FULL REPORT

The Nordic Battery Value Chain

- Market drivers, the Nordic value proposition, and decisive market necessities

Report from Innovation Norway, Business Finland, Business Sweden, and the Swedish Energy Agency
Conducted by Business Sweden

Published: February 2023

Swedish Energy Agency
BUSINESS FINLAND
Innovasjon Norge
BUSINESS SWEDEN

Table of contents

Agenda

This report maps out the Nordic battery value chain and highlights key necessities of the Nordic ecosystem on how to grasp the opportunity of sustainable batteries

Background

- There is an emerging battery industry in Sweden, Finland, and Norway, with the business and employment potential to become a new basic industry. The battery value chain builds upon Nordic traditional strongholds such as automotive, maritime, chemicals, manufacturing and mining. Actors within the Nordic battery ecosystem are active on global markets with strong ambitions and devotion to sustainability. The European context is decisive for business as Europe and the EU is the main region for Nordic trade and investments. The new battery industry is established at a time when markets and economies are in a green transition driven by climate goals and electrification.

- In the Nordics, the Nordic Council of Ministers has set out its vision to become the most sustainable and integrated region in the world by 2030. In April 2021, Innovation Norway, Business Finland, and Business Sweden signed a Letter of Intent for Nordic Collaboration in trade and invest promotion. The ambition is to work closely together in carefully selected initiatives where the value of acting as one united force is stronger.

  – In 2021 the Swedish Energy Agency and Business Sweden published two reports* concluding the complementary strengths within the Nordic battery value chain, a strong momentum for industry potential, a shared interest in joint trade and investment promotion as well as a need for coordinated actions.

  – The Nordic Battery Collaboration is a key initiative. The decision to carry out this report was taken by Business Sweden, Business Finland, Innovation Norway and the Swedish Energy Agency together. All parties are financing the report. The report is conducted by Business Sweden.

Objective of the report

- An updated overview of the value proposition and developments of the Nordic battery value chain
- An updated joint understanding of the key necessities by the Nordic battery ecosystem to grasp the business opportunity of sustainable batteries across the value chain on global markets

Prerequisites of the report

- The report is based on
  – in-depth interviews with 40 representatives from leading players along the value chain in Sweden, Finland, Norway, Denmark and Iceland. About 85% of the interviews have been conducted with Finnish, Norwegian or Swedish market actors as batteries is a national priority here.
  – market and desktop research for main developments on global, European, and Nordic markets
  – market perspective and highlights the market until the end of 2022
- Audience and application
  – The report is publicly available targeted towards collaboration partners to the Nordic industry
  – The targeted audience are still new to the battery industry or already market experts
  – The report is to be used for discussions with and within the battery ecosystem in the Nordics as well as a foundation for Nordic trade and invest promotion
- Limitations
  – The report objective does not include a full analysis of the background of each identified necessity or a deep consequence analysis of the developments. The objective is to state facts.
  – The value chain is a simplified version of reality to fit the scope of the assignment. The value chain can be analysed both deeper and in more detailed steps
  – The interviews were conducted before the EU battery regulation was announced on 9th December
  – The report focuses on the value chain for lithium-ion batteries but touches on developments in R&D and innovative solutions for other technologies

* “The Nordic battery value chain - part 1: key players along the value chain in the Nordic region and overall criteria for foreign investors”
* ”The Nordic battery value chain - Part 2: the opportunities for a joint Nordic value proposition to attract investments and collaborations within the battery value chain”

The overall objectives are broken down into three areas of analysis with ten defined sub-questions addressed in the report

Key questions of the report

Overall objectives

- An updated overview of the value proposition and developments of the Nordic battery value chain
- An updated joint understanding of the key necessities by the Nordic battery ecosystem to grasp the business opportunity of sustainable batteries across the value chain on global markets

Key areas of analysis

Current market drivers

1. What are the overall drivers for current growth of lithium-ion battery demand and supply in Europe?
2. Which decisive developments on global markets influence the European opportunity?

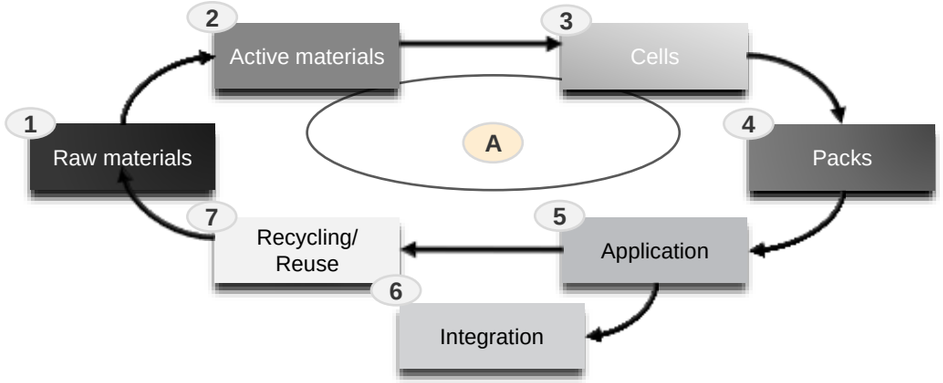
Overview of the Nordic battery value chain

3. What are the key strengths per Nordic country when building a battery value chain?
4. How are these strengths complementary on a Nordic level?
5. Who are the key players within the Nordic battery ecosystem?
6. What is their business focus for the battery industry?
7. What are the key current developments among market actors?

Needs to secure a competitive and sustainable Nordic battery value chain

8. What are the key necessities of the battery industry considering current market dynamics globally, in Europe and in the Nordics?
9. What are the Nordic opportunities considering the necessities?

The steps of the battery value chain



1. Mining and extracting + refining and material processing of raw materials into usable battery materials
2. Chemically active materials + production of anodes, cathodes, electrolyte and separator materials
3. Production of battery cells + stack and roll cells into form
4. Assembly of cells into modules and modules into packs + connect hardware and software, Battery Management System (BMS), into complete packs
5. Producers and users of vehicles and other machinery using lithium-ion batteries to function
6. Integration of the battery application to the energy system including charging stations for EV, other grid solutions and battery storage units
7. Reuse batteries for new purposes or recycle systems, components and materials

A. Academia, public organisations, networks

In addition: we recognise the key role of manufacturing equipment, technologies, and digitalisation as supplier to several steps in the value chain

The findings and analysis in the report are based on 40 interviews with leading players within the Nordic battery ecosystem value chain

Interviewees from Sweden, Finland, Norway, Iceland, and Denmark *

*Excluding additional interviewees wishing to stay confidential

- About the interviews
  - The 40 interviews were conducted throughout November-December 2022.
  - The information from the specific interviews is confidential. No information in the report can be tracked to a specific interviewee.
  - Business Sweden takes full responsibility for the compilation of the information from the interviews. Although confidential, individual opinions are from the interviewees and not from Business Sweden

- Acknowledgements
  - Business Sweden, Business Finland, Innovation Norway, and the Swedish Energy Agency would like to express our gratitude to all interviewees for dialogue and support throughout the work with this report

Agenda

The Nordics have a tangible potential to decisively contribute to the European need for a sustainable, resilient and innovative battery industry

An immense demand in challenging times pushes for a sustainable, resilient and innovative battery industry	• Climate targets and the electrification trend have caused an unprecedented battery demand – A vast supply-gap parallel to ESG issues creates an exceptional need for sustainability • The battery industry, dominated by a few markets, is affected by the current global situation – A regional value chain is key for European competitiveness, resilience, and sustainability
The Nordics have preconditions to contribute	• The Nordics have key industry actors along the full battery value chain including R&D • Finland, Norway, and Sweden are among the top eight global battery nations – Complementary strengths along the value chain reinforces a Nordic value proposition • The Nordic offer facilitates efficient operational expenses and sustainable value chains • Industrial traditions with flat hierarchies, strong work ethics, and joint triple helix innovations together with green, stable and affordable energy is the core of the Nordic competitiveness
The Nordic industry highlight seven pivotal necessities for growth	1. The need for **access to raw materials** entails stability of available market volume and price 2. **Secured supply chains** of materials, machinery cells, and packs needs to be regional 3. Electrification and the new battery industry has generated a disruptive need for **competence** 4. Fundamental movements within value chains has created need for **strategic partnerships** 5. This new industry needs **public framework** to enable trade, scale, and levelled playing field 6. To support charging and ease fast establishments and **enabling infrastructure** is important 7. An increased supply of **green energy**, stable grids, and affordable prices is fundamental
There are opportunities for the Nordics within all seven necessities	• The Nordics have rich deposits of critical materials in a political stable region • Solid cases for cells with close off taker collaborations and interesting active material initiatives • The foundation for competence is solid in industrial traditions and actors along the value chain • The ecosystem is well connected with international private and public partners • Hotbed for new business models, for example in recycling or transport/battery as a service • Drivers for charging infrastructure and collaborative support for local establishments • Historically lower electricity prices with a higher share of renewables than the EU average

> *With an immense gap between demand and supply throughout the value chain and a decisive need for sustainability the Nordics have a wonderful position to impact*
>
> [Swedish actor]

> *The Nordics have a collaborative way of working and strong commitment to sustainability. We have a chance to make actual difference.*
>
> [Finnish actor]

> *The necessities stated are equally important and decisive. With only one of them solved we will not succeed. They are all highly significant.*
>
> [Norwegian actor]

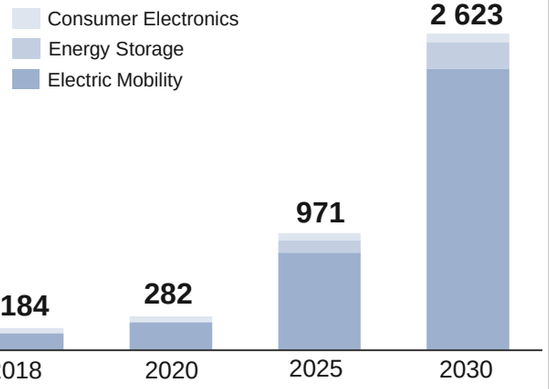
Climate targets and electrification have caused an unprecedented battery demand
- A vast supply-gap parallel to ESG issues opens a window for sustainability impact

Climate targets create business opportunities within electrification

- The Paris Agreement is driving zero-carbon solutions in sectors signifying >70% of global emissions, most noticeable within power and transport sectors
  - 46% of greenhouse gas emissions in Europe 2020 come equally from energy and transport
  - In June 2022, the European Parliament voted to ban sales of new internal combustion engines in the European Union from 2035
- 75% of the overall global battery demand is in China, EU, and the US
- Global battery demand is foremost driven by electric vehicles with 93% of global sales in China, Europe, and the USA in 2021
  - Nations and leading automotive companies are devoted to the transition

Deadlines for 100% Zero emission vehicles, or no new internal combustion engine vehicles sold

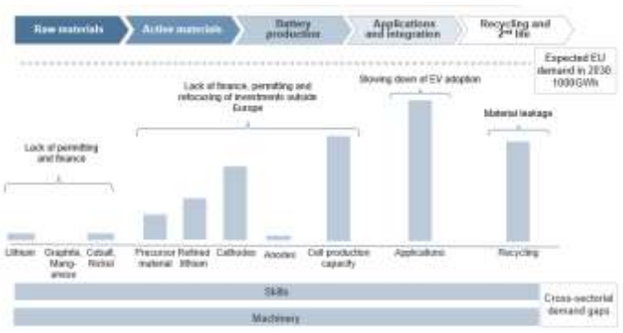
Battery demand per application (GWh per year)



The gap between demand and supply calls for sustainability

- There are significant gaps between demand and supply along the full battery value chain
  - Considering initiatives with clear investment - the gap in Europe is predominately within raw materials, active materials and recycling
  - Considering actual capacity - the gap is however wider, especially concerning battery cell production
- Benchmark Minerals predict the need for 400 new mines by 2035 and it typically takes about 15 years or more to get a mine up and running
- In today's global supply chain of raw materials there are several issues of environmental and human-rights abuses, vast volume of water usage, and geopolitical concerns as battery metals are of strategic significance

European Battery Alliance
Estimated realistic share of EU + Norway production capacity compared to estimated demands per value chain step



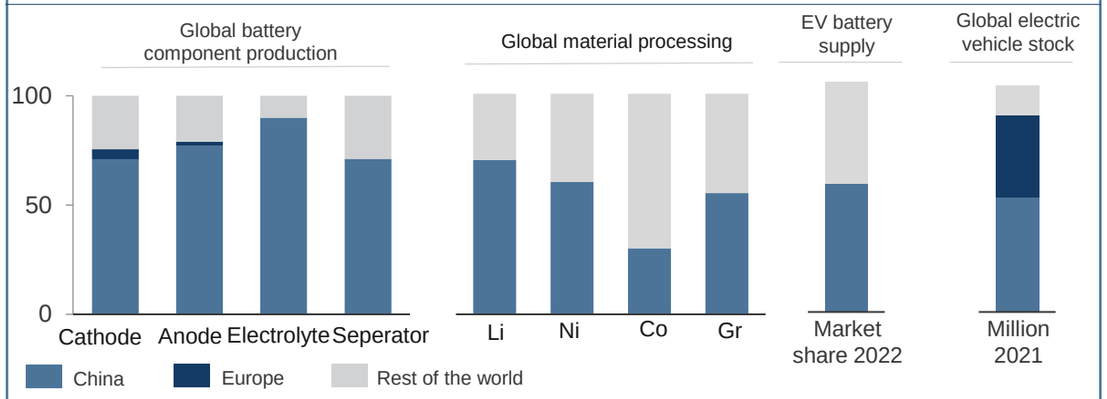
Issues in the global battery value chain

Source: World Economic Forum - A Vision for a Sustainable Battery Value Chain in 2030, BloombergNEF Electric Vehicle Outlook 2020, European Battery Alliance, Battery2030+, McKinsey Analysis, IEA Global Supply Chains of EV batteries, IEA Global EV Outlook 2022, BloombergNEF, EU; European Environment Agency, Foreign Policy, Swedish Environmental Research Institute, Benchmark Minerals, Global Battery Alliance, United States Department of State, Australia Clean Energy Council , Amnesty International

The battery industry is dominated by a few markets in times of a 'perfect storm'
– A regional value chain is key for European competitiveness, resilience & sustainability

In times of regionalisation, resilient supply chains become decisive

- China has a clear dominance across the full global battery value chain, with one-third of the world's EV batteries coming from Chinese CATL
- Current market challenges create an almost perfect storm, increasing the importance of a resilient regional supply chain
- Several key initiatives for sustainability are being launched as the proof of concept for the Battery Passport, the European Critical Minerals Act, the European Battery Regulation, and the US Inflation Reduction Act



Current developments as a "perfect storm"

- Geopolitical effects on trade
- Russia's war in the Ukraine
- Scarcity of components in a booming industry
- Supply chain disruptions from Covid-19
- Long lead times from limited regional supply
- Interest rates and inflation
- Energy supply and electricity prices

European initiatives and need for own industry

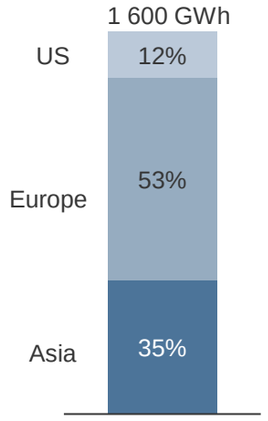
- The establishment of a complete domestic battery value chain is imperative for Europe, both for the clean energy transition and a competitive industry
- Today there are initiatives for more than 1,600 GWh in Europe
  - Among the announced battery cell initiatives, 47% have a non-European company origin

Automotive is a strategic industry for European employment

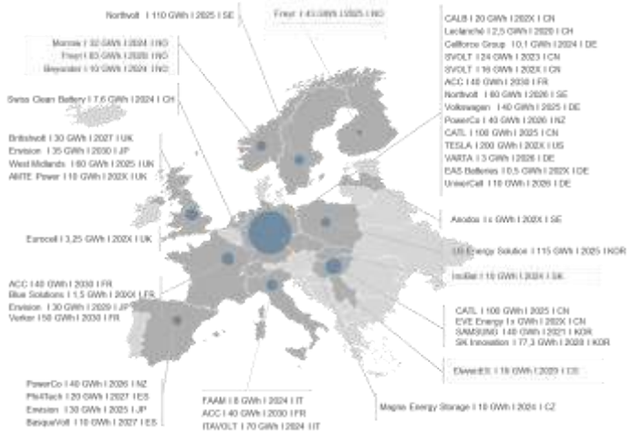
Batteries are strategic components for automotive

Grids will need energy storage systems

Announced battery cell capacity in Europe by company origin



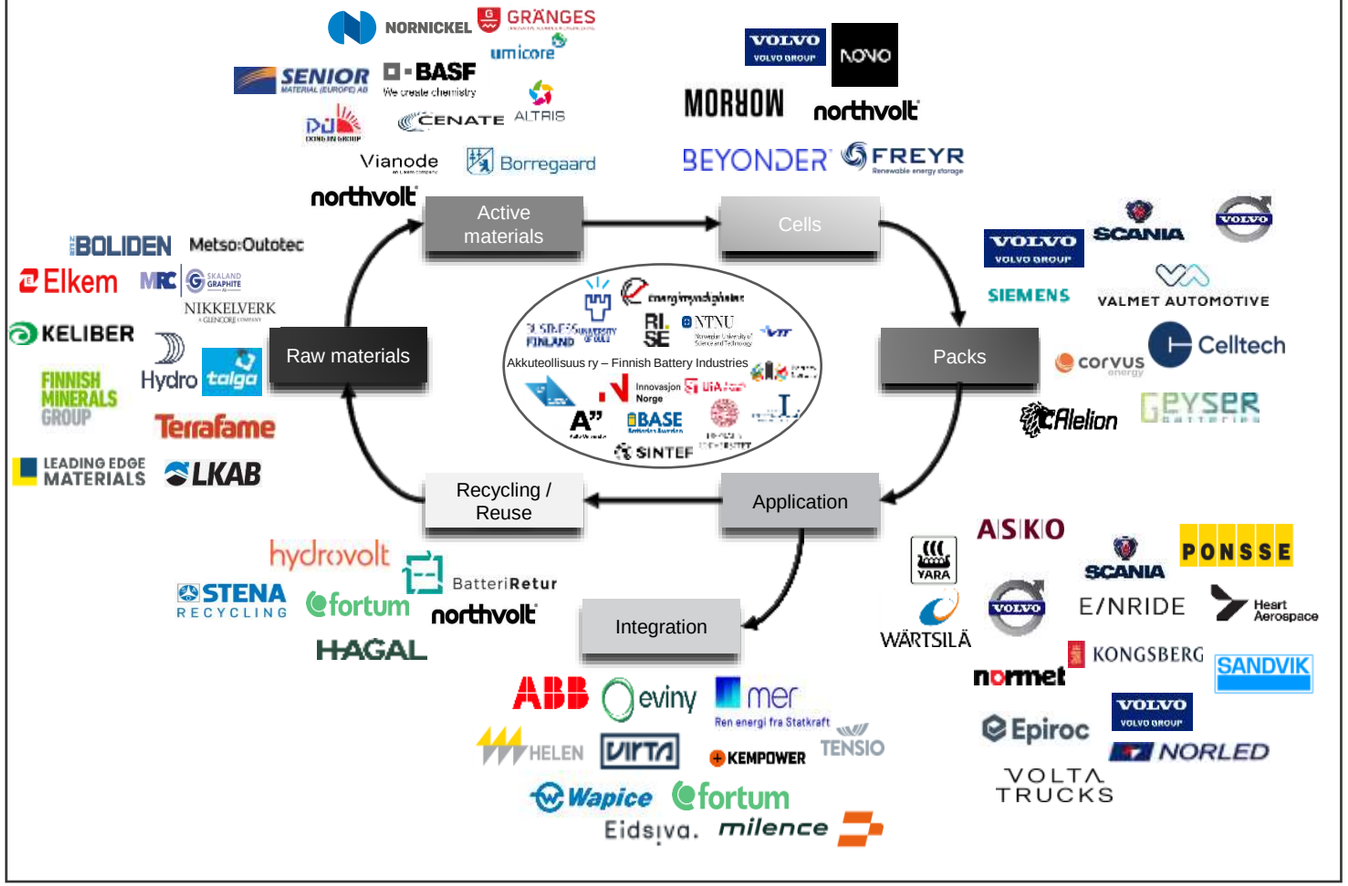
Initiatives for more than 1,600 GWh battery cell capacity is announced in Europe



Source: IEA, Reuters, IPCEI batteries EU ***** Identified battery plants, Battery News **Note**: Map showing: Company I Capacity GWh I Year of production I HQ of Company (Freyr HQ located in Luxembourg)

The Nordic region has key actors in all parts of the value chain with continuous foreign and domestic investments in the industry

Key industry actors in the Nordic battery value chain



Investments in the Nordic region

Examples of ongoing investment cases in the Nordic region 2022*

Previous examples of ongoing investments in the Nordics 2021**

* Examples of Foreign and domestic investments
** Extract from report published 2021:"The Nordic battery value chain - Part 2: the opportunities for a joint Nordic value proposition to attract investments and collaborations within the battery value chain*

Finland, Norway, and Sweden are among the top eight global battery nations offering preconditions for efficient operations and sustainable value chains

The Nordics offer preferable preconditions for business

- Green, stable, and affordable energy enabling sustainable business
- Competitiveness and potential along the value chain at global level
- Long industrial traditions, digital innovations in a triple helix approach

Overall share of fossil fuel-free 2021

Denmark	Finland	Norway	Iceland	Sweden	EU
74.1%	84.8%	99.3%	100%	98.1%	62.5%

Among the top global 10 of Bloomberg NEF ranking 2022

Global rank		Raw material	Battery manufacturing	Environmental, social, and governance factors (ESG)	Industry, innovation & structure	Downstream Demand*
1	China	1	1	17	9	1
2	Canada	3	8	6	4	10
3	US	6	4	16	5	2
4	Finland	9	15	2	1	11
5	Norway	18	10	1	3	7
6	Germany	21	6	4	7	2
7	South Korea	17	2	10	6	5
8	Sweden	21	9	3	2	8
9	Japan	13	3	8	12	8
10	Australia	2	15	9	13	11

Prerequisites for Nordic business

- Green energy at low costs
- Stable energy supply and cold climate
- Productive workforce
- Connected logistics
- Tangible actions for sustainability
- Abundant deposits of raw material

The Nordics have complementary strengths

	Finland	Norway	Sweden
1. Raw materials	• Active mines • R&D and initiatives for further production • Further deposits	• Refinery • Aluminum • Further deposits	• Initiatives for prospecting • Further deposits
2. Active materials	• Production ongoing (e.g. cathode material)	• Production ongoing (graphite)	• Initiatives for production (graphite, cathode) • R&D • Cell production ongoing; two larger initiatives announced
3. Cell production	• One initiative announced	• Three initiatives ongoing • One initiative announced	
4. Pack production	• Automotive suppliers	• For maritime industry	• Automotive and trucks in-house
5. Application	• Machinery and forest industry	• Maritime industry • EV market share	• Automotive & trucks • Machinery • Maritime and aviation
6. Integration	• Grid, storage, and charging projects	• Grid, storage, and charging projects	• Grid, storage and charging projects • Battery integration in application system
7. Re-use / Recycling	• Ongoing recycling and reuse	• High volume of EV batteries • Ongoing recycling and reuse	• Ongoing recycling

Source: Bloomberg NEF 2022, IEA, Business Sweden interviews and analysis

The Nordic battery ecosystem shares decisive market necessities with Europe
- There are opportunities for the Nordics within each highlighted necessity

Highlighted industry needs for a successful Nordic and European battery industry

Within the value chain

Access to raw materials
- Increased available volume
- Stable deliveries and prices
- Informed public debate about supply and sustainability
- Awareness of a Nordic potential

Secured supply chain
- Successful establishment of regional cell supply in Europe
- Short run imported supply to build up industry in Europe
- Long run supply to lower risk

Competence
- Initiatives for short term supply as talent attraction and re- and up-skill current workforce
- Long term supply through national educations and established ecosystem

Strategic partnerships
- Fundamental value chain movements demands new management knowledge and trusted business partners
- Strategic alliances along the value chain to secure business

Market prerequisites

Public framework
- Levelled global playing field
- Framework for battery as a service or recycling on global markets to scale business
- Updated purchasing processes to enable new business models

Enabling infrastructure
- Charging infrastructure to support demand
- Support for fast establishments, including power, permits and pilots
- Municipal support to ease process of establishments

Green energy growth
- Increased volume of renewable energy and stable grids
- Competitive electricity prices
- Public awareness of the importance of green, stable, and affordable energy to business

Source: Business Sweden interviews and analysis

Access to raw materials and secured supply chains within Europe is decisive

- There is a Nordic opportunity of rich mineral deposits and innovative supply chain actors

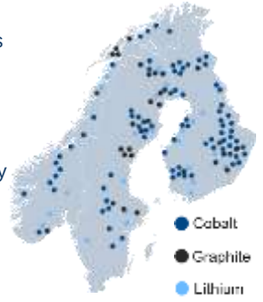
ACCESS TO RAW MATERIALS

Market dynamics

- There is an immense demand as the world moves from an oil to a mineral dependent value chain parallel to severe issues for environmental & social sustainability globally
- A few countries dominate the supply chain and EU production, and reserves are limited
- Lithium prices increase influencing battery prices to rise after a decade of decline
- There is an urge for technology innovations for e.g. manufacturability and recyclability

Battery characteristics for battery demand

Deposits in the Nordics, 2022



Critical areas for the industry

Increased and secured regional supply

- Investments and permits for mining and refineries, regulations for increased recycling and test arenas for innovations
- Secondary raw materials and innovations

> *It is quite simple really: if we want the green transition, we need more mines*
>
> [Swedish actor]

Informed public debate for sustainability

- Public holistic awareness of growing demand and pivotal need for sustainability
- Knowledge of the full mining process, mining heritage and potential for impact

Nordic supply of raw materials

- National decisions on prioritisations for use of land and resources
- Continued high demands on sustainability and respect for all groups with interests

> *Of the material needed 2027 we have about 10% accessible today*
>
> [Finnish actor]

The Nordic opportunity

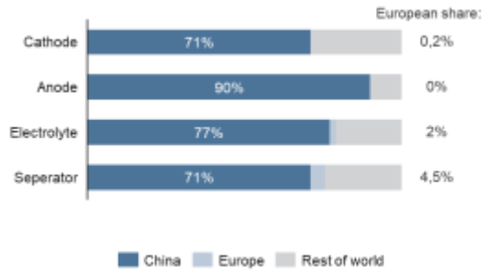
The Nordics have extensive mineral resources deposits of cobalt, graphite and lithium not yet excavated. High rankings in innovations, digitalisation, and sustainability and being a stable region make the Nordics trustworthy business partner. Key: an informed public debate, national priorities and permits.

SECURED SUPPLY CHAIN

Market dynamics

- As European transport producers of all types transfer towards electrification the need for battery cells become decisive. As battery cell factories are set up in Europe the supply chain becomes critical
- Today Europe is dependent on supply dominated by China for cell production, battery component production and battery manufacturing equipment imports, now short on supply

Global battery component production



Critical areas for the industry

Successful cell production initiatives

- Critical to have commercial contracts, investor capital, market trust secured up-stream supply chains and competence
- Need for cell supply to all transport modes

> *In the short run we need Asian suppliers. In the long run we must invest to build up in Europe.*
>
> [Norwegian actor]

Short term supply

- To get the European industry going global business is key
- Solution for scarce supply and lead times of machinery and chemicals affecting time plans

Long-term lowered risk

- Awareness of the current dominance within supply chain is crucial
- Today's dependency should encourage resilience, investments and risk mitigation

> *We are highly dependent on imports of critical inputs. With long lead times or lack of sourcing we need to compete for suppliers in Asia. We might even loose pace in critical phases of our investment*
>
> [Swedish actor]

The Nordic opportunity

Highly interesting active material initiatives. Strong battery cell production cases in close collaboration with solid off takers spanning over multiple technologies and client segments. As a global leader for light and heavy vehicles, offroad & machinery and maritime strengths in packs & BMS*.

