

ECONOMIC VALUE OF THE SWEDISH MINING CLUSTER

Today and in the future

Prepared for Svemin
November 2021

Preface

For centuries and even millennia, mining has been an important part of human society. It is increasingly due to our modern lifestyle, behaviours, modes of communication and transportation. Metals are everywhere. Yet, mining tends to be a low interest area from a political point of view and even an area of dispute for opponents of mining or other land users.

But mining remains an important industry. Also, we see a number of companies from other industries working together closely with mining companies forming what is often called the Swedish Mining Cluster.

Copenhagen Economics A/S has been commissioned by Svemin, the association of mining companies in Sweden, to analyse:

1. The economic value of the Swedish mining cluster to society.
2. The future opportunities and potentials offered by the mining cluster.

Approach and limitations

As no official definition of the mining cluster

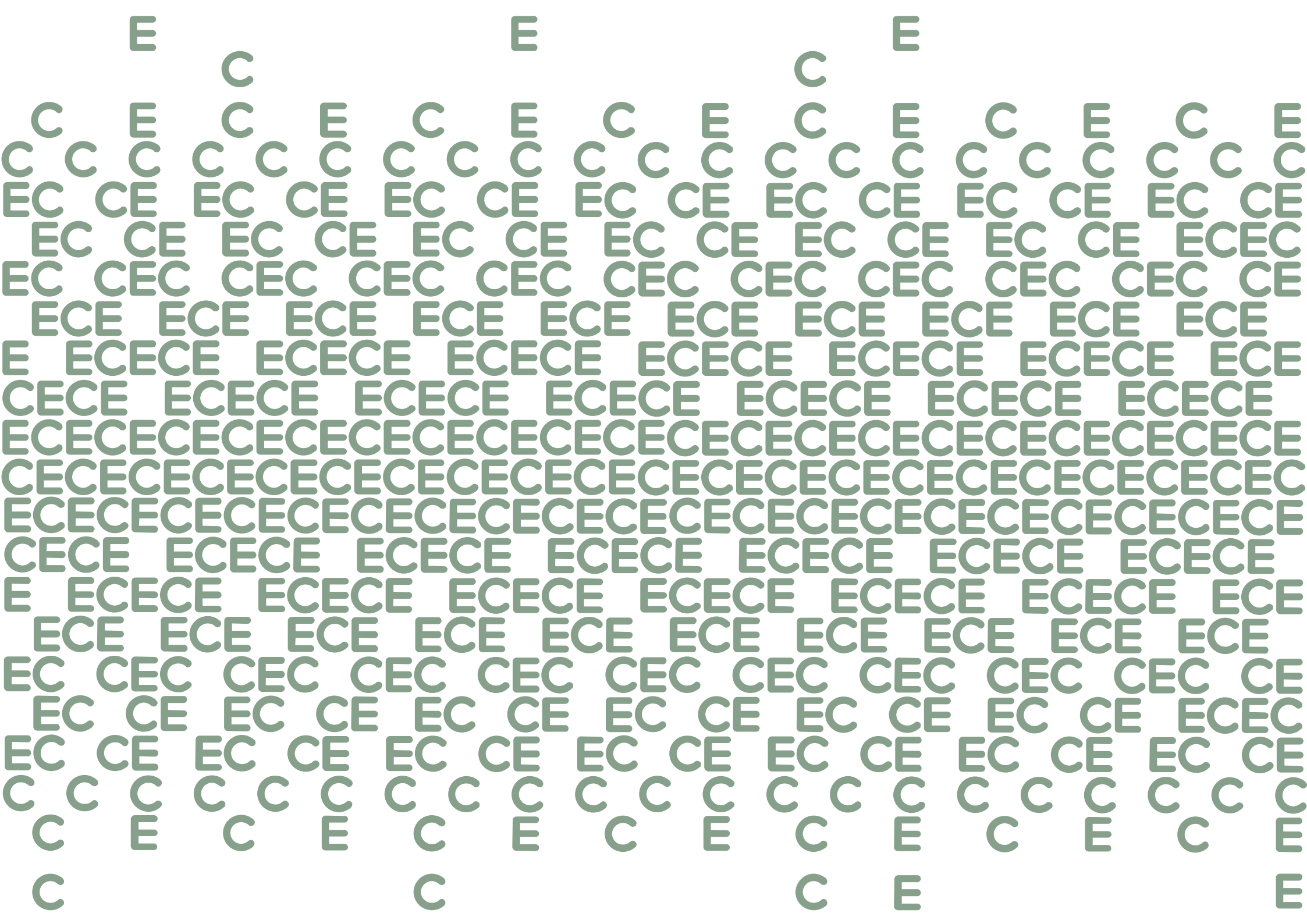
exists, this is where we start; by developing a so-called input-output model to estimate the economic contributions of the cluster measured by Gross Domestic Product (GDP), jobs, and exports. To quality assure our assumptions and scoping of the mining cluster, we have carried out semi-structured interviews with representatives from companies across the cluster.

Sources

We rely on national account data and other public sources for mining specific investments and taxes paid by the industry.

While we have compiled a lot of data from public sources and from interviews, data is sometimes unavailable, preventing us from reporting all numbers for the same definition of the mining cluster. We flag where definitions differ.

Finally, when deep diving into seven development projects in Sweden to assess the potentials of the mining cluster to deliver significant contributions to Sweden also in the future, we rely on interviews with project experts and desk research.



1

**Executive
summary**

2

**The economic contribution of
the Swedish mining cluster**

3

**Future opportunities
brought about by the
mining cluster**



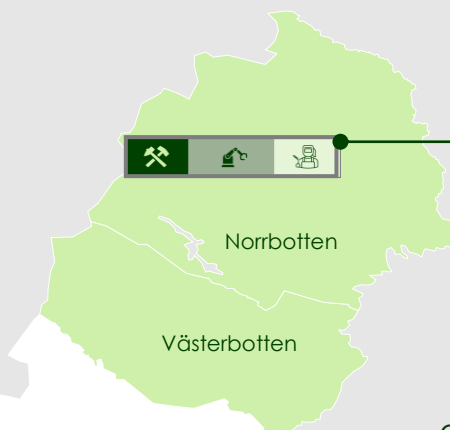
1 EXECUTIVE SUMMARY

A large mining truck is shown from a low angle, carrying a heavy load of grey ore. The truck is on a dirt road that leads into a deep mine shaft. In the background, another similar truck is visible, and a smaller piece of machinery is further down the road. The sky is bright and clear. The overall scene is industrial and rugged.

EXECUTIVE SUMMARY

The mining cluster is a large contributor to the Swedish economy

4-6 times the amount of minerals and metals used today are required to reach the EU climate target of reducing emissions 55% by 2030. This increase is primarily driven by demand for **lithium, graphite, cobalt, nickel** and **copper** used for e.g., batteries, steel, alloys, and wiring.¹



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

“ The Nordic countries have a bedrock similar to the major mineral-rich countries globally, and together represent a land area comparable in size to the most mineral-rich parts of either Canada, USA, Australia, South Africa, or Brazil.² - Nordic Innovation (2021), p.6.²

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



■ Level 1: Mining companies ■ Level 2: Mining equipment and supporting industry ■ Level 3: Steel- and metals production □ Level 1-3: Mining cluster

(1) International Energy Agency (2021), [link](#). (2) Nordic innovation (2021). *) 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.

Key messages

1 EUROPE'S NUMBER ONE PRODUCER OF IRON ORE

Sweden is already a primary producer of metals and minerals, producing 93% of all iron ore and about one third of lead and zinc in the EU.

2 A STRONG CLUSTER WITH MINING AT ITS CORE

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.

3 THE MINING CLUSTER IS A LARGE CONTRIBUTOR TO THE SWEDISH ECONOMY

Swedish mining, and the cluster surrounding it, is a large contributor to the Swedish economy supporting

- **3%** of annual Gross Domestic Product
- **100,000 – 125,000** direct and indirect jobs
- **8%** of exports

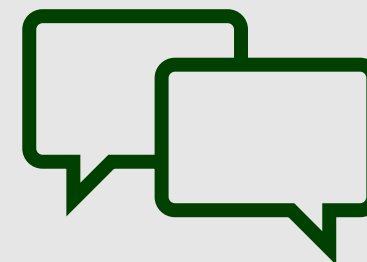
4 THE MINING CLUSTER IS A DRIVER OF INVESTMENTS

The mining cluster is a significant driver of investments supporting:

- **13-20%** of annual industrial investments in Sweden
- **5%** of foreign direct investments in Sweden*
- **75%** of planned investments in the regions of Norrbotten and Västerbotten in coming years**

5 MINING IS PART OF THE TRANSITION TOWARDS A LOW-CARBON FUTURE

Sweden is home to many promising projects from mining and recycling to technology development projects at the research frontier. But barriers exist and must be overcome to bring them closer to realisation and become the next flagships of Sweden.



* Due to data limitations, numbers do not fully correspond to our definition of the mining cluster. We here include the mining and metal sector and some production of relevant equipment. ** Due to data limitations, numbers do not fully correspond to our definition of the mining cluster. It reflects investments directly or indirectly linked to mining (domestic and foreign direct investments).

A large yellow mining truck is shown in a dark, rocky underground tunnel. The truck is positioned in the foreground, with its large tires and yellow body clearly visible. In the background, another smaller yellow mining vehicle is visible, working on the rock face. The scene is dimly lit, with light sources creating highlights on the rock surfaces and the truck's body.

2 THE ECONOMIC CONTRIBUTION OF THE SWEDISH MINING CLUSTER

Sweden can become instrumental in increased EU self-sufficiency in raw materials, even coming from a strong starting point

The European Commission's industrial strategy emphasizes the need for increased **self-sufficiency of raw materials**, to ensure environmentally responsible mining, supporting the industry's transition to carbon neutrality.

“ **Industry has a leading role to play in what is the greatest challenge and opportunity of our time.** All industrial value chains, including energy-intensive sectors, will have a key role to play. They will all have to work on reducing their own carbon footprints but also accelerate the transition by providing affordable, clean technology solutions and by developing new business models.

