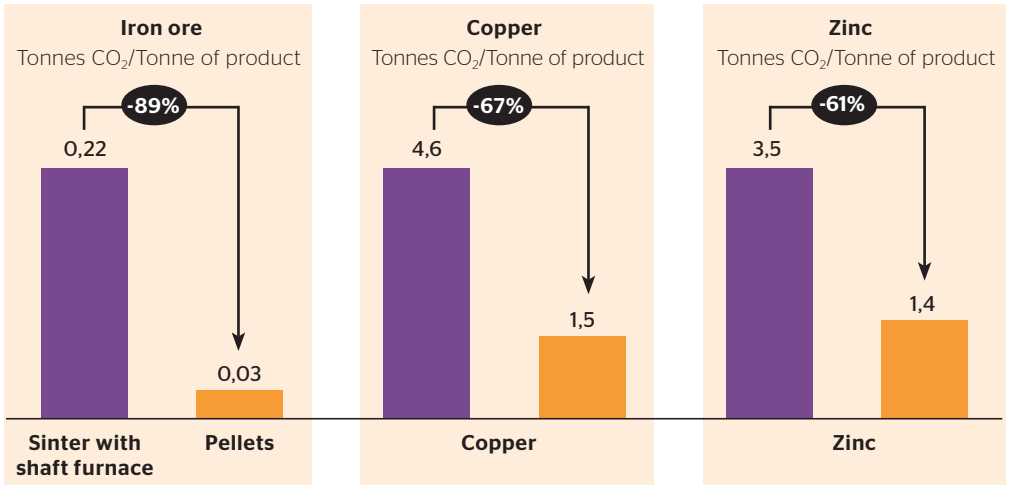
Swedish mining has a low carbon footprint

The current production of ore and metals in Sweden is 60–90 per cent less emissions intensive than equivalent production internationally.

The low emissions can be explained by the availability of favourable raw materials and almost completely fossil-free electricity in combination with major investments in climate-smart technology, efficient processes, and electrification of both transportation and processing. This has led to significantly lower emissions per tonne of product than the global average.

The close cooperation between mining sector companies, metal producers, machine suppliers, and research has, together, produced highly efficient mines that are widely regarded as among the most efficient in their class.[15]

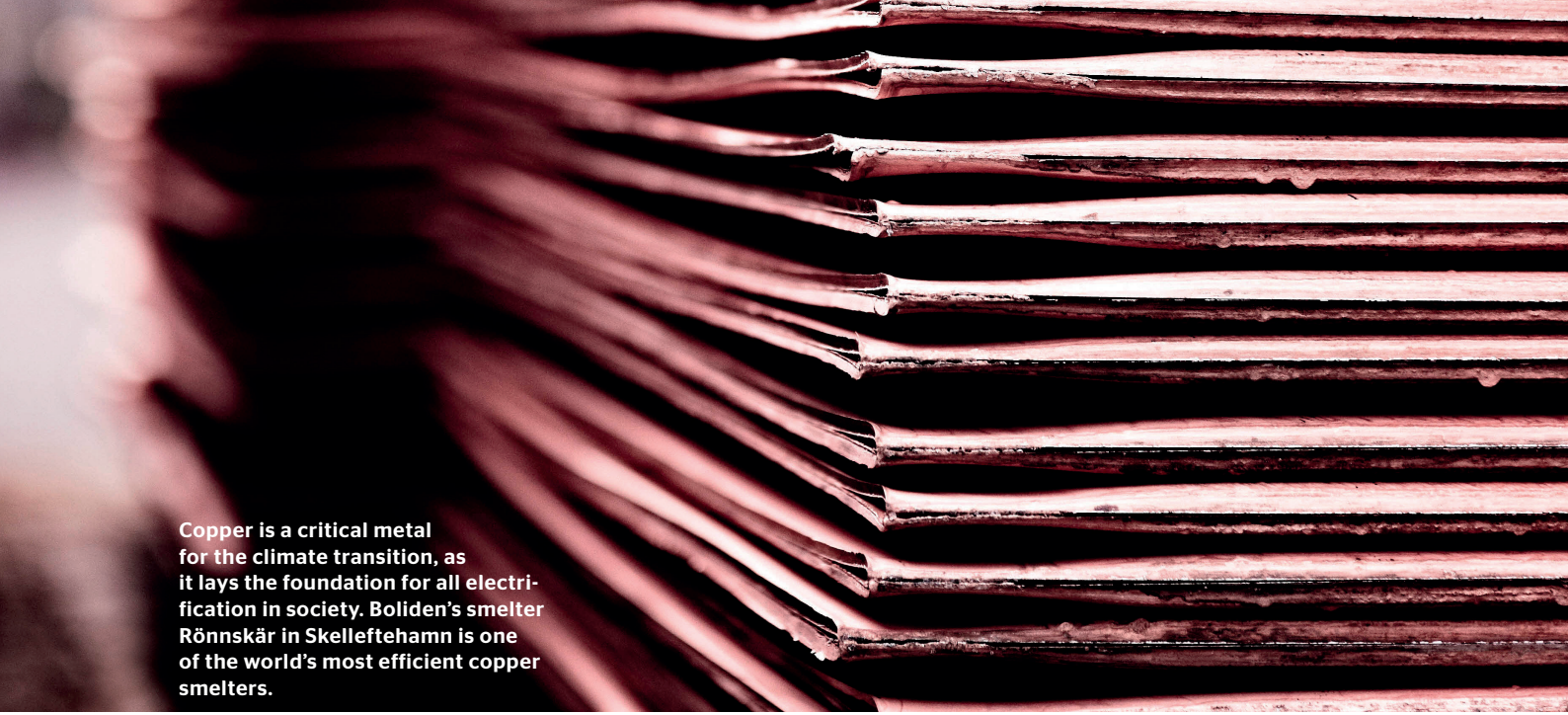
The Swedish mining and metal sector has a significant lead in the green transition



Emissions from iron ore include mining, enrichment, and refining into iron ore products (pellets and sinters). Emissions for copper and zinc include mining (within Sweden), enrichment and refining into finished metal.

Source: Material Economics (2022).

15 Svemin (2022).



Copper is a critical metal for the climate transition, as it lays the foundation for all electrification in society. Boliden's smelter Rönnskär in Skelleftehamn is one of the world's most efficient copper smelters.

Boliden has introduced the world's first low carbon copper and zinc

Boliden's Low Carbon Copper and Low-Carbon Zinc are produced from concentrate from Boliden's own mines with a drastically lower carbon footprint than the global average. According to calculations verified by an external party, the copper products have emissions of 1.5 kg CO_2/kg copper, compared with the global average of 4.1 CO_2/kg. Boliden's Low-Carbon Zinc emits less than 1 kg CO_2/kg zinc, compared with the global average of 3.64 CO_2/kg. Boliden has also launched Recycled Copper and Zinc, which are produced from secondary raw materials.

Boliden reduces carbon footprint of world's largest offshore wind farm

The world's largest offshore windfarm, Dogger Bank, has chosen to use Low-Carbon Copper from Boliden in its high-voltage offshore export cable systems for the third phase of the project, Dogger Bank C. By using Low-Carbon Copper, the CO2-footprint of this part of the windfarm will be reduced by more than 23,000 tons.

Great potential for European critical raw materials in Sweden

Sweden has the potential to mine many metals and minerals critical to the clean energy supply and innovation required for the green transition. More than half of the metals and minerals on the EU's list of raw materials considered critical for our society and welfare have been found in the Swedish bedrock.

Building up European domestic production is one way of improving the security of supply. Another advantage is the potential value-chains associated with the products, creating jobs and growth as well as potentially lowering the production costs. An additional benefit is that it increases opportunities to observe and influence the environmental impact of the extraction, favoring opportunities to construct a strong industry around climate-technology value chains.[16]

Selection of critical raw materials and its applications

Co **Cobalt** is a sought-after metal for the green transition. It is needed, for example, in turbines. It is also magnetic in a way that makes it important for rechargeable batteries of various types such as lithium-ion batteries, nickel-cadmium batteries and in nickel-metal hydride batteries. A metal that is simply needed, that exists in Sweden but is not mined. Instead, mining largely takes place in the Democratic Republic of the Congo.

Li **Lithium** is used primarily in lithium batteries, which are found in electric cars and other vehicles that run on electricity. In other words, lithium is very important for the future of a climate-smart society. It is also used in the manufacturing of special glass for things like telescopes and in alloys for making lightweight and durable construction materials. Lithium is not being mined in Sweden today, but it exists in the bedrock.

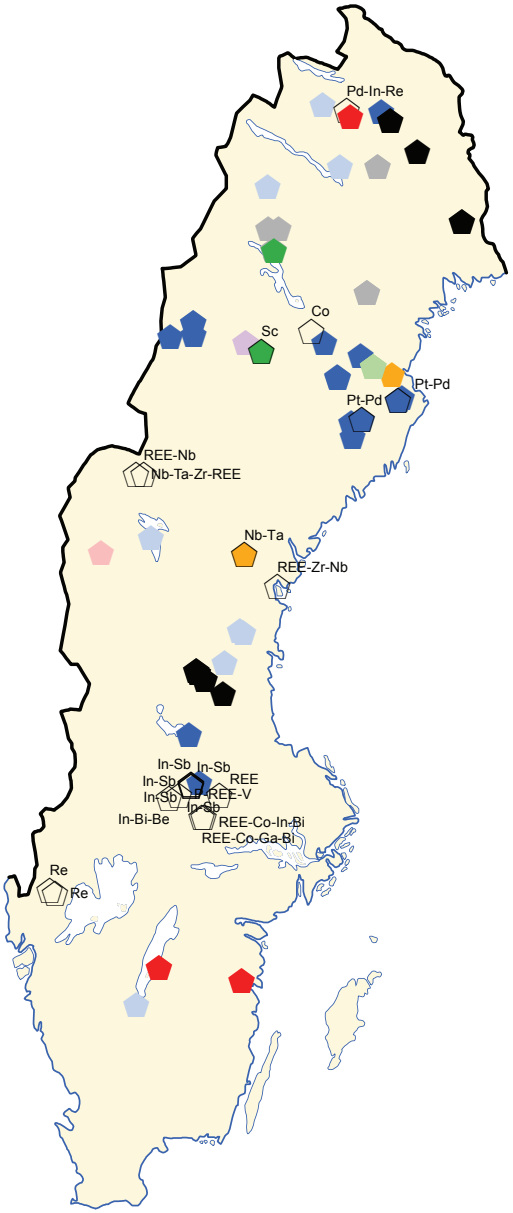
Source: Den Svenska Gruvan (retrieved 2023a).