*BMS = Battery Management Systems

Source: IEA,European Geological Data Infrastructure (EGDI); FRAME, EGDI/MIN4EU, EC Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability 2020, Norsk Bergindustri, Nordic Innovation: The Nordic Supply Potential of Critical Metals and Minerals for a Green Energy Transition

The electrification created fundamental movements within traditional value chains

- There is a disruptive need for competence and a vital need for strategic partnerships

COMPETENCE

Market dynamics

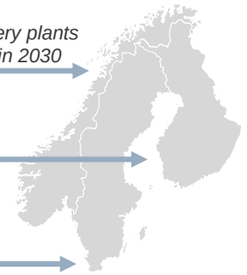
- There is a disruptive need for competence across manufacturing to academia. The Nordics has a strong foundation, but a severe need for more skilled employees
- There is a strong Asian experience from battery industry, highly attractive to Europe
- The greatest quantitative need is for production and process workers
- Current initiatives is a start, but further attraction of talent, re-skill, up-skill is needed

Estimates of employment in battery production

Norway
~7000 employed in battery plants in 2025-2026 and 8000 in 2030

Finland
Yearly needs of ~ 1000-1200 engineers per year

Sweden
~ 8000 employed in battery plants towards 2025-2026



Critical areas for the industry

Talent attraction re- and upskill	• Kept multi-cultural Nordic societies and fast and open permit process and support • Nordic vocational and university trainings • Visualise the attractiveness of Nordic living
National education	• Nurture world-class research for battery focused education and basic topics • Cross silos and creative working to fostering innovation and fit for the future
Competence within value chain	• Keep commitment to sustainability and high quality which attracts top talents • A focus on a long-term competitive ecosystem attracting and keeping talent

"Today's lack of competence has a risk of becoming a limiting factor of growth for all of Europe"

[Norwegian actor]

"How to solve it? We need to showcase our high-profile companies setting global frameworks for sustainability and collaboration in a triple helix modus"

[Swedish actor]

The Nordic opportunity

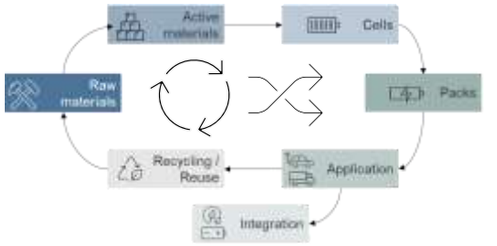
The Nordics have key actors and competence along the full battery value chain, building upon strongholds of the Nordic industrial traditions. The Nordic management culture with flat hierarchies & high trust in the individual foster creativity and innovation

STRATEGIC PARTNERSHIPS

Market dynamics

- Being a new industry new capabilities are required throughout the structure, including new management or educational skills
- The introduction of a battery industry has created fundamental movements within traditional value chains generating a need for strategic alliances
- There is a high pace of new market actors
- Market developments happen very fast

Movements and new sectors within the battery value chain



Critical areas for the industry

Gain industry intelligence	• Joint ventures and projects for knowledge sharing and building up skills • Quality networking and meetings • Cross-industry knowledge sharing
Partners for integrated value chains	• Strategic partnerships across the value chain to grasp the added value • R&D projects and cross border funding to make reality of circular business models
Credibility and visibility	• Global, European and Nordic partnerships with trusted partners (public and private) • Credible visibility to attract serious business partners for joint growth

"Our strategic collaborations with key clients and academia are set to have win-win results, but also increase the credibility of the individual strengths"

[Swedish actor]

"We set out partnerships along our vertical integration of the value chain to share risks but also increase innovation and investments for sustainability"

[Finnish actor]

The Nordic opportunity

Nordic companies and academia are well connected with European private and public partners and have trusted close intra-Nordic ventures. The Nordic Battery Collaboration act with the Nordic ecosystem, the European Battery Alliance, Nordic Innovation and the global teams

Source: Business Sweden interviews and analysis, Norsk Industri, Northvolt, Swedish Energy Agency, Finland's Ministry of Economic Affairs and Employment, Engineers Finland

Nordic actors along the battery value chain operate in global markets

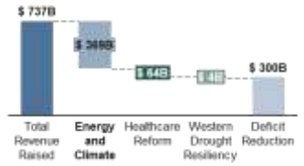
- Strategic investments on all levels fostering electrification and business of scale are key

PUBLIC FRAMEWORK

Market dynamics

- China, Europe and the US have all set strategic support for batteries in the last decade
- The US Inflation Reduction Act to accelerate the green transition is the largest single investment in climate and energy in US history
- Enabling trade regulations is crucial for recycling of scale. EU potential decisions for producer responsibility would be structural
- New business models challenge traditional manners of doing business

The US Inflation Reduction Act August 2022



Simplified global recycling value chain

Critical areas for the industry

Global levelled playing field	• European domestic and foreign investors need prerequisites to succeed • The IRA as well as domestic investments in China have an impact on Europe
Regulations supporting competitiveness	• Enabling trade regulations and governance is crucial for building up recycling of scale • Regulations for customs, transport and producer responsibility have a key impact
Enabling new business models	• New business models for e.g. Battery as a Service do not fit in business systems • Circular value chains need levelled regulations across borders

> *"The Inflation Reduction Act is highly positive for our customers and will grow our global markets."*
>
> [Finnish actor]

> *"We need Europe to act for a global levelled playing field for battery production. Europe can compete, but need a chance to finish building what we have started"*
>
> [Swedish actor]

> *"We must improve prerequisites for recycling across border to enable this business to grow"*
>
> [Norwegian actor]

The Nordic opportunity

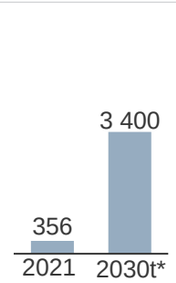
Nordic players invested in recycling facilities early on both at home and in Europe. With strong investors, innovative technologies and closeness to future market volume the Nordic are a highly relevant

ENABLING INFRASTRUCTURE

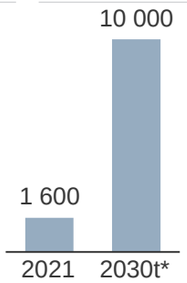
Market dynamics

- European charging infrastructure of about 350,000 public charger stations need to tenfold until 2030 to meet demand
- To keep pace with the overall battery value chain investments in Europe there is a demand for fast industrial establishments
- As this is a new industry it needs test facilities and R&D collaboration to mature and decrease its error margin

Public chargers required to meet the needs of the future EV fleet (in thousands)



Installations per week



Critical areas for the industry

Charging infrastructure	• Public, private and co-investments in charging infrastructure is decisive • Easy charging is key for technologies, payments, availability, frequency and time
Establishment support	• Industry parks, power supply and construction support (permits, prices) are key for fast establishments • Testing facilities and academia alliances
Municipal support	• Local knowledge, local and public support • Valuable with support for incentives, subsidies and grants • Collaboration and public dialogue

> *"Charging infrastructure is an enabler for further growth. It is decisive. Just as reasonable payment methods and number of Apps you need to travel through Europe"*
>
> [Swedish actor]

> *"The diesel market has been developed over 100 years. Now we need to build up the EV market in Europe during about 10 years, we need to be agile."*
>
> [Finnish actor]

The Nordic opportunity

Nordic companies invest in charging infrastructure at home as well as in major projects across Europe. Nordic academia build on broad chemistry and material skills, close triple helix collaborations, creative and independent culture and close ties to Europe

*Utilisation scenario where charging points are installed in line with current utilisation growth rates. The Masterplan is based on the proposed EU regulatory CO_2 targets for 2030 in the road transport sector, i.e., –55% for passenger cars (PCs) and –30% for trucks. **Source**: Business Sweden interviews and analysis, Reuters, Veolia, The EV Charging Infrastructure Masterplan

Green, stable and affordable energy is fundamental for Nordic competitiveness

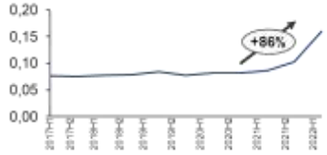
- Within the green transition renewable generation, stable grids and storage are key

GREEN ENERGY GROWTH

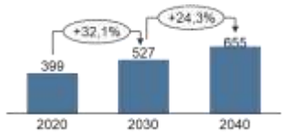
Market dynamics

- Russia accounted for over 24% of all energy in Europe in 2020. Strategic decision is to decrease it decisively
- The integrated Europe electricity market had 86% price increase H1 2021 – H1 2022 being linked to the high price of gas and eased Covid-19 restrictions summer 2021
- The Green Deal, REPowerEU and Fit for 55 are initiatives for European competitiveness and sustainability

EU electricity prices for non-household consumers, excluding taxes - EUR/ kWh



Nordic electricity consumption demand (TWh)



Critical areas for the industry

Awareness of importance	• Public and political awareness is key for further investments • The green, stable and affordable Nordic energy is a competitive edge
Competitive prices	• Investments to improve distribution capacity and stability in grids are key • New energy markets business models for who can sell and buy electricity
Renewable energy volume	• Increased production of renewable energy from wind and solar • Improved decision processes for permits and investments

> *Power is a resource creating competitive edge for the Nordics*
>
> [Finnish actor]

> *Increased need for energy production is fundamental and should not be an issue between political blocks or between Europe and the Nordics. We need green energy everywhere and it is fundamental.*
>
> [Norwegian actor]

The Nordic opportunity

The Nordics have lower electricity prices with a higher share of renewables than the EU average. With further investments in energy volume the Nordics stay a relevant partner for green and OPEX efficiency

Source: Business Sweden interviews and analysis, Eurostat 2022, BP Statistical Review of World Energy

Agenda

Climate targets and electrification have caused an unprecedented battery demand

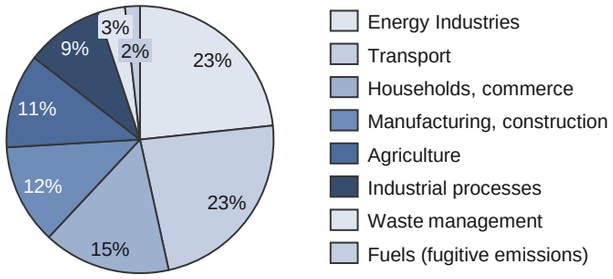
- The demand is driven by electric vehicles, but growing for storage and heat pumps

Transport & energy industries main areas for lowering emissions in Europe

The Paris Agreement

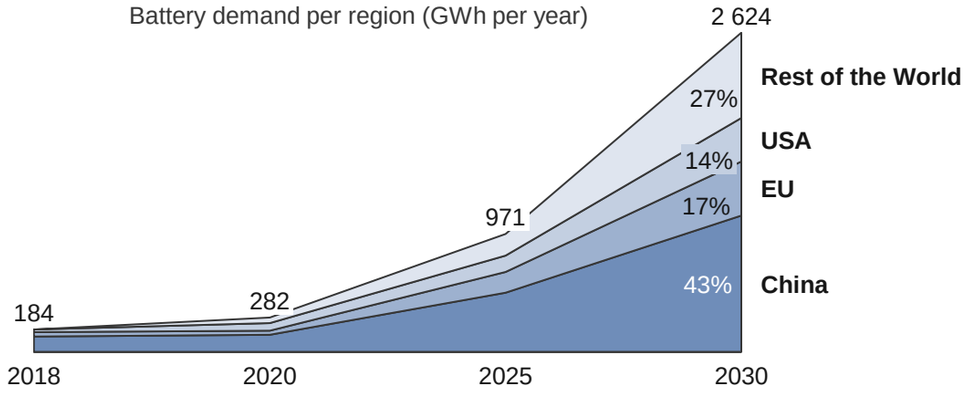
- Limit global warming <2 Celsius compared to pre-industrial levels
- Achieve climate neutral by 2050
- Zero-carbon solutions are becoming competitive, most noticeable within power and transport sectors
- By 2030, zero-carbon solutions could be competitive in sectors representing >70% of global emissions.

Greenhouse gas emissions in Europe 2020



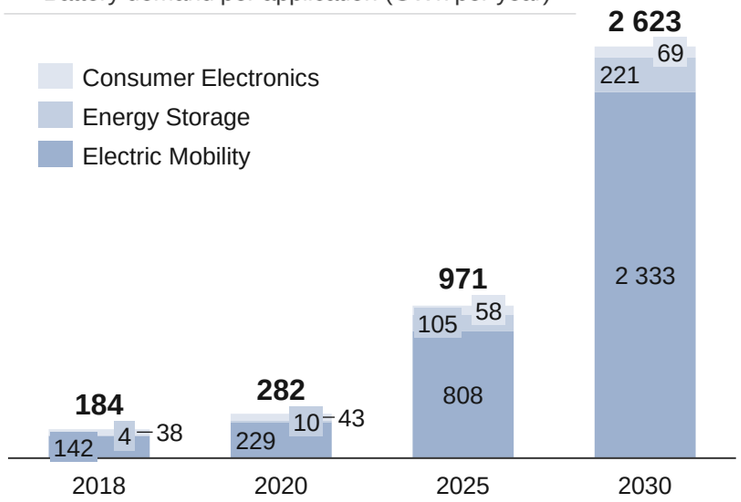
The unprecedented battery demand is focused on China, the EU and USA

Battery demand per region (GWh per year)



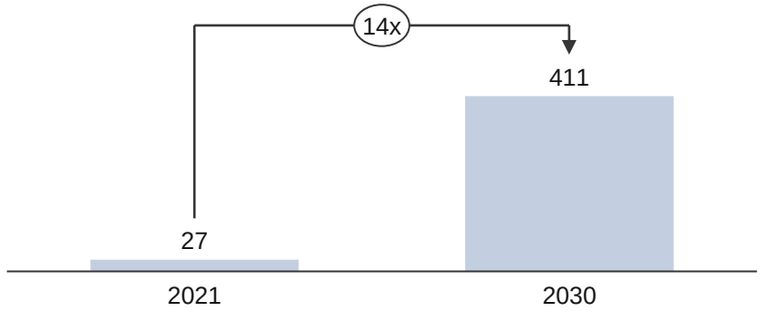
The battery demand is mainly driven by mobility

Battery demand per application (GWh per year)



Global energy storage is expected to grow by 2030

Global energy storage installations (GW)*



Continued growth

- The consumers of China, the EU and USA are adopting the electrification in a high pace
- Electric mobility is driven by both subsidies and supply of electric vehicle models as well as investments in infrastructure for charging
- Demand for batteries to energy storage is expected to grow with the demand to level the grid for increased use of renewable energy
- Batteries for heat pumps is another area where future battery demand is expected to be high

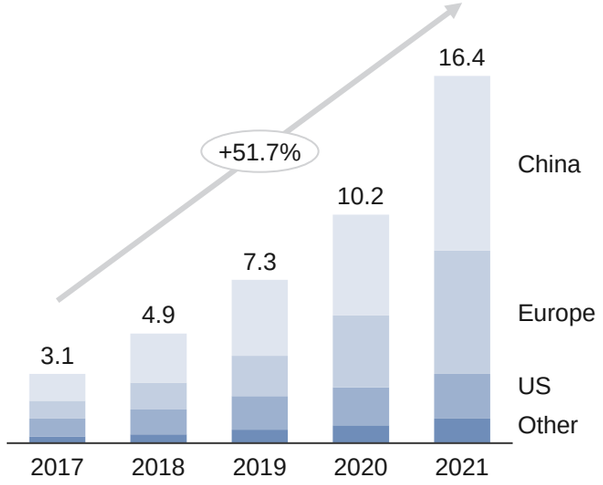
*Graph in gigawatt, compared to above graph with gigawatt per hour; forecast data varies depending on source
Source: Battery2030+, McKinsey Analysis, IEA Global Supply Chains of EV batteries, IEA Global EV Outlook 2022

The electric vehicle uptake is growing rapid in China, Europe and the US

- Both European nations and OEMs have set ambitious targets for electric vehicle sales

Electric vehicle sales led by China and Europe

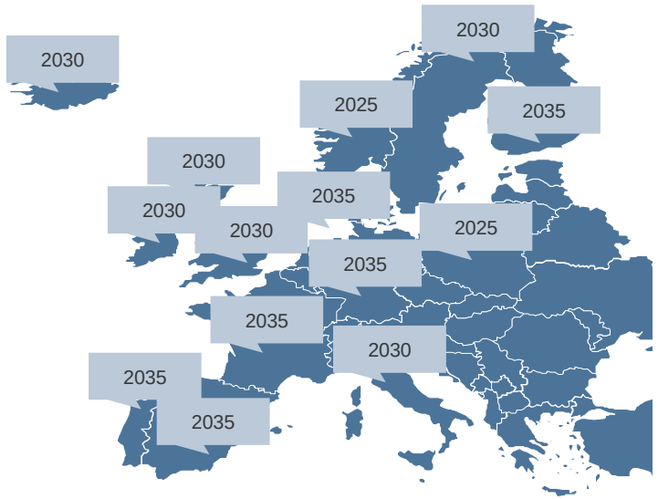
Global electric passenger car stock (millions, CAGR %)



- 93% of the global EV sales are happening in China, Europe, and the USA

National zero emission vehicle goals in Europe

Deadlines for 100% Zero emission vehicles, or no new ICE* vehicles sold



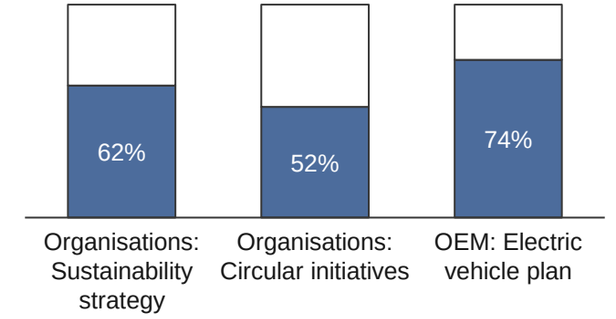
- In June 2022, the European Parliament voted to ban sales of new internal combustion engines in the European Union from 2035

Proposed EU CO2 Truck Emission Reductions***

45%	65%	90%
2030	2035	2040

OEMs are devoted to the electric vehicle transition

Strategies of automotive organisations and Original equipment manufacturers **



Examples of industry EV sales goals by 2030

- BMW: 50% of global sales
- Stellantis: 100% in Europe and 50 in USA
- Volkswagen: 100% in Europe. 50% in the U.S. and China
- Volvo Cars: 50% of all car sales by 2025
- Mercedes-Benz: 100% - where market conditions allow

*Internal Combustion Engine
** Capgemini Research Institute: Out of 800 automotive organisations and experts 62% of the organisations have a sustainability strategy and 52% support and promote circular economy initiatives. 74% of the OEMs have a plan for electric vehicles
*** Proposed by the EU Commission February 2023; for new trucks – value compared to 2019 CO2 emission values
Source: Eurostat, Battery2030+, EU; European Environment Agency, Capgemini Research Institute, Forbes, OmEV

European application players need a strong regional battery production industry – Decisive for European competitiveness, jobs, resilience and sustainability targets

Automotive is a strategic industry for European employment

- The automotive sector is a crucial strategic sector for Europe
  - Employment: 13.8 million direct and indirect jobs, representing 6.1% of total EU employment
  - Income and R&D**:** Annual trade surplus of EUR 79.5 billion , EUR 375 billion in taxation for governments in major EU markets and EUR 59 billion annual investment in R&D, accounting for one third of the region's total spending
- Predictions of jobs created by the battery manufacturing industry are on levels of 155,000 jobs by 2033
- To keep jobs within the strategic sector it is crucial for Europe to stay competitive on global markets

Battery is a strategic component for automotive

- The battery is a strategic component
  - Battery cells represent about 40% of the value added in the production of an electric vehicle
  - Battery packs entail digital intelligence for innovations in the Battery Management System
- To stay competitive, it is crucial for OEMs to have short lead times to suppliers for development and production, vertically integrated supply chain and security of supply and with low-cost and low-risk transporting

Grids will need energy storage systems

- The increase in renewable energy generation the demand for battery energy storage systems (BESS) in growing faster
- There are several unison market drivers for using batteries for energy storage systems and examples are the decreasing battery costs, improved battery performance, decisive grid modernisation efforts, transition to smart grids, increase of renewable energy, changed wholesale market structure for electricity, available financial incentives for storage investment, increased need for self-sufficiency and national policies
- Managing the potential incremental energy demand that EV charging could put on the grid is crucial

Current global developments impact supply

- The immense demand for batteries alongside crucial climate targets increase the need for implemented and governed actions for sustainability
- With the current global market developments for geopolitical developments for trade, implications of supply chains from Covid-19 and war and rising commodity prices and competition of commodities
- On 18th January 2023, the Global Battery Alliance launched the proof of concept for its Battery Passport at the World Economic Forum's Annual Meeting in Davos

Need for sustainability and resilience

- For Europe, the establishment of a complete domestic battery value chain is imperative for a clean energy transition and a competitive industry

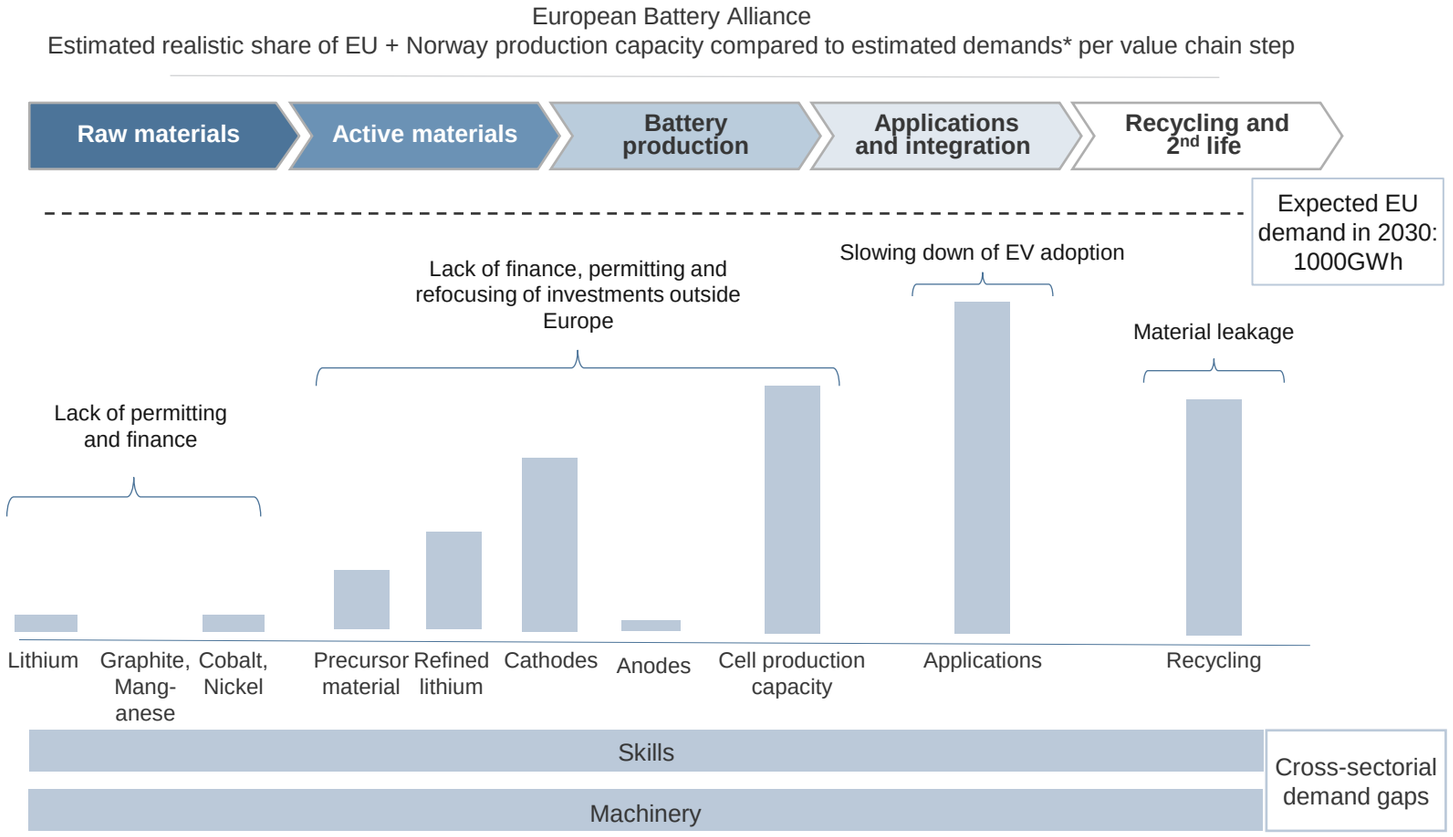
Source: New EU regulatory framework for batteries (europa.eu), European Battery Alliance, European Commission, European Automobile Manufacturers' Association, Deliotte 2022, IDTechEx 2022, Business Sweden interviews and analysis

Current global markets are strongly influenced by an almost perfect storm
- At the same time Europe needs continued critical investments in its value chain

Current developments as a "perfect storm"

- Geopolitical affects on trade
- Russia's war in Ukraine
- Supply chain disruptions from Covid-19
- Energy supply and electricity prices
- Interest rates and inflation
- Scarcity of components in a booming industry
- Long lead times from limited regional supply

Significant gaps within raw materials, active materials and recycling



Source: European Battery Alliance, Business Sweden interviews
*Demands based on public announcements with current framework in 2030

The Nordics have several global leading players in the application part of the value chain pushing for electrification across modes of transport

Some recent developments in the Nordics*

- The Nordics continue electrification across road, aviation, and maritime sectors, including:
  - A continued production and development of new electric trucks and vehicles with larger battery capacity
  - Ongoing construction and testing of electric aircrafts as well as electric boats for private use
  - Electrification of public express boats
- Both autonomous vehicles and vessels are developed and tested:
  - Autonomous vehicle tested on commercial roads in the US
  - Autonomous ferry construction is ongoing with a new passenger ferry planned for commercial use in 2023
- The Nordics are paving the way in production and use of electric machinery with multiple companies operating in the field

Source: Business Sweden interviews, Company webpages, Business Sweden analysis *For case details see the following chapter

Nordic application | Recent developments in the Nordic value chain (1/2)

Producers

SCANIA

- Swedish trucks and bus manufacturer. The company was incorporated 1962 and has approximately 48 300 employees.
- Scania aim to make electric solutions for 10% of the total vehicles sales volume by 2025 and 50% by 2030.
- In October 2022, the company introduced a new heavy battery truck in Mälardalen, an initiative to accelerate electrified emission-free road transport. The project is a corporation between Scania, Foria, and Ragn-Sells.

XSHORE

- Swedish marine technology company registered in 2015 and has approximately 48 employees.
- Launched the Eelex 8000 2021 Edition in late 2020. The electrically powered boat was ready for delivery same year and is the company's first commercial product for private use.

VOLVO CARS

- Multinational car manufacture founded in 1935 and has approximately 41,000 employees.
- Volvo Cars aims for sales by 2025 to consist of 50% fully electric vehicles. One of its two car brands, Polestar, consists of a series of full-electric passenger cars. The second model Polestar 3 was launched in in 2022.

Producers

VOLVO PENTA

- Swedish developer of power solutions for land and sea-based vehicles. The company was registered in 1935 and has approximately 1,000 employees.
- In 2022 the company showcased electrified power solutions for land and sea-based vehicles. Projects in 2022 at sea include a hybrid-electric vessel and hybrid-electric crew transfer. Land projects included purpose-built electric driveline powering electric terminal tractors and electric fire trucks.

EINRIDE

- Swedish transport services company specialising in electric and autonomous trucks. The company was registered in 2016 and has approximately 123 employees.
- In December 2022 the company secured 461 MEUR to accelerate development of sustainable fright solutions globally. During 2021-2022 the company has announced expansions in several European countries and completed a pilot on a US public road with its autonomous vehicle.

HEART AEROSPACE

- Swedish company developing electric aircrafts. The company was founded in 2018 and has approximately 24 employees.
- The company expects to deliver its first ES-30 aircraft in 2028. In September 2022, the company announced the construction offices, production and flight test facilities at Säve Airport, Gothenburg.

Machinery producer

PONSSE

- Finnish forest machine manufacturer founded in 1970 and has approximately 1,800 employees.
- In August 2022 Ponsse and its subsidiary Epec introduced the electrical forestry machine technology concept PONSSE EV1. The forestry machine is not yet commercially available, but the technology developed by Epec can also be used in other commercial vehicles and non-road machines.

NORMET

- Finnish manufacturer of underground mining and tunneling machines founded in 2005 and has approximately 1,600 employees.
- The company has developed different modular battery electric vehicles based on Lithium-ion battery technology. In January 2023, the company announced expansion of their underground BEVs offering: two applications for lifting and installations, and one for material transportation.

EPIROC

- Swedish manufacturer of mining and infrastructure equipment. The company was incorporated 1942 and has approximately 14,600 employees
- In September 2022 the company tested the world's first battery-electric drill rig for surface operations. Expects to offer complete emission-free equipment and fleet from 2025-2030.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Nordic application | Recent developments in the Nordic value chain (2/2)

Users

LKAB

- Swedish state-owned mining company founded in 1890 and has approximately 4,500 employees.
- Two battery-powered machines from Epiroc are being tested in 2022. An underground truck and a mine loader from Sandvik, two battery trucks from Scania and another underground truck from Epiroc was, as of May 2022, expected to be delivered.

BOLIDEN

- Company within prospecting, extraction and refining of base metals, founded in 1931 and has approximately 6,000 employees globally.
- In June 2022 the company ordered battery-electric versions of the Boomer face drilling rig, Boltec rock bolting rig and Epiroc's automated loader for Kristineberg and Renström mines in Västerbotten, Sweden.

NORLED

- Norwegian ferry operator registered in 2000 with approximately 784 employees.
- In August 2022, the company announced a collaboration with the public transport company Ruter for the electrification of express boats in the Oslo fjord using a new battery replacement robot. The boats are scheduled to start operation in summer 2024.

Users

ASKO

- Norwegian goods transport company founded 2012 with approximately 87 employees.
- In December 2022 the company announced the use of a converted Volvo electric truck with a battery of 900 kilowatt and driving range of 500km on one charging for operations in Norway. Asko aims to expand electric freight transport on regional routes in Norway in coming years.

Producers

VOLVO TRUCKS

- Swedish truck manufacturing division of Volvo Group, registered in 1996, approximately 57 employees.
- In December 2022 the company announced several new electric trucks: Volvo FH, Volvo FM and Volvo FMX. The new trucks will have a battery capacity between 180-540 kWh and is planned to start production first quarter 2023.

CANDELA

- Swedish electric boat manufacturer, founded in 2014 and has 37 employees.
- In November 2022 Candela announced a production version of its electric hydrofoil C-8 watercraft. The watercraft will have a top speed of 30 knots and the ability to cruise for over two hours at 20 knots. First delivery expected spring 2024.

Producers

BRØDRENE AA

- Norwegian company constructing electric and autonomous ferries, founded in 1947 with approximately 135 employees.
- In November 2022, the company announced construction and design of a new autonomous passenger ferry. The ferry is expected to be in operation in Stockholm in April 2023. Project owners are shipping company Torghatten and autonomy supplier Zeabus.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Agenda

Nordic countries in the top ten ranked battery nations globally

- Norway, Sweden, and Finland have prioritised their battery industries at a national level

Global lithium-ion battery supply chain ranking (Top 10 ranked countries)

Global rank		Raw material	Battery manufacturing	Environmental, social, and governance factors (ESG)	Industry, innovation and structure	Downstream Demand*
1	China	1	1	17	9	1
2	Canada	3	8	6	4	10
3	US	6	4	16	5	2
4	Finland	9	15	2	1	11
5	Norway	18	10	1	3	7
6	Germany	21	6	4	7	2
7	South Korea	17	2	10	6	5
8	Sweden	21	9	3	2	8
9	Japan	13	3	8	12	8
10	Australia	2	15	9	13	11

National priorities for batteries in Sweden, Finland and Norway

2020

Fossil Free Sweden, an initiative of the Swedish Government, launched a strategy for a sustainable Swedish battery value chain

2021

Finland's official battery strategy was launched in January 2021 and presents six blocks for how Finland will develop into a competitive, competent, and sustainable part of the international battery industry

2022

June 2022: Norway’s national battery strategy was launched and presents 10 measures for how Norway will further develop a coherent and profitable battery value chain

October 2022, the Swedish Export Agency, the Swedish Environmental Protection Agency and the Geological Survey of Sweden presented the report *“Develop cooperation between authorities for Sweden's parts of a sustainable European value chain for batteries*” along with twelve proposals on how to strengthen a Swedish sustainable and competitive battery value chain

Source: BloombergNEF 2022, Business Sweden Interviews, Business Sweden analysis *Local demand for electric vehicles and energy storage

The Nordics offers preferable preconditions for efficient operating expenses, sustainable production and possibilities for untapped potential

Green energy at low costs	• Renewables corner stone in energy mix, Lower CO_2-emission from production • Attractive pricing - the Nordics have among the lowest energy prices in Europe
Stable energy supply and cold climate	• Excellent grid systems - robust grid network with great redundancy. Functioning and stable electricity supply • One of the worlds most integrated electricity markets • Six months cold climate reduce need for cooling
Productive workforce	• Deep knowledge in industrial processes, manufacturing and great focus on R&D • Educated population and high productivity
Connected logistics	• Well-connected with regional and continental industries • Geographical distance reduced by digital communication, frequent travels and efficient logistics
Tangible actions for sustainability	• Production site in the Nordics create positive brand awareness for sustainability • High national demands on as well as high level of investments in sustainable and clean production processes
Abundant deposits of raw material	• Abundant deposits of raw material for batteries • Ability to supply responsible and sustainable mined raw materials

Source: Business Sweden interviews and analysis

The emerging Finnish, Norwegian and Swedish battery value chains have complementary strengths with valuable additions from Denmark and Iceland

	Nordic countries with batteries on the national agenda			Nordic countries with some lighthouse strengths within batteries	
The Battery Value Chain	Finland	Norway	Sweden	Denmark	Iceland
1. Raw materials	• Active mines • R&D and initiatives for further production • Further deposits	• Refinery • Aluminum • Further deposits	• Initiatives for prospecting • Further deposits	• Greenland minerals and rare earth materials deposits	• Aluminum
2. Active materials	• Production ongoing (e.g. cathode material)	• Production ongoing (e.g. graphite)	• Initiatives for production (graphite and cathode) • R&D	• R&D on novel materials • Cathode material initiatives for production	
3. Cell production	• One initiative announced	• Three initiatives ongoing • One initiative announced	• Cell production ongoing; two larger initiatives announced		• Aluminum batteries under development
4. Pack production	• Automotive suppliers	• For maritime industry	• Automotive and trucks in-house	• Battery management systems	
5. Application	• Machinery and forest industry	• Maritime industry • EV market share	• Automotive and trucks • Machinery • Maritime and Aviation	• Maritime industry • Energy storage	• Electrification of EV fleet
6. Integration	• Grid, storage, and charging projects	• Grid, storage, and charging projects	• Grid, storage and charging projects • Battery integration in application system	• Grid, storage, and charging projects	• Charging projects
7. Re-use / Recycling	• Ongoing recycling and reuse	• High volume of EV batteries • Ongoing recycling and reuse	• Ongoing recycling	• Investments in recycling	

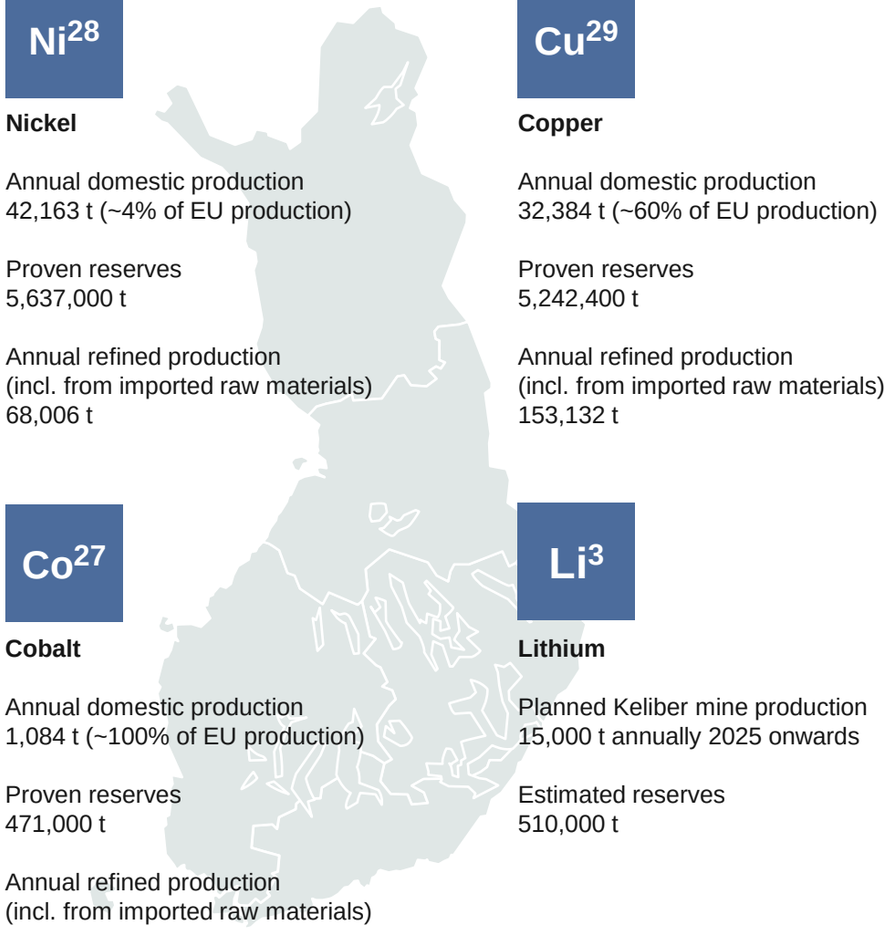
*** Triple helix =** industry, government and academia
Source: Business Sweden interviews and analysis

Finland combines long traditions in mining and technology with substantial raw materials upstream, recycling, R&D and machinery

KEY STRENGTHS

Raw materials	Finland has major mineral resources for key battery materials, with an established metals refining industry enabling environmentally sustainable access to raw material. These resources are supported by globally leading technologies in mining and processing.
Recycling	Developed system for recycling of battery materials. Also, opportunity to use industrial by-materials as raw materials. Ongoing local commercialisation of bio-based alternatives for anode materials.
Machinery and technology	Strong existing industry in battery systems, heavy duty vehicles (including opportunities in maritime sector) and electrification technologies. In addition to leading global companies, specialised SMEs add manufacturing competence to the value chain.
R&D	Several high-level academic and research institutions generate R&D in wide range of areas along value chain, with a long track record of promoting and supporting research and innovation (including access to public research funding and local and international venture capital).
National battery strategy	Has a national battery strategy, outlining priorities and goals and ensuring a focused effort on selected key areas. In addition, public partners support businesses in their operations.
Energy and electricity	Increasing supply of renewable energy especially due to growth in wind power production.