To become more competitive as it becomes greener and more circular, **industry will need a secure supply of clean and affordable energy and raw materials.**'

- European Commission (2020A), p.3.³

However, **Sweden is coming from a very strong starting point** having some of the strictest environmental regulations in the world and several different sustainability projects underway in the mining sector to make the industry even more far-sighted and climate-smart.⁷

“ **The geological potential** is fundamentally linked to the fact that the Nordic countries have a bedrock similar to the major mineral-rich countries globally, and together represent a large (ice-free) land area **comparable in size to the most mineral-rich parts of either Canada, USA, Australia, South Africa, or Brazil.**¹

- Nordic Innovation (2021), p.6.¹

4-6 times the amount of minerals and metals used today are required **to reach EU climate target** of reducing emissions 55% by 2030. This is primarily driven by growing need for lithium, graphite, cobalt, nickel, REE and copper, used as input for e.g., electric vehicles, batteries, and renewable energy. Global demand for steel is projected to rise with more than 30% by 2050.^{1,8}

26 out of 30 metals and minerals on **EU's Critical Raw Materials list**, are proven available in Sweden's bedrock.²

6 million tonnes of CO₂ savings are generated by exporting Swedish metals, due to the lower climate footprint of Swedish mining compared to foreign production.⁸

12 mines are today in operation in Sweden - half of these being more than 50 years old. Since the beginning of the 20th century, where Sweden had around 250 mines in operation, total production has more than doubled.⁶

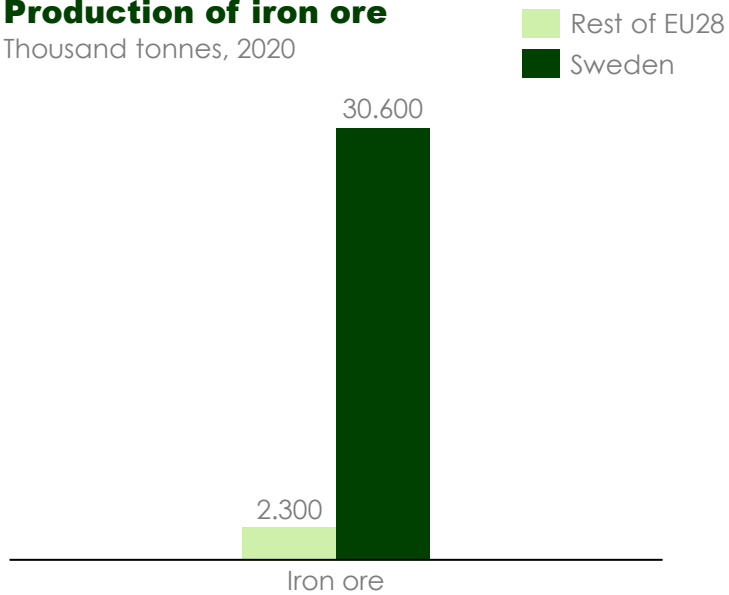
(1) Nordic Innovation (2021) / (2) Svemin (2020a), [link](#) ; European Commission (2020b), [link](#) / (3) European Commission (2020a), [link](#) / (4) Geological Survey of Sweden (2020A), [link](#) / (5) Eurostat (2018), [link](#) and UEPG (2018), [link](#) / (6) Geological Survey of Sweden (2020b), [link](#) / (7) The Swedish Mine (2021), [link](#) / (8): Svemin (2021a), [link](#)

Sweden is already an important mining country in Europe

Sweden is the primary producer of iron ore in the EU

Production of iron ore

Thousand tonnes, 2020

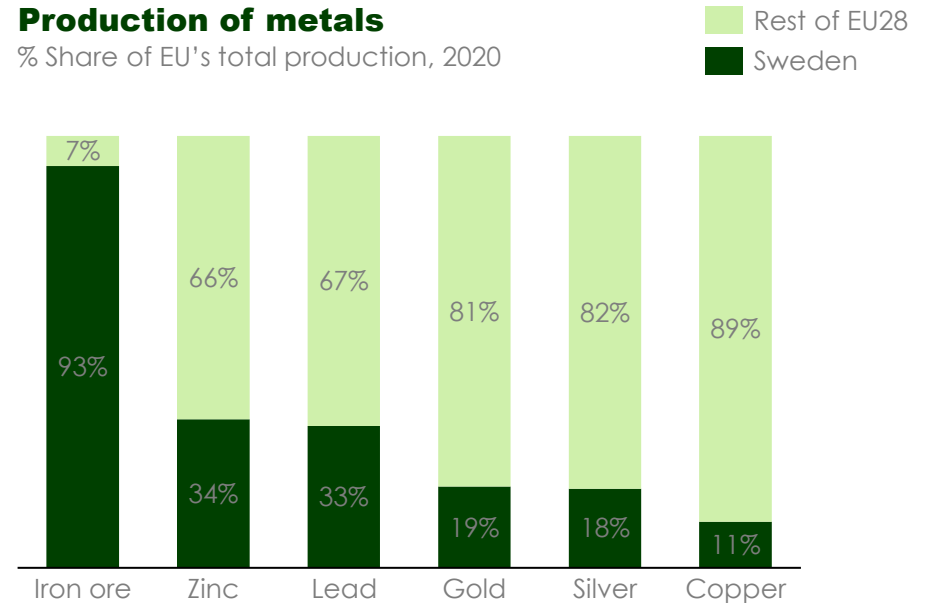


Source: Copenhagen Economics based on Geological Survey of Sweden (2021a), p.19, [link](#).

Sweden produces crucial raw materials in Europe

Production of metals

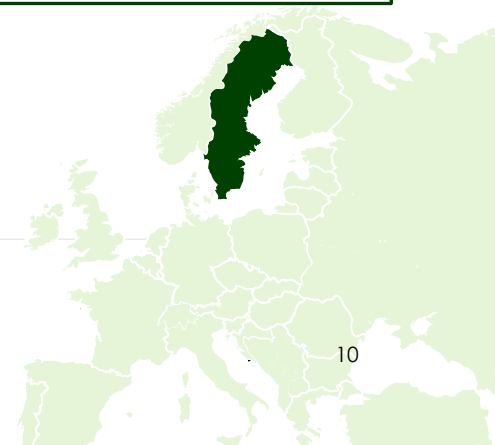
% Share of EU's total production, 2020



Source: Copenhagen Economics based on Geological Survey of Sweden (2021a), p.19, [link](#).

Iron ore is the main ingredient in steel production

Copper is a conductor and essential in wires and cables, and hence for electrification of society



A complex value chain has formed a cluster around mining

A long history in mining

Sweden has a long history of mining going back more than a thousand years.¹ Today, Sweden is a world leader in sustainable and responsible mining, environmentally and socially.

As sub-contractors and partners to the mining industry, numerous businesses have developed simultaneously with mining and today contribute to a strong cluster around Swedish mining.² These companies, like ABB, Epiroc, Sandvik and SSAB have become world leaders in their own right.

The long history in mining and complex value chain leads to large interdependencies between companies. This has created significant spill-over effects and competitive advantages. The Swedish mining industry thus sustains a larger ecosystem of highly specialised companies. Without it, the economic loss would be significantly larger than the industry's direct economic contribution.

The life cycle of a mine

Mining is a long and complex value chain, and many activities must be performed before mining can commence.

- Prospecting and exploration of a deposit can take many years and even decades. Many companies, especially from big mining jurisdictions like Australia and Canada, specialise in prospecting, exploration, and development of potential new mining projects to a level of maturity where they can be mined.
- Once a mine is in operation, it can often run for several years. As the site and deposit is further explored and developed, a mine is often expanded, increasing the life of the mine. Half of operating mines in Sweden are more than 50 years old.³ This helps facilitate a cluster of supporting companies to form around it.
- When a mine is depleted, the mine is closed, and the area rehabilitated.

The lifecycle and value chain for an operating mine involves many different stakeholders



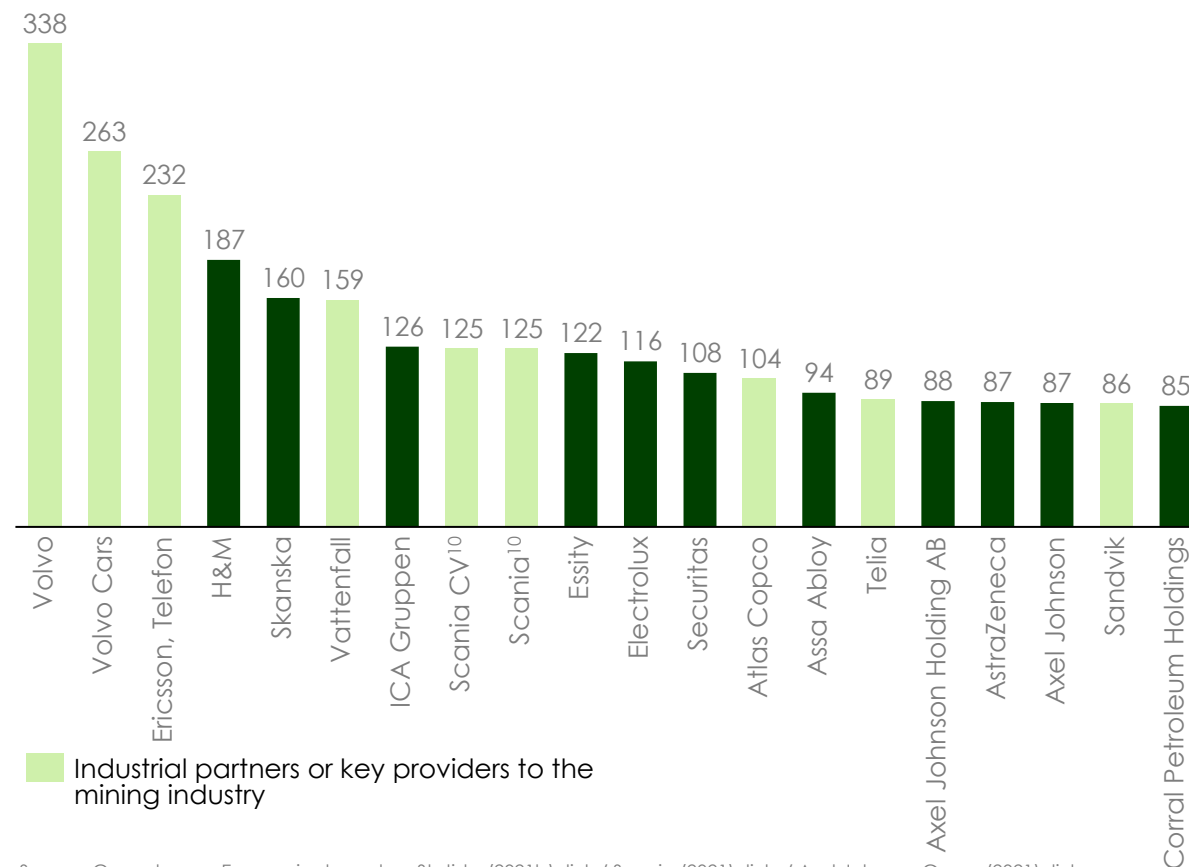
(1) Geological Survey of Sweden (2020b), [link](#) / (2) Copenhagen Economics (2016), [link](#) / (3) Geological Survey of Sweden (2021b) – 7 out of 12 mines.