Nd Dy **Neodymium** and **Dysprosium** are two of the seventeen rare earth elements (REE). Their role in the climate transition is primarily about their magnetic properties, which allow them, despite their small size, to efficiently transfer energy. For example, from the battery to the wheel in your electric car, or in generators in wind turbines for sustainable electricity supply. No mining takes place in Sweden today, but deposits can be found in several places.

V **Vanadium** is used primarily in alloys with other metals. But it can also be used in so-called "flow batteries." These are large, stationary, rechargeable batteries with long life, high capacity, and rapid response time. That means they can contribute to the energy sources of the future, since flow batteries are ideally suited to storing energy from sources like wind power plants. Vanadium is found in Sweden's bedrock, but it is not yet being mined.

16 Hallberg & Reginiussen (2019); Nordic Innovation (2021); Svemin (2021a).

Estimated ore deposits with critical raw materials in Sweden



The map shows deposits with ore estimates that include some critical raw materials. The map also shows discoveries where new analyses or digitised older analyses have demonstrated the presence of some critical raw materials in closed mines, in mining waste or in exploration projects.

Mineral resources

- cobalt
- lithium-tin
- rare earth elements
- graphite
- tungsten
- platinum-palladium
- titanium-vanadium
- molybdenum
- tellurium
- fluorspar

New analyses

Source: Hallberg & Reginiussen (2019).

> More than half of the metals and minerals on the EU's critical raw material's list have been found in Sweden.

Talga's graphite becomes anode material for green batteries

As one half of the active materials in a lithium-ion battery, green anodes can dramatically reduce the CO_2 emissions of making electric vehicles, energy storage systems and consumer electronics. Talga's natural graphite anode material has an extremely low climate footprint – 96 per cent lower than the Chinese dominating product on the market today. Europe is currently 98 per cent dependent on imports for our graphite supply. Talga's graphite project in Vittangi is expected in its first stage to supply anodes for roughly 200,000 newly produced electric cars each year.[17]

Europe's largest deposit of Rare Earth Elements found in Kiruna

LKAB has identified significant deposits of rare earth elements in the Kiruna area in northern Sweden, in the form of Rare Earth Oxides, which are used to produce Rare Earth Elements (REE). This would be sufficient to meet a large part of the EU's future demand for manufacturing the permanent magnets that are needed for electric motors in, among other things, electric vehicles and windpower turbines. No rare earth elements are currently mined in Europe. The demand for rare earth elements for electric cars and wind turbines, among others, is expected to increase more than fivefold by 2030. Today, Europe is dependent on imports of these minerals, where China completely dominates the market.[18]

17 Svemin (2022).
18 LKAB (2023).

Copper project to support Europe's electrification

Boliden is currently developing a large scale copper project in northern Sweden. In operation, the mine could produce equal to ten per cent of the copper production in Europe today. The deposit is also strategically located close to one of Boliden's copper smelters and existing infrastructure will support efficient and climate effective transportation. Copper demand is likely to increase heavily in light of electrification and decarbonization of economies.

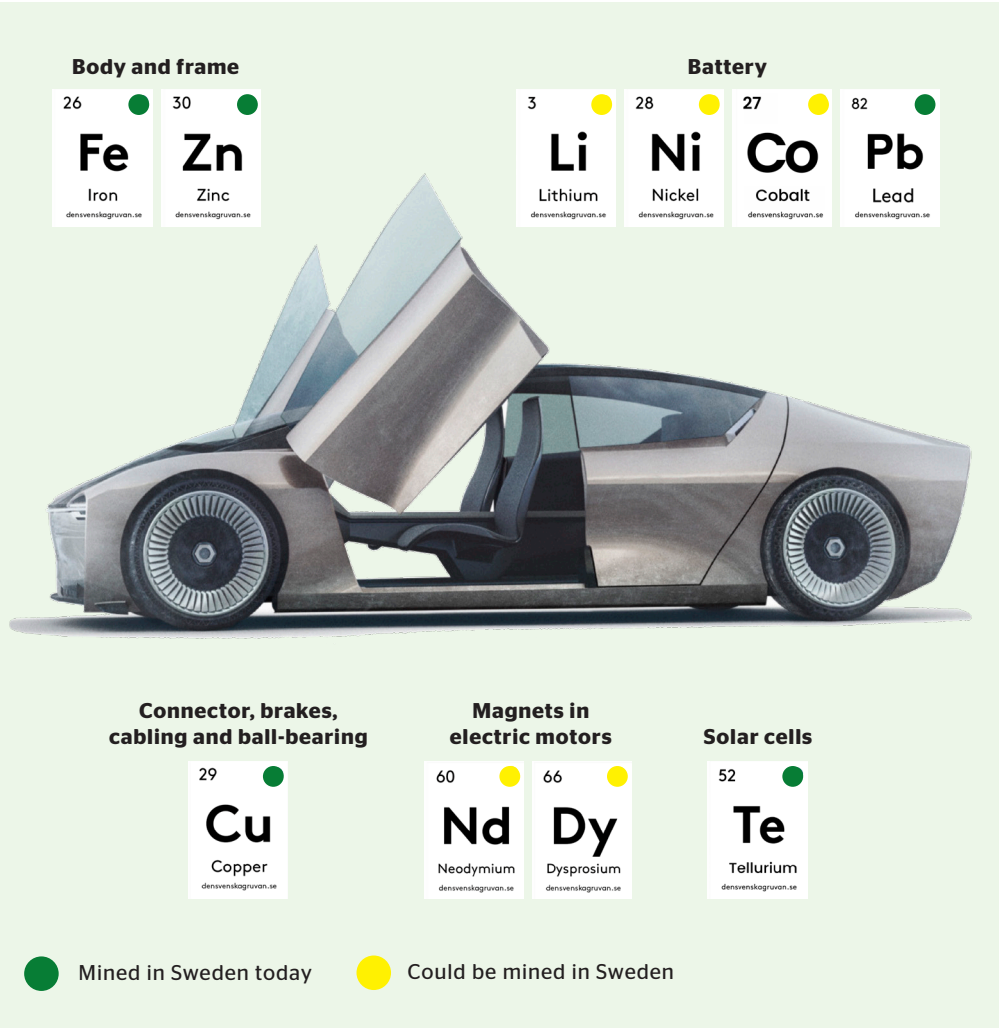
One of the world's largest deposits of Heavy Rare Earth Elements located in Norra Kärr

The rare earth element deposit in Norra Kärr is one of the largest known deposits in the world of heavy rare earth elements, and represents an opportunity for production that can cover large parts of Europe's need for a number of metals. It has one of the lowest levels of uranium and thorium globally, which can otherwise cause challenges in waste management. Research has shown that the extraction of rare earth elements from Norra Kärr would mean a greatly reduced impact on the environment and climate compared to existing production in China, the United States, and Australia. Leading Edge has identified that the deposit in Norra Kärr can provide earth metal oxides sufficient for the production of strong permanent magnets for 1–2 million electric cars per year.[19]

19 Svemin (2022).

Most of the metals an electric car needs are found in Sweden's bedrock.