Substantial production and reserves of key battery minerals



Ni[28]

Nickel

Annual domestic production
42,163 t (~4% of EU production)

Proven reserves
5,637,000 t

Annual refined production
(incl. from imported raw materials)
68,006 t

Cu[29]

Copper

Annual domestic production
32,384 t (~60% of EU production)

Proven reserves
5,242,400 t

Annual refined production
(incl. from imported raw materials)
153,132 t

Co[27]

Cobalt

Annual domestic production
1,084 t (~100% of EU production)

Proven reserves
471,000 t

Annual refined production
(incl. from imported raw materials)
14,287 t

Li[3]

Lithium

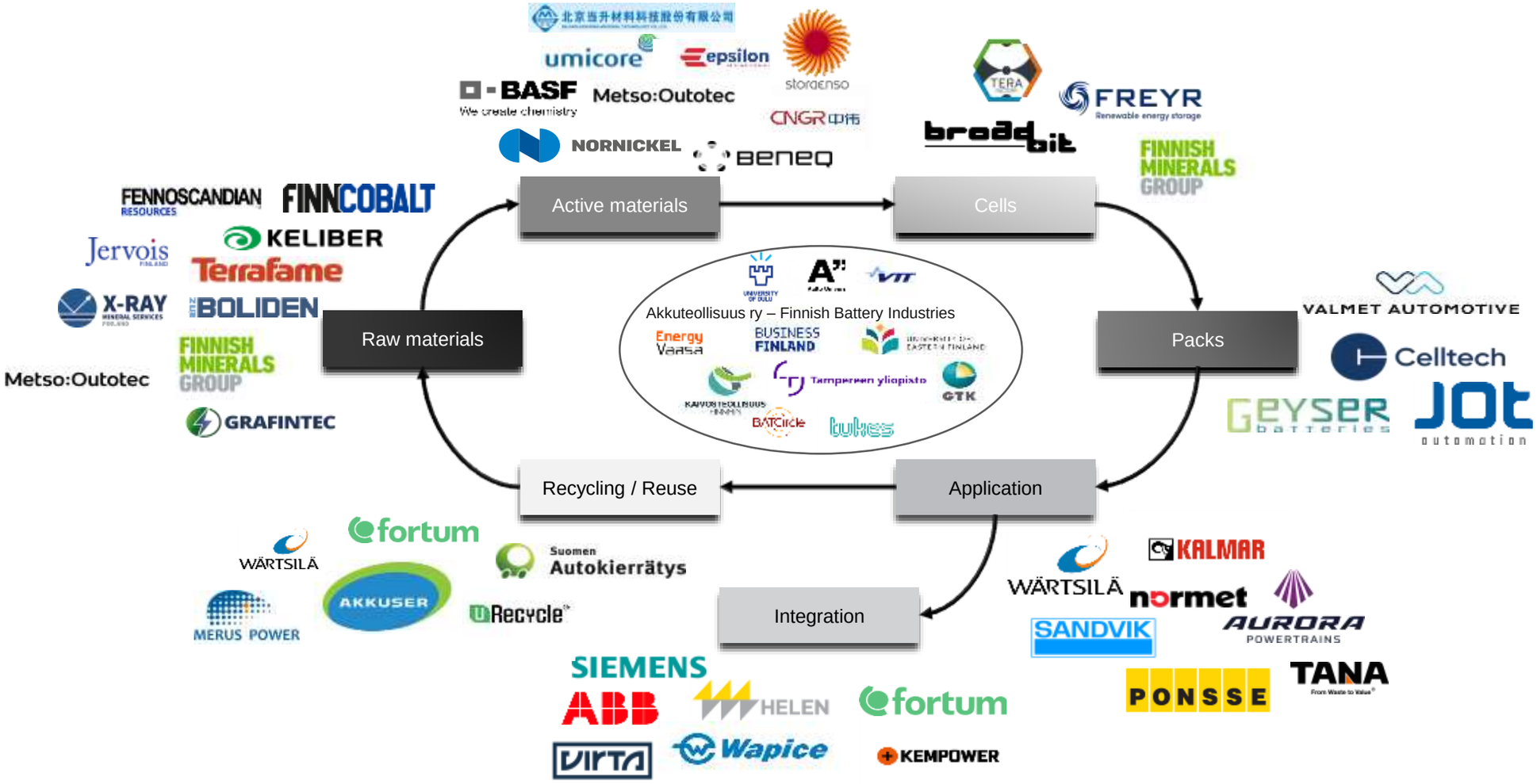
Planned Keliber mine production
15,000 t annually 2025 onwards

Estimated reserves
510,000 t

Source: GTK, TEM, Euromines, Business Finland, Company webpages, Business Sweden analysis

Established conditions for a strong market position, with competence and technology along the full value chain

Leading players in the Finnish battery value chain



Source: Company websites

Leading players in the value chain

(1/2)

Company	Short description*
KELIBER	• Finnish battery chemicals company focused on lithium hydroxide production, founded in 1989, approx. 16 employees*
Terrafame	• Finnish battery chemicals company focused on nickel and cobalt sulphates, founded in 2015, approx. 870 employees
BOLIDEN	• Swedish mining company focused on nickel and zinc, Finnish subsidiary founded in 2000, approx. 581 employees
FINNISH MINERALS GROUP	• Finnish state-owned company investing in domestic mining and battery sector, founded in 2015, approx. 16 employees
Metso:Outotec	• Finnish technology/equipment provider for lithium, nickel, cobalt production, founded in 1997, approx. 2193 employees
GRAFINTEC	• Finnish company developing graphite technology, founded in 2012, approx. 2 employees
FINNCOBALT	• Finnish company preparing to open cobalt mine, founded in 2009
FENNOSCANDIAN RESOURCES	• Finnish natural resources company founded in 2012 and owned by Nordic Graphite Ltd
Jervois	• Finnish manufacturer of cobalt-based chemicals and powders founded in 1968
X-RAY MINERAL SERVICES	• Finnish company founded in 1997 working, among other things with, battery mineral science
北京当升材料科技股份有限公司	• China-based company founded in 1998 planning to cooperate with The Finnish Minerals Group*
BASF We create chemistry	• German multinational to begin active material production in Finland, subsidiary founded in 1984, approx. 87 employees*

Company	Short description*
NORNICKEL	• Russian mining company focused on nickel, subsidiary in Finland since 2000, approx. 294 employees*
umicore	• Belgian manufacturer of cathode materials, subsidiary founded in 2013, approx. 302 employees*
TERA	• Finnish company founded in 2010 working with foil coating and separator coating
beneq	• Finnish provider of thin film coatings for batteries, founded in 2005, approx. 126 employees
CNGR中伟	• Chinese company in joint venture to open a Precursor cathode active material plant in Finland, subsidiary founded in 2020*
Celltech	• Part of Swedish Addtech AB, offer battery system design and manufacturing, founded in 1992, approx. 18 employees*
epsilon	• Indian company examining setting up anode production in Finland, no subsidiary present on market
GEYSER batteries	• Finnish company setting up production of proprietary power batteries in Finland, founded in 2018, approx. 5 employees
VALMET AUTOMOTIVE	• Finnish company operating as contract manufacturer of batteries, founded in 1968, approx. 3,068 employees*
fortum	• Finnish majority state-owned energy company operating also in battery recycling, founded in current form in 1998*
FREYR Renewable energy storage	• Norwegian company planning battery cell production in Finland, subsidiary founded in 2021*
ABB	• Swedish-Swiss multinational company providing electrical equipment, subsidiary founded in 1989, approx. 4,703 employees

Note: *For further case details see examples in Nordic recent developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Leading players in the value chain

(2/2)

Company	Short description*
broadbit	Finnish company developing sodium-based batteries, founded in 2015, approx. 8 employees
WÄRTSILÄ	Finnish company focused on energy solutions and marine applications, founded in 1914, approx. 18,000 employees
SANDVIK	Swedish technology/equipment provider for mining operations, subsidiary since 1897, approx. 2015 employees
AURORA POWERTRAINS	Finnish electric snowmobile manufacturer, founded in 2017, approx. 5 employees
KALMAR	Cargo handling equipment provider, part of Finnish company Cargotec, founded in 1994, approx. 744 employees
TANA From Waste to Value	Finnish environmental technology company founded in 1971
normet	Finnish equipment provider for mining operations, founded in 2005, approx. 45 employees*
Suomen Autokierrätys	Finnish producer association coordinating recycling of EV batteries, founded in 2001
KEMPOWER	Finnish provider of electric vehicle fast charging system, founded in 2017, approx. 83 employees
HELEN	City of Helsinki owned energy company focused on EV charging, founded in 2014, approx. 923 employees
PONSSE	Finnish company developing first electric forest vehicle, founded in 1992, approximately 976 employees*
Wapice	Finnish software company focused on energy and industry, founded in 2000, approx. 326 employees

Company	Short description*
uRecycle	Finnish company focused on managing battery recycling process, founded in 2006
AKKUSER	Finnish company focused on battery recycling, founded in 2005, approx. 26 employees
VIRTA	Finnish company developing charging solutions, founded in 2013, approx. 103 employees*
storaenso	Finnish-Swedish multinational forest company developing bio-based graphite replacement, founded in current form 1998*
JOT automation	Automation solutions company for battery industry, founded in 1998, approx. 83 employees
SIEMENS	German multinational offering wide range of services for battery sector, several subsidiaries present in Finland*
MERUS POWER	Finnish company offering energy storage solutions, founded in 2008, approx. 51 employees

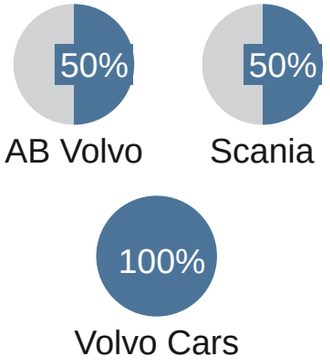
Note: *For further case details see examples in Nordic recent developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Swedish industry drive, active cell production, mineral resources, green energy and foreign expertise characterise a favourable battery climate

KEY STRENGTHS

Large automotive industry drive the electrification process	• The automotive industry in Sweden has an export value of SEK 219 billion, which corresponds to nearly 14% of total Swedish goods exports in 2022. • Heavy truck producers as well as car producer has ambitious plans to increase electric vehicle sales by 2030
Active cell manufacturing and new investments	• Northvolt was the first company in Europe to design, develop and assemble a battery cell at their gigafactory in Skellefteå in 2021. • In 2022 three new battery cell plants investments have been announced
Untapped mineral resources	• Sweden has potential for additional discoveries of 22 critical raw materials in the EU including the non-critical metals (copper, manganese, nickel)
Green, affordable and stable energy	• 98% of energy produced in Sweden is fossil fuel-free • Affordable energy; Sweden had second lowest energy prices for non-household consumers in the EU first quarter 2022 • Stable energy with 99.99% reliability in the system ensures low network costs
Foreign establishments supply the industry	• Establishments of foreign companies to supply current cell production strengthen the battery industry as a whole

Goal of new vehicle sales to be electric by 2030



Three main growing battery clusters with actors along the battery value chain

Selection of Critical and Non-critical resources with potential for discovery in Sweden (on land as of 2021)

- Cobalt
- Graphite
- Platinum group metals
- Phosphorus
- Rare Earth Elements
- Scandium
- Silicon metal
- Copper
- Manganese
- Nickel

Swedish energy characteristics

99.99%

Reliability in the grid system

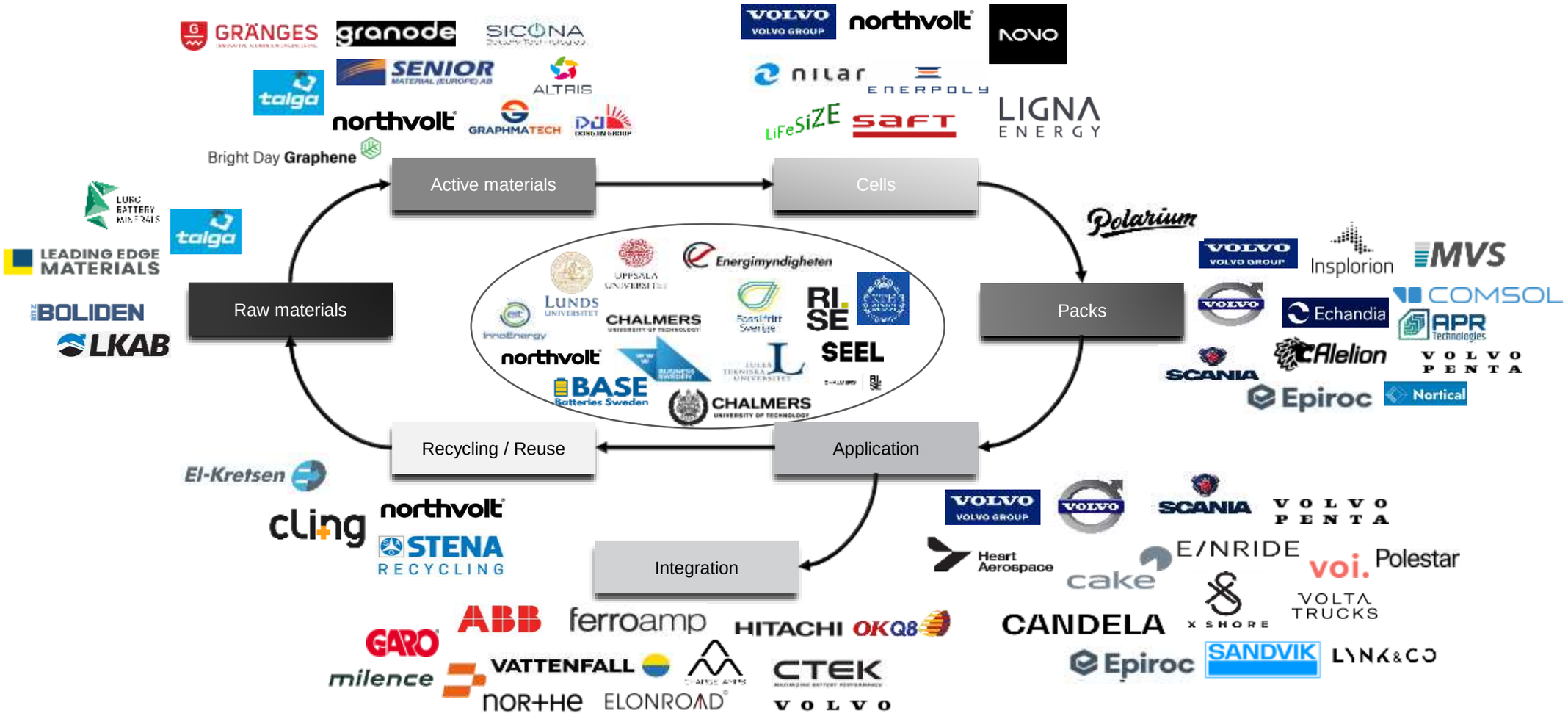
98%

Share of energy produced in Sweden that is fossil fuel-free

Source: Eurostat 2022, Nordic Innovation 2021, IEA, Swedish Energy Agency, Company webpages, Business Sweden analysis

The establishment of Northvolt close to strong industries within application, packs, integration and raw materials drive investments to the full value chain

Leading players in the Swedish battery value chain



Source: Company and Organisation websites, Business Sweden, Di, Castellum, Teknisk Ukeblad, SVT,

Leading players in the value chain

(1/3)

Company	Short description*	Company	Short description*
LKAB	Swedish state-owned mining company, founded in 1890, approx. 4500 employees*	NOVO	Joint venture established in 2001 between Northvolt and Volvo Cars. To build a battery giga-factory in Sweden*
BOLIDEN	Swedish company prospecting, extraction and refining, recycling of base metals founded in 1931, approx. 6,000 employees*	nilar	Swedish company, specialised in battery production. Founded in 2000, approx. 185 employees
LEADING EDGE MATERIALS	Canadian mining company focused on graphite and rare earth metals mining, founded in 2010*	ENERPOLY	Swedish company with production of zinc-ion battery cells founded in 2018 and have 8 employees in Sweden*
talga	Australian mining company, also present within active materials, incorporated 2009 and has approx. 40 employees*	saft	French-based company with production of Nickel-Cadium batteries. Registered 1916, approx. 491 employees
northvolt	Swedish battery developer, manufacturer and recycler of li-ion batteries, founded in 2016, approx. 3000 employees*	Polarium	Swedish company providing energy storage solutions built on lithium-ion batteries. Founded in 2015, approx. 97 employees*
granode	Swedish developer of graphene-based anode material for lithium-ion batteries, founded in 2021.	VOLVO	Multinational car manufacturer, founded in 1935 approx. 41,000 employees*
SENIOR MATERIAL (EUROPE) AB	Chinese-based company to establish a production facility of separator film in Sweden. Registered in Sweden in 2021*	Epiroc	Swedish manufacturer of mining and infrastructure equipment. Incorporated 1942, approx. 14,600 employees*
SICONA Battery Technologies	Australian based producer of silicon-graphite composite anode and polymer binder materials, founded in 2019*	SCANIA	Swedish company that manufactures trucks and buses. Incorporated 1962, approx. 48,300 employees*
ALTRIS	Swedish producer of cathode material in pilot scale expecting to scale production 2023. Founded in 2017, approx. 7 employees*	ABB	Swedish/Swiss MNC in electrification, charging infrastructure and automation; founded 1988; 110,000 employees globally
GRAPHMATECH	Swedish producer of graphene-based materials in cooperation with Northvolt. Founded in 2017, approx. 12 employees*	cake	Swedish Electric bike manufacturer. Founded in 2016 and have approx. 53 employees
DJ	South Korean-based producer of Carbon Nanotube Slurry for Northvolt. Registered in Sweden 2020, approx. 2 employees	LiFeSiZE	Swedish R&D company that develop among other things lithium and sodium-ion pouch-cells. Incorporated 2006, approx. 2 employees
Bright Day Graphene	Swedish company to offer graphene-based materials. Company incorporated 2017 and have approximately 8 employees	E/NRIDE	Swedish transport company specialising in self-driving EVs. Founded in 2016 and have 130 employees*
VOLVO VOLVO GROUP	Swedish automotive company aiming to establish battery cell production in Sweden. Founded in 1927, approx. 84,000 employees*	Heart Aerospace	Swedish startup company developing electric aircrafts. Founded in 2018 and have approx. 24 employees*

Note: *For further case details see examples in Nordic Recent Developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Leading players in the value chain

(2/3)

Company	Short description*
CANDELA	• Swedish electric boat manufacturer, founded in 2014 and have 37 employees*
X SHORE	• Swedish electric boat manufacturer, founded in 2015 and have 48 employees*
VATTENFALL	• Swedish state producer of electrical energy founded in 1909, approx. 19,000 employees
CHARGE AMPS	• Develops smart charging solutions for electric vehicle. Founded in 2012 and have 42 employees
CTEK	• Develops smart charging solutions for electric vehicles. Founded 2019 and have 176 employees*
HITACHI	• Provider of power technologies and energy systems. Registered in 1931 and have 3,931 employees in Sweden
ferroamp	• Develops, manufactures and markets innovative power electronics founded in 2018 and have 8 employees in Sweden
STENA RECYCLING	• Swedish recycling company. Registered 1970 and have 1,491 employees in Sweden*
VOLVO PENTA	• Swedish producer of boat and industrial engines, incorporated 1935 and employ approximately 1,000 persons*
LIGNA ENERGY	• Swedish start-up company developing electrical energy storage solutions. Founded in 2017 and have approx. 4 employees
Alelion	• Swedish company providing power solutions. Incorporated in 2006 and have approx. 38 employees*
Echandia	• Swedish developer of energy storage solutions for marine applications, founded in 2006 with approx. 19 employees

Company	Short description*
GARO	• Swedish manufacturer of electric charging solutions founded in 1939, approx. 520 employees
greenely	• Energy company with electric charging solutions founded in 2014 in Sweden, approx. 10 employees
APR Technologies	• Swedish supplier of thermal management solutions, incorporated 2011 and approx. 18 employees
COMSOL	• Swedish software company optimising battery systems founded in 1990, approx. 472 employees
El-Kretsen	• Swedish non-profit company offering collection systems for discarded industrial batteries. Founded in 2001, 14 employees
voi.	• Swedish micro mobility company providing rentable e-scooters. Incorporated in 2018 with approx. 598 employees
VOLTA TRUCKS	• Swedish manufacturer of electric trucks. Founded in 2019, have approx. 2 employees in Sweden
Nortical	• Swedish software company developing battery analytics software tools. Incorporated in 2019, approx. 10 employees
ELONROAD	• Swedish developer of electric road systems for EVs. Incorporated in 2019 approx. 16 employees
SANDVIK	• Swedish tools, machinery and system manufacturer within mining and construction. Founded 1862; 40,636 employees
Insplorion	• Swedish sensor technology company active within battery management systems. Incorporated 2010; approx. 15 employees
cling	• Swedish trading platform for used EV batteries. Incorporated 2020 and have approximately 2 employees

Note: *For further case details see examples in Nordic Recent Developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Leading players in the value chain

(3/3)

Company	Short description*
MVS	• Swedish company specialised in battery and power supply systems. Incorporated in 2020, have approx.14 employees
NORTHE	• Swedish Tech startup providing one EV charging platform with different operators. Incorporated 2020; approx. 2 employees
milence	• European Joint venture between. Daimler Truck, TRATON GROUP, and the Volvo Group for charging infrastructure. Estab. in 2022
OKQ8	• Swedish fuel company established 1928 and have approximately 1231 employees*
VOLVO	• Swedish branch of Swedish truck manufacturer. Incorporated 1996 and have approximately 57 employees*
GRÄNGES	• Swedish company specialised in aluminum technology, established 1898 and have approximately 449 employees*

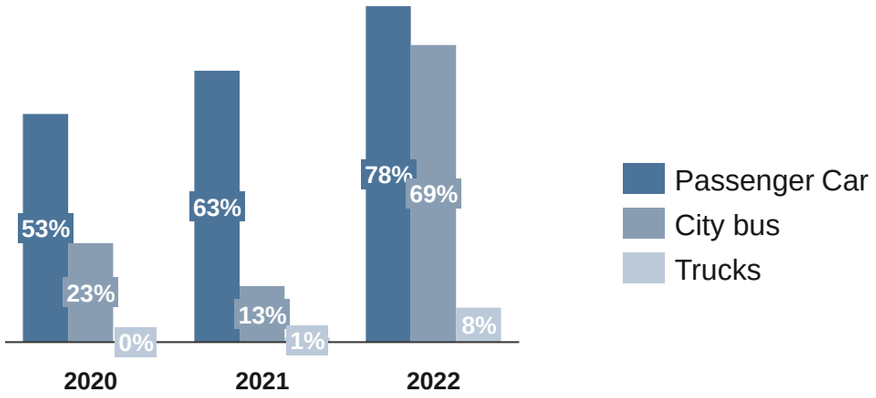
Note: *For further case details see examples in Nordic Recent Developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Norway is world leading in EVs, with a government industry backing, cell and recycling initiatives, green energy supply and strong R&D collaboration

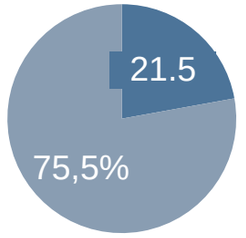
KEY STRENGTHS

High percentage of EV and maritime electrification	• World leading in percentage of electric vehicles per capita • Frontrunner of production of battery systems for maritime use
National Battery Strategy	• 2022: National Battery Strategy launched - Government vision for Norway to develop a complete and profitable battery value chain
Cell initiatives	• Three ongoing cell initiatives and one additional announced in January 2023
R&D	• Strong collaboration between academia and industry within battery clusters and academic programs
Recycling	• Europe's largest recycling facility for EV batteries established in Norway • Large quantities of used car batteries available for collection, reuse and recycling due to early electrification of market
Green energy supply	• 99.3% of electricity in Norway comes from renewable energy sources • 2022: Government announced large-scale investment in ocean wind towards 2040
World-leading process industry	• Long history and competence within process industry (e.g. chemicals, aluminium, metallurgy)

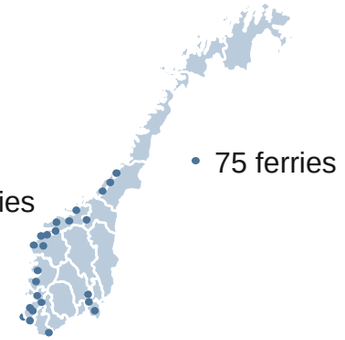
New sales of fully electric EVs in Norway (year and type)



Electric ferries (% 2022)



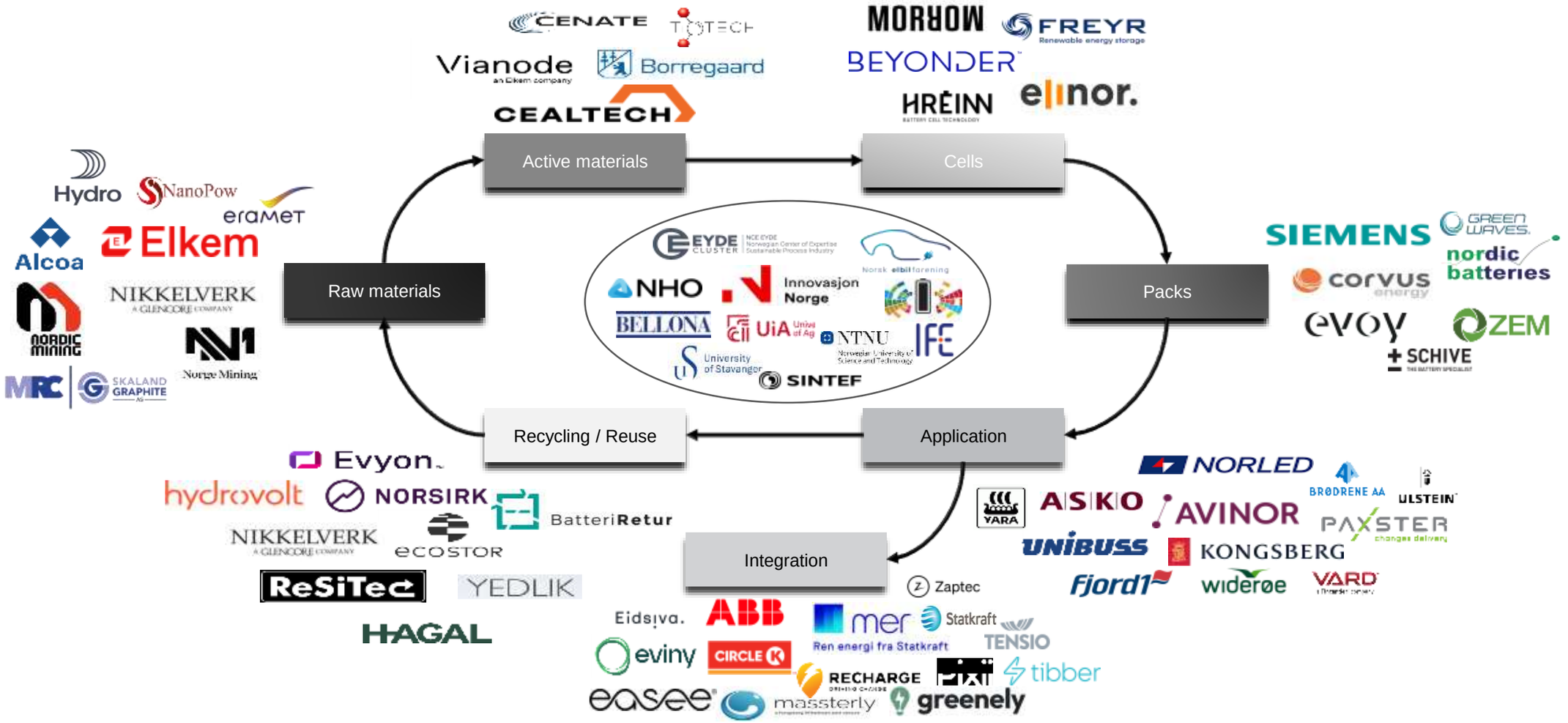
Electric ferry locations in Norway



Source: regjeringen.no, NHO, Battery 2030, EU Commission, Norsk Elbilforening, tilnull.no, Statens Vegvesen, Energy Industry Review, Forskningsrådet

There are established and emerging companies with competence and technology across the full value chain

Leading players in the Norwegian battery value chain



Source: Company websites, Business Sweden, Regjerningen.no

Leading players in the value chain

(1/3)

Company	Short description*
Nordic Mining	Norwegian mining company founded in 2006 working mainly with industrial minerals and metals
NanoPow	Producer of silicone nano-powder established in Norway 2016; approx. 9 employees
eramet	French mining company founded in 1880; around 12 500 employees globally
Hydro	Multinational Norwegian aluminum producer founded in 1905; over 30,000 employees worldwide
Alcoa	American aluminum production company established in Norway 1962; over 700 employees in Norway
Norge Mining	Norwegian extraction and mineral processing company; founded in 1995; approx.12 employees in Norway
Elkem	Norwegian manufacturer of silicone materials founded in 1904; over 1500 employees in Norway
MRC / Skaland Graphite	Norwegian graphite operator founded in 2003; approx. 43 employees in Norway*
Nikkelverk	Norwegian nickel, copper, and cobalt refinery and battery recycling, founded in 1929; over 550 employees*
Cenate	Norwegian developer and producer of silicon-anode materials founded in 2015; approx. 10 employees*
Vianode	Norwegian synthetic graphite producer founded in 2020; approx. 74 employees*
Cealtech	Norwegian company in development and production of graphene founded in 2012; approx. 8 employees