The mining industry has industrial partners and providers from across the economy

Nine of Sweden's largest companies are either providers or industrial partners to the mining industry

Top 20 largest companies in Sweden by turnover

bn SEK, 2020



As most other sectors, the Swedish mining industry has linkages across all sectors of the economy, for example through the purchase of goods and services from other companies or through industrial partnerships for development and collaborative efforts. In particular, we find that mining companies in Sweden work with both providers and industrial partners to customize and develop new tools and technologies for the use in mining.¹ A few examples are:

- Volvo² and Scania³ deliver equipment (e.g., trucks) to the mines. In 2016, Volvo even tested the use of driver less trucks in Boliden's Kristineberg mine.⁴
- Telecommunication providers Ericsson⁵ and Telia⁶ have developed and tested local 5G networks in mines.⁷ These networks can be used to monitor and control machines in operation.

Additionally, the mining industry is also an important supplier to several of these companies (and a range of other companies across sectors). Several of the mentioned companies are highly dependent on metals for their own production of goods; for example the equipment sector uses 32% and transportation 12% of worldwide copper consumption.⁸ 86% of all lead is used for producing batteries.⁹

Source: Copenhagen Economics based on Statista (2021b), [link](#) / Scania (2021), [link](#) / Axel Johnson Group (2021), [link](#)

(1) Swedish Energy Agency (2016) / (2) Volvo (2021), [link](#) / (3) MiningDotCom (2017), [link](#) / (4) VolvoGroup (2016), [link](#) / (5) Ericsson, [link](#) / (6) Telia, [link](#) / (7) International Mining (2020), [link](#) / (8) Statista (2021a), [link](#) / (9) Statista (2021c), [link](#) (10) Scania CV and Scania have a consolidated net sales of SEK 125 bn, see Scania (2021), [link](#)



2.1 THE ECONOMIC CONTRIBUTION OF THE SWEDISH MINING CLUSTER AT THE NATIONAL LEVEL

No official definition of the mining cluster complicates the assessment of economic contribution

How do we define the Swedish mining cluster?

As such, there is no clear definition of which companies or activities belong to the Swedish mining cluster. However, the complex value chain surrounding mining implies that the mining cluster consists of more than only traditional mining companies working to extract metals and minerals from the ground. Upstream subcontractors like mining equipment producers and engineers are part of the cluster as well as downstream producers of e.g., steel and highly specialised technology companies.

Our definition of the Swedish mining cluster covers three levels; the mining sector itself, mining equipment and supporting industry (upstream subcontractors, producing input to the mining industry) and steel- and metal production (downstream producers, based on inputs from the mining sector).¹

In our definition of the Swedish mining cluster we have drawn upon value chain analysis and national account statistics from Statistics Sweden (SCB) on the flows of value between sectors in the economy (the so-called input-output table). We rely on interviews with representative companies from the different parts of the value chain to calibrate and quality assure key assumptions of our model. Please refer to appendix 1 and 2 for a more detailed description of our methodology.

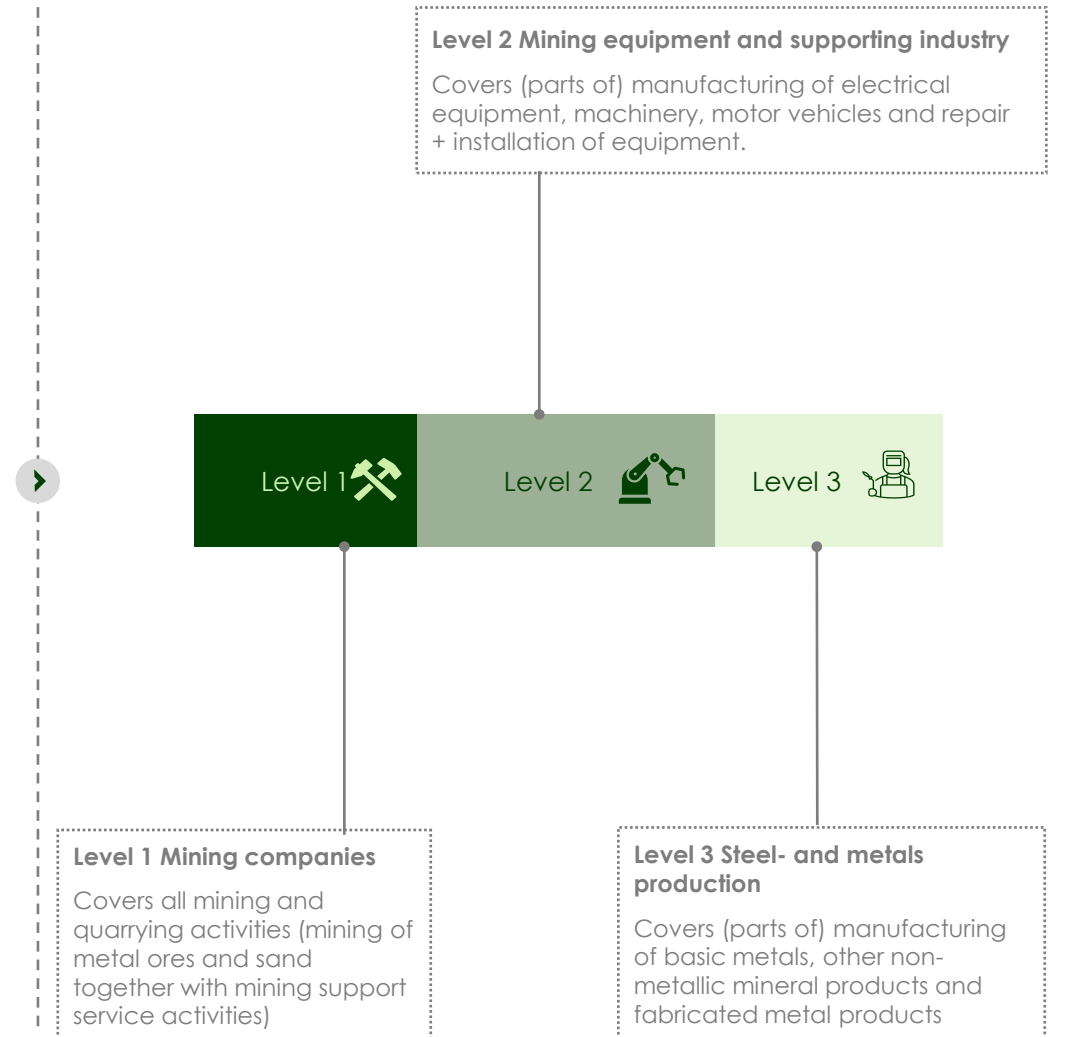
Due to data limitations (for instance for regional deep dives), we are, however, not able to present all statistics for our definition of the mining cluster. Therefore, we sometimes present statistics for e.g. the mining sector only or for the mining and metal sectors together. We will throughout the report mark such cases with a warning sign:

Due to data limitations, numbers do not fully correspond to our definition of the mining cluster.



(1) For the exact definition of the mining cluster for input-output modelling purposes see appendices 1 and 2.

The Swedish mining cluster: an ecosystem with mining at its core



The mining cluster supports roughly 3% of Swedish GDP

Two channels of economic footprint

To analyse the economic contribution of the Swedish mining cluster, we use a so-called **input-output (IO) model**. This model allows us to measure the economic importance of a sector in the overall economy by using data on the interdependence between sectors from SCB. Relying on SCB's input-output table we can calculate the economic footprint from the mining cluster via two different channels.

1 The direct effect:
Reflects the value creation by companies which are part of the mining cluster (i.e., mining sector companies, metal- and steel production, mining equipment and supporting industry)

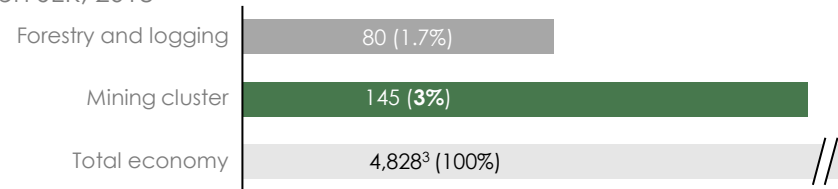
2 The indirect effect:
Reflects the value creation by subcontractors to the mining cluster and their subcontractors. I.e. how expenditure by the mining cluster companies supports an increased economic activity throughout the value chain.