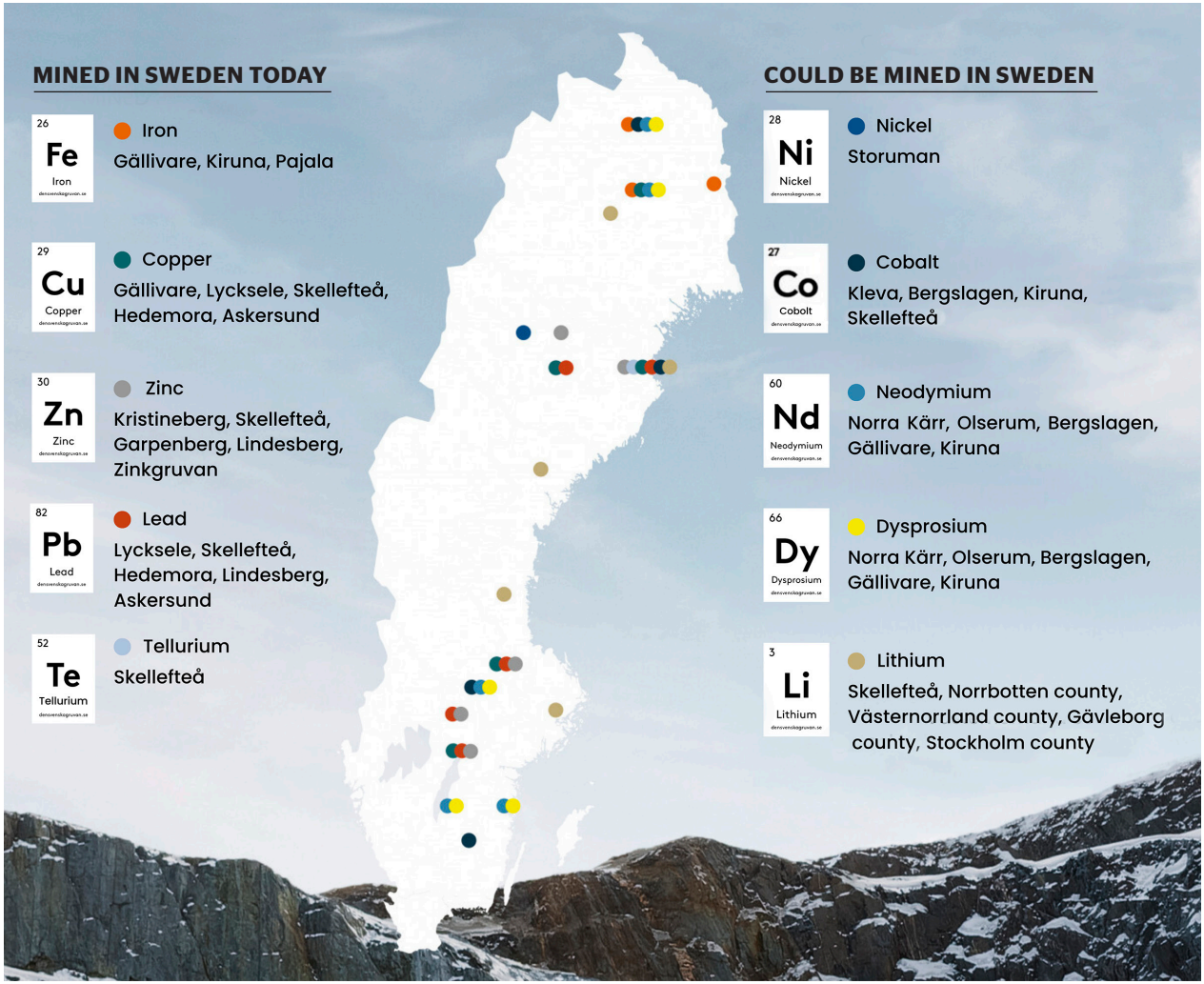
Swedish potential for metals needed in electric car



Metals and minerals in an electric car that are extracted in Sweden today or that could potentially be extracted, i.e. that deposits have been identified. Most of the metals an electric car needs are found in Sweden's bedrock. Aluminium is also crucial, but there are no known deposits in Sweden.

Source: Den Svenska Gruvan

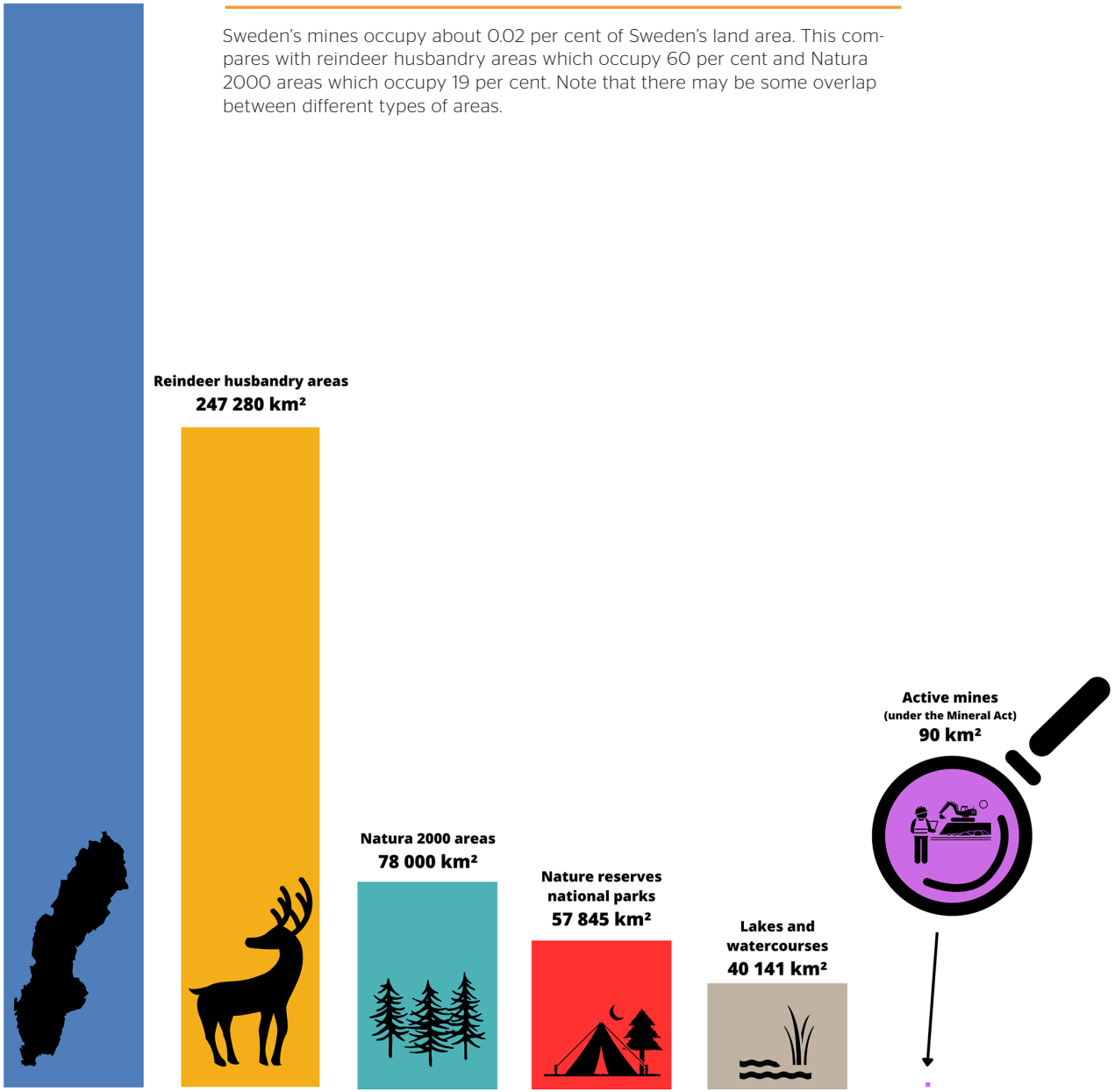
Swedish deposits for metals needed in electric car



This is an example of metals and minerals that are extracted, and known deposits that could be extracted in Sweden.
Source: Den Svenska Gruvan

The total area for Sweden's...

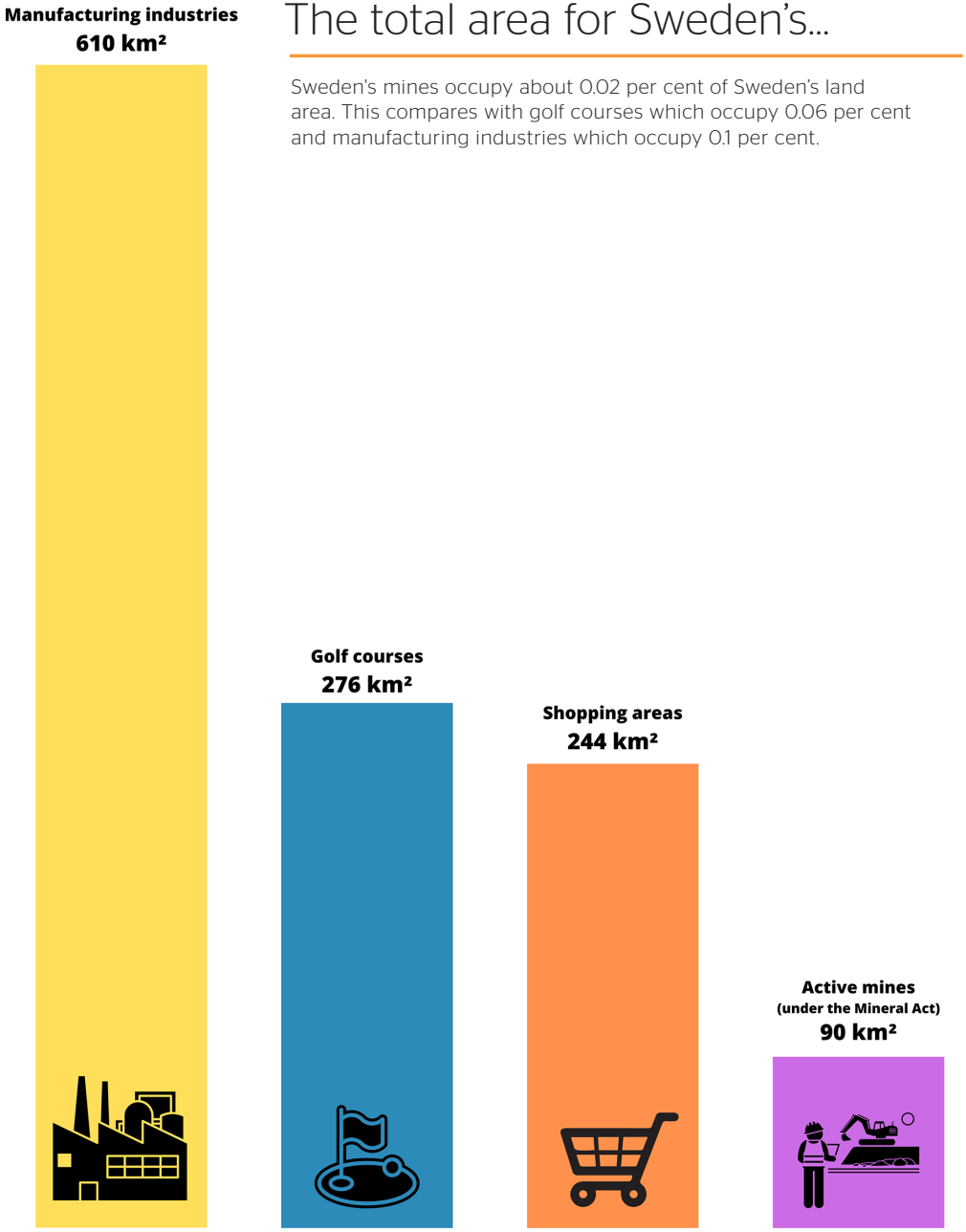
Sweden's mines occupy about 0.02 per cent of Sweden's land area. This compares with reindeer husbandry areas which occupy 60 per cent and Natura 2000 areas which occupy 19 per cent. Note that there may be some overlap between different types of areas.