Company	Short description*
Borregaard	Norwegian biorefinery manufacturing additives for lead and lithium-ion batteries registered in 2010; over 1100 employees
Tytech	Norwegian manufacturer of titanium dioxide founded in 2005; approx. 11 employees
Morrow	Norwegian company, founded in 2014 with approx.84 employees has initiated the build of a 43 GWh battery cell gigafactory*
Beyonder	Norwegian company founded in 2016 that develops batteries from sawdust for industrial use. Approx. 56 employees*
Freyr	Norwegian company, founded in 2018, initiated the production of 32 GWh gigabyte lithium-ion battery cells factory in Mo i Rana*
elinor.	Norwegian cell initiative announced in January 2023 for establishment of a giga-factory in Trondheim, Norway*
Hreinn	Norwegian manufacturer of battery cells for energy storage solutions founded in 2021, approx. 1 employee
nordic batteries	Norwegian battery pack and energy systems assembler and manufacturer founded 2014; approx. 4 employees
Siemens	Norwegian battery pack developer and producer for maritime industry registered 2002; approx. 63 employees*
corvus	Energy storage provider for maritime industry registered in Norway 2019; approx. 6 employees*
ZEM	Norwegian company offering battery management systems to the maritime sector; founded 2009; approx. 15 employees
Green Waves	Norwegian provider of systems for electric boats, founded in 2017; approx. 7 employees

Note: *For further case details see examples in Nordic recent developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Leading players in the value chain

(2/3)

Company	Short description*
SCHIVE	Provider of lithium-battery storage systems, founded in 1963; approx. 12 employees
evoy	Norwegian company developing electric motor systems; founded in 2009; approx. 15 employees*
ASKO	Norwegian transporting company operating EV trucks; founded 2012; approx. 87 employees
YARA	Norwegian chemicals company operating a fully electric and autonomous container vessel; founded 1905; approx. 17,000 employees globally
AVINOR	Norwegian air navigation company testing electric flights; founded in 2002; approx. 2,200 employees
KONGSBERG	Kongsberg Maritime amongst other providing autonomous ship systems; established 1998; over 3,500 employees
BRØDRENE AA	Norwegian company constructing electric and autonomous ferries founded in 1947; approx. 135 employees
PAXSTER	Norwegian company building all-electric delivery vehicles founded in 2015; over 60 employees
ULSTEIN	Norwegian company designing and building ships including hybrid ferries, founded in 1917; 400 employees
VARD	Shipbuilding company building electric ferries, founded in 1998; over 700 employees
widerøe	Norwegian airline company with plans for electric passenger flights founded in 1934; 2,500 employees
massterly	Norwegian autonomous vessel operator; founded 2018; approx. 2 employees*

Company	Short description*
NORLED	Norwegian ferry operator operating among others electric ferries founded in 2000; over 780 employees*
UNIBUSS	Norwegian bus company operating electric busses founded in 2003; approx. 1,647 employees
Fjord1	Norwegian ferry operator operating electric ferries founded in 2001; approx. 1,547 employees
ABB	Swedish/Swiss MNC in electrification, charging infrastructure and automation; founded 1988; 110,000 employees globally
RECHARGE	Public charging operator registered 2019; approx. 40 employees
mer Ren energi fra Statkraft	Public charging operator owned by Statkraft registered in 2009; approx. 66 employees*
eviny	Public charging operator registered in 1998; approx. 201 employees
easee	Smart charging provider for homes registered in 2018; approx. 334 employees*
CIRCLE K	Public charging operator and gas station; founded in 1920 with approx. 224 employees
Eidsiva.	Norwegian energy company with energy storage collaborations founded in 2001; approx. 76 employees*
TENSIO	Norwegian energy provider with energy storage collaborations founded in 1997; approx. 500 employees*
Statkraft	Norwegian energy production company with energy storage projects founded in 1986; approx. 3,600 employees

Note: *For further case details see examples in Nordic recent developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

Leading players in the value chain

(3/3)

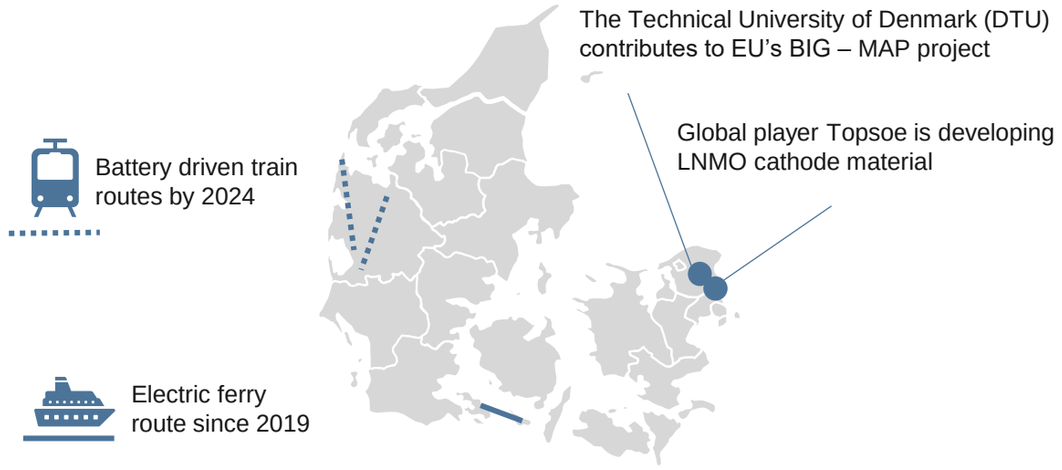
Company	Short description*
Zaptec	• Electric vehicle charging company founded in Norway 2012
	• Norwegian company working with power conversion and energy storage founded in 2018; 22 employees
greenely	• Energy company with electric charging solutions founded in 2014 in Sweden, approx. 10 employees
tibber	• Norwegian energy company founded in 2015, approx. 77 employees
NORSIRK	• Norwegian battery collection company founded 1998; approx. 20 employees
BatteriRetur	• Norwegian battery collection company founded 1993; approx. 15 employees
hydrovolt	• Joint venture between Norwegian Hydro and Swedish Northvolt for battery recycling*
ReSiTec	• Norwegian technology company focused on battery materials founded in 2021; no employee information
HAGAL	• Norwegian reuse company founded in 2018; 27 employees*
ECOSTOR	• Norwegian second life company for energy storage systems founded in 2018; approx. 14 employees
YEDLIK	• Norwegian second life company founded in 2020; approx. 1 employee
Evyon	• Norwegian reuse company using EV batteries for energy storage founded in 2020; approx. 24 employees*

Note: *For further case details see examples in Nordic recent developments. The number of employees and year founded may differ due to multiple legal structures and/or registration information
Source: Company websites, Third-party corporate registration database

The battery industry in Denmark and Iceland is limited, focusing on electrification of transport and materials research

KEY STRENGTHS DENMARK

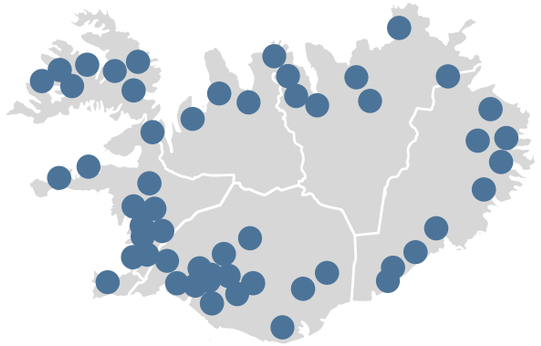
Leading R&D initiatives	• Denmark is leading several cross-border battery research projects in battery technology
New battery materials	• Development of cathode material for next generation lithium-ion batteries • Battery mineral deposits available on Greenland
Battery systems	• Denmark has a few companies active in battery management systems and battery solutions for storage and industrial applications
Commencing electrification of transports	• Early-stage electrification trend with initiatives to apply battery technology within maritime, rail and road transport



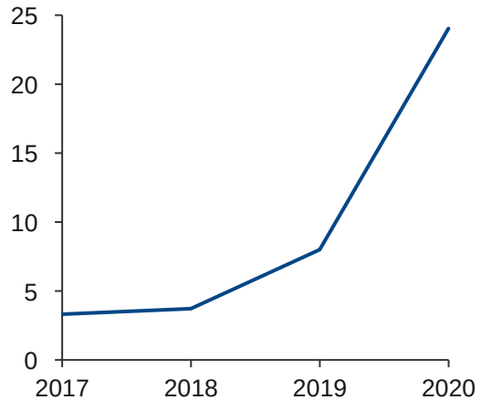
KEY STRENGTHS ICELAND

Aluminium batteries under development	• Iceland has large aluminium production and one company developing an aluminium based battery technology
Electrification ongoing	• Increase in EV coverage • Inexpensive electricity production provided by nearly 100% renewable sources
Good EV charging network	• Iceland has expanded its charging network for EVs with around 25% of new car sales being electric

EV charging station clusters in Iceland



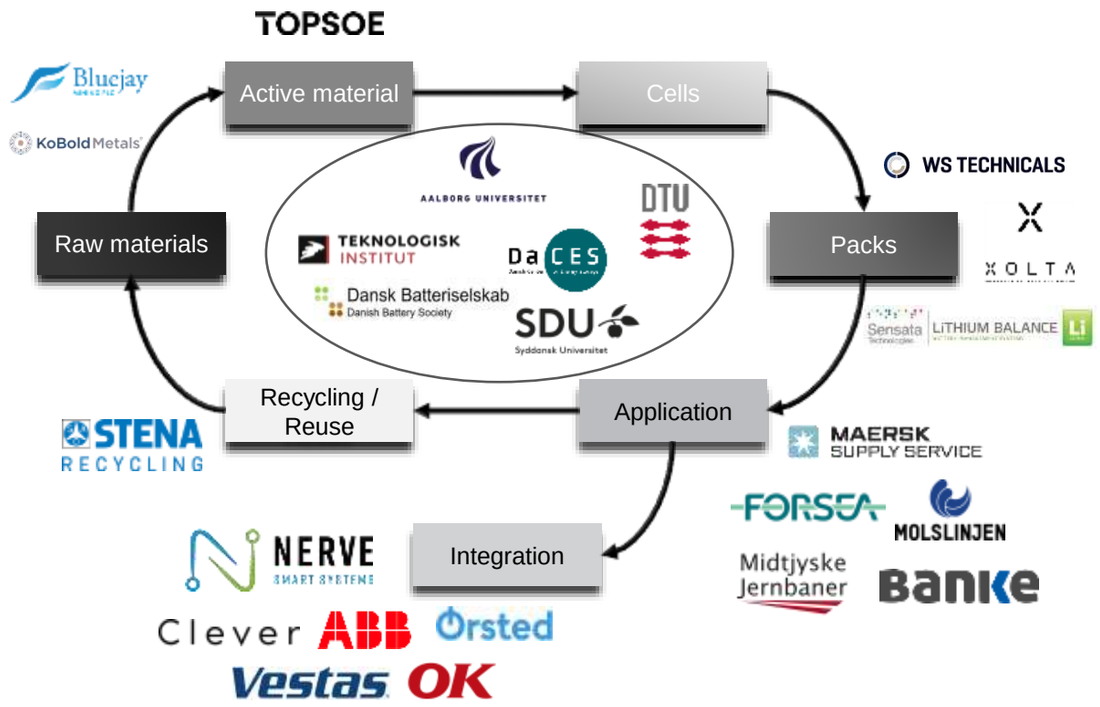
New EV passenger car registrations (% of total new car registrations)



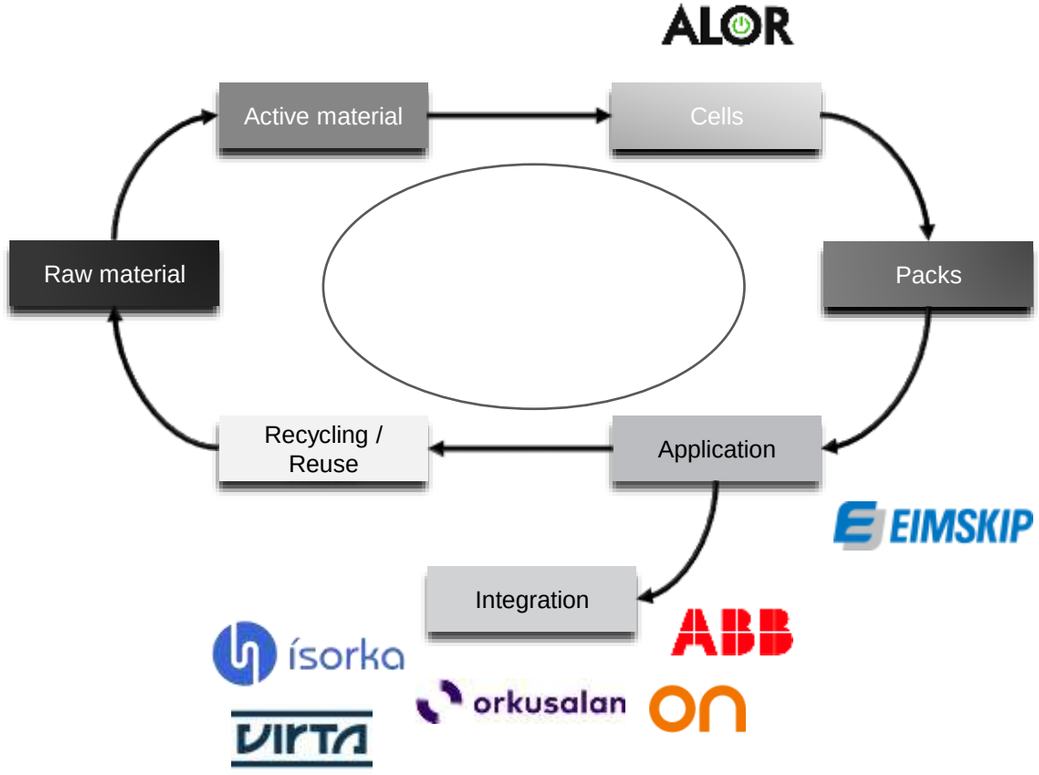
Source: Eurostat, BIG-MAP, Alor, Plugshare, Topsoe, Government of Iceland, Business Sweden Analysis

Active materials and battery management systems are main Danish battery competences; Iceland focused on application and alternative batteries

Leading players in the Danish battery value chain



Leading players in the Icelandic battery value chain



Source: Company Websites, Business Sweden Analysis

Leading players in the value chain

Company	Short description
Bluejay	UK based mining exploration company with projects in Greenland, founded 2005, 7 employees
KoBold Metals	American exploration company providing solutions for battery mineral exploration, founded 2018, 35 employees
TOPSOE	Large company developing LNMO cathode material, founded 1940, 2,400 employees
WS TECHNICALS	Manufacturer of Lithium-ion packs, founded 2016, 12 employees
XOLTA	Battery producer devoted to energy storage systems, founded 2006, part of Sensata Technologies 22,000 employees
Sensata / LITHIUM BALANCE	Developer of Battery Management Systems (BMS) for advanced monitoring and management, founded 2006, part of Sensata Technologies 22,000 employees
MAERSK SUPPLY SERVICE	The subsidiary of Maersk A/S installs battery packs in their vessels, founded 1967, 1,300 employees
MOLSLINJEN	Ferry company that will operate two routes in Denmark with battery driven ferries, founded 1964, 700 employees
Banke	Developer of battery systems for heavy-duty vehicles, founded 2010, 21 employees
FORSEA	Ferry operator converting their vessels to become electric, founded 1996, 750 employees

Company	Short description
Midtjyske Jernbaner	Train operator buying battery trains for routes in Denmark, founded 2008, 69 employees
Ørsted	Large energy company integrating their wind farms with charging stations, founded 2006, 6,800 employees
ABB	Swedish-Swiss technology company delivering battery storage solutions in Denmark, founded 1988, 110,000 employees
Vestas	Large wind turbine manufacturer installing grid battery to charge EVs from wind power, founded 1945, 29,000 employees
OK	Large cooperative operating gas stations and is now working with Vestas to integrate EV charging stations run by electricity from wind power, founded 1978, 12,500 employees
NERVE SMART SYSTEMS	Developer of ultra-fast electric car chargers and battery management systems, founded 2016, 10 employees
Clever	Developer of electric car chargers and the largest EV charging station in Denmark, founded 2009, 230 employees
STENA RECYCLING	Swedish recycling company offering battery recycling services with operations in Denmark, founded 1939, 3,500 employees*
Dansk Batteriselskab / Danish Battery Society	Organisation consisting of companies and institutions working and promoting batteries, founded 2013, 15 members
TEKNOLOGISK INSTITUT	Research and technology institute researching in the development of new battery technology and lightning-fast charging, founded 1964, 1,000 employees

Source: Company websites, Third-party corporate registration database

Leading players in the value chain

Company	Short description
SDU Syddansk Universitet	• University researching in alternative materials to lithium-ion batteries, founded 1966, 3,900 employees
DTU	• University actively researching in battery technology together with Danish players and through EU lead project BIG-MAP, founded 1829, 6,000 employees
AALBORG UNIVERSITET	• University researching in how to improve lifetime and reliability of batteries, founded 1974, 3,800 employees
DaCES	• Partnership organisation with ambition to strengthen cooperation between companies and universities in the battery field, founded 2020, 60 members

Company	Short description
ALOR	• Icelandic start-up company developing and producing sustainable aluminum batteries, founded 2020, 12 employees
EIMSKIP	• Shipping company and owner of ferry Herjólfur – the first battery driven ferry in Iceland, founded 1914, 1,770 employees
ABB	• Swedish-Swiss technology company integrating battery solutions in Denmark for charging infrastructure and ferries, founded 1988, 110,000 employees
orkusalan	• Power company installing EV charging stations all over Iceland, founded in 2006, 25 employees
on	• Leading electricity company in Iceland and engaged in the development of EV charging infrastructure, founded 2014, 60 employees
VIRTA	• Finnish EV charger manufacturer collaborating with Isorka to expand Iceland's charging network, founded 2014, 350 employees*
ísorka	• Icelandic EV charging network operator who developed an app with live information about charging stations, founded 2014, 6 employees

Source: Company websites, Third-party corporate registration database

Agenda

Access to raw materials will be critical to Europe to increase resilience, realise the initiated projects as well as make an impact for sustainability

DRIVERS

The unprecedented demand for batteries…

…is far from matched with raw material supply

- Competition other industries
- Skyrocketing prices
- Lack of structural investment in new supply capacity

Global supply dependent on few sources

- Concentrated ownership
- Covid-19 and geopolitical supply chain challenges
- Lead times for new mines

Environmental, Social, and Governance (ESG) issues

- E.g. High environmental footprint, human rights issues

NEEDS

Increased regional supply

Permits for new mines

- To facilitate new investments, transparent and fast permit processes are needed with fast decision times for sustainable mining
- Attract foreign investments for mining and refineries to realise supply

Recycling

There is a need for EU Regulations to drive and facilitate a green battery value chain through EU Battery regulation and environmental standards

Innovation

- The lack of raw material encourages innovation of new materials to meet the raw material demand

A resilient European supply

- There is a need for in-house production and recycling in Europe with current value chains linked to ESG issues
- EU Regulations act as a sustainability driver e.g. EU Critical Materials Act
- There is a sense of urgency and need for immediate action to address the raw material demand; because it takes 15 years to start mining

Sustainable raw materials

- Supply of raw materials is seen as geopolitical tool
- A need for ESG issues to be addressed through regulations and standards e.g. EU Battery regulation facilitate for Europe's supply of raw material
- A sustainable value chain enabled by EU Policies e.g. in recycling

NORDIC INDUSTRY QUOTES

> *To be resilient in Europe and the Nordics minerals must be mined and permit processes need to be quick with an awareness of the current dependency on other parts of the world*

[Swedish actor]

> *European companies need to be sustainable, meet price demands and customer timelines. This sets limits on the geographical and sourcing alternatives*

[Norwegian actor]

> *Of the material needed 2027 we have about 10% accessible today*

[Finnish actor]

> *To meet demand we need mines in Europe. The Nordics are frontrunners for sustainable mining*

[Finnish actor]

Source: Business Sweden interviews and analysis

There is an immense expected growth of battery raw material demand

- A few countries dominate the current raw material production, processing and refining

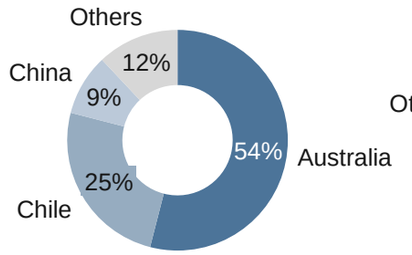
Immense growth in raw material demand

- Mineral demand for use in EVs and battery storage is forecasted to grow at least thirty times to 2040
- Lithium demand is forecasted to have the main growth, with demand growing by over 40 times by 2040, followed by graphite, cobalt, and nickel (around 20-25 times)*
  - The International Energy Agency forecasts that EV battery demand will require 50 new lithium projects, 60 nickel mines, and 17 cobalt developments by 2030
  - Benchmark Minerals predict the need for 400 new mines by 2035

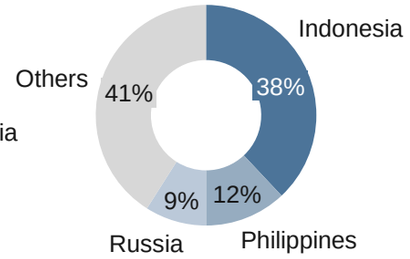
Mineral content battery electric vehicle* (kg/vehicle)

Raw material production is dominated by few countries

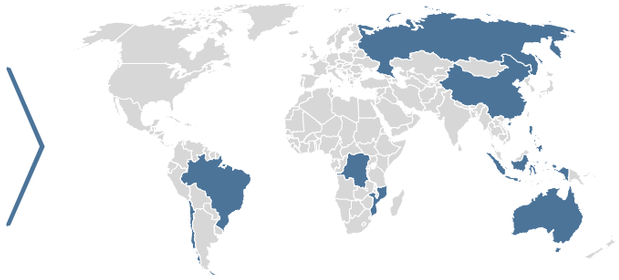
Lithium



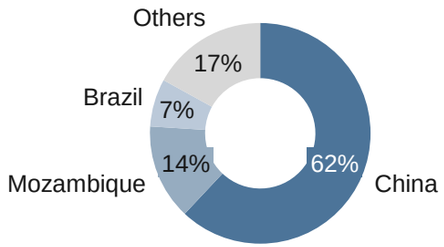
Nickel



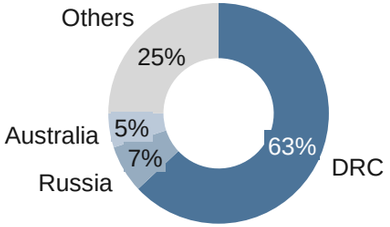
Top battery minerals producing countries



Graphite - natural

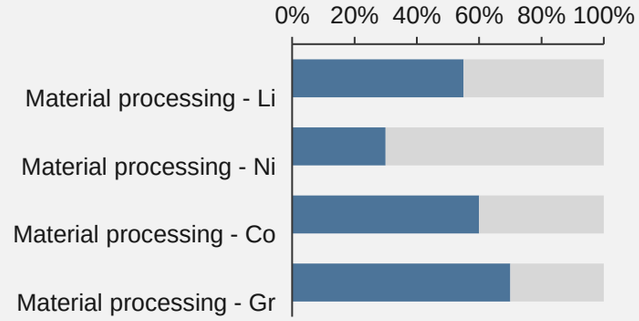


Cobalt

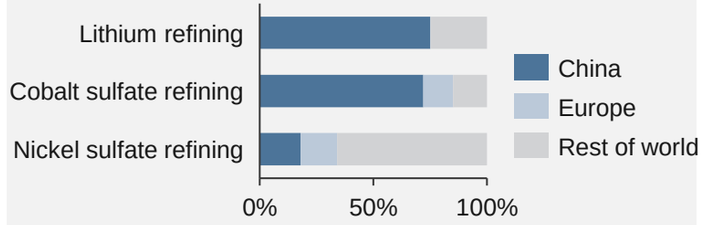


China in the lead for the battery supply chain

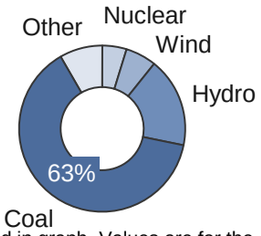
China percentage of material processing



Refining per region (%)



China electricity mix 2020

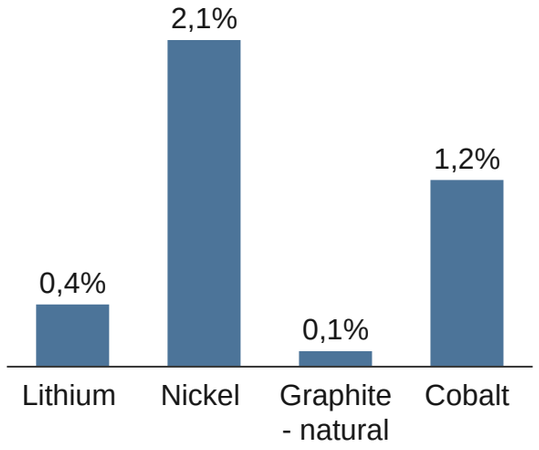


Source: Financial Times, RMIS - Raw Materials Profiles (europa.eu), Benchmark Minerals UNEP, Human Rights Watch, Swedish Energy Agency, IEA; Critical Raw Materials Act (Europa.eu). ***** Steel, aluminum not included in graph. Values are for the entire vehicle including batteries and motors. Based on a 75 kWh NMC 622 cathode and graphite-based
*Average price across several industries that use lithium-ion battery packs

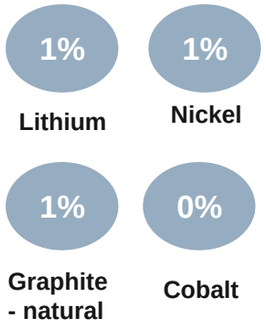
Current EU raw material production and reserves are limited at the same time as lithium prices increase influencing battery prices to rise after a decade of decline

Current EU production and share of world reserves are limited

EU Share of World Primary Production (%)



EU Share of World reserves

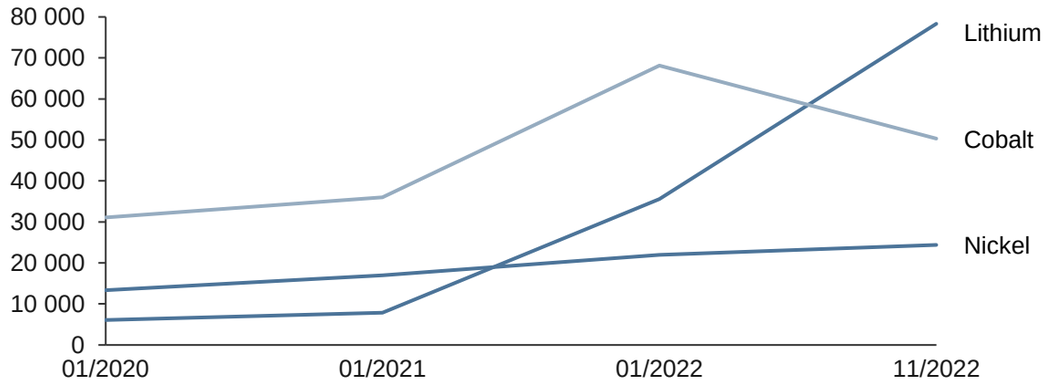


Access to battery minerals at decent price levels is crucial

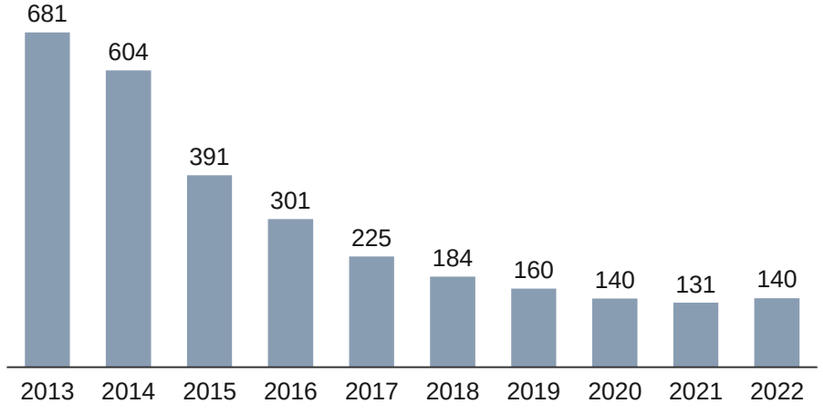
- Raw materials are a 50-70% of total cost of lithium-ion batteries
- Lithium chemical and battery-grade nickel might face tight supply in the years ahead
- **EU Critical Raw Materials Act** announced September 2022 to act on the urgency and need to secure raw material
- Automotive groups are looking for ways to take greater control of their raw material supply chains in the race to electrify the global car fleet, signing offtake agreements with miners and working on their own processing facilities

The rising raw material costs paused decline in battery prices 2022

Raw material price changes on the global market (EUR / Tonne)



Lithium-ion battery prices (EUR / kWh 2022)**



- Overall costs for batteries have been pushed down by 90% over the past decade
- Increases in mineral prices could disrupt the decreasing cost trend

Source: IEA, Bloomberg

There are severe issues for environmental and social sustainability globally

- With an accelerating battery demand focus on sustainability is urgent and crucial

Baseline	**A skyrocketing demand for more batteries**	• The transition to electric vehicles is accelerating with an enormous pace – The transition is initially happening in high-income countries • The International Energy Agency forecasts that EV battery demand will require 50 new lithium projects, 60 nickel mines and 17 cobalt developments by 2030 – Benchmark Minerals predict the need for 400 new mines by 2035
Issues in the global battery value chain	**Human rights**	• Mining operations, for example in the Democratic Republic of Congo, have been linked to both environmental and human-rights abuses such as child labour. Mining conditions have been reported hazardous, lacking adequate protective equipment and with exposure to toxic dust contributing to hard metal lung disease. • Growing evidence link some renewable energy supply chains to modern slavery in mineral extraction and manufacturing in China, Africa, and South America
	Environment	• Currently there is a high environmental footprint in the production of a battery with the extraction of minerals demanding a vast volume of water, risking drying out areas or leakage of mining waste or chemicals into the environment • In Chile and Argentina, lithium mining from salt deserts (Salars) is reported to cause droughts in the local areas, threatening local livestock and vegetation farms
	Strategic resources	• Due to the strategic significance of battery metals, there is a risk for development trajectories towards sustainability to be used by geopolitics in an unwanted manner
	Global market dynamics	• EVs are foremost sold by actors from developed countries and raw material sources foremost found in emerging markets. This could place a risk for replication of an unfair balance between value creation and ESG issues among global markets
	Energy mix	• The electricity mix of manufacturing within the battery value chain as well as the electricity mix for battery charging greatly impacts the emissions from the industry
	Timing	• It typically takes about 15 years or more to get a mine up and running

There is an **urgent need** for adherence to environmental, social, and governance (ESG) standards in battery supply chains

Source: Foreign Policy, Swedish Environmental Research Institute, Benchmark Minerals, Global Battery Alliance, United States Department of State, Australia Clean Energy Council , Amnesty International

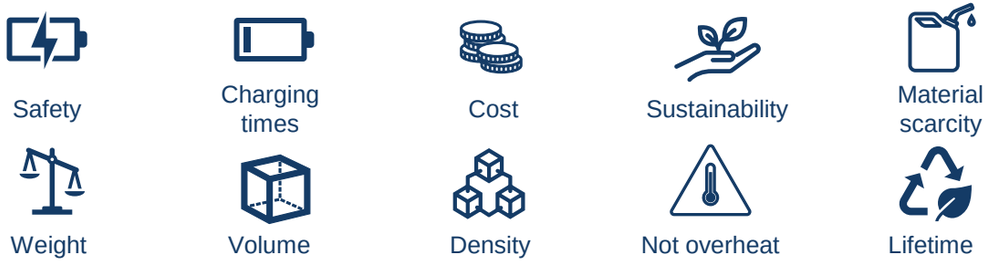
The severe lack of accessibility of materials urge for technology innovations
- Cross-cutting areas for BATTERY 2030+ are manufacturability and recyclability