The entire mining cluster's GDP contribution corresponds to 3% of Swedish GDP¹

In comparison, the forestry and logging industry supports around 2% of Swedish GDP, taking into account both direct and indirect GDP contribution.²

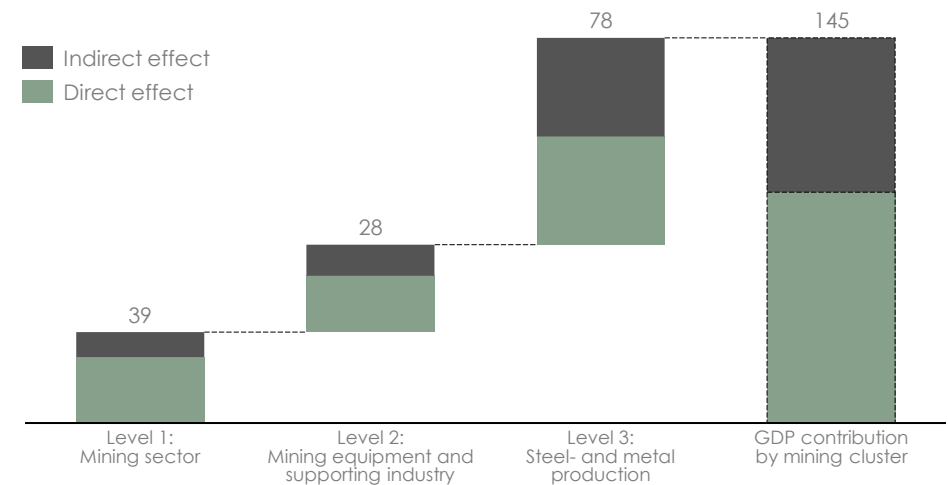
Sweden's GDP

bn SEK, 2018



Breakdown of GDP contribution from mining cluster (level 1-3)

Direct and indirect effect from IO analysis, bn SEK, 2018



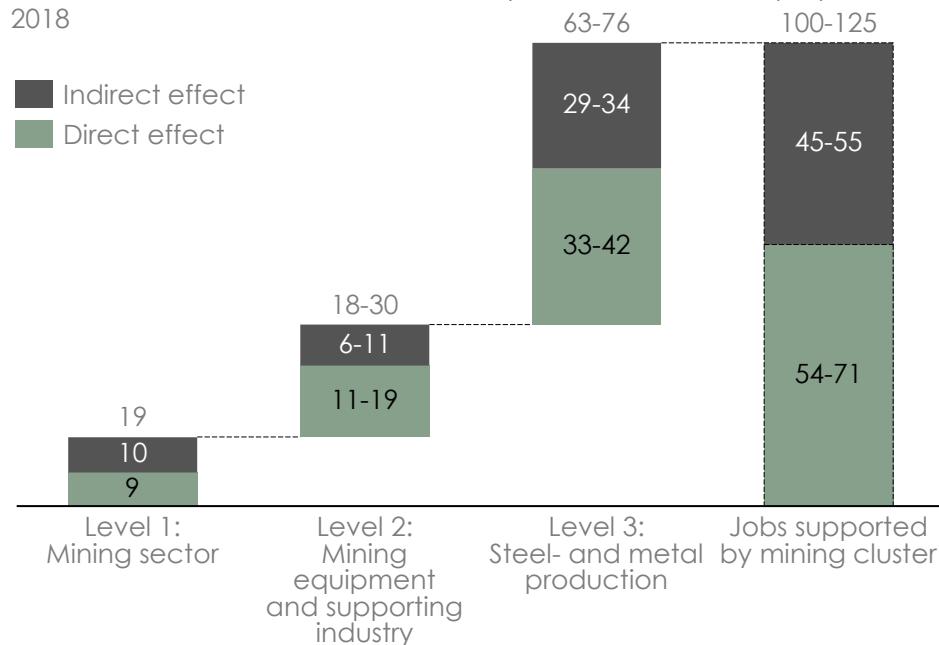
Note: The different levels of the mining cluster is defined in appendix 1 and 2
Source: Copenhagen Economics based on SCB input-output tables 2018

(1) We estimate an interval of 2.7-3.4% of Swedish GDP, based on assumptions on the size of the Swedish mining cluster, please see appendix 1 / (2) We note that the definition of the Swedish mining cluster goes across industries, whereas the forestry and logging industry here corresponds 1:1 to the sector defined in the national accounts. / (3) 4,828 bn SEK was the official Swedish GDP in 2018 according to SCB (2021a), [link](#).

The mining cluster supports 100,000 – 125,000 jobs in Sweden¹

Jobs supported by the mining cluster (level 1-3)¹

Direct and indirect effect from IO analysis, thousands of employees, 2018



Note: Jobs are given by employees in the given sector, cluster or industry. Total jobs do not add up to the sum of level 1, 2 and 3 due to rounding.

Source: Copenhagen Economics based on SCB input-output table 2018, SCB (2021 d)



Both **direct** jobs (within the mining cluster) and **indirect** jobs (supported in the wider economy from e.g., purchases by the mining cluster) are included

Fact box: Estimation of jobs supported by the Swedish mining cluster

- We estimate that the mining cluster supports at least 100,000-125,000 jobs in Sweden - amounting to approximately **2-4% of total jobs in Sweden**.¹ This estimate is **conservative**.
- This estimate is based on our input-output model, relying on data from SCB for Structural business statistics.
- The dataset does not include all employees in Sweden. Primarily public jobs are left out, implying we might **underestimate the indirect job effect**. However, most indirect jobs are located in the private sector (construction, transport).

Our estimate compared to previous estimates is low

- The Association of Swedish Engineering Industries estimate that 1 job in mining supports another 1.6 jobs in the wider economy.²
- From our input-output model we find that 1 job in mining supports 1.3 jobs in the wider economy.
- The discrepancy in the estimates is due to data limitations as described above (public jobs not being included). Our estimate should thus be seen as conservative.¹

(1) Numbers are rounded; Employment data from SCB used in our input-output model does not include all jobs in Sweden but is based on data for Structural Business Statistics implying (primarily) public jobs are left out. This causes us to underestimate the indirect effect. / (2) The Association of Swedish Engineering Industries, "The competitive sector more than industry".

The Swedish mining cluster drives close to 8% of Swedish exports

Fact box: Positive network effects within clusters

- Companies within a cluster tend to specialize in relation to each other, some acting as subcontractors, others becoming effective competitors.
- The demand for goods or services produced by Swedish companies within the mining cluster will be higher when these companies are relatively more productive or innovative compared to competitors.³
- Swedish mining companies create the foundation for the competitive advantage in the mining cluster. Thereby it enables export larger than just mining related products and services. Our analysis can thus be seen as a conservative estimate.
- This is exemplified by Sweden being a large exporter of not only raw materials but also underground technology.

**31
mn
tonnes***

of metal ores, iron, steel and other processed metals were exported from Sweden in 2020.¹

60%

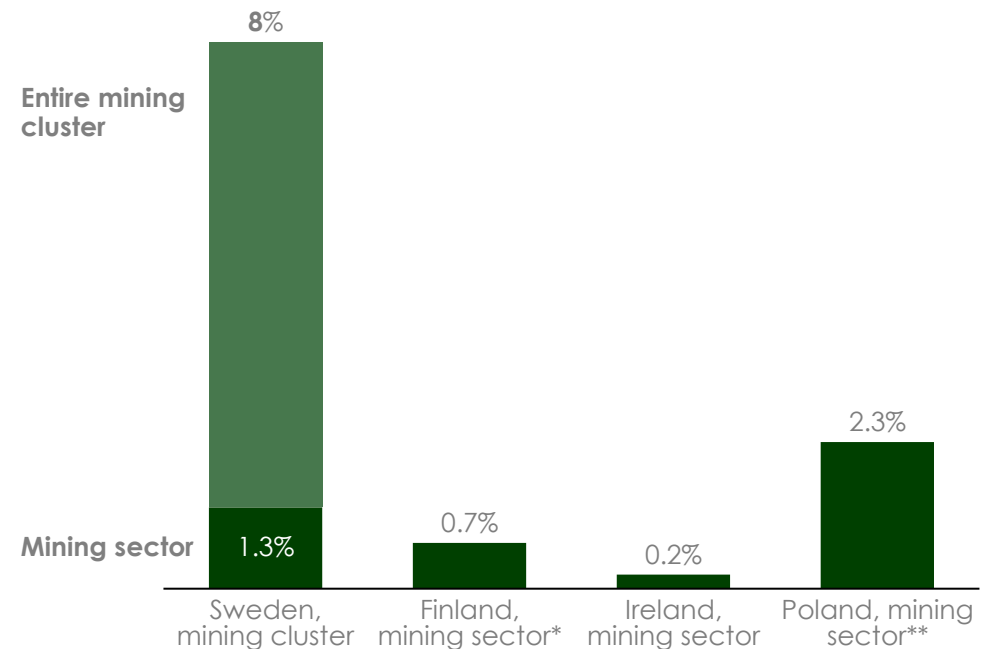
of the world market for underground technology is sales by Epiroc and Sandvik.²

The Swedish mining cluster is a large driver of exports

- The Swedish mining cluster drives close to 8% of Swedish exports
- In comparison, manufacturing of paper and pulp products drive above 5% of Swedish exports, whereas the television and music industry drives around 0,5%.⁴

Mining sector exports in large European mining countries

% of total exports, 2018



Note: *Finland numbers for export are 2019 numbers / **Numbers for Poland includes export of coal and other energy minerals. / All export numbers are converted from USD to SEK using 8.56 SEK/USD / Constant prices using national base-year

Source: Copenhagen Economics based on SCB input-output table 2018 and OECD stats (2021a).

*In addition, 10 mn tonnes of minerals (energy-, building- and industrial minerals), were exported from Sweden in 2020.