Source: Statistics Sweden, The Geological Survey of Sweden, The Swedish Environmental Protection Agency.

The total area for Sweden's...

Sweden's mines occupy about 0.02 per cent of Sweden's land area. This compares with golf courses which occupy 0.06 per cent and manufacturing industries which occupy 0.1 per cent.



Source: Statistics Sweden, The Geological Survey of Sweden, The Swedish Environmental Protection Agency.

Sweden's mines occupy about 0.02% of Sweden's land area.

The industry's sustainability targets

The mining and mineral industry has jointly adopted a number of overall objectives for climate and sustainability work. These point out the direction for the long-term work that the industry's companies have undertaken to implement, and require both a strong commitment and large investments from the companies to become a reality.

Environmental sustainability targets

- Contribute to increased biodiversity in all the regions where mining and exploration are ongoing at the latest by 2030.
- Fossil-free mining by 2035.
- Climate-neutral processing and fossil-free energy use by 2045.
- To recycle as many residual products in production as possible and to work towards further synergies between primary and secondary raw materials.

Social sustainability targets

- Aim to be an active player and make a positive impact in the communities where we operate.
- The mining industry and reindeer husbandry to co-exist in the long run with a fair, positive, and respectful dialogue.
- That the workplaces in our companies are free from accidents and work-related ill-health.
- Develop healthier, safer and more attractive workplaces for all women and men based on modern leadership, organisation, and technology and included in the digital and green industrial transformations.

Economic sustainability targets

- The Swedish mining cluster is to be a global leader in terms of technological development and research in mining and mineral-related issues.
- The companies to remain competitive at the global market through the green transition.
- Secure the right skills and knowledge to enable the green transition.

The 2030 Agenda for Sustainable Development and Global Goals are integrated and cover three dimensions of sustainable development: economic, social and environmental. The mining and mineral industry's companies have both an opportunity and an obligation to influence all these dimensions, both locally and globally.

Environmental sustainability

Targets

- ✿ Contribute to increased biodiversity in all the regions where mining and exploration are ongoing at the latest by 2030.
- ✿ Fossil-free mining by 2035.
- ✿ Climate-neutral processing and fossil-free energy use by 2045.
- ✿ To recycle as many residual products in production as possible and to work towards further synergies between primary and secondary raw materials.

Preconditions to reach the targets

- ➜ Efficient and predictable environmental permit processes to ensure the new and necessary, climate-efficient investments can become a reality.
- ➜ Access to fossil-free electricity and biofuels at competitive costs.
- ➜ Removal of barriers by the political level and closer cooperation between businesses, authorities, and civil society.
- ➜ To increase recycling further, more knowledge, technological developments and amended policy instruments, market instruments, and incentives are all required as well as the targeted coordination of different bodies and infrastructure that enable the implementation of these measures.

Mining with nature

The basis for achieving the target to contribute to biodiversity net gain by 2030 in all regions where mining and minerals operations and exploration take place, is to fully implement the steps of the mitigation hierarchy, which is an internationally accepted methodology and guideline for the considerate management of biodiversity in various development projects[20].

Through the Mining with Nature roadmap, the industry has taken important steps in setting goals and proposing industry-wide working methods and solutions. In order to facilitate implementation of the mitigation hierarchy at all member companies, further work is being done to develop industry specific guidelines on various topics, online trainings on biodiversity for staff, as well as joint reporting on biodiversity for transparancy.

A guidance for Biodiversity Management Plans have been developed as a tool to incorporate biodiversity activities in everyday operations at site, by assigning mandates, allocating resources and developing competence and surveying risks, dependencies and opportunities. Key performance indicators has also been developed to enable tracking progress towards the goal.

The next steps include developing more guidance documents on for example ecological compensation and habitat banking, ecological restoration, and evaluation of significant biodiversity aspects.

Developing a new biodiversity valuation model

The tool CLImB (Changing Land Use Impact on Biodiversity) has been developed in order to assess nature in Sweden and the Nordics in a transparent and comparable way. It enables the calculations in all parts of the mitigation hierarchy. Ways of working with CLImB is unique thanks to a strong cross-industry commitment. In close collaboration between companies, industry associations, municipalities and authorities, CLImB is being implemented as a new biodiversity valuation model[21].

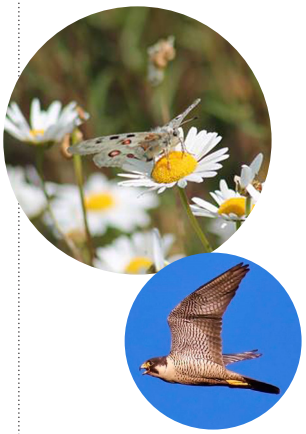
Working according to the mitigation hierarchy means:

Step 1: Avoid impacts and adapt the project, perhaps with a different location.

Step 2: Where nature will still be adversely affected, minimize the impact as far as possible.

Step 3: Build nature restoration into the project.

Step 4: Offset for and balance any remaining loss of nature that still occurs despite steps 1–3. Offsetting can be done elsewhere and may contribute to an overall, net positive impact.[22]



20 Svemin (2020b).

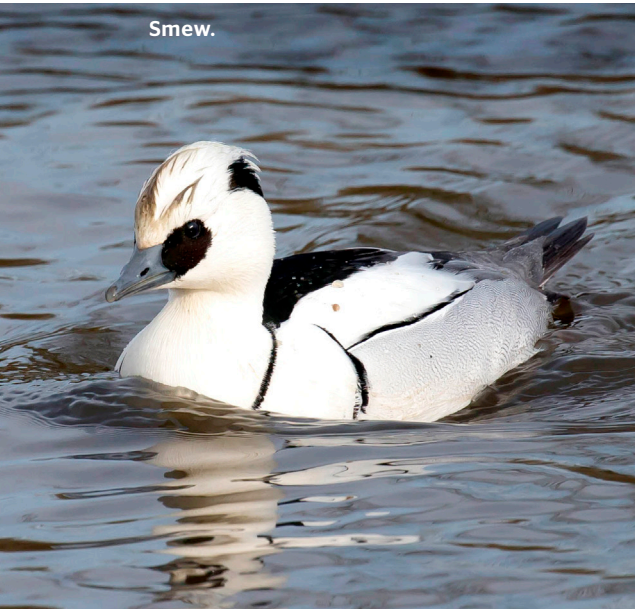
21 Ecogain (retrieved 2023).

22 Ecogain (retrieved 2023).

Step 1: **Avoid impact example: Nordkalk avoids prospecting and mining in areas with high biodiversity**

Nordkalk avoids prospecting in areas with high natural values. “For example, on Gotland, there are many areas we have refrained and divested over the years,” says Tua Welin, environmental manager at Nordkalk, Sweden. Even before Nordkalk began to work with the mitigation hierarchy more strictly, avoidant measures were applied as knowledge of high natural values became known. “On Gotland, we ceased exploration near the Mölnermyr wetland. We have also sold the land at Hoburgsmyr, which today is protected as a Natura 2000 area, and we have set aside a protection zone against the wetland”, Tua continues.

Marsh fritillary.



Smew.

Step 2: **Minimise impact example: Boliden builds knowledge of how the business can coexits with rare species**

In Kevitsa, Boliden contributes with scientific knowledge on the rare species smew, moor frog and the moss Dichelyma capillaceum and their habitats. “By builing up this knowledge we can run and develop our operations whilst minimising out impact on these species,” says Johanna Holm, environmental permits manager. With monitoring programmes and surveys Boliden has followed the development of these species over time and can demonstrate clear results. Around ten pairs of smew ducks breed each year in the nest boxes we set up by the lake near the mine. Ten new sites for Dichelyma capillaceum moss have been found, significantly further north than was previously known. And moor frogs have been shown to live side by side with the mining operations without being disturbed by the loss of water flow machine noise.

Step 3: **Restauration Example: Kaunis Iron conducts Sweden's largest restauration of wetlands when claiming new land**

Kaunis Iron, who operates an open-pit mine in Pajala municipality, is facing an expansion. This leads to more land being claimed, which changes the living conditions for species in the area. For instance are these natural environments habitat for different species of plants and birds. Therefore, the company is now carrying out Sweden's largest wetland restoration, in total about 700 hectares forest and wetlands until 2025. The aim is that the loss of habitat will not affect these species negatively and to promote biological diversity in close proximity to the mining area. In addition to that, the project also contributes to reduced emissions since wetlands store carbon dioxide. This project is also unique because these actions will be done before land for the expansion of the mine is taken, ie before any loss of habitat occurs. The restoration is extensive and is therefore carried out in different stages. "We carry out felling of trees (nature conservation trees will be kept) and closing/damming of ditches. This leads to a more open landscape. The water level will rise to an original level and after a number of years the vegetation will change to suit more wetland-demanding species", says Emma Grönberg, environmental manager of Kaunis Iron. In this way, natural environments are recreated and species will be moved before they are damaged in the place where Kaunis Iron inevitably need to claim land. "The project is also very important to us because we are keen to take responsibility for the natural environment in which we operate and to achieve our vision of producing the world's most sustainable iron ore", says Emma Grönberg.