Lack of raw materials a driving force for new solutions

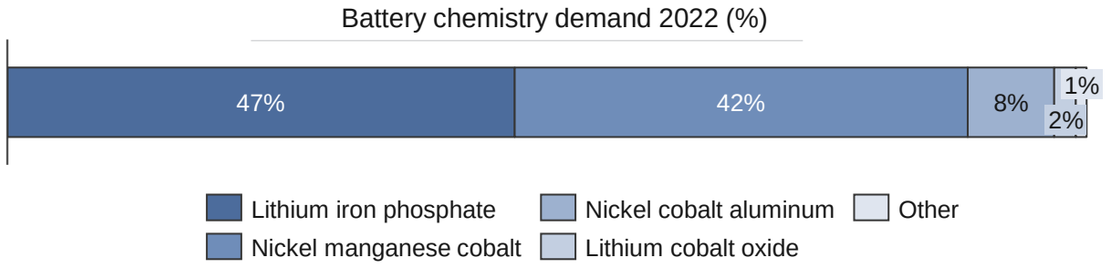
- **BATTERY 2030+** is a large scale, long-term European research initiative with the vision of inventing the sustainable batteries of the future.
  Research areas e.g.
  - Materials Acceleration Platform, Battery Interface Genome, Integration of smart functionalities: Sensing and Self-healing respectively
  - Cross-cutting areas:
    - **Manufacturability** and **Recyclability**

- Key battery research institutions in Europe with relevant patents
  - Karlsruhe Institute of Technology (DE)
  - Uppsala University (SE)
  - University of Münster (DE)
  - Technical University of Munich (DE)
  - Max Planck Institute (DE)
  - University of Picardy Jules Verne (FR)
  - French National Centre for Scientific Research (FR)
  - Bern University of Applied Sciences (CH)

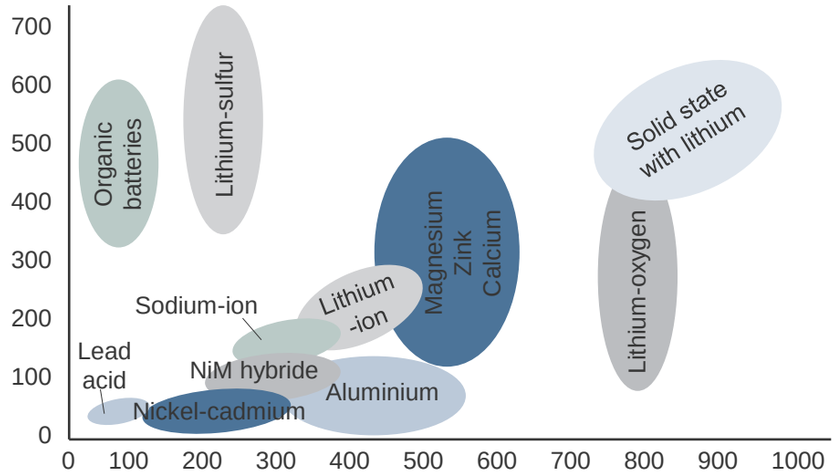
Battery characteristics for current and future segmented battery demand



Lithium iron phosphate batteries expected to increase in popularity by 2030



Current commercial batteries and targeted performance of future possible chemistries*
From the BATTERY 2030+ Roadmap



*The post lithium batteries chemistries are given as names indicating all kinds of metal-type batteries in respective category. There is a large uncertainty of their respective position in the graph. NiM hydride refers to nickel metal hydride
Source: Battery 2030+, IEA: Global Electric Vehicle Outlook 2022, McKinsey, Business Sweden Interviews and Analysis

The Nordics could impact sustainability by mining and refining raw materials
- An informed public debate and national priorities are key and permits are decisive

OPPORTUNITY

The Nordics have extensive mineral resources…

- E.g. cobalt, graphite and lithium

…with several promising local and foreign investment cases…

… as well as high standards for sustainability

The Nordics share political and economic stability

- High rankings globally

NEEDS

Informed public debate

- Public awareness of the balance between a tremendous growing battery demand, its current sustainability status throughout the value chain and the decisive need of increased sustainability
- Public awareness of the full mining and refining process, the shared history of being mining nations and the opportunity to impact future market prerequisites towards sustainability

National prioritisations

- Respect for all groups with interests for the same geographical land
- National decisions on prioritisations for usage of land and resources with clear strategies and actions to follow decisions
- Continued high demands on sustainability to impact industry standards

Improved permit decision processes

- Increased transparency for decision times and documentation needed
- Shortened decision times for the full permit process
- Public dialogue according to national prioritisations to prevent appeals

Highlighted investment cases

- Highlight approved permits to the market, investors and the public to exemplify timelines and visualise taken actions
- Showcase the full value chain sustainability impact on current mining and refining projects to reach a holistic understanding

Highlight the Nordics as a reliable partner

- Make use of the potential of taking position for sustainability if or when developing into a
  - global partner for raw materials
  - investment site for mining and refinery projects
  - receiver of capital to back up investments in exploration phase

NORDIC INDUSTRY QUOTES

> *The Nordics have a key role to play in raw material supply*
>
> [Swedish actor]

> *If we want the green transition, we need more mines*
>
> [Swedish actor]

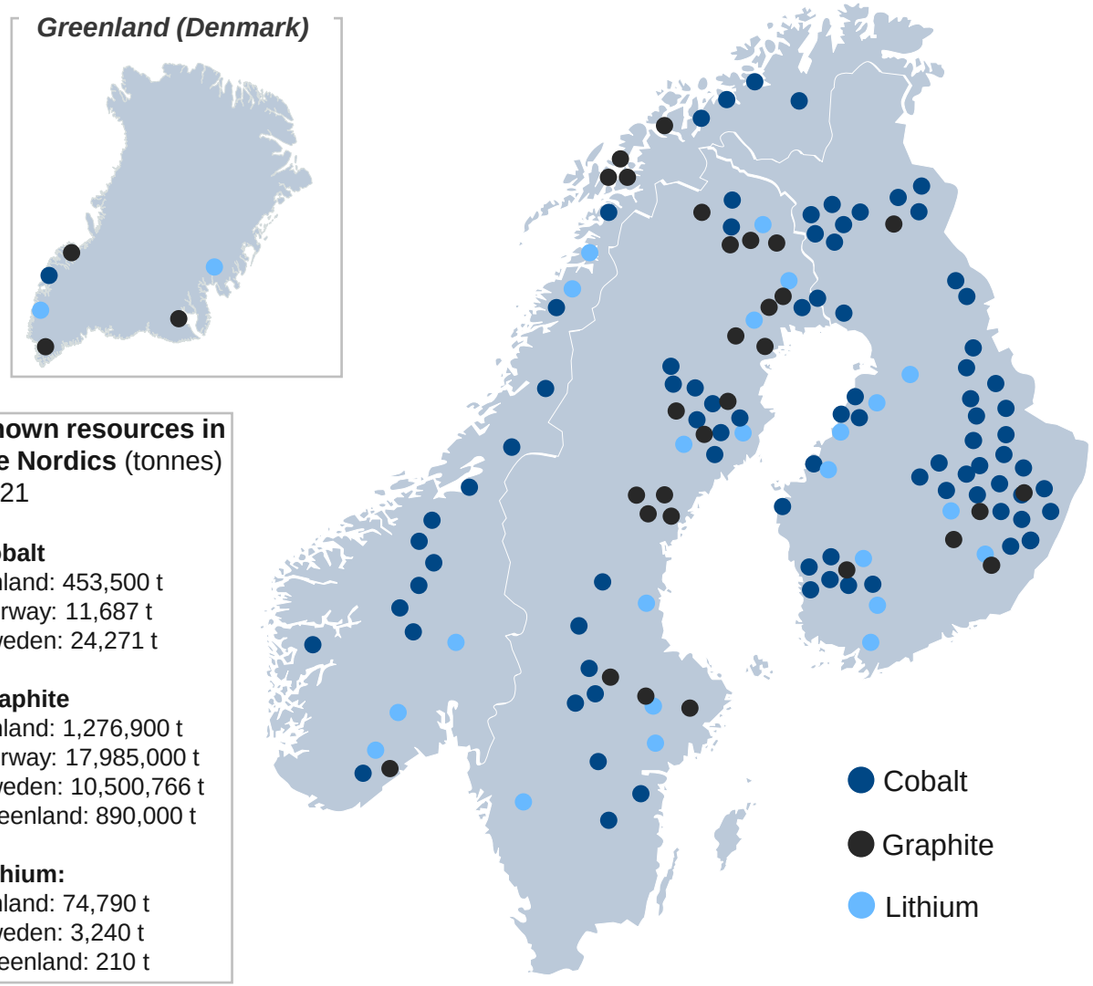
> *Why does the public not understand that we need mines? Mines do not destroy the environment if we make sure to keep and develop our high standards for sustainability*
>
> [Swedish actor]

> *As demand for raw materials increases also in Asia, whereto might they sell? There is a need to to increase resilience of raw materials in Europe*
>
> [Finnish actor]

Source: Business Sweden interviews and analysis

The Nordics have extensive mineral resources deposits of cobalt, graphite and lithium not yet excavated

Map of Cobalt, Graphite and Lithium deposits in the Nordics, 2022



Known resources in the Nordics (tonnes) 2021

Cobalt
Finland: 453,500 t
Norway: 11,687 t
Sweden: 24,271 t

Graphite
Finland: 1,276,900 t
Norway: 17,985,000 t
Sweden: 10,500,766 t
Greenland: 890,000 t

Lithium:
Finland: 74,790 t
Sweden: 3,240 t
Greenland: 210 t

Existing and future mining potential in the Nordics

- The Nordics have approximately **67 active mines**, 41 of them in Finland, 16 in Sweden, 8 in Norway and 2 in Denmark (Greenland) as of late 2022.
- The raw material needs are addressed through policies including the 2022 Swedish Export Credit System (EKN) guarantee and the 2022 Norwegian proposal for a new national minerals act
- The EU source 30% of the **silicon metal** from Norway and 51% of g**ermanium** from Finland. Norway also has active mining for **graphite** and Finland has Europe's only **cobalt** mine in production as of 2021. Others:
  - **Copper** often used in cables, wires, electric motors, EVs. Sweden and Finland have mines in production today. Available additional unexplored deposits.
  - **Manganese** often used in steel, dry-cell and lithium batteries. No known mining in the Nordics. Finland and Sweden are seen to have unused deposits.
  - **Nickel** is mainly used in stainless steel but also in some type of batteries. Finland has active production. Exploration projects in Sweden and Greenland. Finland, Sweden and Greenland are seen to have unused deposits.
- To increase accessible volume secondary raw materials are important
  - The Eyde Cluster in Norway has led a project that has mapped 11 million tons of 250 side streams from the process industry in Norway
  - Side stream materials are a low-risk material source available now. Material upgrade is needed, but has a predictability on content, volume and history.
  - Research and regulation of 2nd use and of transport (as end of waste) needed

Note: Lithium: Deposit type Pegmatite-aplite, Activity status: Active, Closed, Not Exploited**; Graphite** Deposit type: Amorph, flake, unclassified, Activity status: Active, Closed, Not Exploited; Markings of deposits are approximate in terms of size and location
Source: European Geological Data Infrastructure (EGDI); FRAME, EGDI/MIN4EU, EC Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability 2020, Electrive, Di, SGU, Mining for Generations, Norsk Bergindustri, Nordic Innovation; The Nordic Supply Potential of Critical Metals and Minerals for a Green Energy Transition; EKN, Reuters, Miningforgenerations, GTK

High rankings in innovation, digitalisation, and sustainability makes the Nordic a stable region and trustworthy business partner

	Sustainability		Business climate and digitalisation						Innovation		
Global rank	Country Sustainability Index	Corruption Perception Index	Talent Ranking	Global Resilience Index	Digital Competitiveness Index	World Competitive-ness Index	Robot density in manufacturing	The Logistics Performance Index	Innovation Union Scoreboard	Network Readiness Index	Global Innovation Index
1	**Finland**	**Denmark**	Switzerland	**Denmark**	**Denmark**	**Denmark**	Korea Rep.	Germany	**Sweden**	United States of America	Switzerland
2	**Norway**	**Finland**	**Sweden**	Switzerland	USA	Switzerland	Singapore	**Sweden**	**Finland**	Singapore	United States
3	**Sweden**	New Zealand	**Iceland**	Luxembourg	**Sweden**	Singapore	Japan	Belgium	**Denmark**	**Sweden**	**Sweden**
4	**Denmark**	**Norway**	**Norway**	Singapore	Singapore	**Sweden**	Germany	Austria	Netherlands	Netherlands	United Kingdom
5	Switzerland	Singapore	**Denmark**	Germany	Switzerland	Hong Kong SAR	China	Japan	Belgium	Switzerland	Netherlands
6	**Iceland**	**Sweden**	**Finland**	United States	Netherlands	Netherlands	**Sweden**	Netherlands	Ireland	**Denmark**	Republic of Korea
7	Austria	Switzerland	Luxembourg	**Sweden**	**Finland**	Taiwan, China	Hongkong	Singapore	Luxembourg	**Finland**	Singapore
8	Germany	Netherlands	Austria	**Norway**	Korea Rep.	**Finland**	Chinese Taipei	**Denmark**	Austria	Germany	Germany
9	Netherlands	Luxembourg	Netherlands	Austria	Hong Kong SAR	**Norway**	United States	United Kingdom	Germany	Korea, Rep.	**Finland**
10	Luxembourg	Germany	Germany	Belgium	Canada	USA	Slovenia	**Finland**	Cyprus	**Norway**	**Denmark**
Source:	Robeco 2022	Transparency International 2021	IMD 2022	FM Global 2022	IMD 2022	IMD 2022	IFR 2022	The World bank 2018	EIS 2022	Portulans Institute 2022	Global Innovation Index 2022

The Nordics have several global leading players within mining and refining evolving from centuries of high skills and successful trade as mining nations

Some recent developments in the Nordics*

- There are ongoing exploration activities, planned openings of mines, and ongoing production in the Nordics, including:
  - One million tonnes rare earth materials discovered in Kiruna, Sweden; the largest of its kind in Europe
  - Announced plans to open a new lithium mine and smelter in Kokkola, Finland
  - Plans to build a new circular industrial park in Luleå in the north of Sweden
  - Test mining of graphite in northern Sweden

Source: Business Sweden interviews, Company webpages * For additional cases and details see the following chapter

Nordic raw materials | Recent development in the Nordic value chain

Mining

LEADING EDGE

- Canadian-owned mining company founded in 2010.
- The company announced in 2022 plans to resume operations for graphite in Woxna, near Edsbyn. In June 2022 the company initiated a permit application process for the Norra Kärr rare earth element project which potentially include (nepheline syenite, niobium (Nb) and zirconium (Zr)).

TALGA

- Australian-owned mining company incorporated 2009 with approximately 40 employees.
- Talga owns Vittangi graphite mine for anode battery production. In 2021 the company completed the Vittangi definitive feasibility study (DFS) and aim to begin commercial production in 2024. In September 2021 Talga began test mining 25,000 tonnes graphite in Niska, northern Sweden.

LKAB

- Swedish state-owned mining company founded in 1890 and has approximately 4,500 employees globally.
- The company announced in May 2022 plans to build a new circular industrial park on Svartön in Luleå for extraction of phosphorus, fluorine and rare earth metals, and production of gypsum.
- In January 2023, the company announced findings of one million tonnes rare earth materials near their existing mine in Kiruna, Sweden. The deposits are the largest of its kind in Europe.

Mining

EUROBATTERY MINERALS

- Swedish mining company founded in 2009 and has approximately 1 employee.
- Prospecting Copper, Nickel, Vanadium, Molybdenum, Gold, Silver, Lead and Zinc at seven sites in Norrland, Sweden.
- In November 2022, the company announced that all exploration permits have been extended until June 2023.

SKALAND GRAPHITE

- Australian Mineral Commodities (MRC) finalised its acquisition of Norwegian Skaland Graphite, founded in 2003 and has approximately 43 employees, during 2019.
- The company has a production volume of 12,000 tons per year; considered to be the biggest crystalline graphite producer in Europe.

KELIBER

- Finnish-minority-owned mining company founded in 1989 and has approximately 16 employees.
- Plans to open a lithium mine and a smelter in Kokkola, Finland to produce 15,000 tonnes of lithium hydroxide annually. Investment decision of 588 MEUR was confirmed in November 2022, production start is planned in 2025.
- In October 2022 South African mining company Sibanye-Stillwater acquired a larger share in Keliber, holding around 85-% share the company; the Finnish Mineral Group holds 14-%.

Refining

GLENCORE NIKKELVERK

- Refined nickel, copper and cobalt producer founded in 1929 and has approximately 550 employees.
- The company exports 100% of the production across the world and has the ambition to increase the sustainability of battery production.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Agenda

For the European cell production initiatives to meet demand on a long-term basis it is critical to secure a resilient supply chain of materials and machinery

DRIVERS

Supply of battery cells is critical to have within Europe

- Need to have battery production close to OEMs
- Automotive is a strategic industry for European employment

There are geopolitical and supply chain issues…

- Russia's war in Ukraine
- Geopolitical trade tensions
- Covid-19 impact on supply chains

…and a value chain dependency on others

- Battery supply chain dominated by Asian players

NEEDS

Realisation of cell production initiatives

- The large number of investments within battery cell production in Europe needs to be realised to keep market trust and capital investments and to get production going
  - Statistically some of the projects might not be realised
  - Decisive for realisation are e.g. commercial contracts and partnerships with customers, secured up-stream supply chains and competence
- The extremely high market pace is forcing initiatives to test as they build, increasing both the project risk and the need for market trust

Cell demand beyond EVs

- With a broad electrification at the same time as a high percentage of the cell manufacturing initiatives focus on the main market segment
- There is a need and worry for the supply of batteries for other applications than electric passenger cars
- Influence willingness for investments as well as time plans

Resilient supply within Europe for

- Active materials, separators and chemicals

- Machinery and manufacturing equipment

- Short-term supply for materials and machinery
  - To get the European industry going global business is decisive
  - Anode and cathode materials, electrolytes, separators and chemicals are currently imported to Europe at very high levels
  - Supply of machinery is lacking within Europe and supply is scarce with long lead times affecting time plans
- Long-term lowered risk for supply of critical inputs
  - Awareness of the current dominance within supply chain is crucial
  - The strong domination of non-European actors is a factor for resilience, lack of European investments and a long-term risk

NORDIC INDUSTRY QUOTES

"Probability to succeed increase with secured capital, OEM collaborations and off taker agreements, secured energy, supply chain contracts and competence/experience within the company"

[Norwegian actor]

"In the short run we need Asian suppliers. In the long run we must invest to build up in Europe."

[Norwegian actor]

"We need Asian suppliers to build up this industry, but we must be aware of the dependency"

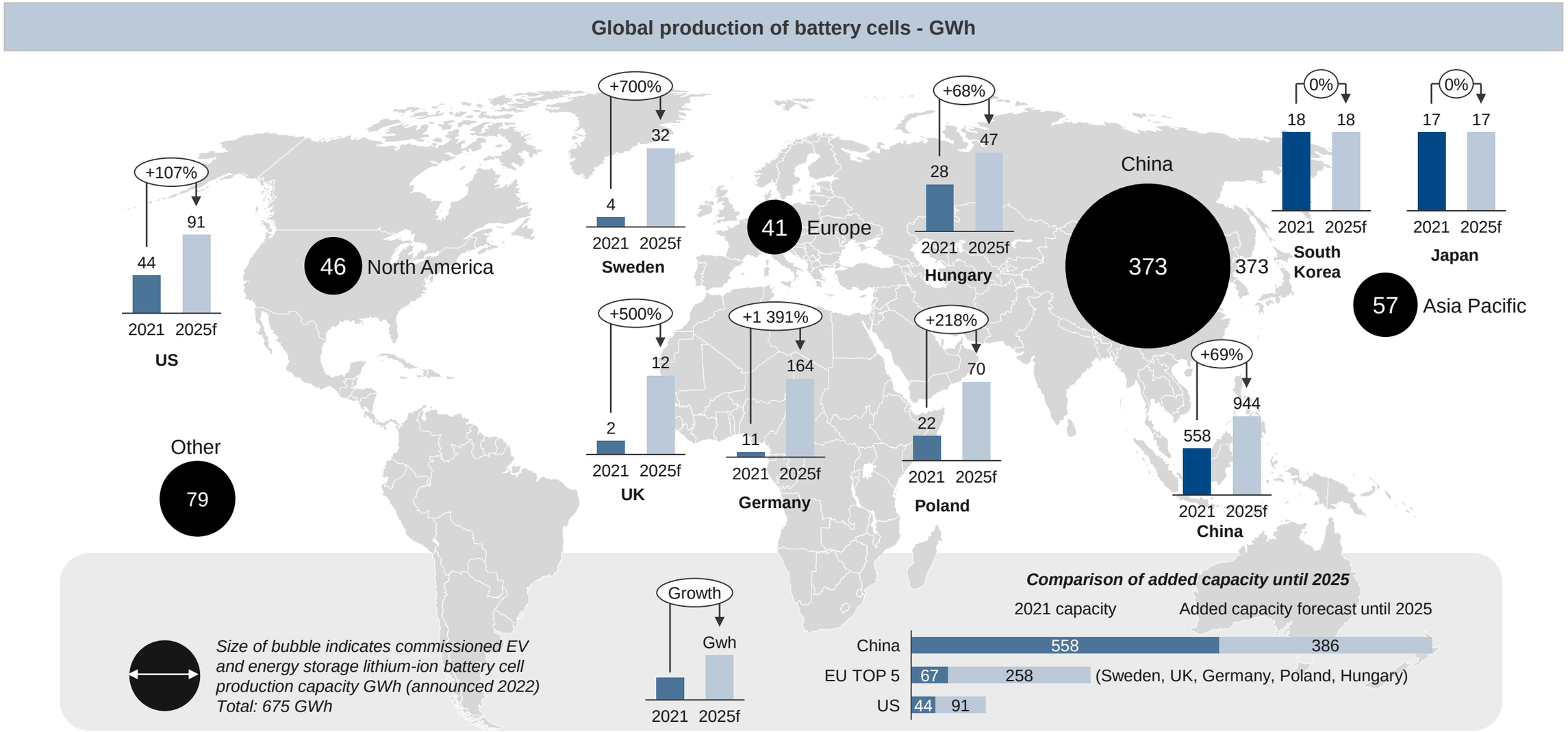
[Industry actor]

"Few companies globally are producing the machinery, so we buy from Asia: Japan, Korea and China."

[Swedish actor]

Source: Business Sweden interviews and analysis

China is with 55% of commissioned battery cell production capacity in 2022. The largest producer of global Li-ion batteries and is expected to keep its lead



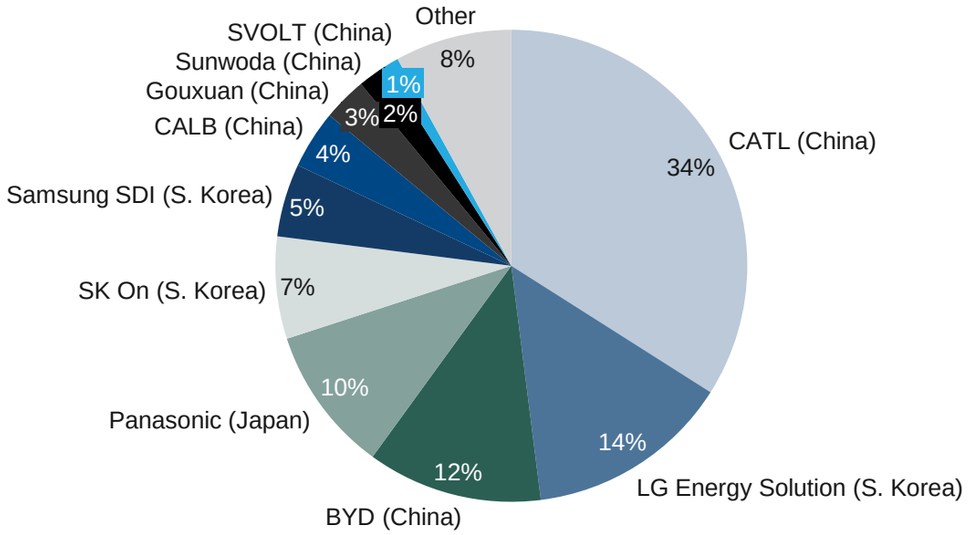
Source: IEA, S&P Global Market Intelligence **Note**: Production figures and forecast are subject to uncertainty due to the fast-moving landscape

Chinese, South Korean and Japanese cell producers hold 98% market share

- Six electric vehicle manufacturers share 52% of the global market

The top EV battery manufacturers are all from Asia

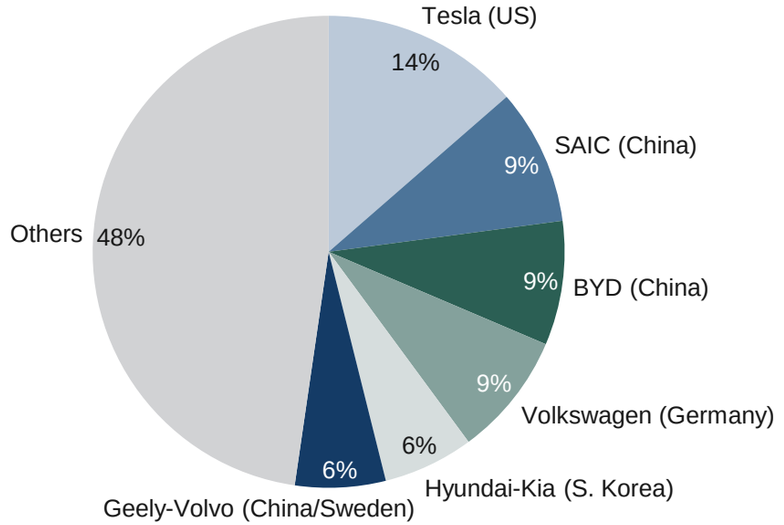
Top 10 battery manufacturers 2022 - Global market shares (%)



- Chinese companies make up 56% of the EV battery market, followed by Korean companies (26%) and Japanese manufacturers (10%)
- One-third of the world's EV batteries come from the CATL who provides batteries to Tesla, Peugeot, Hyundai, Honda, BMW, Toyota, Volkswagen, and Volvo

American, Chinese and European brands lead the electric vehicle sales

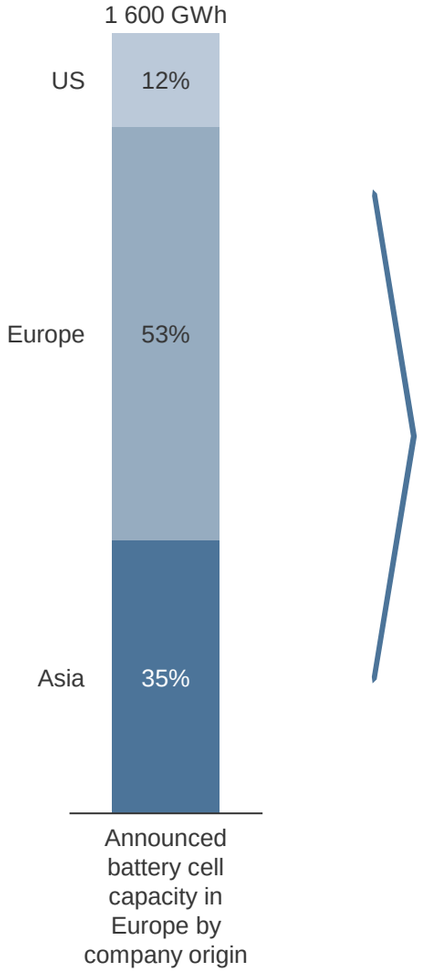
Top 10 Electric vehicle manufacturers 2022 - Global market shares (%)



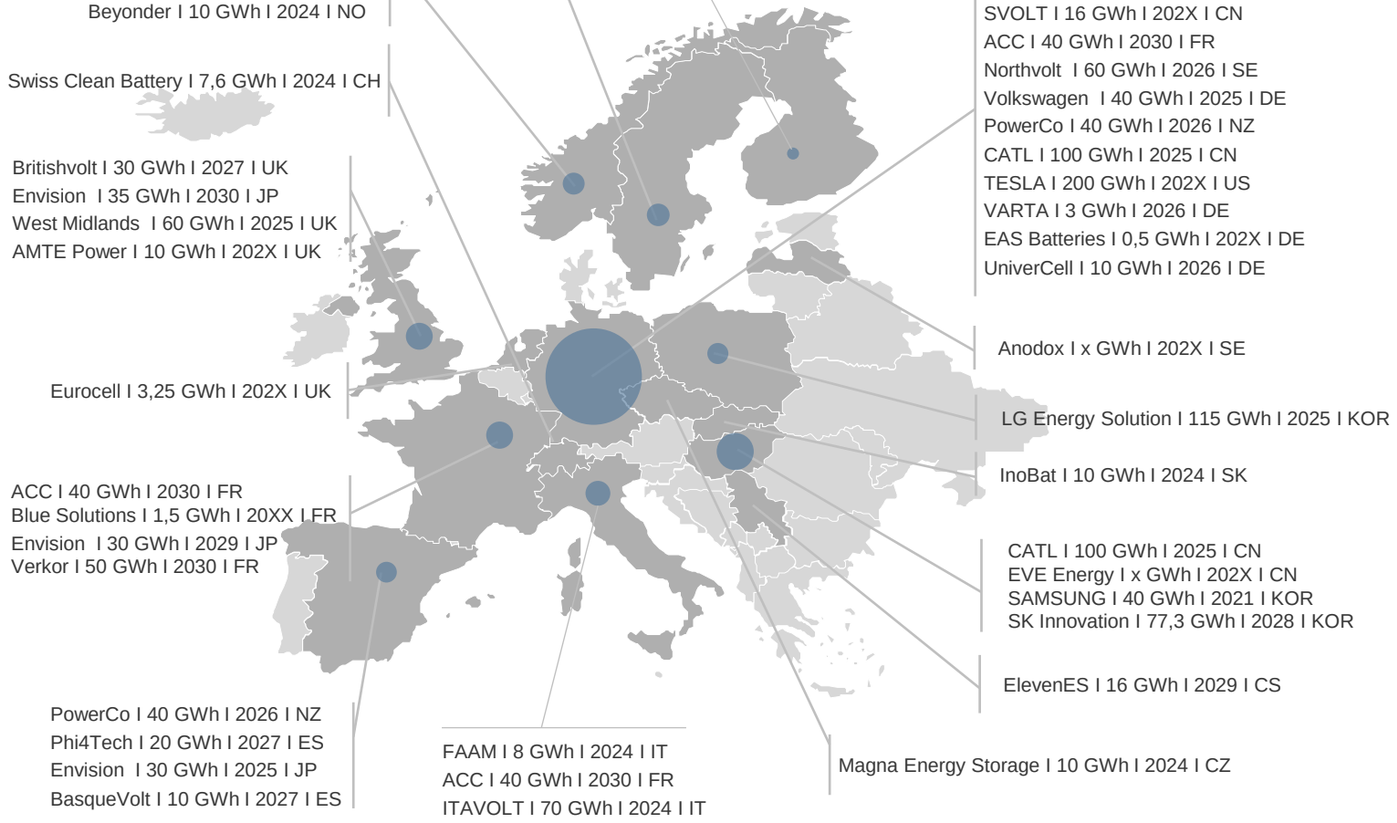
- Tesla was the best-selling brand in 2021 with just below 936,200 units sold

Source: InsideEVs, Visual Capitalist, Global EV Outlook 2022

Initiatives for more than 1,600 Gwh battery cell capacity is announced in Europe – 53% of investments with European ownership, the rest from Asia and the US



More than 1,600 GWh of battery cell capacity announced*

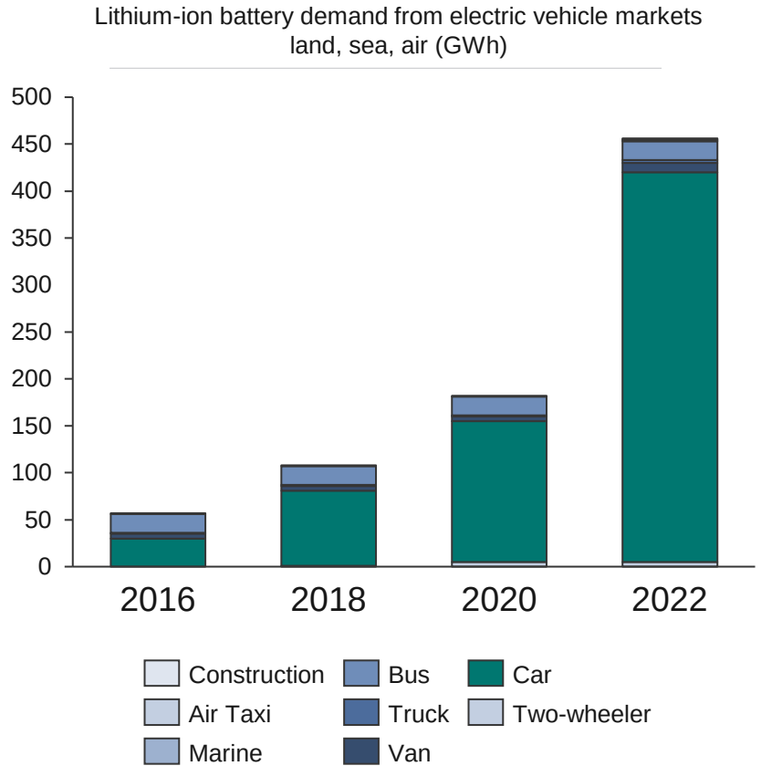


Source: Reuters, IPCEI batteries EU ***** Identified battery plants, Battery News **Note**: Map showing: Company I Capacity GWh I Year of production I HQ of Company (Freyr HQ located in Luxembourg)

The demand for lithium-ion battery cells within transport is dominated by cars

- Future electrification and thereby battery demand is expected across transport modes

Battery cells are demanded across modes of transport



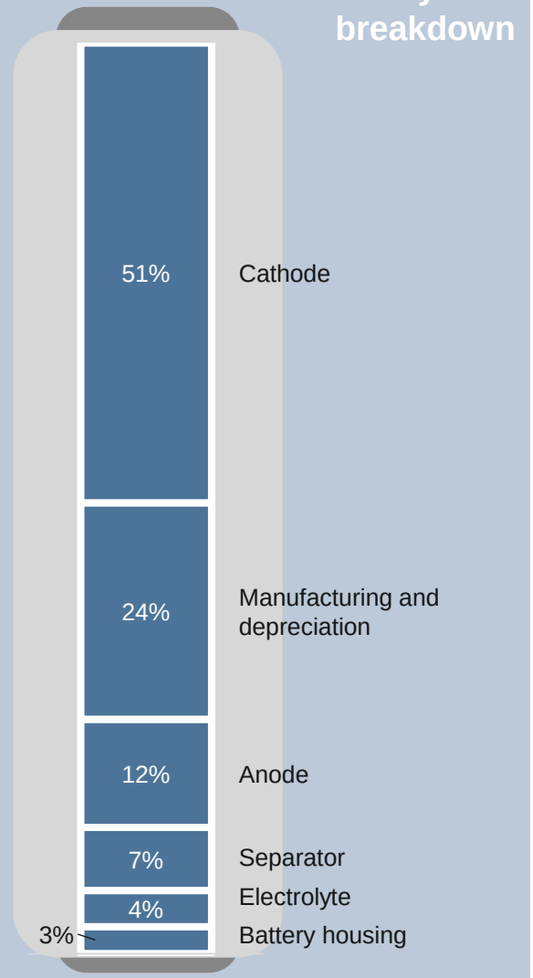
- The electric passenger car is predicted to be the main electric vehicle market for the coming 20 years considering battery demand
- China was the first market to adopt electric buses
  - Future near-term growth is expected to be driven by Europe
  - A local supply chain underpinned by European OEMs will be key
- Vans are Electric Light Commercial Vehicles is today a small market with few available models
  - Demand is also driven by e-commerce deliveries and Mobility as a Service. Ageing diesel vans are expected to be replaced
- The electrification of truck fleets is expected to happen rapidly when diesel petrol fueled vehicles are phased out by 2030
  - Fuel cell electric vehicle (FCEV) is the technology for long haul, despite issues with efficiency and cost of hydrogen as a fuel
- The market for electric two-wheelers* is saturated in China and growth is driven by Europe and India
  - They have relatively low upfront cost to consumers and innovative business models, e.g. battery swapping. They are key to reduce pollution where car is not the dominant transportation mode.
- Larger commercial electric and hybrid vessels developed exponentially since 2016 being less price sensitive and maritime battery prices halved
  - The electric boating market has tripled since covid-19 emerged increased interest and free time for leisure boating
- Electric vehicles in construction is still to be developed on a global scale. The main sectors are expected to be mini-excavators, excavators and loaders
- The timelines for electric air taxis are highly dependent on the final flight certification process in each geographical market.