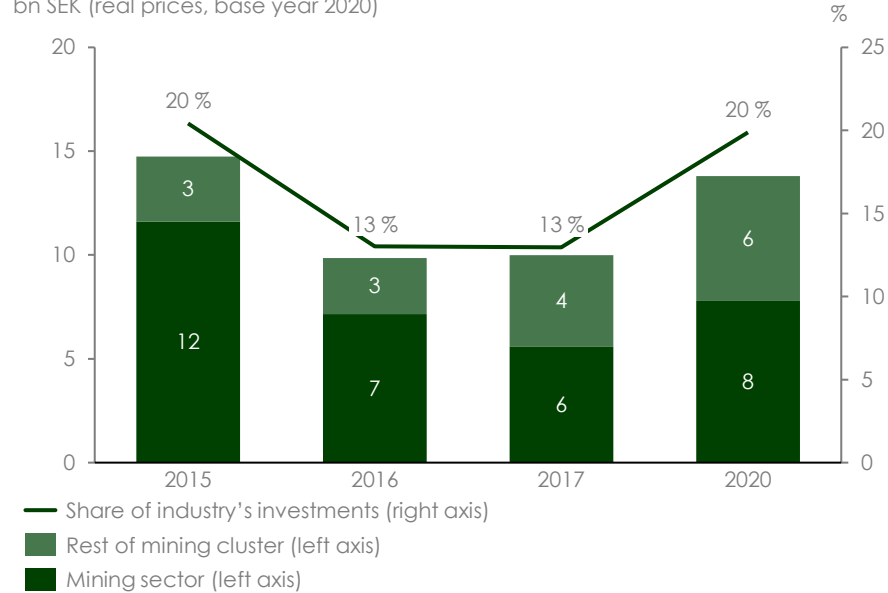
(1) Geological Survey of Sweden (2021a), p.87, [link](#) / (2) Svemin (2021B), [link](#) / (3) Copenhagen Economics (2016), [link](#) / (4) Copenhagen Economics based on SCB input-output table 2018

Mining is an important driver of investments in Sweden

The mining cluster drives 13-20% of investments made by the mining and manufacturing sectors

New domestic investments per year

bn SEK (real prices, base year 2020)



Note: Industrial investments is those belonging to the mining and manufacturing sector (NACE codes B+C) following the Swedish Agency for Economic and Regional Growth. Data is in current prices from SCB and deflated with the producer price index for mining and manufacturing.
Source: Copenhagen Economics based on SCB, table "Planned and executed investments, full year, by industry SNI2007 and investment objects"

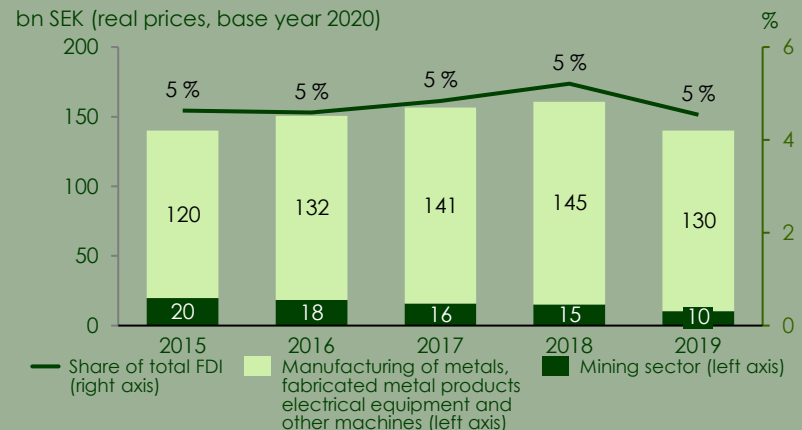
- We follow the approach by the Swedish Agency for Economic and Regional Growth and define the industrial investments as those belonging to the mining and manufacturing sector.
- Domestic investment data is flow data and follows our definition of the mining cluster, see appendix 1 and 2. Data is not available for the years 2018-2019.

Fact box: Foreign Direct Investments (FDI) - when foreign companies invest in e.g., mining and metals production in Sweden

- Available data for FDI is stock data, implying we look at total positions in mining and metal production by foreign companies.
- Data is grouped differently from our definition of the mining cluster and is not 1:1 comparable with data for the mining cluster.
- We include the mining sector (corresponding to level 1) and manufacturing of electrical equipment, machinery, metals and metal products (parts of level 2 and 3).

Mining and metals production accounts for 5% of total FDI

bn SEK (real prices, base year 2020)



Due to data limitations, numbers do not fully correspond to our definition of the mining cluster. We here include the mining sector and parts of level 2 and 3.

Note: Data in current prices from SCB and deflated with the producer price index for mining and manufacturing.

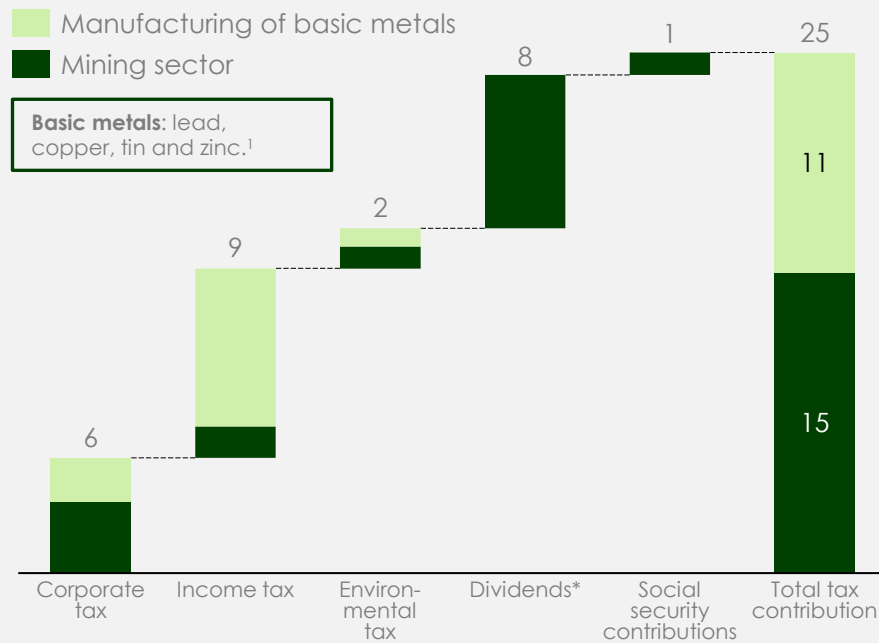
Source: Copenhagen Economics based on SCB table "Direct investment. Assets by economic activity NACE 2007" and "Producer Price Index by market and product groups SPIN 2015", 2020=100"

Mining and metal companies contribute with 1.2% of total tax income in Sweden

The mining and basic metal sectors generate more than bn SEK 25 per year in tax revenue and dividends to the state

Tax payments and dividends

bn SEK, 2018



Note: Numbers do not add up to total, due to rounding. *These dividends are paid by LKAB to the state, since LKAB is a state owned company. Total tax revenue in Sweden in 2019 was SEK 2,154 bn, amounting to mining and metal companies paying 1,2% of the total tax income. Source: Copenhagen Economics based on SCB, [link](#) / Geological Survey of Sweden (2021a), [link](#) / OECD (2021b), [link](#),



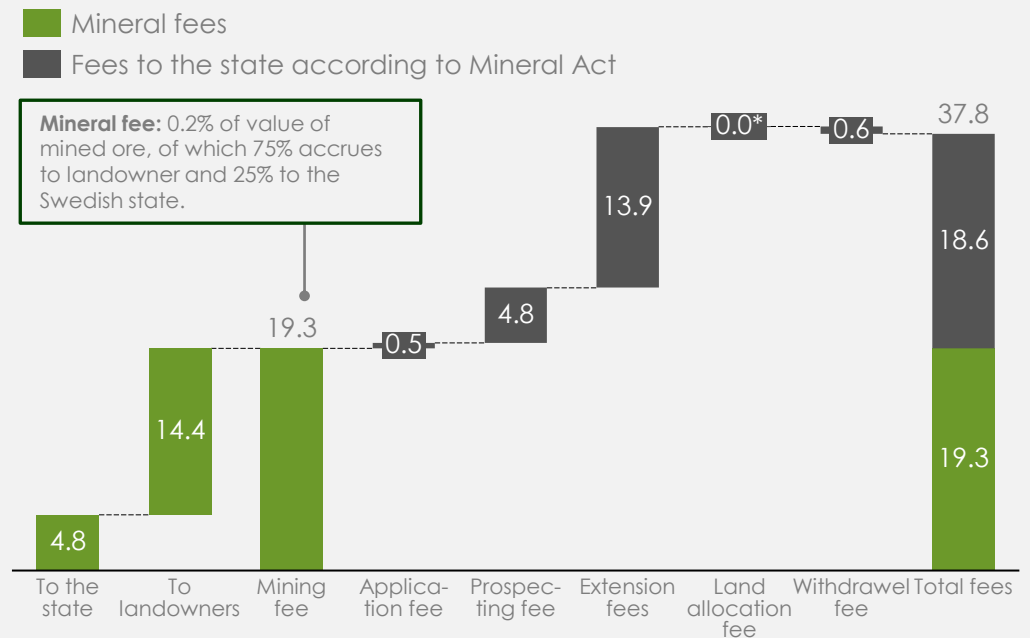
Due to data limitations, numbers do not fully correspond to our definition of the mining cluster. We here include the mining and basic metal sectors.

(1) Nationalencyklopedin, [link](#)

Mining also pays SEK 38 millions in sector specific fees

Mineral fees

mn SEK, 2020



Note: * The actual number is SEK 40,000. Source: Copenhagen Economics based on Geological Survey of Sweden (2021a), [link](#)

A miner wearing a yellow safety suit and helmet stands in a dark tunnel, looking towards a bright opening in the distance. The miner is holding a tool or device. The tunnel walls are rough and rocky. The lighting is dramatic, with the miner's suit glowing against the dark background.

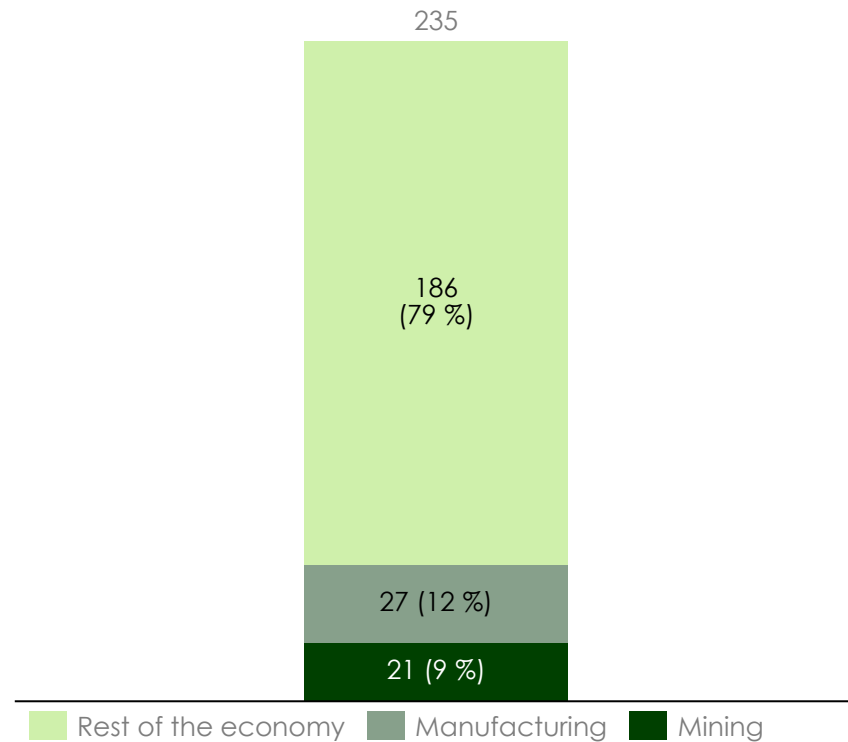
2.2 THE ECONOMIC CONTRIBUTION OF THE SWEDISH MINING CLUSTER – REGIONAL LEVEL

Greater relative economic importance of mining in the two most northern regions



Gross regional product for Norrbotten and Västerbotten

bn SEK, 2018



Note: Manufacturing includes the NACE codes C10-C33. Since the entire manufacturing sector is included here, data is not 1:1 comparable with data shown on a national level, which follow our definition of the mining cluster se appendix 1 and 2.