Wetlands in Kaunisvaara.

Old-growth forest in Mertainen.

Step 4: **Compensation example: LKAB restores mires and forest areas**

Since 2015, LKAB has the ambition that its operations should not contribute to a net loss of natural values. Therefore, LKAB works to evaluate the direct and indirect effects of the operations and offset the residual impact on biodiversity. Offsetting is usually implemented when new land needs to be used, but it can also be relevant when natural environments change due to changed groundwater flows resulting from ongoing operations. LKAB's offsetting area in Mertainen is one of the largest in Sweden. In Mertainen, areas are protected and natural values are strengthened for 50 years. The conservation measures implemented in the area include increasing the amount of deadwood, by moving it from the area that is being exploited into the offsetting area, restore mires, carry out haymaking on mires, and controlled burning. "We work on the basis of a management and monitoring plan to follow up on how natural values develop over time in the area," says Stina Eriksson, section manager at LKAB.

The mining and mineral industry's climate targets

Goal 2035: Fossil-free mining

Goal 2035: Climate-neutral processes and fossil-free energy use

Climate roadmap for a competitive and fossil-free mining and mineral industry in Sweden

The mining and mineral industry's ability to successfully manage the green transition is crucial for the other sectors following in the value chain to meet their climate targets. These include the concrete, construction, electrical, automobile, and steel industries. A sustainable green transition requires sustainable metals and minerals.

By 2035, the industry's target is for mining in Sweden to be fossil-free. Reaching fossil-free mining primarily means switching to fossil-free transportation, as well as automation and digitalisation and replacing fossil fuels used in heating and ventilation.

By 2045, the mining and mineral industry's target is to have climate-neutral processes and fossil-free energy use. This means that emissions throughout the sector's value chain will be reduced by a 100 per cent through changes in fuel usage, processes, or complementary measures. The sector's electricity needs will grow significantly as a result of the rapid technological developments underway in electrification, hydrogen reduction, and carbon capture and storage (CCS), which are all necessary steps in reaching the target by 2045.[23]

Kaunis Iron tests fossil-free heavy ore transport with electric trucks in Arctic climate

Kaunis Iron plans to operate a completely fossil-free mine in Pajala by 2025. The majority of the processes are already electrified and, as such, near fossil-free, but the mining machinery and transportation still produce carbon emissions. Electrically powered excavators are already in operation in the mine, and in the next step, other machinery and mining trucks are to be converted from diesel to electricity. The plan is for all machinery and transportation to be powered by electricity (either by cable or batteries) or hydrogen where appropriate. The ore is transported daily by trucks from the mine in Kaunisvaara to Pitkäjärvi, a distance of 160 km, before it is transferred onto trains. This accounts for about 40 per cent of Kaunis Iron's total carbon dioxide emissions. The company has taken a first step in the electrification of its transportation and in 2021 tested the use of battery-powered trucks together with Volvo Trucks, power company Vattenfall, and technology company ABB, among others.

23 Svemin (2022).

Boliden's conversion to electrified mining trucks in Aitik

Boliden's large-scale production in Aitik – with its optimised mining methods, high degree of automation and partly electrified conveyor belts and trucks – make Aitik the world's most productive open-pit copper mine. Boliden's electric trolley system in Aitik should be able to operate completely without fossil fuels and, thereby, reduce CO_2 emissions by 80 per cent and diesel consumption by 30–50 per cent compared to the previous system.

LKAB takes a step forward in the value chain to produce fossil free sponge iron for steel-making

Sweden's current iron exports are mainly in the form of iron ore pellets. The iron ore is then used at steelworks for the production of iron and steel. The processing produces high emissions. In the main production process, coke (produced from coal) is used to separate the iron from oxygen in a blast furnace. Carbon dioxide is then formed as a chemical by-product at a rate of two tonnes of CO_2 per tonne of metal produced. LKAB's goal is to refine the iron ore further into iron using an alternative, so-called direct reduction process, where coal is replaced by hydrogen. The technology for this is being developed in the HYBRIT collaboration with power company Vattenfall and steel making company SSAB. By using fossil-free electricity to produce the hydrogen, CO_2 emissions from iron production can be eliminated. The amount of electricity required for the hydrogen is as much as 70 TWh per year, corresponding to around half of today's total Swedish electricity production. The CO_2 gain would be of a corresponding enormous magnitude. In addition to LKAB's current 700 000 tonnes of CO_2 annually, as much as 40–50 million tonnes of CO_2 per year can be avoided by steelworks operators, compared to producing the same amount of iron through the blast furnace process that is currently used. This is approximately the equivalent of Sweden's total annual greenhouse gas emissions.

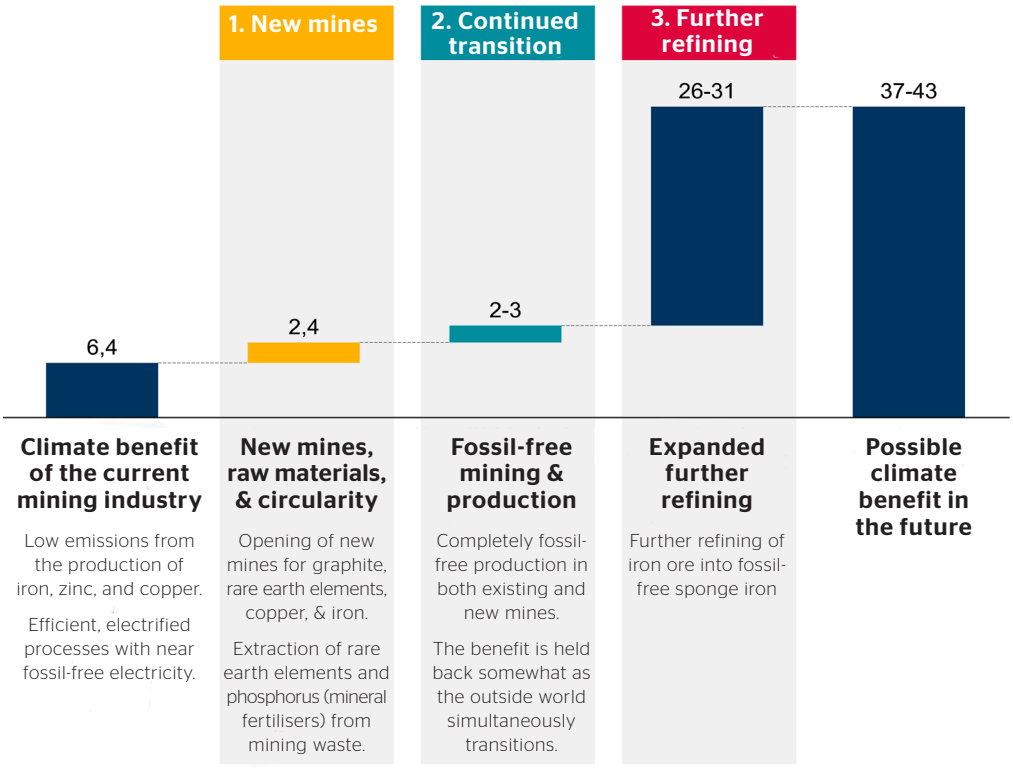
The global climate benefit of the Swedish mining industry corresponds to more than 10% of Sweden's total emissions.

The global climate benefit of Swedish mining

The global climate benefit of the Swedish mining industry today is 6.4 million tonnes of CO_2 per year, corresponding to more than ten per cent of Sweden's total emissions of 47.8 million tonnes (2021). The climate benefit corresponds to the reduction in global emissions that Swedish production makes possible because of lower emissions.

By 2045, the climate benefit could increase further by some 37–43 million tonnes of CO_2 per year, corresponding nearly to Sweden's total emissions – if the companies' plans for new mines, more advanced and fossil-free processes, a new generation of mining machinery, and further refining using CO_2-free energy and inputs can be implemented.[24]

The climate benefit of the Swedish mining industry compared with production abroad
Million tonnes of CO_2 per year



Source: Material Economics (2022).

24 Material Economics (2022); Naturvårdsverket (retrieved 2023).

New equipment – the electrification of mining machinery reduces emissions

Mining equipment is an area where Swedish companies have a major impact on the development of global technology, as they account for the majority of the machinery used in underground mines globally and can drive further electrification and greater efficiencies within the sector. Swedish mining equipment suppliers, such as Epiroc and Sandvik SMRT, which are world leaders with a market share of around 60 per cent for underground mines globally, offer a number of battery-powered models and have ambitious investments to replace today's diesel-powered machines with electric alternatives.

Today, mining machinery used for transportation and loading account for a large percentage of the fuels used in mining. A rough estimate of the total CO_2 emissions from diesel used in these machines (above and below ground) amount to as much as 70 million tonnes of CO_2 per year globally. With the successful shift towards the electrification of mining machinery, whereby half of the mining machines sold by Swedish companies are electrified and where these are integrated efficiently for reduced ventilation, it is estimated that emissions of 10–14 million tonnes of CO_2 annually can be avoided globally, partly from reduced diesel use, but above all from the reduced need for electricity used for ventilation in mines.