*Batteries are typically under 4kWh compared with over 50kWh for a Battery Electric Vehicle car
Source: IDTechEx 2022,

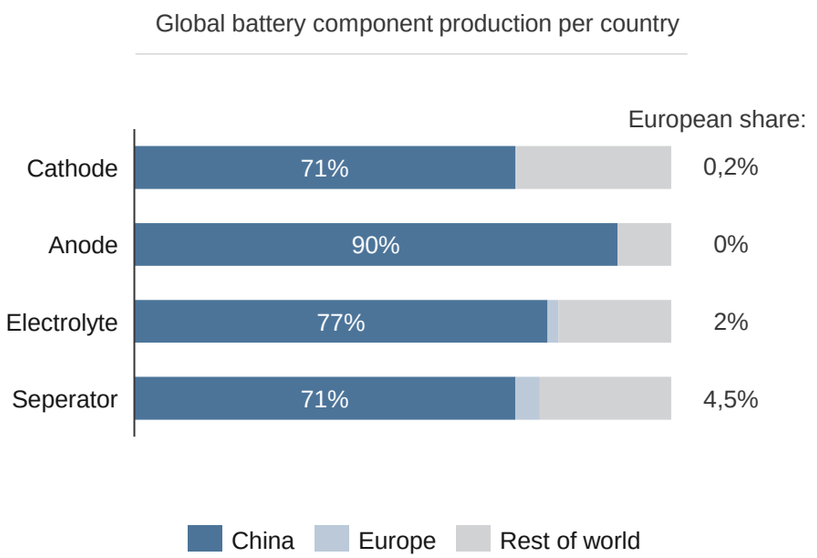
Global battery component production is led by China with petite European share

- Europe dependent on battery manufacturing equipment imports, now short on supply

Battery cost breakdown



Global battery component production



- The world relies heavily on China for lithium refining and cell manufacturing capacity
- The dominance of China is highest for components such as anodes and electrolytes

Supply of battery manufacturing equipment

- Investment in cell manufacturing technology is expected to rise rapidly in Europe to an annual market of EUR 5-7 billion in 2025
- Only a handful of companies that specialise in battery cell manufacturing equipment* are operating in Europe; the majority are in China, Japan, and South Korea
- Lead times are crucial and currently very long
  - Most European battery cell manufacturing suppliers are operating at more than 95% capacity, limiting the ability to increase output
- New European battery cell manufacturing companies are likely to face a bottleneck in equipment supply
- Chinese equipment enterprises gradually enter the global lithium battery production equipment supply chain system

Source: Bloomberg NEF, Mckinsey & Company ***** Equipment used for slurry mixing, electrode manufacturing, cell assembly, and cell finishing

The Nordics have several companies and innovations within active materials focusing on increasing sustainability throughout the battery life cycle

Some recent developments in the Nordics*

- There are several planned and active anode and cathode material activities in the Nordics, including:
  - In February 2022 plans were announced for a cathode material plant in Borlänge, Sweden, with expected production start in 2024
  - Plans announced in 2021 and 2022 for two cathode active material production plants in Finland
  - A pilot plant was constructed in Norway 2021 for production of silicon-containing anode materials for lithium-ion batteries
  - Inauguration took place in April 2022 for an Electric Vehicle Anode (EVA) qualification plant in Luleå
  - A pilot facility to produce bio-based carbon from lignin to carbon-based anode material began operations in Finland 2021

Source: Business Sweden interviews, Company webpages *For additional cases and details see the following chapter

Active materials | Recent development in the Nordic value chain (1/2)

Anode

CENATE

- Norwegian company founded in 2015 with approximately 10 employees developing and producing silicon-containing anode materials to be directly used in lithium-ion batteries.
- Collaborating with battery producers and building on Norway's long silicon industrial competence. A pilot plant was constructed 2021 outside Oslo, Norway.

TALGA

- Australian-owned mining company incorporated 2009 with approximately 40 employees.
- In April 2022 Talga inaugurated its Electric Vehicle Anode (EVA) qualification plant in Luleå. The EVA plant uses graphite concentrate to produce the Lithium-ion battery anode product.

SICONA

- Australian based battery technology company founded in 2019.
- Produces silicon-graphite composite anode and polymer binder materials.
- Proposed a joint venture with Leading Edge Materials in 2021 to operate out of Sweden with intention to produce advanced anode materials.

GRANODE

- Swedish company founded in 2021 developing silicon-graphene anode materials.
- In February 2022 2D fab AB formed a new company, Granode Materials AB, which plans to develop a new graphene-based anode material.

Anode

VIANODE

- Established by the Norwegian company Elkem in 2021 to develop and produce sustainable synthetic graphite anode materials.
- In 2022, Hydro and Altor Equity Partners announced the acquisition of 30% ownership each while Elkem retained the remaining 40%. The company announced the investment of a new factory with expected production end of 2023 with a first phase production estimate of 2,000 tonnes of anode graphite per year.
- In 2022, Vianode opened an R&D center for sustainable battery materials in Norway.

STORA ENSO

- The Finnish-Swedish forest company Stora Enso, founded in 1998 with approximately 22 000 employees is developing bio-based alternatives for the automotive industry.
- A pilot facility to produce bio-based carbon from lignin to carbon-based anode material began operations in 2021 at Sunila Mill in Finland. This material can be used to replace graphite in batteries.

Cathode

ALTRIS

- Swedish company founded in 2017 that has approximately 7 employees.
- In March 2022 Altris secured SEK 100 M in funding for production scale up of Fennac cathode material.
- Altris is expected to begin producing cathode material Fennac for sodium batteries in 2023.

Cathode

FREEPORT UMICORE

- Belgium-based Umicore completed the acquisition of the cobalt refining and cathode precursor activities in Kokkola, Finland during 2019.
- The Kokkola refinery is Europe's largest cobalt refinery. Umicore plans to serve the European operations of its battery cell and automotive customers with this plant.

BEIJING EASPRING MATERIAL TECHNOLOGY

- China-based company founded in 1998 announced in late 2021 plans to start a cathode active material production plant in Kotka, Finland in cooperation with The Finnish Minerals Group, which is scheduled to be completed and put into operation in 2024.
- Estimated production 50,000 tonnes of cathode active material.

NORTHVOLT

- Swedish developer, producer and recycler of lithium-on batteries. Registered in 2015 and has approximately 790 employees.
- In February 2022, the company announced plans for a 100 GWh/year cathode material plant in Borlänge, Sweden. The plant is expected to start production in 2024.

CNGR ADVANCED MATERIAL

- Joint venture between China-based CNGR and The Finnish Minerals Group in 2022, to start a cathode active material factory in Hamina.
- Estimated production 60,000 tonnes of precursor cathode active material.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Active materials | **Recent development in the Nordic value chain** (2/2)

Cathode

GRÄNGES

- Swedish aluminum technology company founded in 1898 that has approximately 449 employees.
- In January 2023, Gränges announced plans to invest 53 MEUR to double battery cathode foil production in Finspång, Sweden. The capacity change is expected to be operational 2025.

FREYR

- Norwegian company, founded in 2018, listed on the New York Stock Exchange
- In October 2022, Freyr signed a lease and services agreement with the Taiwan-based lithium-iron phosphate (LFP) cathode battery material manufacturer to produce active cathode material, with plans to establish a cathode plant in the Nordic region and planned production start 2024

Other

DONGJIN

- Dongjin Sweden AB, registered in 2020, is a subsidiary of Dongjin Semichem Co Ltd in South Korea.
- In an agreement with Northvolt to supply Carbon Nanotube Slurry (CNT) to be put on the electrodes of the battery cells. The facility started construction in Skellefteå, Sweden in 2021 and was planned to be completed in 2022.

Other

SENIOR MATERIALS

- Senior Material (Europe) AB registered 2020 in Eskilstuna Sweden with headquarter in Shenzhen, China.
- Announced in April 2021 a construction of a separator film factory in Eskilstuna, Sweden.
- In 2022 Senior Material Properties AB entered into a new land agreement with Eskilstuna municipality for 40,000 square meters to ensure continued expansion and possibility for another production facility.

BASF

- German multinational BASF founded in 1865 and has approximately 110,000 employees, chose Harjavalta Finland as their first location for battery materials production serving the European automotive industry.
- The plant construction began June 2020 adjacent to the nickel and cobalt refinery.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

The Nordics have strong cases of battery cell production in close collaboration with solid off takers spanning over multiple technologies and client segments

Some recent developments in the Nordics*

- The Nordics have several ongoing cell initiatives as well as ongoing cell production
- There is active cell production in Sweden by Northvolt who in early 2022 assembled its first battery cell in Skellefteå, Sweden
- Cell production initiatives and commenced construction in the Nordics include:
  - A large-scale production plant for battery cells in Mariestad, Sweden; large scale production is estimated to start 2030
  - A new factory in Gothenburg, Sweden with expected operation start in 2025
  - Construction commenced for two battery cell factories in Norway in Arendal and Mo i Rana
  - 2023 plans to start construction of a full-scale battery factory in Rogaland, Norway
  - Plans to open a gigafactory in the GigaVaasa area, Finland

Source: Business Sweden interviews, Company webpages * For additional cases and details see the following chapter

Cell production | Recent development in the Nordic value chain

NORTHVOLT

- Swedish developer, producer and recycler of lithium-ion batteries. Registered in 2015 and has approximately 790 employees. The company investors include German car manufacturer Volkswagen
- Early 2022 Northvolt assembled its first battery cell in Skellefteå, Sweden, making it the first European company to design and manufacture a battery in Europe.
- Another battery cell factory is planned in Borlänge in 2024.

NOVO ENERGY

- Joint venture between Volvo Cars and Northvolt established in June 2021.
- NOVO Energy is investing in a new battery factory in Gothenburg which is expected to be put into operation in 2025.
- In 2022 a joint R&D center was established in Gothenburg.

BEYONDER

- Norwegian company founded in 2016 that develops batteries from sawdust for industrial use. Approximately 56 employees.
- Planning for a full-scale battery factory in Rogaland with construction start in 2023. The company is already producing battery cells in-house in their prototype factory.

ENERPOLY

- Swedish battery cell producer registered in 2018 with approximately 8 employees.
- The company raised EUR 0.34 million from Swedish Energy Agency in 2021 to co-develop zinc-ion batteries with Polarium, Uppsala University and KTH Royal Institute of Technology in Stockholm. In December 2022 Enerpoly raised additionally EUR ~1.4 million. Pilots expected to start in 2023.

AB VOLVO

- Swedish automotive company founded in 1927 that has approximately 84,000 employees.
- In 2022 AB Volvo initiated the process to establish a large-scale production plant for battery cells in Mariestad, Sweden. Large scale production is estimated to start 2030.

FREYR

- Norwegian company ,founded in 2018, has initiated the production of 32 GWh gigabyte lithium-ion battery cells factory in Mo i Rana for stationary energy storage (ESS), mobility and marine applications. Ramp up of sample cell production planned for 2023. In December 2022, the company announced an established joint venture with the Japanese motor manufacturer Nidec Corporation
- Plan to open a Gigafactory in the GigaVaasa area, Finland. The planning reservation for a plot in the GigaVaasa was approved by authorities in November 2022.
- December 2021 Letter of Intent with Swedish company Logistea AB for site planning in Sweden for a cell factory in Svenljunga.

ALTRIS

- Swedish company founded in 2017 with approximately 7 employees.
- The company is collaborating with LiFeSiZE AB, to develop a sodium-ion battery cell. The cell matches the performance, life cycle, and energy density of a lithium-ion battery. The battery is based on Altris' Fennac cathode technology. Larger cell testing and production is planned with a goal of mass market introduction.

MORROW

- The Norwegian company Morrow Batteries, founded in 2014 with approximately 84 employees has initiated the build of a 43 GWh battery cell gigafactory for use in automotive applications and energy storage.
- In 2022 the state-owned Industrial Development Corporation of Norway went in as an investor in the construction of the factory that is planned to be in operation end of 2023.

ELINOR BATTERIES

- Norwegian cell initiative announced in January 2023 for establishment of a giga-factory in Trondheim, Norway.
- Construction to commence in 2024 with estimation of production start mid-2026.
- In January 2023 SINTEF and Elinor Batteries entered into a Memorandum of Understanding on strategic cooperation of the technological aspects of battery production.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Along with being in global lead within light and heavy vehicles, offroad and machinery as well as the maritime industry the Nordics are strong in packs and BMS*

Some recent developments in the Nordics**

- In addition to ongoing production plants there are recent factory initiatives within packs and battery management systems in the Nordics, including:
  - In 2022 a new factory focusing on battery systems for industrial vehicles was opened in Sweden
  - In 2023 production is expected to start in a new battery assembly plant for modular production in Sweden
  - Ongoing production of packs for maritime sector in Norway
  - Expansion of operations in a Finnish factory for battery packs; in 2022 the delivery of one million battery packs to automotive customers in less than three years was announced

***BMS = Battery Management Solutions**
Source: Business Sweden interviews, Company webpages ** For additional cases and details see the following chapter

Pack production | **Recent development in the Nordic value chain**

SCANIA

- Swedish trucks and bus manufacturer incorporated in 1962 and has approximately 48,300 employees.
- Has invested in a battery assembly plant for modular production in Södertälje. The 18,000 sqm facility began construction in 2021 with the goal of starting production in 2023.

CELLTECH

- Swedish Addtech-subsidiary, founded in 1982, produces primary alkaline battery packs to highly advanced lithium battery systems with cloud based online monitoring and management.
- Celltech invested in a new factory that was opened in October 2022, focusing on battery systems for industrial vehicles.

SIEMENS

- Global German-based industry group established in 1847.
- Opened an automated pack-production facility in Trondheim, Norway in 2019 to primarily supply the maritime cluster. In June 2021 SINTEF announced to build a new battery lab in immediate vicinity of the Siemens pack facility.

EPIROC

- Swedish manufacturer of mining and infrastructure equipment incorporated in 1942 and has approximately 14,600 employees.
- Epiroc has a fully electric underground vehicle fleet loaders, mining trucks, drilling rigs, production drilling and rock reinforcement.
- Epiroc manufactures its own packs for their vehicles. Epiroc has a strategic partnership with Northvolt, announced already 2019.

VALMET AUTOMOTIVE

- Finnish vehicle contract manufacturer founded in 1968 and has approximately 5 000 employees.
- In 2019 they expanded their operations with a new factory for battery packs in the municipality of Salo. In 2020 the company decided to double the capacity of the Salo-plant and expand the plant in Uusikaupunki for production of battery packs. In 2022 the company announced that they have delivered one million battery packs to automotive customers in less than three years.

ALELION

- Swedish producer of high voltage battery systems founded in 2006 and has approximately 39 employees.
- In September 2022 the company won a EUR 11.65 M order for production of a high voltage battery system.

CORVUS

- Energy storage provider for maritime industry registered in Norway 2019, approximately 6 employees.
- In December 2022 the company announced its partnership in two green shipping projects that were awarded EUR 10 million funding from the Norwegian Government support scheme “The Green Platform Initiative”.
- In February 2021, the company announced to start development and production of sustainable, large scale maritime-certified hydrogen fuel cell systems with Toyota as key partner and supplier.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Agenda

The fast electrification and battery manufacturing demands fast increase of new competences on all levels – as in Europe, so in the Nordics

DRIVERS

A new industry demands a new competence area…

- Immense need for competence within in all areas along the value chain
- Strong Asian experience from battery industry

…even though competence areas build upon strong European traditions

- Electrification and batteries build upon engineering skills found within Europe

Initiatives are available

- Competence need is a well-defined European prioritisation

NEEDS

Talent attraction

- Multi-cultural societies within the Nordics are needed to attract the top international talents across the manufacturing and recycling process
- Fast and open permit process, housing and social support for talents and their families
- Cross-border collaborations across schools and universities for vocational training as well as university programs
- Join forces to visualise the attractiveness of living and working in the Nordics across employment types

National education

- Nurture world-class research programs, institutions and individuals to build flagships in global markets, strengthening attraction level
- Invest in both battery focused education and basic topics, focusing on crossing silos and working in a creative environment fostering innovation
- Impact education from upper secondary schools to fit for the future

Re- and up-skill

- Strengthen and visualise vocational training programs for employees, working force as well as for domestic and foreign investors – key programs to use for broadening the labor basis
- Foster partnerships for joining forces

Visualise Nordic capabilities for foreign investors

- For investors interested to invest in the Nordics current education and experience levels on all degree levels should be exemplified
- Visualise the interplay between Nordic salary levels and the efficient, independent and responsible way of working

Structural investments and visualisation of current initiatives

- Evaluate and set structural investments to secure future labor force
- Communicate and strengthen current initiatives for competence
- Increase the numbers of and volume of talent programs

NORDIC INDUSTRY QUOTES

> *We need to be the best in the world at competence in order to keep our high-quality level of deliveries*
>
> [Swedish actor]

> *Today's lack of competence has a risk of becoming a limiting factor of growth for all of Europe*
>
> [Norwegian actor]

> *How to solve it? We need to showcase our high-profile companies setting global frameworks for sustainability and collaboration in a triple helix modus*
>
> [Swedish actor]

> *We need a multi-cultural country embracing talents coming. As a society we must see the need for and value of talents coming here!*
>
> [Finnish actor]

Source: Business Sweden interviews and analysis

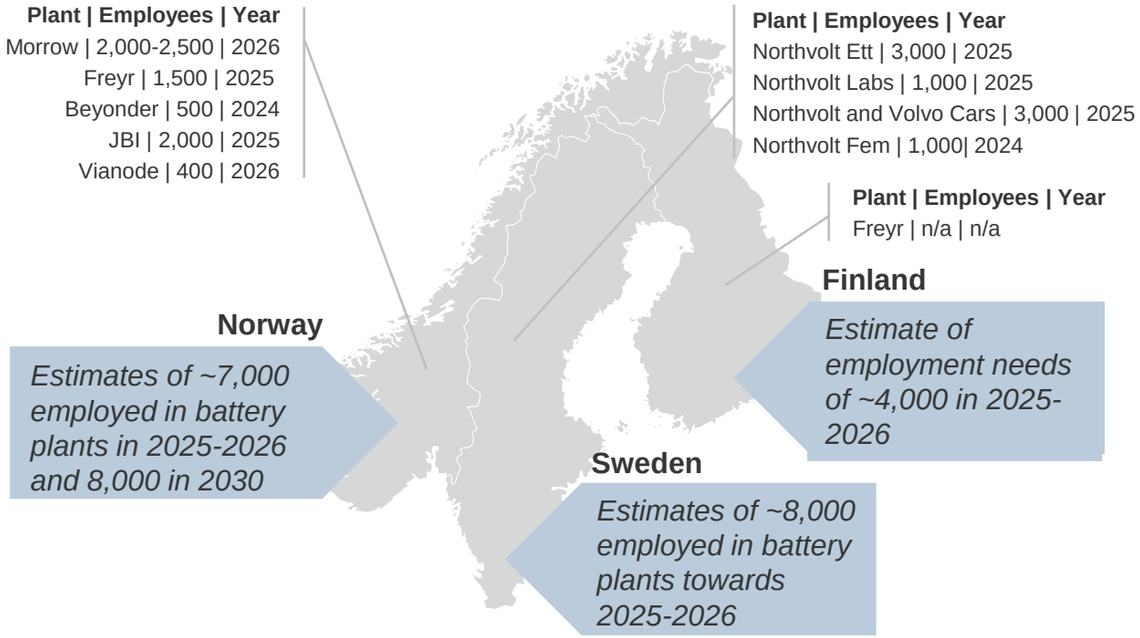
There is a disruptive need for competence across manufacturing to academia

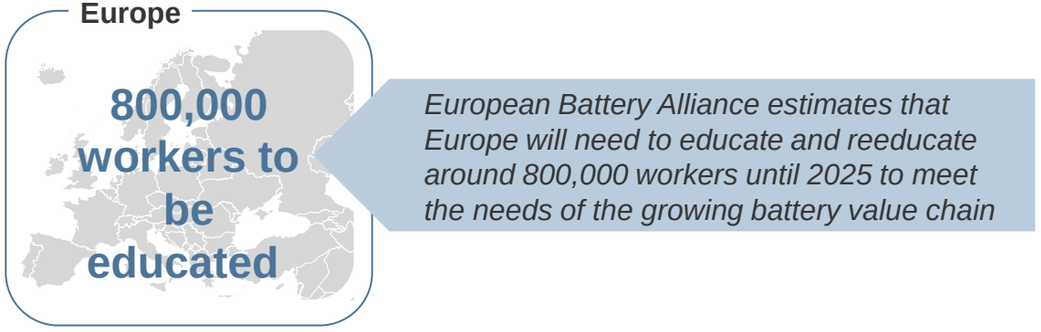
- The Nordics has a strong foundation, but a severe need for more skilled employees

The battery industry needs competence and skilled labor

- There is a growing shortage of experts throughout the battery value chain and a need to educate the workforce and attract foreign specialists
- The workforce needed is not limited to the battery production plants. Studies show that the need for workforce in the upstream value chain is 4–6 times higher than for the battery production itself
- The greatest quantitative need is for production and process workers
  - In the early phase of the factory establishment, the core team is typically built around specialists (MSc/PhDs with industrial experience from battery production) brought in from abroad, mostly from Asia*, Europe** and the US

Estimates of employment in battery production



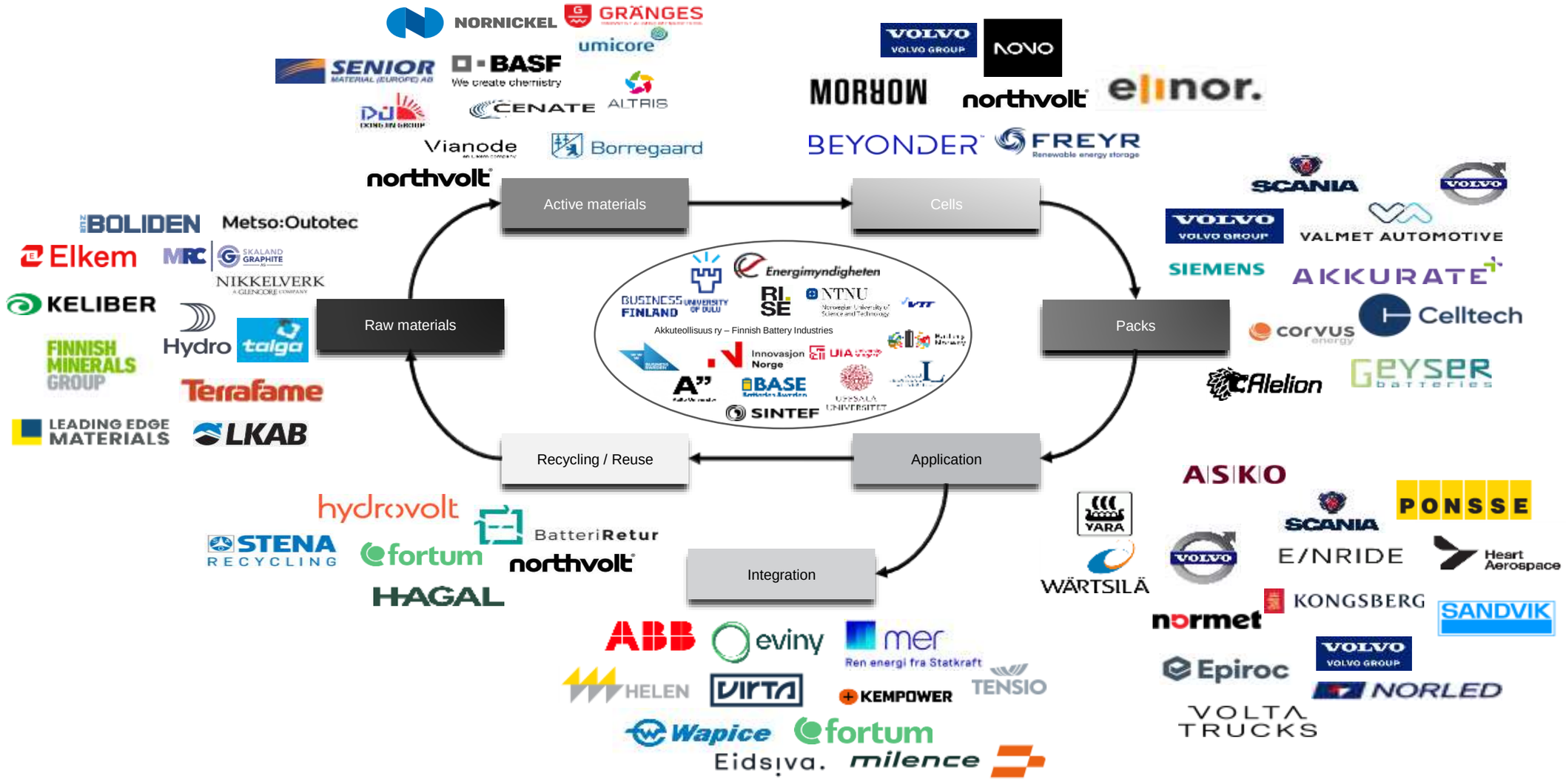


Examples of job types		Example competences
• Material handlers • Operators • Production logisticians • Technicians • Team leaders • Line managers • Project managers	• Product engineers • Quality engineers • Maintenance engineers • Health, safety and environment specialist • Electrical engineers • Software engineers • Research specialists	• Material technology • Process technology • Fluids • Electrochemistry • Design and manufacturing • Application and integration • And more…

Source: Norsk Industri, Northvolt, Swedish Energy Agency, Finland's Ministry of Economic Affairs and Employment, Engineers Finland ***** South Korea, China and Japan, Germany, France, Belgium and Poland, Engineers Finland/Gaia Consulting
Source: Eurostat 2021 ***** Persons with tertiary education and/or employed in science and technology **ISCED-levels 3-8 covers from Upper secondary education up to Doctorate or equivalent

The Nordics have key actors and competence along the full battery value chain

- The value chain builds upon strongholds of the Nordic industrial traditions



The Nordics have several cross-industry initiatives to attract and educate talent
- The demand and will for further collaboration is strong

Some initiatives for attracting talent

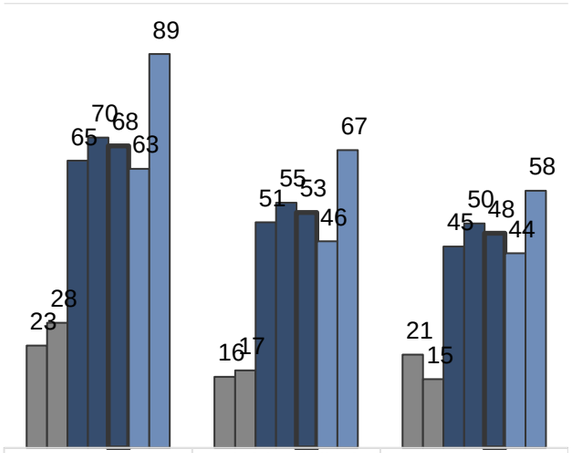
- **BattKOMP (Norway) -** The spring of 2021, the interest organisation Norwegian Industry started to map and analyse the need to develop more talent for the battery industry, along with the employees' organisation and Process21
- **University of Stavanger (Norway)**, in cooperation with Beyonder, have established new Bachelor's program: engineer in battery and energy technology
- **Agder Battery Project (Norway),** UiA has initiated an interdisciplinary education and research project
- **NTNU** in Trondheim **(Norway)** working on Master's programs to retrain engineers (from i.e. oil sector) within battery
- **Talent Boost program (Finland)** launched 2017, focused on attracting and recruitment of international specialists and promoting Finland as an attractive location to work
- **Lahti GEM (Finland)** is a cooperation platform for companies, research/education organisations and cities to develop and commercialise mobility technologies, including attracting and educating talent for the industry

- **ALBATTS (Sweden) -** The Alliance for Batteries Technology, Training and Skills is led by Skellefteå municipality
- **Arctic Centre of Energy (Sweden) -** a strategic collaboration for research and education within batteries between Skellefteå municipality, Northvolt, RISE and Luleå University of Technology
- **Project T25 (Sweden)** with the goal to attract 25 000 talents to the north of Sweden within five years. Collaboration between a.o. H2 Green Steel, Northvolt, Boliden, LKAB, SSAB, Skellefteå Kraft, Mobilaris and Luleå University of Technology
- **Government task the *Public Employment Service* (Sweden)** for more efficient competence supply for industrial establishments (Dec. 2021)
- **Chalmers University of Technology, Lund University and Uppsala University (Sweden)** will jointly contribute to new knowledge, coordination and research in battery technology and power electronics
- **University of Oulu (Finland)** is coordinating the BattValue project. The project is aimed towards professionals within mining, metal refining, processing and battery end-user sectors between 2022-2024.
- **Centria University of Applied Sciences (Finland)** has begun engineering retraining for battery technology to grow a competent workforce for battery investments particularly in the OstroBothnia area