Source: Copenhagen Economics based on SCB (2021b), "Bruttonationalprodukt efter region och näringsgren". Special extraction by SCB.

On a regional level only direct effects are included, (i.e. the direct GDP contributions by companies which are part of the mining cluster) as we cannot model regional effects in our national level input-output model.

We do, however, see that the mining and manufacturing sectors (which have a great overlap with our mining cluster definition) have a **significant economic importance**.

The mining and manufacturing sectors account for **20% of the Gross Regional Product**.

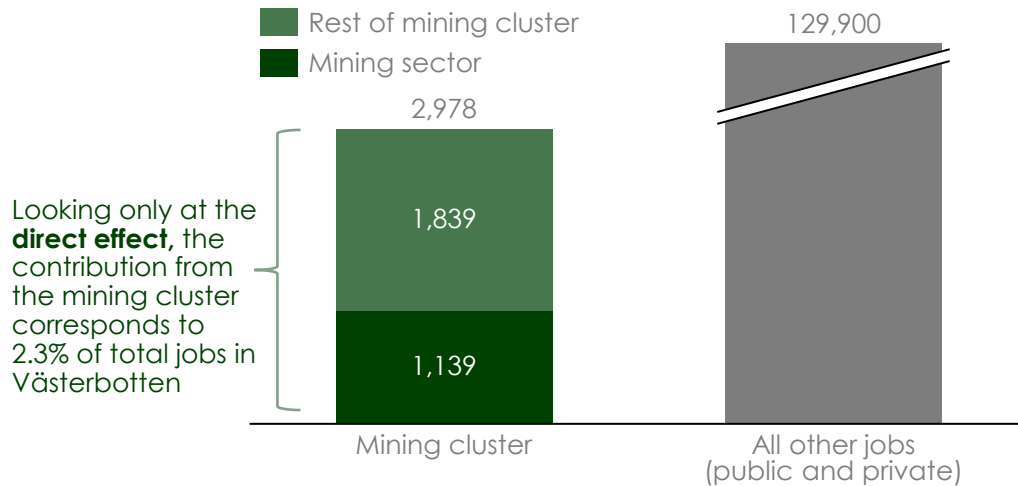
Due to data limitations, numbers do not fully correspond to our definition of the mining cluster. We here include the mining sector and the entire manufacturing sector.



Mining is an important regional employer in Västerbotten and Norrbotten

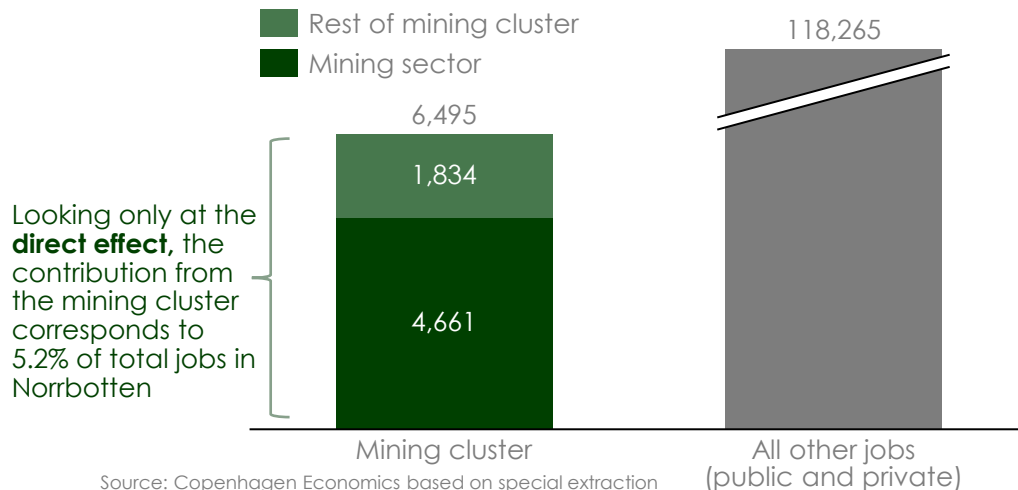


Total employment in Västerbotten



Source: Special extraction from SCB, regional employment on industry level

Total employment in Norrbotten



Source: Copenhagen Economics based on special extraction from SCB, regional employment at sector level

(1) Regional facts (2021), [link](#)

The mining cluster plays an important role in creating regional jobs.

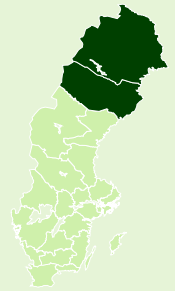
In Norrbotten, steel manufacturer SSAB is the largest private employer with more than 1,100 workers¹.

In Västerbotten, mining company Boliden is the largest private employer with more than 1,700 workers¹.

In Västerbotten, the mining cluster accounts for 2.3% of total direct employment and in Norrbotten it accounts for 5.2%.

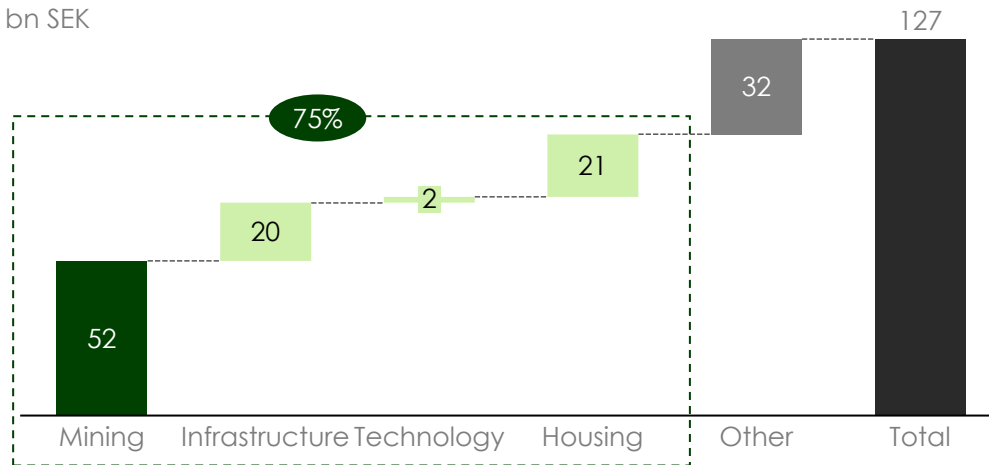
In comparison to the national job estimates, this may seem small as we here only include **the direct effect**, i.e. people employed directly by the mining cluster. We do not know exactly how many indirect jobs this gives rise to in other sectors (the indirect effect).

Mining also drives regional investments in the North of Sweden



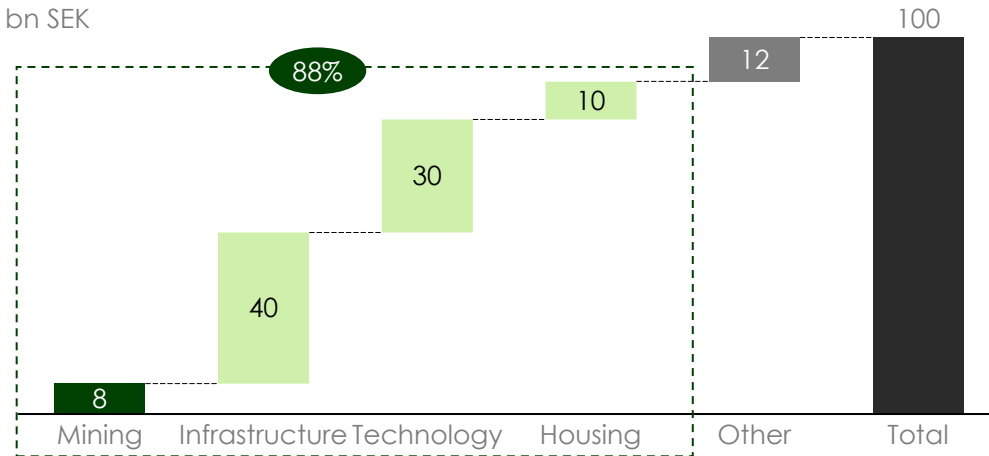
Mining-related investments in Norrbotten towards 2035

bn SEK



Mining-related investments in Västerbotten towards 2035

bn SEK



■ Directly linked to mining
 ■ Indirectly linked to mining
 ■ Not mining related

The mining industry is capital intensive and requires surrounding infrastructure. Therefore it can be a driver of investments.

Swedish Chamber of Commerce estimates that out of total realised or planned investments worth of **SEK 230 bn** from 2016 to 2035, **75% of investments into Norrbotten and 88% into Västerbotten are directly or indirectly related to mining**. Note that this is both domestic investments and foreign direct investments.

Looking only at investment directly linked to mining, the actual investments from 2014 to 2019 covered 37% and 1% of total investment in Norrbotten and Västerbotten, respectively.¹ Also note that investments may change a lot from one year to the next.

Due to data limitations, numbers do not fully correspond to our definition of the mining cluster. We here include investments directly and indirectly linked to mining.



Source: Copenhagen Economics based on the Swedish Chamber of Commerce (2020), [link](#)

(1) SCB Statistic Database (2021c), [link](#)

3 FUTURE OPPORTUNITIES

A landscape photograph showing rolling hills under a soft, hazy sky. A thick layer of mist or fog fills the valley between the hills. In the distance, several wind turbines are visible, their silhouettes softened by the atmospheric conditions. The overall color palette is muted, with soft blues, greys, and earthy tones.