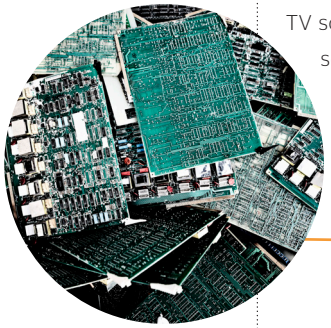
The initiatives underway in Sweden, including the Sustainable Underground Mining (SUM) project, are of global importance in creating reference points allowing other companies to quickly adopt the new technology.[25]

A new world standard in sustainable mining

The mining and mineral industry has come far in its digitalisation work to enable sustainable mining at greater depths. In the Sustainable Underground Mining (SUM) project, LKAB, ABB, Epiroc, Sandvik SMRT, and Combitech have joined forces with the shared goal of setting a new world standard for sustainable mining at great depths. The project will make cost-effective and carbon-free mining possible at a depth of around 2,000 metres and revolves around three principal areas: electrification, automation, and digitalisation.

25 Svemin (2022).

Boliden Rönnskär brings new life to old electronics

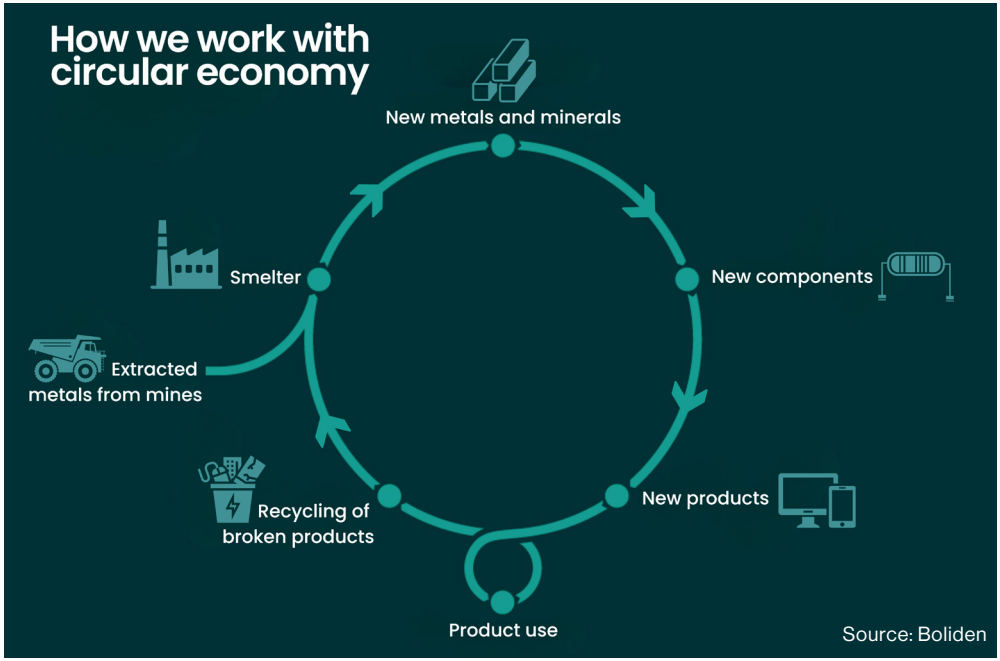


Boliden smelt the metals that, once upon a time, were your old coffee machine, HDMI cables or TV so that they can bring to life new products. Your old mobile or computer could even become someone else's wedding rings. The plant in Rönnskär, just outside of the Swedish town of Skellefteå, is a world leader in electronics recycling and on top of that, takes care of the by-products from steel mills, brass foundries and power stations. The great thing with metal is that, unlike plastic and paper, it can be recycled infinitely without ever losing its properties or quality. Other people's residual materials can become new raw materials.[26]

LKAB's circular industrial park – from mining waste to valuable products

LKAB is planning a circular industrial park in Luleå with new technology for the extraction and processing of phosphorus, rare earth elements and fluorine based on today's existing mining production – instead of landfilling the material, it can be used to create new, sustainable products. The project has the potential to meet 30 per cent of the EU's need for rare earth elements, five times Sweden's need for phosphorus mineral fertilisers, and 100 per cent of Sweden's need for gypsum[27].

26 Boliden (retrieved 2023b).
27 Svemin (2022). LKAB (2023).



Metals mined in the mines are supplemented with recycled raw material. It is good for both the environment and the economy to combine primary and recycled raw materials in the processing process. Recycling alone does not cover the needs of today and the future. A growing population and new technological solutions for the climate require more metals and minerals in the circular flow.
Source: Svemin (2020a).

Metals fit perfectly in the circular economy

Many metals and minerals are well-suited to the circular economy as they are elements that can be recycled without any significant loss of quality. The need for recycling is growing as the demand for metals increases. Companies within the sector have long been active in working on improved recycling for environmental, resource, and economical reasons, and great progress is being made in developing circularity on an industrial scale. There is great potential in improving the collection and recycling of minerals, including metals critical to innovation from electronic waste, and in recovering metals currently lost within the various material streams. More research and the development of resource-efficient, carbon-neutral processes are needed to enable both an increase in the yield of recycled metals and the extraction of additional elements that end up in slag, dust, and mud.[28]

> New technological solutions for the climate require more metals and minerals in the circular flow.

28 Svemin (2022).

Social sustainability

Targets

- ✿ Aim to be an active player and make a positive impact in the communities where we operate.
- ✿ The mining industry and reindeer husbandry to co-exist in the long run with a fair, positive, and respectful dialogue.
- ✿ That the workplaces in our companies are free from accidents and work-related ill health.
- ✿ Develop healthier, safer and more attractive workplaces for all women and men based on modern leadership, organisation, and technology and included in the digital and green industrial transformations.

Necessary preconditions

- ➜ Clear legislation and regulations as well as the state taking responsibility for balancing future land use in order to allow for both reindeer husbandry and mining.
- ➜ That all parties work to achieve and maintain a good dialogue in order to find suitable solutions that minimise the impact on reindeer husbandry.
- ➜ That legislation and regulations in the work environment area are reasonable, practical, and achievable.
- ➜ That cooperation between companies, trade unions and authorities remains strong.
- ➜ Collaboration between industry and (local and regional) society for attractive, diverse and gender-equal mining communities that are also adaptable to change.

Mining and the local community

Where mining occurs, there is an impact on the local community. While mines often provide jobs and economic benefits, operations also have potential environmental and social dimensions. To contribute to sustainable development, the mining and mineral industry and other parts of society need to recognise the wider positive and negative impacts of mining on society at local, regional, national and global levels. This entails developing methods for local relations work and contributing to foreseeable, transparent, and effective permit processes.

Achieving this requires an increased understanding of societal impacts, including legislation and its application, employment and income generation, distributional effects, land use conflicts, indigenous rights, demographics, and cultural heritage. How different responsibilities for sustainable development can be shared between the industry and different public authorities is also important.[29]

Kaunis Iron invests in the local community

As many as 95 per cent of the citizens of Pajala municipality in northern Sweden believe that Kaunis Iron's operations have a positive impact on the community in Pajala. The current plans to open two new open pit mines are also met with positive reactions – 88 per cent are in favor of expanding operations with more open pit mines. Kaunis Iron want to be a driving force for local business and reinvest where they can when buying services and goods. During 2022 the company reinvested about 551 million SEK (52 million EUR) locally and 1,033 million SEK (97 million EUR) regionally. Kaunis Iron's close collaboration with Luleå University of Technology also contributes to both strengthened research and improved skills supply for companies in the industry. Kaunis Iron is also involved in developing meeting places, such as Folkets Hus community centre in Kaunisvaara and Tornedalen Pride, and are pleased to engage in projects focusing on children and young people. During 2023, Kaunis Iron sponsors 30 nonprofit associations in the municipality with approximately 1.5 million SEK (132,000 EUR) in total, aiming to promote the local community and contribute to the development of a wide range of activities in the area.

> As many as 95% of the citizens of Pajala municipality in northern Sweden believe that Kaunis Iron's operations have a positive impact on the community.

29 Swedish Mining Innovation (2022b).

Reindeer herding in Sweden

In Sweden there are 51 Sámi villages with specific rights to land and reindeer herding according to Swedish law. This right can only be exercised by a Sámi that is a member of a Sámi village.

A Sámi village is a financial and administrative association with its own board that, for the common good of the members, must lead reindeer husbandry within a certain geographical area. Reindeer grazing rights prevail on approximately 50 per cent of Sweden's land area. There are approximately 4,600 reindeer herders in Sweden.[30]

Mineral extraction and reindeer husbandry

A large proportion of Sweden's known and potential mineral deposits are located within the area where reindeer herding may be conducted under the Reindeer Husbandry Act. The extraction of minerals is a necessary part of civilised human existence and can only be undertaken where such deposits are found. Reindeer husbandry is a civil right and a culture which is promoted under the constitution and which constitutes an essential or even crucial activity for the Sámi and their rights as an indigenous people. The practice of both reindeer husbandry and mineral extraction are documented dating back to prehistoric times. Access to land is of crucial importance to both mining and reindeer husbandry.

Direct land claims in the case of mining are very specific and limited. Reindeer husbandry requires large swathes of land that are connected. However, such functionality can be impacted by an aggregated pressure stemming from various forms of land use. Functional access to the land required is what constitutes the primary conflict of interest which exists between mining and reindeer husbandry. Something which both activities have in common is that they are not constantly undertaken in the same place over time, even though their needs are (obviously) very different. In order to find ways for the mining industry and reindeer husbandry to co-exist in the long run, the mining industry is persuing knowledge development and dialogue to provide the right framework and conditions for such co-existence. The possibilities for the remediation of former mining areas so that they may once more serve as functional reindeer husbandry areas is also a crucial matter within this context[31].