*Foreign and domestic investments. Continuously updated.
Source: Business Sweden interviews and analysis, Business Sweden report "the Nordic battery value chain" January 2021, organisation websites

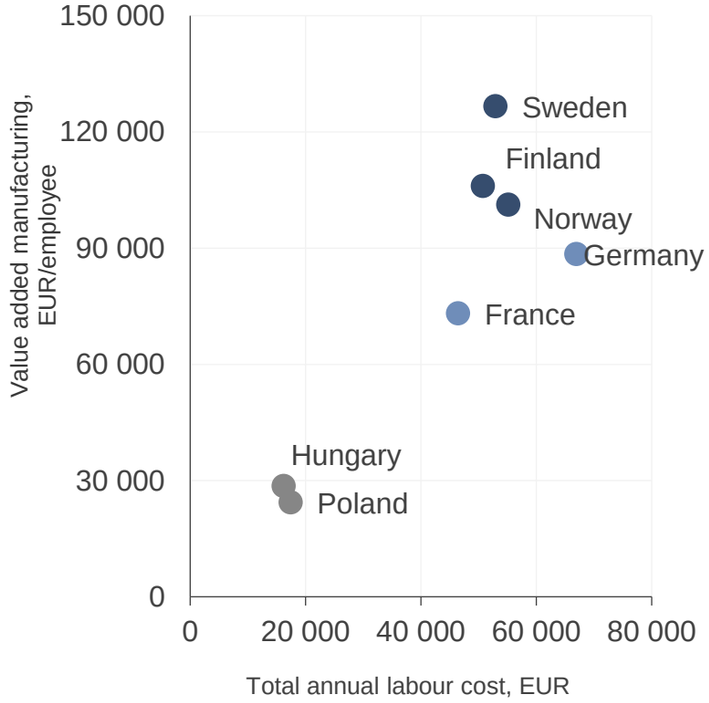
The Nordics provide the most affordable energy in combination with the highest value add per employee in manufacturing

Total annual labor cost (salary + social contribution), KEUR



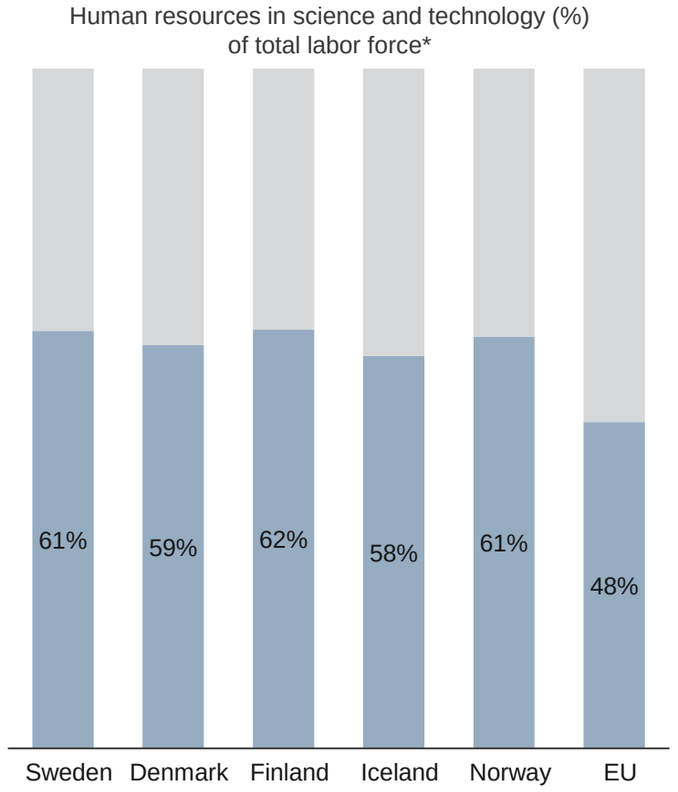
	Senior chemical engineer	Highly skilled production operative	Quality control specialist
Hungary	23	16	21
Poland	28	17	15
Finland	65	51	45
Norway	70	55	50
Sweden	68	53	48
France	63	46	44
Germany	89	67	58

Cost and productivity comparison for skilled production operative



- The Nordics are leading the Value add per employee to justify cost of labor

Tertiary education and/or employed in science and technology



- Central Europe and The Nordics have the highest cost of labor

Source: European Environment Agency 2019, Eurostat, Nordpool electricity exchange 2020, World Bank Doing Business 2020, Eurostat 2021

Agenda

As a new industry to Europe new capabilities and partnerships are decisive

- As value chain roles are shifting the importance of strategic partnerships increase

DRIVERS	NEEDS	
New industry require new capabilities - E.g. new management skills	**Gain industry intelligence (know-how)**	• High value of joint venture and joint projects to gain joint knowledge transfer and build-up of skills • Need for quality networking and meetings to meet industry players to learn from and be inspired by • Make use of existing industry knowledge from other industries
The new industry has enabled new roles within the value chain - New industry creating new roles and partnerships for MNCs and start-ups	**Partners for integrated value chains**	• It is critical to set up strategic partnerships as market actors have taken strategic decision for new roles within the value chain to grasp the added value • Partnerships for R&D projects, joint projects, cross border funding and to make reality of circular business models
	Trustable business partners	• The Nordic industry further need joint business focused actions on global markets • Investments made in the Nordics need to be supported to stay in the region and be supported to grow • Tangible support to keep and enable industry growth
Fast market movements and new industry players	**Credibility and visibility**	• It is decisive to have global, European and Nordic partnerships with trusted partners, e.g for IPCEI and Horizon as well as with the European Battery Alliance • Credible visibility to attract serious and valuable business partners is key in an industry with such fast movement

NORDIC INDUSTRY QUOTES

> *"Being a part of a consortium is useful and important – it provides structure and credibility"*
>
> [Norwegian actor]

> *"Our strategic collaborations with key clients and academia are set to have win-win results, but also increase the credibility of the individual strengths"*
>
> [Swedish actor]

> *"We set out partnerships along our vertical integration of the value chain to share risks but also increase innovation and investments for sustainability"*
>
> [Finnish actor]

Source: Business Sweden interviews and analysis

The introduction of a battery industry has created fundamental movements within traditional value chains generating a decisive need for strategic alliances

- Active materials for batteries including separators and electrolysis is new to Europe in the extent of the demand we see today
- The supply is strategically important to realise investments in the following steps of the value chain

Strategic partnerships have become significant important to try to secure supply

- The immense wide gap between demand and supply for raw materials have spurred strategic investments in mining and refining across the globe

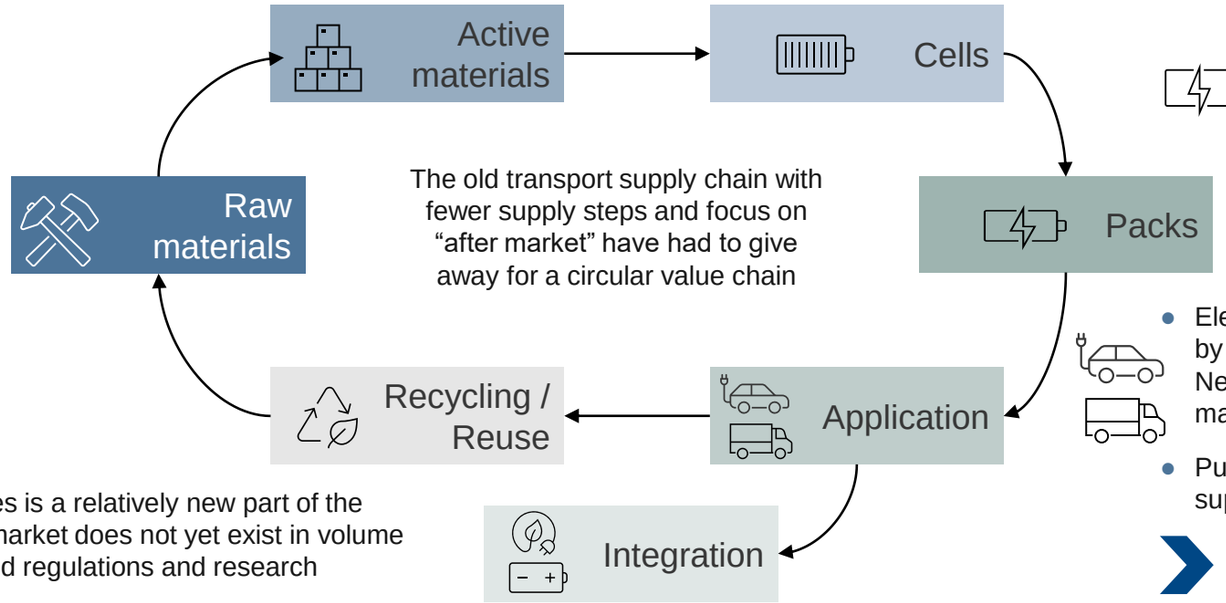
Partnerships for sourcing and innovations to close the gap can be a matter of company survival, but also about sustainability

- Recycling of EV batteries is a relatively new part of the value chain where the market does not yet exist in volume of scale. Reuse still need regulations and research
- To make better use of raw materials and increase efficiency along the value chain, innovations are extremely important

Partnerships are decisive to affect and grasp regulations, build up business and to stay ahead of future battery composition

- Battery component is a key strategic part of the application and in the energy system for considering value, delivery times and security, innovations and demands on sustainability. The manufacturing of battery cells is depended on equipment, machinery and competence
- The value chain step is NEW to Europe

Foremost OEMs have reconsidered their value chain engagements to capture the value potential of battery and battery cell manufacturing



The old transport supply chain with fewer supply steps and focus on “after market” have had to give away for a circular value chain

- Ownership of big data has increased in value for future management systems of vehicle or energy system
- Battery management systems and risk mitigation of safety has impact on brand value

Decisive strategic need for battery pack in house or trusted partners

- Electric vehicles have been developed and manufactured by both traditional market players as well newcomers. Newcomers have fast taken a strong position on main markets
- Public framework of e.g. subsidies and tax credits have supported growth of actors taking a first mover position

Decisive strategic need for battery pack in house or trusted partners

- The imperative need for charging stations and payment models has created strategic alliances among non-traditional partners
- The across-value-chain demand for renewable energy has set partnerships for grid capacity, smart grids, storage and market dynamics

Decisive strategic need for battery pack in house or trusted partners

The Nordic Battery Collaboration aims to enable the opportunities of a new basis industry

Nordic Trade and Promotion Collaboration

- In 2021, the CEOs of Innovation Norway, Business Sweden and Business Finland initiated collaboration for trade and investment promotion when
  - the value of acting together is greater than working alone

Why Nordic Battery Collaboration

- Nordic industry players have during the last years intensified their investments in the battery value chain. The industry is new, although based on industries of traditional Nordic strengths
  - The battery industry is stated to have the potential to become a new basis industry in Sweden, Finland and Norway
- In 2021, the report *The Nordic Battery Value Chain,* from the Swedish Energy Agency and Business Sweden, concluded:
  - Complementary strengths within the Nordic battery value chain
  - Strong momentum for industry potential
  - Shared interest in joint trade and investment promotion
  - Need for coordinated actions
- Sweden, Finland, and Norway have all published national battery strategies and in May 2022 the three governments entered bilateral agreements for, among others, the battery value chain.

The vision for the Nordic Battery Collaboration

- The Nordic Battery Collaboration was officially launched in August 2021
- The joint vision
  - The Nordic region aims to be home to Europe’s leading sustainable, competitive, and innovative battery ecosystem by 2026

Source: Nordic Battery Collaboration, “The Nordic Battery Value Chain” by Swedish Energy Agency and Business Sweden, Bloomberg NEF ranking 2022

The Nordic Battery Collaboration acts with the Nordic ecosystem, the European Battery Alliance and our global teams

Nordic Battery Collaboration

- In partnership with the European Battery Alliance, InnoEnergy and with the support of Nordic Innovation
- More than **1020 registrations** from **50 countries** to the *Nordic Battery Thursdays* community
- Raising **key topics** for the Nordic industry to support market development
  - Sustainability and innovations driven by Nordic industry
  - Nordic electric and digital Innovation + global competence living in the Nordics
  - Sustainability through Circularity – Recycling
  - The Nordics in a European policy context
  - Value of Critical Materials and Market Frameworks
  - Nordic academia collaboration and Battery 2030+ at Nordbatt (SE)

- Over **50 Nordic actors** as companies, academia and regions introduced through Nordic Battery Thursdays
- **Multiple Nordic regions** activated

Nordic Global Events

- **Joint presence** at global key conferences
- **Nordic panel on main stage** about our value proposition and collaboration

- Joint presence at EVS35 (NO) and the Battery Show (DE)
- “Nordic Battery Investment Forum” at the Chinese International Battery Industry Cooperation Summit
- Kokkola Material Week’s GeoKokkola session (FI)

Agenda

As global competition fosters initiatives and support for new industries the industry urge for a leveled playing field and focus on the European needs

DRIVERS

Regional public frameworks to boost electrification have an impact across the globe

- Public profitable framework for domestic or regional business unlevel the global playing field

Regulations hindering scale if not coherent

- The European new industry of batteries need regulations, which must foster long-term business, sustainability and market competitiveness

Regulations impact disruptive business models

- New business models call for regulatory frameworks

NEEDS

Frameworks levelling investments on global markets

- European domestic investors need prerequisites to succeed
  - Current investments are of high capital volume, high risk in a fierce competition and strategic important to Europe
- Europe needs to be attractive for foreign direct investments
  - As Europe is building up its battery industry critical for competitiveness within the electrification global investments are decisively needed
  - Asian investors are the main group for foreign direct investments throughout the value chain
- Government or EU support to facilitate to industry success is decisive
  - Asian players dominate with price, market shares and supply chain security. Europe with sustainability, current investments and market growth. The US aim for a frog leap with the Inflation Reduction Act

New regulations enabling competitiveness

- Regulations need to be made fast and enable companies to be competitive when being compliant
  - With the new EU Battery regulation, the European Union is aiming for both sustainability and to regulate new industries, including recycling
- Regulations need to define materials (waste or input material), ease administration for cross-border transportations (hazardous or not), include mechanisms for governance and enable competitive time plans

Regulations enabling cross market trade

- New business models for battery ownership, charging and re-use as examples define new needs to reach smooth cross-border trade
  - improved customs regulations for battery as a service, as an example
  - regulations for cross-border charging for payments and services
  - Aligned regulations for re-use to prevent dangerous handling and accidents harming individuals and future business

NORDIC INDUSTRY QUOTES

> *Key for sustainability is to form circularity in the business*
>
> [Norwegian actor]

> *We have a new business model moving from selling products to services. We thereby are no longer a capex investments, but an opex cost. The traditional purchasing model of the customer can't handle this. We need new frameworks from our public and private partners to fit in.*
>
> [Swedish actor]

> *The Inflation Reduction Act is highly positive for our customers and will grow our global markets.*
>
> [Finnish actor]

> *We need Europe to act for a global levelled playing field for battery production. Europe can compete, but need a chance to finish building what we have started*
>
> [Swedish actor]

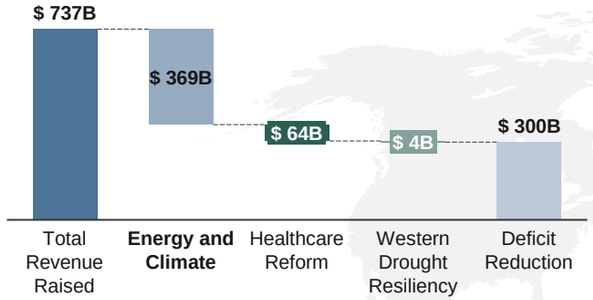
> *We must improve prerequisites for recycling across border to enable this business to grow*
>
> [Norwegian actor]

Source: Business Sweden interviews and analysis

The battery industry is a strategic industry across China, Europe and the US
- Strategic support have been implemented in each region during the last decade

North America

The US Inflation Reduction Act (IRA) signed in August 2022



- In November 2021 the Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Bill, was signed into law by US President Joe Biden. It included funding transportation and road, broadband access, clean water and electric grid renewal
  - It is the largest single investment in climate and energy in American history
- In August 2022, a substantial investment into the US electrification expected to increase EV demand was made public
  - Energy and climate investments for extensive consumer and corporate tax credits, advanced energy R&D loans and grants, and energy efficiency and conservation efforts
- Battery value chain manufacturer benefits from the IRA:
  - Battery minerals – 10% production cost subsidy
  - Electrode materials – 10% production cost subsidy
  - Battery cells – USD 35 / kWh credit
  - Battery modules – USD 10 / kWh credit

Europe

- For Europe, the establishment of a complete domestic battery value chain is imperative for a clean energy transition and a competitive industry.
  - The European Commission launched **the European Battery Alliance** in October 2017 to address this industrial challenge
- **EU Battery regulation** from 9th December 2022, focus on sustainable and circular batteries
  - The regulation sets demand and thereby enable sustainable business within Europe
  - The European Parliament and the Council must formally adopt the new Regulation before it can enter into force
- In September 2022 EU announced its **Critical Raw Materials Act** for the urgency and critical need to secure raw material

  "*Without secure and sustainable access to the necessary raw materials, our ambition to become the first climate neutral continent is at risk*" *President European Commission*
  - Focus is in strategic applications, creation of a European network of raw materials agencies, building a resilient supply chain; facilitating the targeted raw materials projects in the EU and ensure strong and sustainable level playing field, potentially through certification schemes
- IPCEI | **Important projects of common European interest** (IPCEI) allow countries to give increased financial aid to specific key projects or to build a European value chain
  - IPCEI has four Batteries Work Streams and four IPCEI European Battery Innovation (EuBatIn) Work Streams

China

The Belt and Road initiative. China in red. Members of the Asian Infrastructure Investment Bank in orange

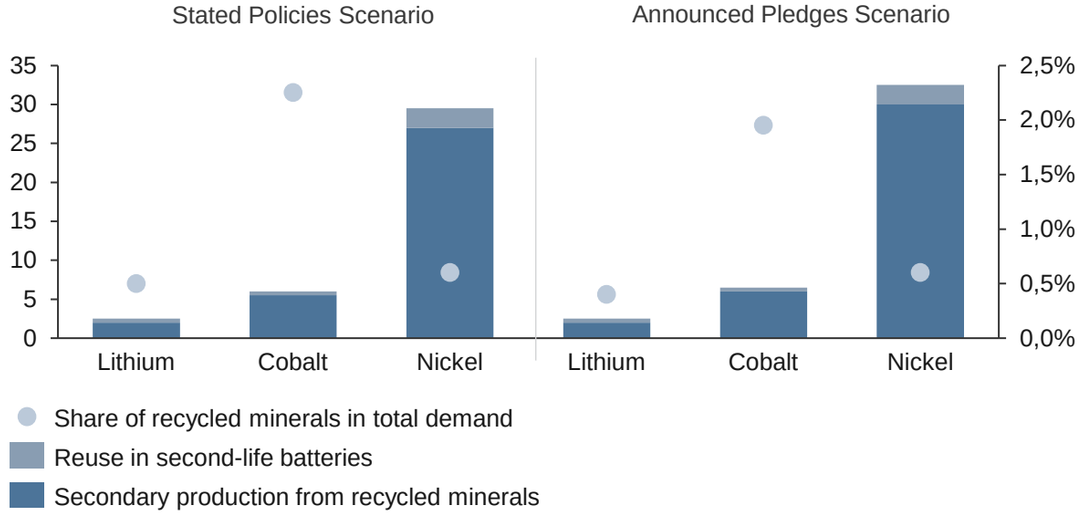
- China is dominating the global battery value chain
  - CATL has given China a commanding lead securing global key clients such as G.M., Volkswagen, BMW, and Tesla as well as securing vast raw material supplies* - like cobalt in the Democratic Republic of Congo
- In 2015 the Chinese government unveiled the Made in China 2025 plan to achieving independence in major industries of the future, including electric cars, in a decade
- Some of the actions for the industry by the Chinese Government
  - Requirements for crucial technology transfer to locals from foreign automakers wanting to sell electric cars in China
  - Subsidies given to electric car buyers only if the battery was made by a Chinese company
- In addition: China's Belt and Road Initiative is a strategy from 2012 to improve regional integration, trade and economic growth
  - China has engaged about 149 countries focusing on infrastructure projects include ports, railways, highways, power stations, aviation and telecommunications

***[In 2021, China produced almost 80% of lithium-ion batteries, whilst also controlling just over 60% of global lithium refining for the batteries and processing 100% of natural graphite
Source: The Guardian, Business Sweden Interviews; Reuters, Infrastrukturatlas 2020 / MERICS

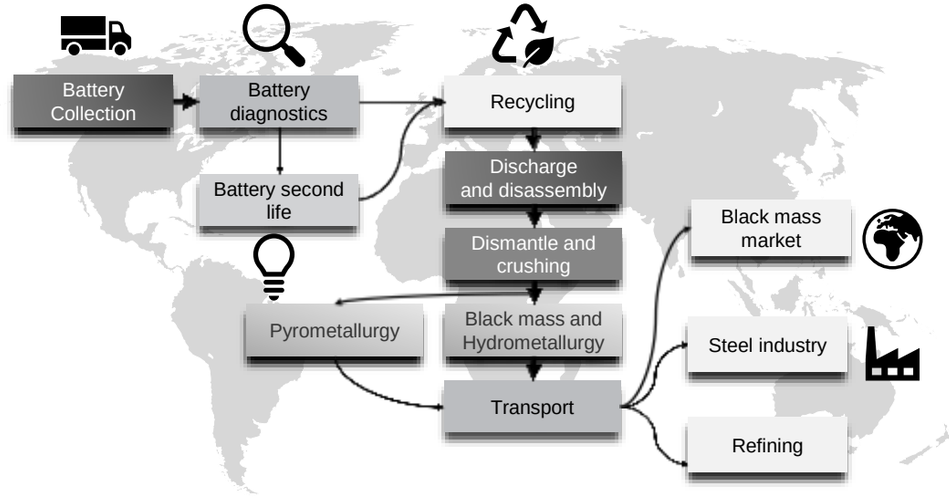
Enabling trade regulations is crucial for recycling of scale

– Regulations and governance are key for customs, transport and producer responsibility

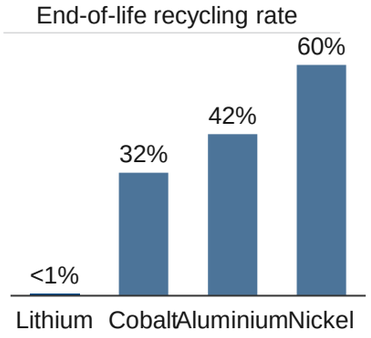
Estimate on secondary battery production from recycling and re-use
in 2030 in kt and percentage



Simplified global recycling value chain



Recycling rates



Global battery passport

- On 18th January 2023, at the Annual Meeting of the World Economic Forum in Davos, the Global Battery Alliance officially launched the first battery passport proof-of-concept pilots
- Since 2019 a three-year pre-competitive multi-stakeholder collaboration has taken place leading to:
  - The Greenhouse Gas rulebook
  - The Child Labour and Human Rights indices.

Key necessities for recycling and re-use

New market for recycling	Critical mass for recycling estimated to be met 2027-2028. The technology is being developed and the heterogeneity of battery is a challenge for performant collection infrastructure. Transport regulations and safety issues need to be made efficient
Lack unified regulation for recycling	Market regulations are to be implemented. The new EU battery regulation needs to set prerequisites and governance, for example in extended producer responsibility. Efficiency in administration is key.
New market for reuse	The reuse market is still very new and there is a lack of needed regulations to ensure safety usage. Regulations for cross-border customs needed to enable trade

Note: The EU battery regulation was signed December 9th, when almost all interviews had been conducted so no part of the interviews
Source: New EU regulatory framework for batteries (europa.eu), IEA, Veolia: “Creating a sage and circular Li-Ion battery value chain, “EY: “10 ways to help build a thriving battery recycling industry in Europe”, Business Sweden interviews and analysis

New business models challenge traditional manners of doing business

- Innovations challenge purchasing and sales processes, trade and consumer regulations

Purchasing processes

- Business models like ***Transport as a Service*** do not always fit in to the purchasing system of the business-to-business customers complicate the process for request for proposals
  - Implicating a stronger need for strategic dialogues above the powerline
- Changing the way of working inhouse at and with the client demands close and trusting partnerships

Trade regulations

- Business models like. ***Battery as a Service*** do not always fit in with the toll and trade regulation categories
  - Implicating an emphasised need for improved global cross-border customs and trade regulations to enable new circular business models

Consumer regulations

- New Business models for ***Mobility as a Service*** *or* ***Sharing economy*** do not always fit with current regulations for consumer purchasing contracts, for example, demands on how to sell a car, or the local or regional regulations for test driving
- Key regulations for insurance, trial periods, closing the deal, demand for physical appearance for purchase and so on differ across markets increasing cost for business of scale

Source: Business Sweden Interviews, Business Sweden analysis

Nordic players invested in recycling facilities early on both at home and in Europe - Initiative across the recycling process as well as for re-use are accelerating

Some recent developments in the Nordics*

- The Nordics have invested early in recycling with ongoing operations across Sweden, Norway, and Finland, including:
  - Operation of recycling plant in Fredrikstad in Norway which began in 2022
  - Announced plans to start commercial operation in new battery material recycling plant in Harjavalta, Finland during Q2 2023
  - Expected start of operations in new giga-scale recycling plant in Sweden in 2023, the plant is expected to recycle 125,000 tonnes of batteries per year
  - Investments of approximately EUR 22.4M in advanced recycling facility in Halmstad, Sweden
- Re-use initiatives are ongoing including converting usable second life EV batteries into battery storage systems

Source: Business Sweden interviews, Company webpages * For additional cases and details see the following chapter

Recycling and re-use | Recent developments in the Nordic value chain

Recycling

FORTUM

- Finnish majority state-owned energy company founded in 1998 with approximately 19,900 employees.
- Has a separate business area providing recycling of cobalt, lithium, manganese and nickel. Fortum is striving to recycle over 80% of today's batteries.
- In December 2022 it was announced that the construction of Fortum's new battery material recycling plant in Harjavalta, Finland is on track to start commercial operations Q2 2023.

HYDROVOLT

- Hydro and Northvolt's joint company Hydrovolt, which was launched in 2020, started operation of the recycling plant in Fredrikstad in May 2022.
- The facility has capacity to recycle 12,000 tonnes of battery packs per year. Hydrovolt aims for 150,000 recycled electric car batteries per year by 2025, and 500,000 batteries by 2030.

HAGAL

- Norwegian battery reuse company founded in 2018 with approximately 27 employees. The company is designing and manufacturing technology to maximise the lifespan of new and used batteries.
- In December 2022 the company was acquired by the US- and Amsterdam based software company Entheos Network.

Recycling

NORTHVOLT-REVOLT

- Swedish developer, producer and recycler of lithium-ion batteries. Registered in 2015 and has approximately 790 employees.
- A giga-scale recycling plant, Revolt Ett, is being built in 2022 with expected operation in 2023. The plant is expected to recycle 125,000 tonnes of batteries per year with aims to become the largest battery recycling plant in Europe capable of recycling lithium, nickel, manganese, cobalt and other metals as well as plastic.

BOLIDEN

- Swedish company within prospecting, extraction and refining, recycling of base metals, founded 1931 and has approximately 6,000 employees globally.
- Boliden has the Nordic region's only secondary smelter for lead and one of Europe's largest recyclers of used lead batteries in Landskrona. According to the company lead is recovered from four million car batteries every year.

STENA RECYCLING

- Swedish recycling company registered 1970 and has approximately 1,491 employees in Sweden.
- In July 2021, Stena Recycling announced an investment of approximately EUR 22.4 M in what will become Sweden's and one of Europe's most advanced facilities for recycling batteries. The facility will be near the Stena Nordic Recycling Center in Halmstad.

Re-use

NILAR INTERNATIONAL

- Swedish company specialised in battery production founded in 2000 that has approximately 185 employees.
- Nilar is claimed to be the first in the world with a technology that allows used batteries to be restored and regain the same storage capabilities as a new battery. A first partial delivery of these batteries is to take place in the beginning of November 2022.

GRAPHMATECH, GRAPHNEA and NORTHVOLT

- Swedish company Graphmatech, Spanish company Graphenea, and Swedish Northvolt have succeeded in up-cycling end-of-life EV batteries into graphene oxide at industrial pilot scale. This process uses the material left after Northvolt has extracted valuable metals and minerals.

EVYON

- Norwegian start-up founded in 2020 that has approximately 24 employees. The company converts usable second life EV batteries into modular plug-and-play battery storage systems.
- In November 2022, the company delivered a repurposed battery energy storage system to the Norwegian real estate company Møller Eiendom. The system will be installed and integrated with a larger solar PV installation.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

Agenda

To enter the disruptive battery industry speed is decisive

- The industry need infrastructure for fast establishments enabled growth of demand

DRIVERS

Facilitate operations

- Charging infrastructure decisive to enable electrification usability

High pace demanded for industry establishments

- Sense of urgency with an industry being build now; no time to wait

New industry needs to mature its error margin

- New industries commonly experience more errors in deliveries in its immature state

NEEDS

Investments in charging infrastructure

- Public, private and co-investments in charging infrastructure is decisive to make the electrification operational. It affects the public and private demand as well as eagerness to invest
- Charging must be made easy concerning payments, time, availability, frequency and open to different technologies

Industry Parks

- Ease the establishment process and cut time plan to initiate operations
  - Relevant on sites where it is possible to plug into existing infrastructure of cooling water, electricity, water treatment plants or electricity
- Greenfield investments are not always an attractive option from a legal point of view where permit processes may have a negative impact on the time plan
- Business clusters or communities are often positive to foster culture and ease understanding of the business prerequisites

Power and construction

- Decisive to be close to power supply: stable, cheap and green. Influence establishment selection to a very high extent
- Efficient construction environment at competitive prices is key to follow set time plan for establishments

Municipal support for large scale projects

- Local knowledge as well as local and public support are critical to succeed with a domestic or foreign investment
- Support for incentives, subsidies and grants is highly valuable
- Collaboration to support needs of labor force is important

Infrastructure for pilots and testing

- Opportunities for testing facilities are highly appreciated. It is costly to build up own infrastructure
- Infrastructure facilitating collaborations with academia and other companies are preferable. Larger players often invest in own strategic partnership but not all players can afford it

NORDIC INDUSTRY QUOTES

"Need for industry parks for pilot factories to tap into already existing steam and cooling water systems and share common water treatment plats"

[Swedish actor]

"Charging infrastructure is an enabler for further growth. It is decisive. Just as reasonable payment methods and number of Apps you need to travel through Europe"

[Swedish actor]

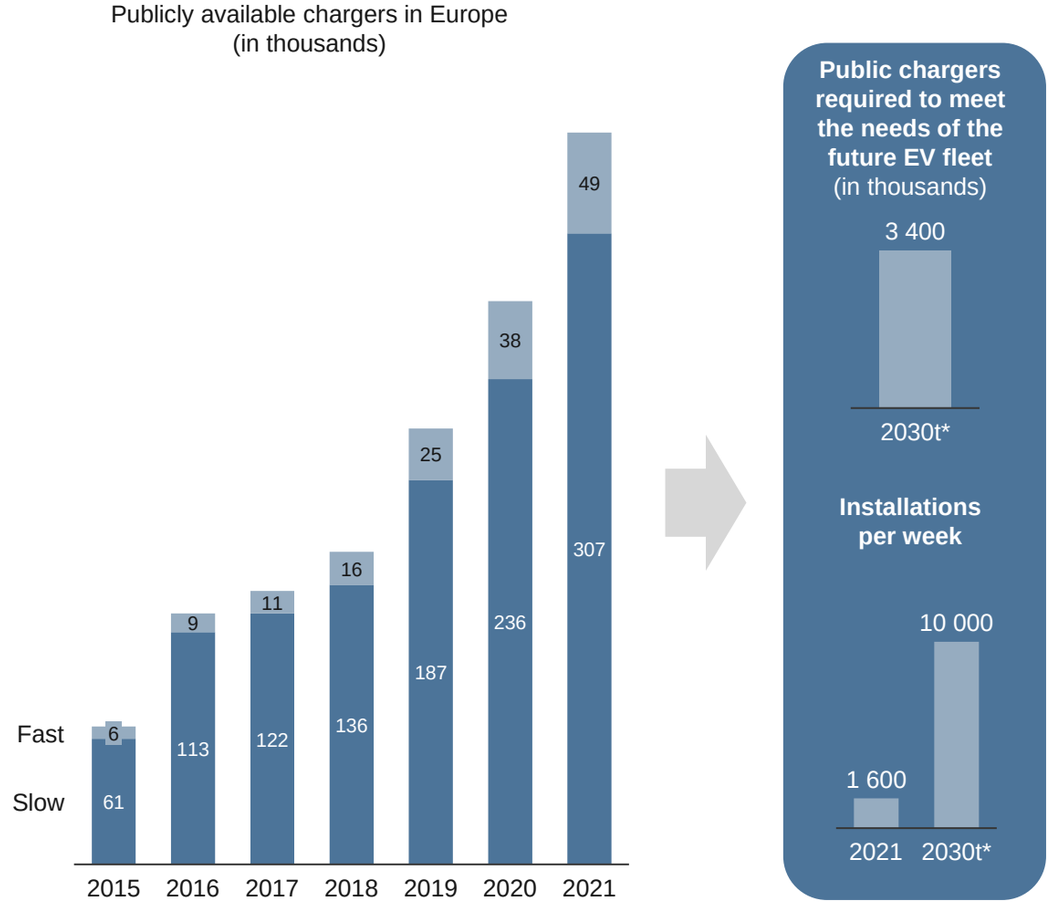
"The diesel market has been developed over 100 years. Now we need to build up the EV market in Europe during about 10 years, we need to be agile."