Mining is part of the transition towards a low-carbon future

Offering a potential to grow and transform

Metals and minerals are essential for the technologies needed for a successful transition to a low-carbon economy.¹

Sweden has the geological potential and the mining specific knowhow to mine more raw materials than today, and to mine them in a low impact way through electrified mines etc.

Looking specifically at iron ore and associated steel production, global demand for steel is forecasted to increase more than 30% by 2050.² Steel manufacturing already accounts for 7% of CO₂ emissions worldwide.³ Thus, carbon-free steel production holds great potential in the combat against climate change.

Several projects on carbon-free steel production already exist in Sweden (Hybrit, H2 Green Steel). This is, however, only one of the areas where the Swedish mining cluster is already at the forefront.

A range of different projects are making their way in Sweden from extraction of metals from mine waste to new research and establishment of new industries and value chains in e.g., batteries as well as green steel. In this section, we look at a handful of examples of such projects, but there are many more.

Clean energy transition drives future higher demand for metals

To combat climate change we need new technologies, to innovate production processes, and we need more primary as well as recycled raw materials

More primary metals and minerals

- To reach the goals of the Paris Agreement, metal companies must significantly increase their level of investment in production capacity for copper, nickel and other metals over the next 15 years compared to the previous 15.⁴

Recycled metals

- Recycling rates for metals have not increased significantly during most recent years.⁵
- Enhancing recycling from e.g. mine waste is one potential source of increased supply.⁵

Technology development

- To increase society's share of renewable energy we need windmills, solar panels etc. These are all made from steel, special metals etc., so metal and steel demand will continue to grow.
- New technologies are needed to produce these metals in ways which have lower carbon footprints.
- Using hydrogen for steel production is one such example of developing technologies and innovate production processes to replace existing, carbon-intensive ones.^{5,6} Electrified mines is another example.

Source: (1) The Conversation (2021): [Link](#) / (2) IEA (2020): Iron and Steel Technology Roadmap: [Link](#) / (3) Wood MacKenzie (2020) / (4) IEA (2020) The role of Critical Minerals in Clean Energy Transitions, p. 176. / (5) MidRex (2018): [Link](#) / (6) Industrial Efficiency Technology Database: [Link](#) /

7 projects offering raw materials, technological advancements and local battery production

Different levels of maturity and closeness to realisation

The projects we look at for this report are chosen because they all can contribute, in their own part, to the green transition by producing raw materials in high demand, breaking new technological ground or even paving the way for a new value chain in batteries in Sweden.

Through a range of interviews and supporting research, we find that these projects represent vast opportunities for Sweden, both economically and environmentally in their own right, but also as future potential flagships and export opportunities for Sweden. Green steel being just one such example.

The projects, however, differ a lot in maturity and how far they are from producing at commercial scale and realising their full potential.

How close projects are to getting started and run at commercial scale differs a lot depending on 1) technological barriers and 2) framework conditions being either a beneficial or complicating factor.

In the following three slides, we have mapped and assessed the projects in these two dimensions. The further to the bottom left a project is located in the diagram (green square, see next slide), the more likely is the realisation of the project's potentials, and vice versa.

If obstacles to these projects' realisation, being either technical or framework conditions such as permitting or availability of skilled labour etc., are not overcome, the implication could be a loss of economic and environmental opportunity - not only to the detriment of Sweden, but also Europe.

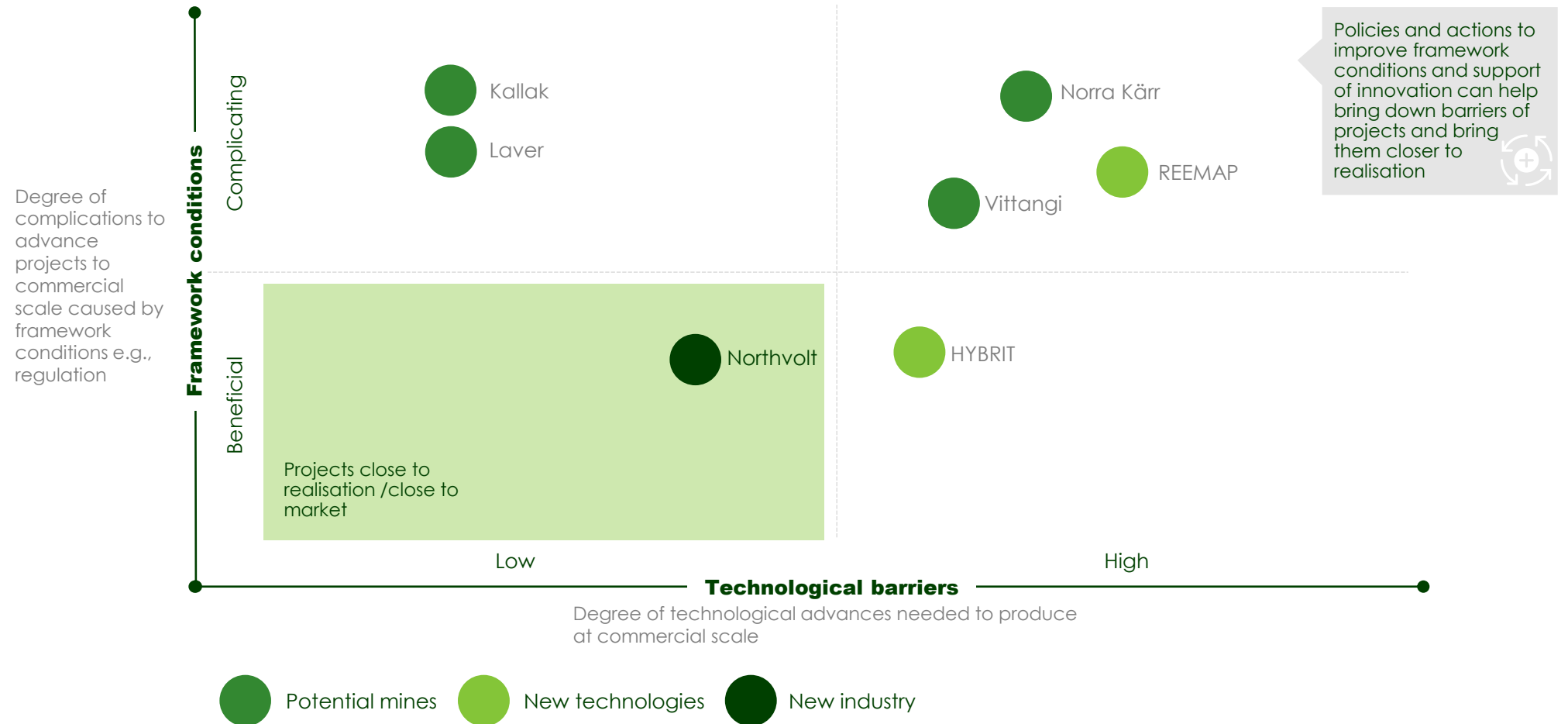
Opportunities brought about by these projects collectively are:

- **Locally produced raw materials in high demand**
- **Carbon free steel**
- **Carbon free mining waste recycling**
- **Jobs**
- **New skills and industrial value chains**
- **Multi billion SEK investments**



Better framework conditions and support to innovation can play a big role in bringing projects closer to realisation

Closeness to realisation: projects with low barriers are closer to production at commercial scale and unlocking economic and environmental potentials



 A qualification of our assessment of the projects' location in the two dimensions is described in following pages

Our assessment of projects - Potential mines

Qualification of assessment in the two dimensions

Project	Framework conditions	Technological barriers	Potentials
Laver, Boliden	<ul style="list-style-type: none"> In January 2021, Boliden appealed the Government's decision against the Laver project to the High Administrative Court¹, where a decision is still pending Multiple environmental permits outstanding 	<ul style="list-style-type: none"> Known production process and existing know-how from Aitik Flagship mine Will take a few years to construct the mine once permitted² Existing technological skills within workforce 	<ul style="list-style-type: none"> Estimated potential to produce up to 10% of European copper production.² Investments estimated to be SEK 10-15 bn.
Vittangi, Talga	<ul style="list-style-type: none"> Mining concession outstanding Multiple environmental permits outstanding 	<ul style="list-style-type: none"> Developing the necessary technology to produce high-quality coated graphite anodes at commercial scale Constructing in-house downstream processing facility Location scouting and skilled labour.³ 	<ul style="list-style-type: none"> Potential to produce high quality anodes for batteries with limited climate footprint – potentially in partnership with Northvolt to ensure a local supply chain or other industrial partnerships.³
Norra Kärr, Leading Edge Materials	<ul style="list-style-type: none"> In June 2021, Leading Edge Material appealed to the Government the decision of the Mining Inspectorate of Sweden against its mining concession application.⁴ Multiple environmental permits outstanding 	<ul style="list-style-type: none"> Finding a suitable location with an industrial park (a need for an chlor-alkali plant on the site of chemical separation of ore)⁵ Technology available at demonstration level, but not at commercial scale No or very limited existing REE industry in Europe and a lack of skilled workforce in the field 	<ul style="list-style-type: none"> Initial investments of SEK 4.2 bn and mining operations lasting for 26 years.⁴
Kallak, Beowulf mining	<ul style="list-style-type: none"> Exploitation concession application submitted in 2013, recommended approval by Mining Inspectorate in 2015. Awaiting government's review of supreme court's decision on Norra Kärr.⁶ Discussions on Laponian World heritage site have prolonged decision process.⁸ Close to rail and port infrastructure⁷ 	<ul style="list-style-type: none"> No technical barriers/ known production process Existing know-how in Sweden 	<ul style="list-style-type: none"> Sweden's largest unexploited iron ore deposit (a potential 389 million tonne resource).⁶ Expected SEK 1 bn in tax revenues over a 25 year mine life⁶ Test work suggests high grade concentrate containing over of 71.5% iron⁷ A potential to supply a fossil-free steelmaking supply chain in Sweden⁷

Notes: (1) Boliden (2021): [Link](#) / (2) CE's interview with Boliden / (3) CE's interview with Talga Resource and [Link](#), (4) Leading Edge Material (2021a): [Link](#) / (5) CE's interview with LEM / (6) Luleå University of Technology and Umeå University (2016), Copenhagen Economics (2017b) and Beowulf mining, [link](#) / (7) Beowulf mining, [link](#) and Beowulf mining, [link](#) / (8) The Swedish Environmental Protection Agency and The National Heritage Board has confirmed that Kallak has no direct impacts on Laponia.