30 Sametinget (2022).
31 Svemin (2019).

Promising results from collaborative project to reduce reindeer collisions

In a normal year, about 60 of Sattajärvi Sami's 1300 reindeer die on a stretch of road west of Pajala, partly due to extensive ore transportation. In a project funded by Swedish Mining Innovation, the Sámi village together with Kaunis Iron, LKAB, Luleå University of Technology, and the Swedish Transport Administration want to find a solution to reduce the number of accidents. During the snowy months of October-April, the reindeer of the Sattajärvi Sámi community go down to the moors around road 395 just north of Pajala to live on the reindeer lichen that grows there. The idea that the project team wanted to test is to lead the reindeer away from the road to a fenced feeding area, using a reindeer spring. The project team has just completed its first season and the results are promising - eight road-killed reindeer compared to 42 the year before the project started. "We can't escape the fact that there are different interests in terms of land use. We can't get stuck in just raising problems from our respective sides. We have to find methods and solutions for different industries to exist together. This is possible if we want to. We are now developing a method to make it work here, but it should also be able to be used elsewhere, by other samebys and businesses," says Johny Lantto, chairman of the Sattajärvi Sámi village[32].

> The goal is for the mining industry and reindeer husbandry to co-exist in the long run with a fair, positive, and respectful dialogue.

Mausjaur Sámi village and Boliden develop new routines for dialogue regarding land use

Boliden's mines in northern Sweden are located in reindeer husbandry areas. To be able to coexist and respect each other both in the short- and long term, continuous dialogue is crucial. Therefore, as a joint idea by Boliden and the Mausjaur Sámi village, a pilot project has been developed with the purpose to safeguard the different interests related to land use.

Herding the reindeer at Mausjaur Sámi village.

32 Swedish Mining Innovation (2023b).

Life long learning

All mining companies and the employees are part of the new transition package improving long-term flexibility, adaptability, and security in the labour market. An important part of the package is the new Student Finance Scheme for Transition and Retrain ensuring life-long learning. This package makes it possible for almost all employes to upskill and reskill, getting 80 per cent of their salary during one year of studying.

Employees safety and health always comes first

Sweden's strong work environment legislation highly contributes to social sustainability. Mining companies, contracting companies and unions cooperate, and together, they drive important issues and joint projects for the industry. To make the work safer, the development has led to automation and remote control of vehicles, digital positioning systems for people and machines and regular safety exercises. Many tasks that were previously performed in underground machines are now remotely controlled by above-ground operators.

Promoting a good working environment in the mining industry is one of the industry's most important goals. The work has produced results. Today we see a long-term downward trend in the frequency of accidents. The industry is also working actively to improve the working environment from the social and organisational aspects. However, the bar can be raised further, and a prerequisite is that laws and regulations in the area of the work environment are reasonable, practical and possible to achieve. Despite the very positive development of accident rates, the mining companies have a strong focus on creating a completely accident-free operation as far as possible. In addition to offering their employees and contractors a physically safe and good working environment, mining companies work very actively to improve people's attitudes and behavior regarding safety. In collaboration with the employee side, a culture is created where everyone, through their own safe behavior, safeguards their own safety and that of their colleagues.[33]

Women in mining

Persistent efforts to make the mining sector more diverse and inclusive, has paid off. Now, 25 per cent of all employees are women. Although, it is a continuous work through careful recruitment, technical advancements and far-reaching measures to change the perception of mining.

Svemin is working actively to highlight the industry's gender equality work and the competent women who already work for the industry's companies, as well as for more women to see the industry as attractive. Therefore, Svemin hosts the Swedish section of the Women in Mining network. The goal is to increase the proportion of women in the industry, in boardrooms, in management groups and in operations in general. Making good role models visible and highlighting women is therefore central.

33 Svemin (retrieved 2023c); Svemin (2020a).

Not a male-only world anymore. Dedicated efforts over the last decades has changed the gender statistics significantly. Now, 25 per cent of all employees are women in the Swedish mining industry and the work to even out the curve even more is ongoing.

Economic sustainability

Targets

- ✿ The Swedish mining cluster is to be a global leader in terms of techno-logical development and research in mining and mineral-related issues.
- ✿ The companies to remain competitive at the global market through the green transition.
- ✿ Secure the right skills and knowledge to enable the green transition.

Necessary preconditions

- ➜ Large-scale, nationally targeted investments in both basic and applied research for a sustainable mining and mineral sector.
- ➜ Ensure stability and a long-term perspective in national and international climate policy that creates the necessary conditions for a competitive green transition.
- ➜ Support front-runners, through for example favourable conditions through policy instruments and financial incentives.
- ➜ Prioritise long-term research funding for sustainable raw materials.

The economic value of the Swedish mining cluster

A long tradition in mining has created not only competitive native Swedish mining companies, but also an ecosystem or cluster of highly specialised companies across a long and complex value chain.

The mining cluster is a large contributor to the Swedish economy supporting three per cent of annual Gross Domestic Product (GDP), 8 per cent of exports, and 100,000 to 125,000 direct and indirect jobs. Being a capital-intensive sector, the mining cluster is a significant driver of investments supporting up to 20 per cent of annual industrial investments and five per cent of foreign direct investments in Sweden.

Regionally, in the north of Sweden, the mining cluster has an even more significant economic impact, as it accounts for 20 per cent of regional GDP and five per cent of jobs. In the coming years, an estimated – slightly incredible – 75 per cent of all regional investments will be linked to the mining cluster.[34]

The Swedish mining cluster

The Swedish mining cluster comprises three levels: the mining sector itself; mining equipment and support industry (upstream subcontractors that produce inputs to the mining sector); as well as steel and metal production (downstream producers, based on inputs from the mining sector).

The mining cluster is a large contributor to the Swedish economy

THE MINING CLUSTER SUPPORTS:

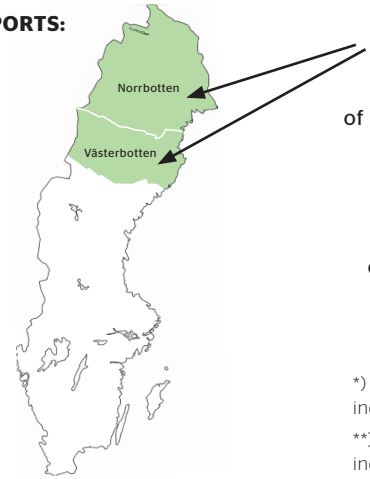
3%
of Gross Domestic Product

8%
of exports

100,000–125,000
direct and indirect jobs

13–20%
of yearly industrial investments

1.2%*
of total tax payments



THE MINING CLUSTER GENERATES:

20%**
of Gross Regional Product

5%
of regional jobs

75%
of regional investments in the coming years

THE MINING SECTOR ALONE SUPPORTS:

1%
of Gross Domestic Product

1.3%
of exports

20,000
direct and indirect jobs

0.7%
of total tax payments

*) Reported number is not for our definition of the mining cluster, but includes the mining and basic metal sector instead.

**) Reported number is not for our definition of the mining cluster, but includes the mining sector and the entire manufacturing sector instead.

■ The mining cluster ■ The mining sector

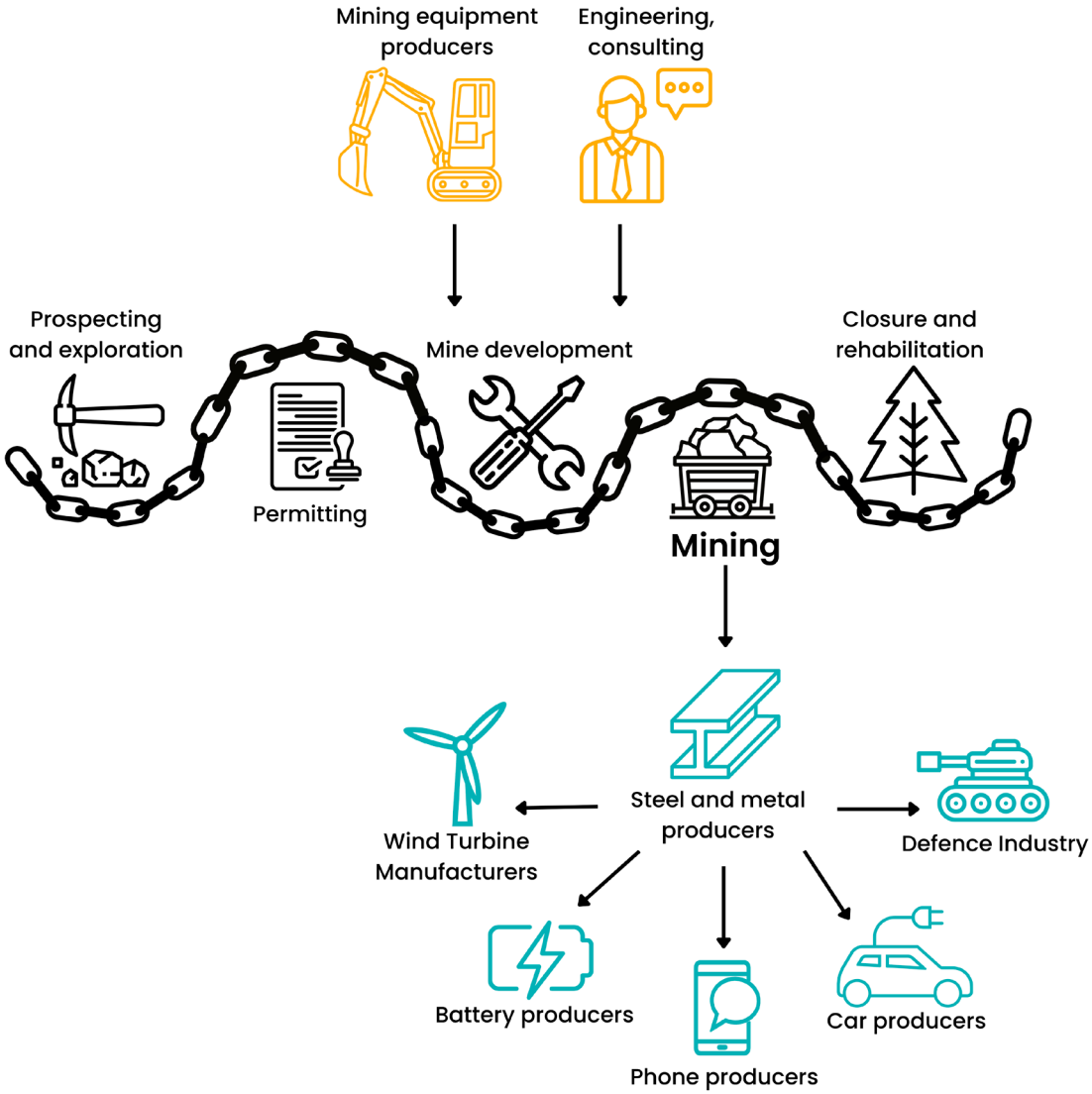
Source: Copenhagen Economics (2021).

34 Copenhagen Economics (2021).

Did you know that you will need about 800 tonnes of metals and minerals in your life? Almost everything you see around you in your home has a direct connection to our bedrock – home appliances, batteries, windows, cell phones, computers and speakers. And when you step outside the door, the products from our bedrock are still everywhere – buses, cars, trains, bridges, lamp-posts, sculptures, signs and much more. Without metals and minerals, our modern lives would simply not be possible.

The lifecycle and value chain for a mine

The lifecycle and value chain for an operating mine involves many different stakeholders. Source: Copenhagen Economics (2021).



Upstream providers to the mining value chain from early exploration to closure of mine e.g., ABB, Epiroc and Sandvik

Life cycle of mine

Downstream producers using inputs from the mining value chain, eg., SSAB or Northvolt

Research and innovation collaboration

The mining and metal producing industry, including technology providers, works on a truly global, international market. The world as well as the market conditions are constantly changing, and the way to survive and prosper is through competitiveness. This is ensured by constant development of products, processes and competence, in which research and innovation are at the core of the corporate strategies. Cooperation has been the key to success of the Swedish mining cluster. To stay competitive, the Swedish mines have asked the technology providers to develop new innovative solutions to increase productivity and sustainability and at the same time the Swedish mines have acted as testbeds for new technology. This has led to mutual benefit between the mines, the technology providers and academia.

The mining research- and innovation cluster is growing and involves stakeholders from industry, academia, research institutes, authorities and NGOs. The mining cluster works towards a common vision presented in a strategic research and innovation roadmap. Sweden is one of the most research- and development-oriented countries in the world. Companies are responsible for around 70 per cent of research investment. However, the injection of public funding over the last twenty years has strengthened the competitiveness of the mining cluster by greater involvement by academia and the public sector. The national funding program, Swedish Mining Innovation, has also contributed to greater internationalisation by creating meeting places and forms of collaboration and to increase funding for Swedish actors from various EU instruments by supporting planning- and internationalisation grants.[36]

Robotic dog Spot, equipped with modern AI technology, is an employee at LKAB. Spot can recognize environments and develop movement patterns. The ambition is that Spot will eventually be able to take over certain tasks from the operators and thus contribute to making the work environment safer.[35]

35 Swedish Mining Innovation (2022a).

36 Swedish Mining Innovation (2022a).

Development of autonomous carbon-free mining processes

Autonomous or remotely operated machinery is important for making mining more efficient, reducing the climate impact and improving the working environment in underground mines. In the Sustainable Intelligent Mining Systems (SIMS) project and the follow-up project NEXGEN SIMS, funded by the EU's Horizon 2020 research program, battery-powered, self-driving machines for use in underground mines were developed, tested and demonstrated. The projects focus on sustainable smart systems and technologies for autonomous, fossil-free underground mines and are the biggest mine-related projects to be financed by the EU to date.

The projects are coordinated by Epiroc and project partners include the mining companies Boliden, Agnico Eagle Finland, KGHM Polska, K+S, and OZ Minerals; service and system suppliers Ericsson, Mobilaris MCE, AFRY, and KGHM Cuprum; and the universities Luleå University of Technology and RWTH Aachen.[37]

Robots to improve mine safety

Prior to blasting in an underground mine, the preparations are undertaken by special charge operators. The work is complex and takes time - the boreholes must be identified, blast caps and detonators fitted before the lines to pump the explosive and the mix of explosives are applied. ABB, Boliden, LKAB and explosive suppliers Forcit and LKAB Kimit have therefore started to cooperate with the aim of equipping ordinary industrial robots with the technology required to perform these tasks. Instead of a charge operator having to program the robot prior to each detonation, the robot shall be able to locate the holes to be charged itself with the aid of an online AI solution that supplies the precise coordinates. If the process can be automated, it would improve safety and the working environment as well as making production more efficient.[38]

> Autonomous or remotely operated machinery is important for making mining more efficient, reducing the climate impact and improving the working environment.

37 Swedish Mining Innovation (2022a); Svemin (2022).

38 Swedish Mining Innovation (2022a).

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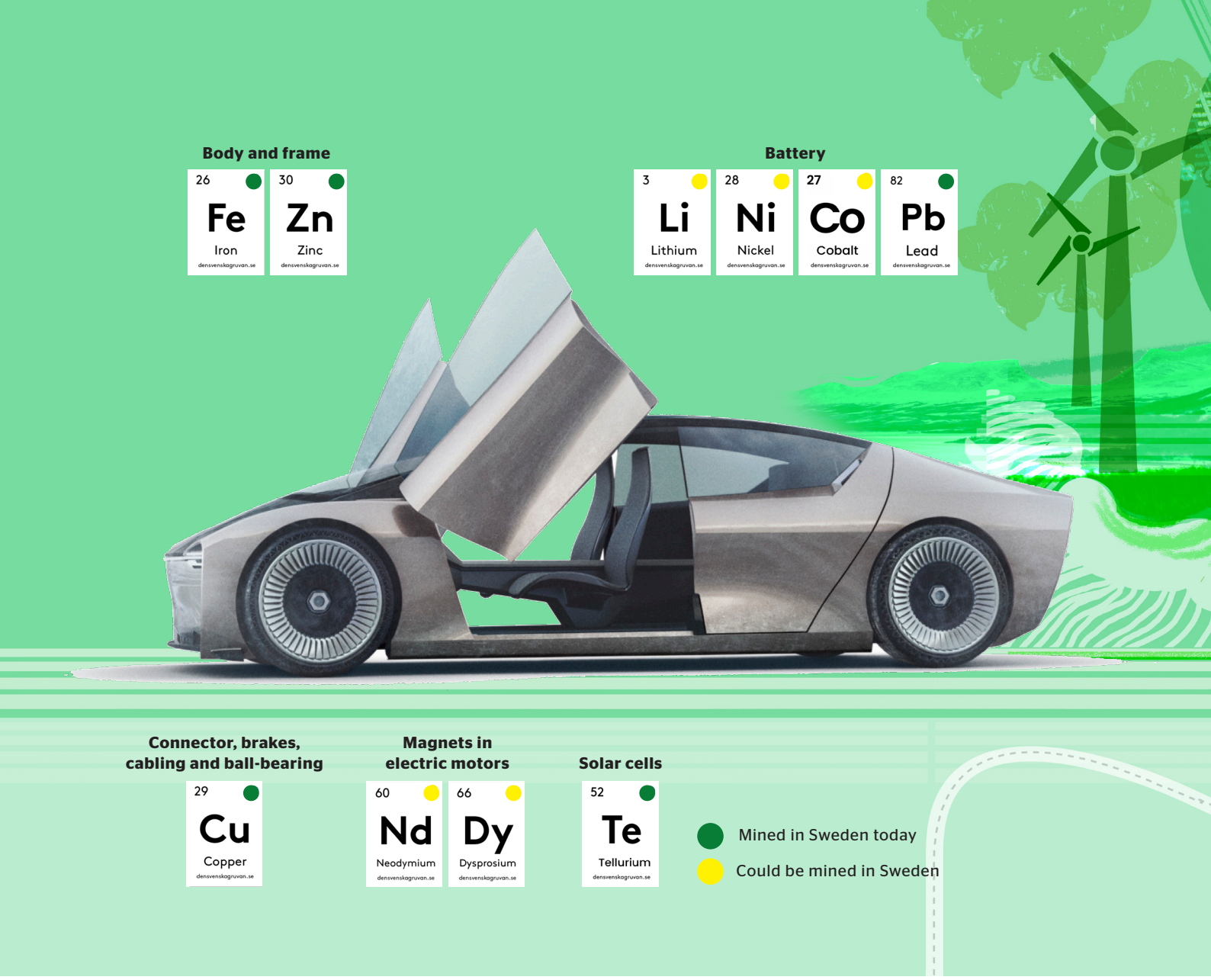

Svemin is the industry organization for mines, mineral and metal producers in Sweden. Svemin represents approximately 60 companies with roughly 13,000 employees in mineral production, exploration and technology. Member activities occur throughout Sweden. The exploration activities as well as the active metal mines are predominately located in northern Sweden and the area of Bergslagen in central Sweden, while the limestone deposits are mainly found on the island of Gotland.

SveMin

www.svemin.se