Our assessment of projects - New technologies and new industry

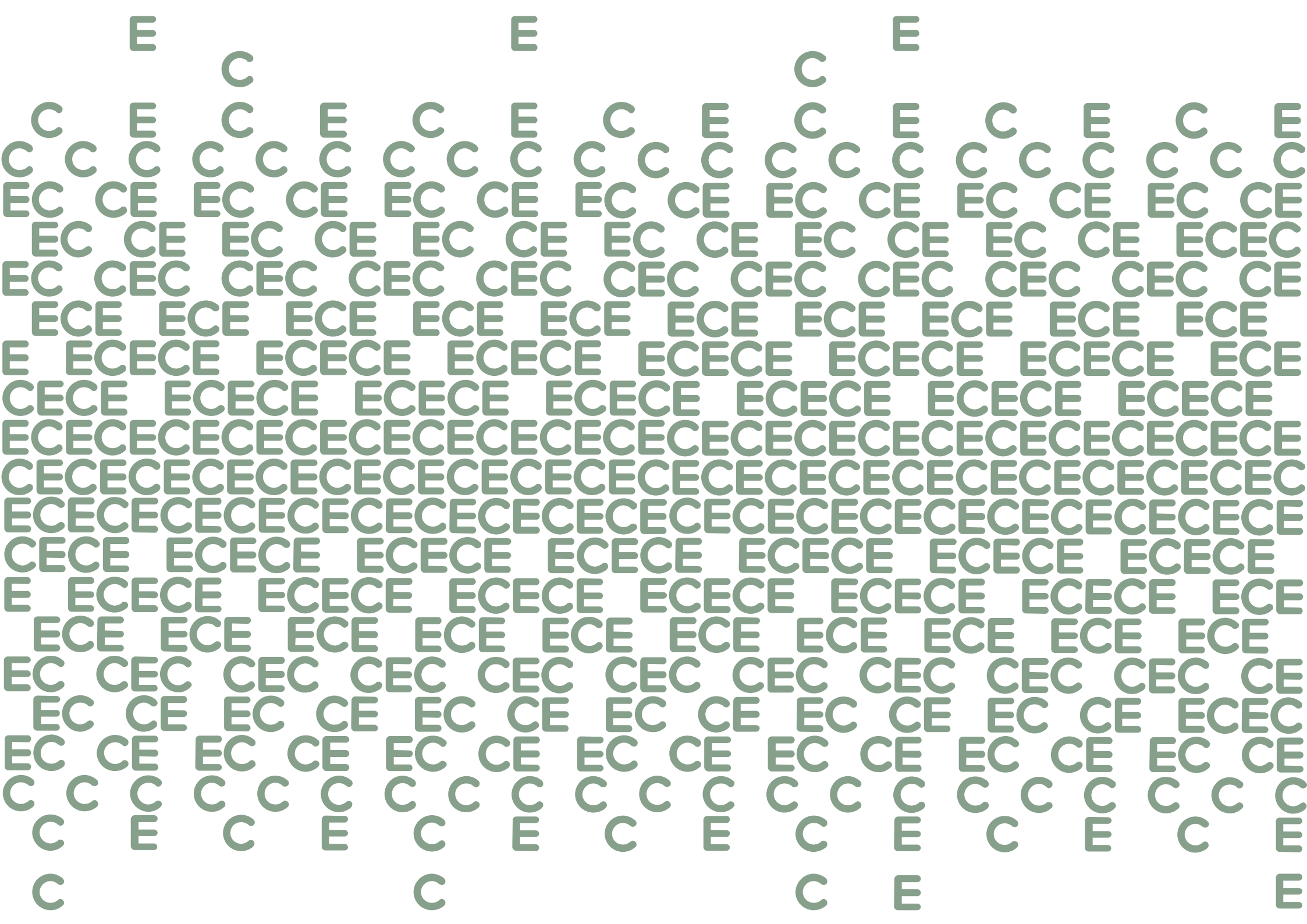
Qualification of assessment in the two dimensions

Project	Framework conditions	Technological barriers	Potentials
HYBRIT, LKAB, SSAB, Vattenfall	<ul style="list-style-type: none"> Pilot plant constructed and have produced first batch of fossil free steel in July 2021. A commercial scale plant will need building permits etc.¹ 	<p>Complicated +</p> <ul style="list-style-type: none"> Technology of producing fossil free steel is now demonstrated, but still long way to go to commercial scale (2026).¹ 	<p>High</p> <ul style="list-style-type: none"> Investments of SEK 10-20 bn per year and employment of 2000-3000 people in the construction phase.²
REEMAP, LKAB	<ul style="list-style-type: none"> Permit to mine from mining waste outstanding³ Multiple environmental permits outstanding Location scouting – will need 50 hectares of land for the industrial park³ 	<p>Complicated ++</p> <ul style="list-style-type: none"> The right competencies in workforce are currently not present in Sweden. LKAB must build skills internally.^{3,4} Recycling of phosphorus or REE requires its own 'mine' with a circular approach. 	<p>High</p> <ul style="list-style-type: none"> Job creation in Northern Sweden and development of knowhow in REE.⁷ Potential to cover 30% of Europe's demand for REEs. Develop new technologies in carbon-free mine waste recycling.⁴ Reduce Sweden's CO2 emissions by 1%.⁴
Northvolt	<ul style="list-style-type: none"> Already permitted, construction process have begun⁵ First production shift to start November 2021⁹ 	<p>Beneficial⁹ +</p> <ul style="list-style-type: none"> Build large scale plant Lack of existing know-how: several thousand people to be employed in a short period of time in a new industry where the right education and training does not currently exist. Collaboration between RISE, Northvolt, Luleå University and Skellefteå Municipality in place.⁸ 	<p>Medium</p> <ul style="list-style-type: none"> In green production of batteries: 80% reduced carbon footprint in 2030 compared to those made by using coal energy.⁶ Recycle 97% of old batteries having 50% reused input for new cells by 2030.⁷ 3000 jobs at Northvolt Ett (first factory)

Notes: (1) HYBRIT – A collaboration with SSAB, LKAB and Vattenfall ([Link](#)) / (2) LKAB (2020) [Link](#) / (3) Based on CE's interview with LKAB / (4) LKAB, [link](#) (5) Tidningen näringslivet: [Link](#) / (6) Northvolt (2021a), [Link](#) / (7) Northvolt (2021b), [Link](#) / (8) RISE, [Link](#) / (9) Northvolt (201c), [Link](#)



Photo: Courtesy of Boliden



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Appendix 1: Definition of mining cluster

We define the mining cluster as (shares of) the following sectors:

Nace code	Sector	Share included
Level 1: Mining companies		
B05	Mining of coal and lignite	100%
B06	Extraction of crude petroleum and natural gas	100%
B07	Mining of metal ores	100%
B08	Other mining and quarrying	100%
B09	Mining support service activities	100%
Level 2: Mining equipment and supporting industry		
C27	Manufacture of electrical equipment	7-10%
C28	Manufacture of machinery and equipment n.e.c.	10-15%
C29	Manufacture of motor vehicles, trailers and semi-trailers	1-5%
C33	Repair and installation of machinery and equipment	10-20%
Level 3: Steel- and metals production		
C23	Manufacture of other non-metallic mineral products	10-15%
C24	Manufacture of basic metals (primarily iron)	90-100%
C25	Manufacture of fabricated metal products, except machinery and equipment	7-15%

Appendix 2: Assumptions

Behind our input-output analysis are the following four crucial assumptions

1 Definition of the mining cluster:

Level 1: We assume 100% of the mining and quarrying industry (NACE B05-B09) is included.

Levels 2 and 3: are calculated as an interval as defined in appendix 1. Throughout the report we show point estimates, being located within this interval. This represent an economic assessment based on:

- **Indirect effects from the mining sector in the IO model**
- **Annual reports for known members of the mining cluster**
- **Industry classifications (NACE)**
- **Interviews conducted with vital companies in the mining cluster**

2 For levels 2 and 3 we only include shares of different sectors. Here, we assume that the share of the sectors included behaves similar to the average of the sector, i.e. that companies in the mining cluster buy goods and services across other sectors in Sweden in the same way as the rest of the sector.

3 Companies within the mining cluster use the same amount of inputs per SEK worth of turnover, as the average company in the given sectors.

4 Indirect effects *within* the mining cluster are excluded:

For IO analysis of the *mining cluster*, indirect effects¹ between mining cluster companies are excluded to avoid double counting.

Notes: (1) Indirect effects mining cluster companies might have on each other, by purchases from one another is excluded

Appendix 3: List of interviews conducted for chapter 2

Company	Date
LKAB	08.10.2021
Boliden	16.09.2021
Zinkgruvan	11.10.2021
Epiroc	23.09.2021
ABB	11.10.2021
Sandvik	7.10.2021

We have qualified the assumptions behind our definition of the mining cluster through interviews with large companies asking the following questions:

- Who do you sell to?
- Who do you buy from?
- What do you buy in Sweden?
- How large a share do you import out of your total purchases?
- What is the export share of your sales?
- How large a share of your revenue is based in Sweden?

Appendix 4: List of interviews for chapter 3

We have conducted interviews with large mining companies and companies part of the mining cluster on future projects in the pipeline (or already in the process of being developed) to get a better understanding of the future potentials presented by the Swedish mining industry. The interviews have been complemented with desk research.

Company	Date	Topics
Leading Edge Materials	24.08.2021	Interview on the project Norra Kärr (rare earth deposit) and its potential economic implications as well as its role relating to European self-sufficiency
Boliden (Laver)	10.09.2021	Interview on (potential) re-opening of Laver mine, its future potentials and current barriers to the project
Talga Resources	17.09.2021	Interview on status and potential on the Vittangi project together with current barriers to achieve it.
LKAB (HYBRIT, REEMAP)	08.10.2021	Interview on REEMAP and HYBRIT projects around current status, potential (in terms of employment, investments and environmentally), barriers and potential synergies with other projects.