[Finnish actor]

Source: Business Sweden interviews and analysis

European charging infrastructure of about 350,000 public charger stations need to tenfold until 2030 to meet demand

Public charging infrastructure needs to expand quickly to meet needs



- A larger uptake of electric vehicles will require a major build-out of Europe's EV-charging infrastructure
- It is estimated that the EU-27 will need at least 3.4 million operational public charging points by 2030
- Investments are needed in installing charging points, upgrading the power grid, and building capacity for renewable energy production for EV charging
- The number of public charging points installations per week needs to increase substantially to meet the needs of future electrical vehicle fleets
- The European Parliament has recently adopted minimum requirements for charging infrastructure for electric cars requiring member states to build EV charging points at least every 60km on main motorways.
  - The new rules are part of the "Fit for 55 in 2030 package"
  - If the parliament's position is agreed with other EU institutions, countries would have until 2026 to reach the target
- The largest bottleneck that charge point operators face in Europe today is the amount of time it takes to establish a grid connection point, the complexity of the process to get one, and access to sufficient grid capacity

Source: IEA, Charge Europe, The EV Charging Infrastructure Masterplan, McKinsey & Company ***** Utilisation scenario where charging points are installed in line with current utilisation growth rates. The Masterplan is based on the proposed EU regulatory CO_2 targets for 2030 in the road transport sector, i.e., –55% for passenger cars (PCs) and –30% for trucks.

Nordic companies are engaged in charging infrastructure at home and in Europe
- Innovations and technology companies enable charging and energy storage solutions

Some recent developments in the Nordics*

- The charging network in the Nordics is continuously expanding both for electric vehicles and trucks; recent examples include:
  - Plans to establish one of Sweden's largest cohesive networks of public charging stations for heavy traffic with 44 charging stations by 2023
  - In 2022 a joint venture committed to invest EUR 500M collectively in charging infrastructure for heavy trucks in Europe
- A partnership was announced in August 2022 to provide battery and charging systems for electric boats
- Initiatives were announced in 2022 to develop solutions for sustainable energy storage

Source: Business Sweden interviews, Company webpages * For additional cases and details see the following chapter

Integration | Recent development in the Nordic value chain

VIRTA

- Established in 2013 by 18 Finnish electricity companies to offer a nationwide network of charging stations for electric vehicles.
- The portfolio includes charging stations for households, real estate, workplaces and commercial places. In December 2022, the company announced a partnership with Swedish charging station operator Nimbnet to build a charging network for electric trucks in Sweden with the first stations to be ready end of 2023

CTEK and POLARIUM

- CTEK was incorporated in 2019, and Polarium, was incorporated in 2014.
- Announced in February 2022 a partnership to develop solutions for sustainable energy storage for electric vehicles. The partnership benefits from CTEK's electric vehicle charging technology and Polarium's energy storage technology with the aim of aim to enable more EV charging more accessible.

EIDSVIDA and TENSIO

- Norwegian energy companies Eidsiva, founded in 2001, and Tensio, founded in 1997.
- Announced a collaboration in 2022 to test the possibility of energy storage through movable large battery packs. The companies are looking at making the solution available on the market through a leasing-model.

POLESTAR

- Car brand manufactured by Volvo Cars, founded in 2003 with approximately 397 employees.
- Polestar will provide battery and charging systems for Candela's electric boats. The partnership was announced in August 2022.

FORTUM

- Finnish majority state-owned energy company founded in 1998.
- Providing charging networks (parking lots and public areas) for electric cars in Finland, Sweden and Norway. The offering also includes energy storage solutions.

EASEE

- Norwegian green-tech company founded in 2018 with approximately 334 employees. The company provides smart EV charging solutions for cars.
- In November 2022 more than 500,000 charging units were in use in Norway, Sweden, Germany and UK, mostly for private and residential use. The charging units are developed and produced in the Nordics.

MILENCE

- Joint Venture between Daimler Truck, Traton Group, and the Volvo Group, established in 2022.
- In 2021 the joint venture plans to install and operate at least 1,700 charge points on, and close to, highways and logistics hubs across Europe for heavy trucks was announced. In 2022 the parties committed to invest EUR 50Mn collectively in charging infrastructure for heavy trucks.

MASSTERLY

- Joint venture between Norwegian companies Kongsberg Maritime and Wilhelmsen established in 2018 with approximately 2 employees.
- The joint venture is a partnership between a leading technology provider and an innovative shipping group in a collaboration to develop autonomous vessels with electric propulsion.

MER

- Norwegian company, a part of state-owned Statkraft was founded in 2009 and has approximately 350 employees.
- Mer Group is specialises in EV charging points for residential and commercial properties and have over 25,000 charging points in Europe. In February 2022, the company announced a collaboration with the largest Norwegian payment application, Vipps, for easier payment solutions for charging that requires no separate app or log-in details.

VOLVO TRUCKS and OKQ8

- In 2022 truck manufacturer Volvo Trucks and Swedish fuel company OKQ8 announced cooperation to establish one of Sweden's largest cohesive networks of public charging stations for heavy traffic. The companies aim to install and operate 44 charging stations in 2023.

Note: Company examples are non-exhaustive **Source**: Company websites, news articles, and publicly available information

The Nordic academia build on broad chemistry and material skills, close triple helix collaborations, creative and independent culture and close ties to Europe

Some recent developments in the Nordics*

- The Nordics continue to develop partnerships and programs in academia, creation of new industry organisations, and R&D center initiatives have been launched including:
  - A new Finnish battery industry organisation formed January 2023 by nine Finnish companies as founding members
  - A Master's programme in battery technology and energy storage was launched in 2022 in Sweden
  - A novel specialisation in battery technology is planned to start in autumn 2023 in Norway
  - A R&D center for sustainable battery materials in Kristiansand in Norway was opened in late 2022
  - In 2022 a joint R&D center was established in Gothenburg
  - Several ongoing research projects for batteries

Source: Business Sweden interviews, Organisation webpages * For additional cases and details see the following chapter

Academia | Recent development in the Nordic value chain (1/2)

ÅNGSTRÖM ADVANCED BATTERY CENTRE

- Established at Uppsala University in Sweden.
- Ångström Advanced Battery Centre is the largest research group for batteries in the Nordics. The research covers most aspects of lithium batteries and fuel cell chemistry. Among other things they lead the Battery 2030+ project.
- During 2022 the new Master's Program in Battery Technology and Energy Storage was launched

AALTO UNIVERSITY

- Finnish university founded in 2010.
- Aalto University's School of Chemical Engineering offers studies in new battery raw materials and manufacturing methods.
- The BATCircle 2.0 consortium consists of six research organisations and 15 companies and is led by Aalto University.

AGDER UNIVERSITY (UiA)

- Norwegian university founded in 1994.
- UiA has carried out several research projects on battery management and initiated an interdisciplinary education and research project called the Agder Battery Project
- A novel specialisation in Battery Technology is planned to launch in autumn 2023

LULEÅ UNIVERSITY OF TECHNOLOGY

- Swedish University founded in 1971.
- Together with Northvolt and Uppsala University, Luleå University of Technology is offering a 7.5 credits course on advanced level: "Batteries for a sustainable society: from raw materials to battery cells". The course provides knowledge of electrochemistry, battery construction, mineralogy, extraction processes and recycling methods for lithium-ion batteries.

NORTHVOLT LABS

- Swedish developer, producer and recycler of lithium-ion batteries. Registered in 2015 and have approximately 790 employees.
- Northvolt Labs has been in operations since 2020 in Västerås. The facilities are R&D Center for materials science, battery research and some cell manufacturing. The center also has full validation capabilities.

UNIVERSITY OF OULU

- Finnish university founded in 1958.
- The university is coordinating the BattValue project (2022-2024). The project is aimed towards professionals within mining, metal refining, processing and battery end-user sectors (energy sector, automotive industry) and provides professional level knowledge of existing and future battery concepts.

VIANODE

- Norwegian Synthetic graphite manufacturer founded in 2020 and has approximately 76 employees.
- In October 2022, the company opened a R&D centre for sustainable battery materials in Kristiansand.
- Plans are to use the centre to expand its R&D activities, including a new office, laboratory and hiring more scientists for Vianode's current focus

CHALMERS, LUND and UPPSALA UNIVERSITY

- In March 2022 a collaboration platform between Chalmers University of Technology, Lund University and Uppsala University was announced.
- The initiative will contribute to new knowledge, coordination and joint research in battery technology and educate more students within this field

SWEDISH ELECTROMOBILITY TEST CENTERS

- SEEL Swedish Electric Transport Laboratory AB founded in 2018.
- Chalmers University and RISE develop Sweden's electromobility test centers (SEEL) to speed up electrification of the transport sector. Three plants in Gothenburg, Nykvarn and Borås expected to be operational in 2023.

Note: Academic examples are non-exhaustive **Source**: Organisation websites, news articles, and publicly available information

Academia | Recent development in the Nordic value chain (2/2)

BASE BATTERIES SWEDEN

- BASE Batteries is a Swedish competence center for battery research, founded in 2020. Sweden will provide a platform for developing materials, components, and full-scale devices for future generations of ultra-high performant batteries. Has, as of late 2022, 17 different research projects ongoing.
- The center incorporates competences within Swedish academia and industry.

VTT TECHNICAL RESEARCH CENTRE OF FINLAND

- Finland's largest research institute, owned by the Finnish state, formed 1942. VTT test and develop new battery manufacturing processes in lab and at pilot scale.
- VTT coordinates a Battery 2030+ H2020 project about self-healing batteries.

SINTEF

- Norwegian research institute, founded in 1950 and is one of the largest independent research institutes in Europe.
- The research institute is covering large parts of the battery value chain including, among others, lithium-ion battery technology development, new battery materials, battery cell design and cooling and control systems (BMS) for battery cells and packs.

NOVO ENERGY

- Joint venture, established in June 2021, between Volvo Cars and Northvolt.
- In 2022 a joint R&D center was established in Gothenburg. The R&D centre, will position Volvo Cars as one of few automotive brands to make battery cell development and production part of its engineering capabilities.

AKKUTEOLLISUUS RY - FINNISH BATTERY INDUSTRIES

- Finnish battery industry organisation formed January 2023 by nine Finnish companies as founding members. Founding members are Suomen Malmijalostus Oy, Terrafame Oy, Umicore Finland Oy, Jervois Finland Oy, Norilsk Nickel Harjavalta Oy, Fortum Battery Recycling Oy, BASF Battery Materials Finland Oy, Keliber Oy and CNGR Finland Oy.
- The members plan to make investments worth 6 billion EUR in total by 2028.

Note: Academic examples are non-exhaustive **Source**: Organisation websites, news articles, and publicly available information

Agenda

Growing battery demand needs more energy at low prices, but supply decrease
- The Nordics have a competitive edge, but actions for increased supply are decisive

DRIVERS

The industries along the battery value chain are highly energy intense…

- Mining, refining, production of active materials as well as cell manufacturing all are high energy intense industries

… simultaneously energy supply decrease

- Russia's war in Ukraine has limited the energy supply to Europe

Nordic competitive edge

- Nordics high percentage of green energy and sustainability targets

NEEDS

Increased volume of renewable energy

- The green transition will increase the energy demand immensely and investments are needed
- Investments are demanded especially in wind energy
  - Improved decision processes for permits are crucial
  - Distinct national prioritisation is decisive
  - Dialogue for "not in my backyard" is highly important to change the view to a holistic perspective

Enable competitive electricity prices

- The green transition impact energy prices
  - Investments to improve the distribution capacity and governance of stability within the grids
- Enable new business models for energy markets for who can sell and buy electricity

Awareness of the importance

- Ensure a public and political awareness of the importance of the energy characteristics in the Nordics
  - The green, stable and relatively cheap energy in the Nordics is a competitive edge enabling competitive business
- Increased investments are needed and benefit from awareness

NORDIC INDUSTRY QUOTES

> *"Power is a resource creating competitive edge for the Nordics"*
>
> [Finnish actor]

> *"Electricity prices are decision factors for investments, also within a country"*
>
> [Swedish actor]

> *"Increased need for energy production is fundamental and should not be an issue between political blocks or between Europe and the Nordics. We need green energy everywhere and it is fundamental."*
>
> [Norwegian actor]

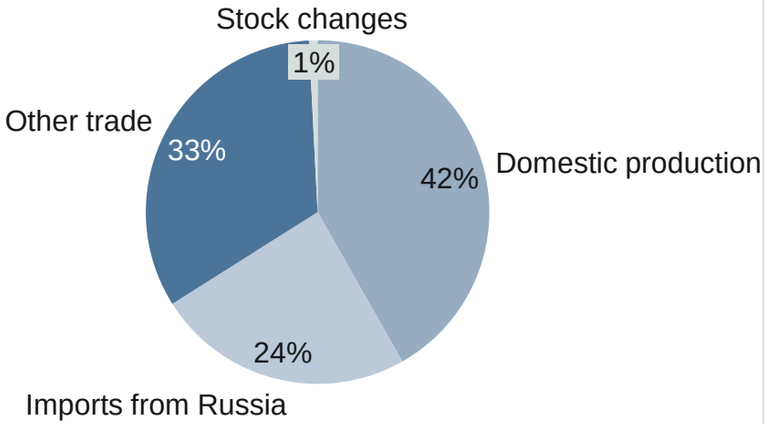
Source: Business Sweden interviews and analysis

Europe is investing to increase resilience of energy and critical supply chains
- Sustainable investments in focus to increase the European competitiveness

Europe is dependent on energy imports

- All 27 Member States of the EU have been net importers of energy since 2013. In 2020, the European Union imported 57.5% of the energy consumed
- Russia accounted for over 24% of all energy in Europe in 2020

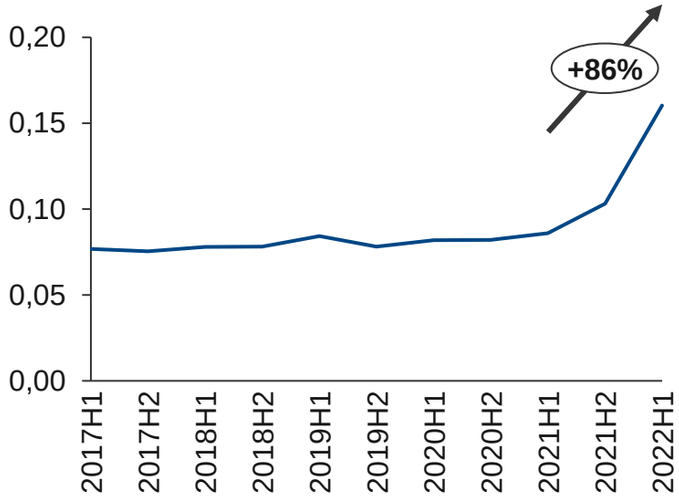
Energy sources in EU in %, 2020



Disrupted supply means higher energy prices

- The skyrocketing electricity prices across Europe are linked to the high price of gas
- Prices started rising summer of 2021 when the world economy picked up after Covid-19 restrictions were eased
- Between H1 2021 until H1 2022 prices grew with 86 percentage

EU electricity prices for non-household consumers, excluding taxes - EUR/ kWh



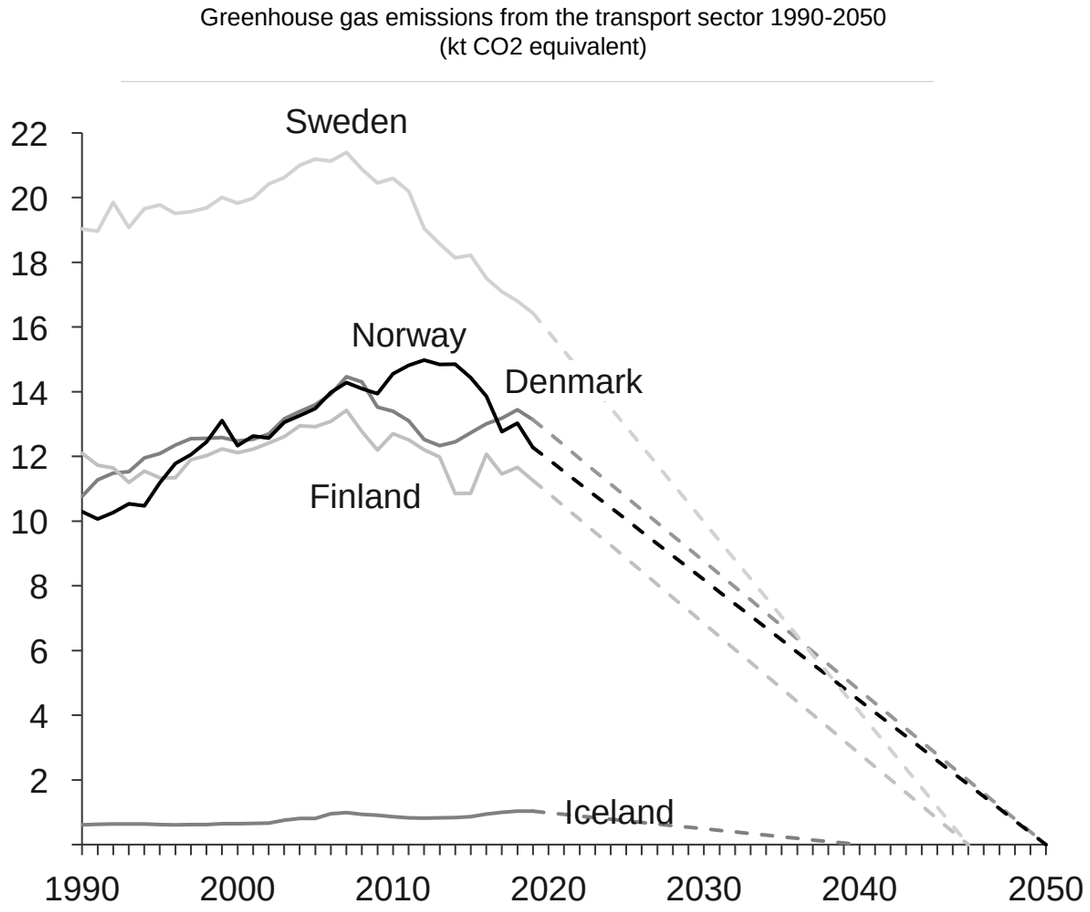
Europe needs investments to close energy gap

- The **European Green Deal** focuses on reducing the greenhouse emission by 55% until 2030 and to reach net-zero by 2050
- **REPowerEU** is the response to the global energy market disruption caused by the invasion of Ukraine
  - Focusing on accelerating the clean energy production and making EU independent from Russian fossil fuels before 2027
  - The transition is mostly funded from the Recovery and Resilience Fund to support investment and reforms worth EUR 300 billion
  - RePower EU ambitions of 69% renewable energy in 2030
- Released in 2021, **Fit for 55** is a collection of legislative proposals intended to help the EU in its green transition to reduce greenhouse gas emissions, decarbonise the economy and by 2050 become climate neutral
  - The framework aims at making the green transition just and socially fair while strengthen the EU industry's innovation and competitiveness, as well as "establish" the EU's position as a global leader in fight against the climate change

Source: REPower EU, WEF: "What is the EU doing to end its reliance on Russian energy?", Eurostat

The Nordic governments have high targets for emission reductions
- Emissions to be cut between 40-70% by 2030

Greenhouse gas emissions from the transport sector in the Nordics



National goals for sustainability drive emission reductions

Finland
- Achieve carbon neutrality by 2035 at the latest
- The emission reduction targets are 60% by 2030, 80% by 2040 and at least 90% but aiming at 95% by 2050, compared to the levels in 1990

Sweden
- Achieve zero net emissions of greenhouse gases by 2045 and hereafter negative emissions. 63% reduction by 2030 compared to 1990
- Emissions from domestic transports are to be reduced by at least 70% by 2030, compared to 2010

Norway
- Reduce emissions by at least 55% by 2030
- 90-95% greenhouse gas reduction below 1990 levels by 2050

Denmark
- The Climate Act sets a target to reduce Denmark's emissions by 70% in 2030 compared to 1990 and climate neutrality by 2050
- The Act was amended in 2021 to include the emission reduction target for 2025 of 50-54%

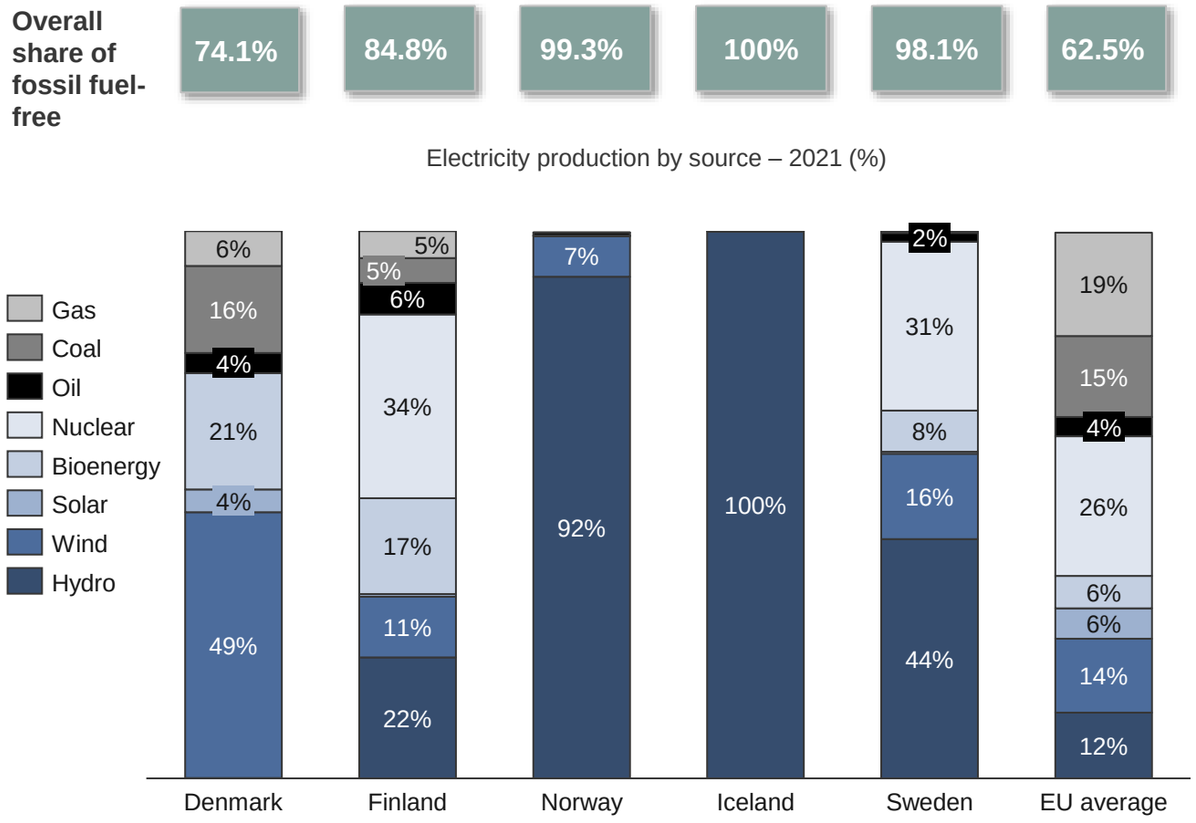
Iceland
- Iceland aims to achieve carbon neutrality before 2040 and to cut greenhouse gas emissions by 40% by 2030

Source: Company websites, Government websites, European Environment Agency
Note: Road Transport includes cars, light and heavy-duty trucks and buses, motorcycles, other road transport

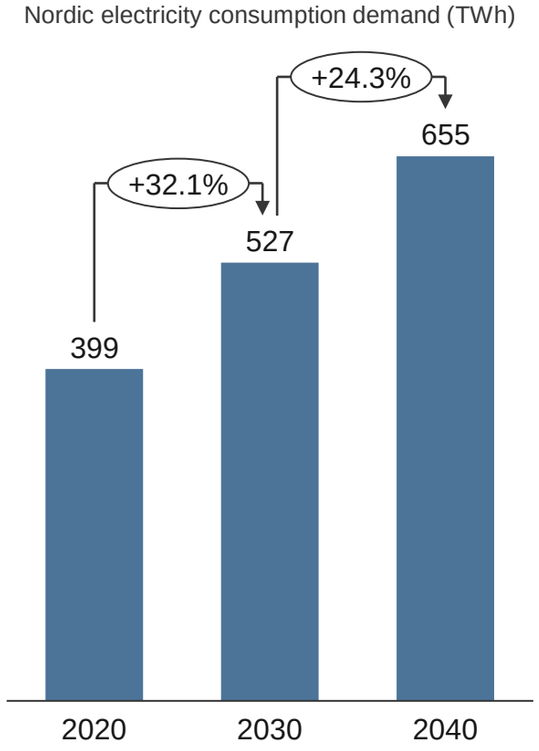
The Nordics have a distinct higher share of renewable energy than EU average

- Electricity demand is expected to increase by 60% until 2040

The Nordic electricity mix has low carbon emissions compared to the rest of Europe



More electricity needed as demand grows

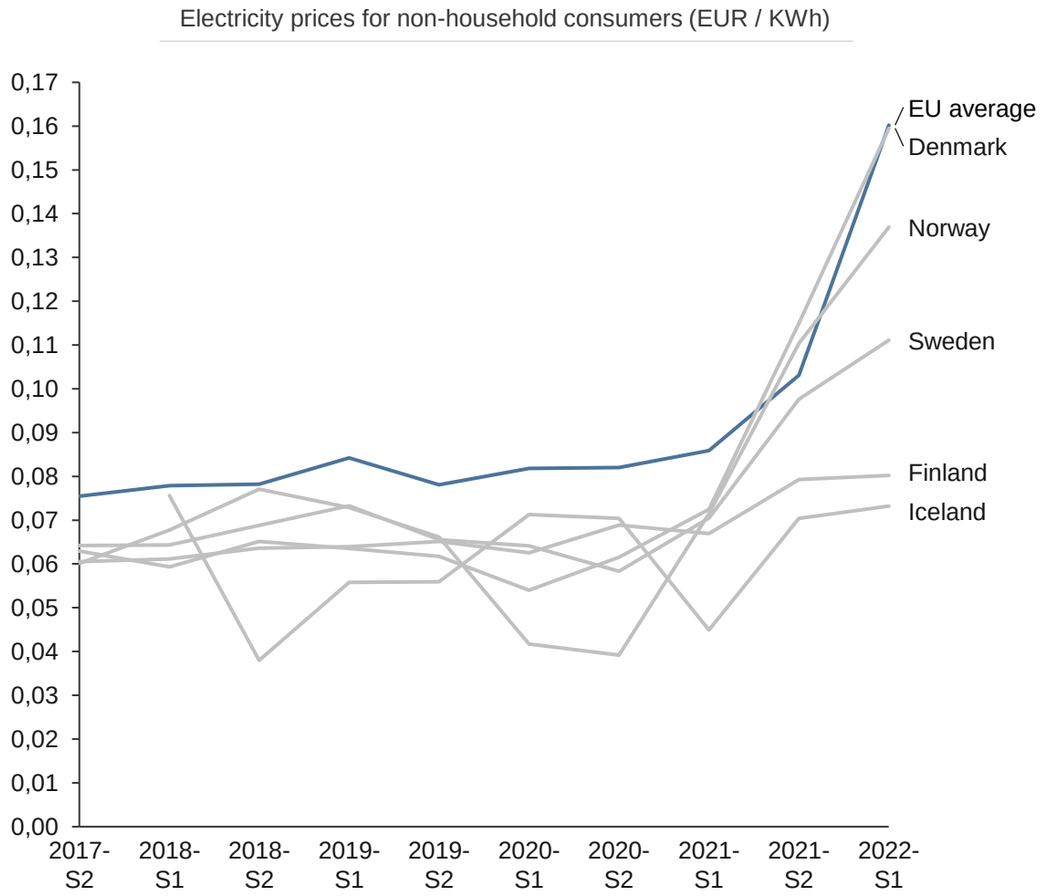


- Demand for electricity is forecasted to increase towards 2030 and 2040

Source: BP Statistical Review of World Energy. IEA

The Nordics have historically had competitive electricity prices and is predicted to remain a low-price area with increasing investment in renewable capacity

The Nordic region has lower electricity prices than the EU average



Forecast indicates that the Nordics will continue to be a low-price area

- Even though the Nordic power prices have risen in recent years due to numerous geopolitical factors in Europe and beyond, the electricity prices have for the most part been lower relative to the Europe average
- Nordic power contracts for Q2 2022 ended at EUR 122/MWh, while the corresponding German power contract ended at EUR 428/MWh
- According to the Climate Neutral Nordics Scenario for years 2030 and 2040, created by the Nordic transmission system operators (TSOs), there will be a lot of competitively priced and green electricity available in the Nordics in the future
- The Climate Neutral Nordics scenario indicates an electricity surplus in the Nordics in the future, with average power prices lower than the prices in continental Europe

Source: Eurostat, Nordic Energy Research 2021; Montel News, Forbes, IEA, Energifaktanorge.no, energinet.dk, Volue, Nord Pool **Note:** S1 = first half of year, S2 = second half of year

Agenda

Companies in Finland, Norway, Sweden, Denmark and Iceland (1/4)

RAW MATERIALS

Company	Country of operation
Boliden Harjavalta Oy	Finland
Boliden Kokkola Oy	Finland
Boliden	Sweden
Beowulf Mining	Finland
Fennoscandian Resources Oy	Finland
Finncobalt Oy	Finland
Finnish Minerals Group (Suomen Malmijalostus) Oy	Finland
Grafintec Oy	Finland
Freeport Cobalt (Jervois Finland)Oy	Finland
Keliber Oy	Finland
Latitude 66 Cobalt Oy	Finland
Mawson Oy	Finland
Metso Outotec Finland Oy	Finland
Stora Enso	Finland
Terrafame	Finland
X-ray Mineral Services Finland Oy	Finland
Bluejay Mining	Greenland
Kobold Metals	Greenland
Alcoa	Norway
Eramet	Norway
Glencore Nikkelverk AS	Norway
Nanopow AS	Norway
Norsk Hydro ASA	Norway
Norway Mining	Norway
Boliden AB	Sweden
Eurobattery Minerals AB	Sweden
Leading Edge Materials	Sweden
LKAB	Sweden
Talga Battery Metals AB	Sweden

ACTIVE MATERIALS

Company	Country of operation
Haldor Topsoe	Denmark
BASF Battery Materials Finland Oy	Finland
Beijing Easpring Material Technology	Finland
Beneq Oy	Finland
CNGR Finland Oy	Finland
Epsilon Advanced Materials	Finland
Finnish Minerals Group (Suomen Malmijalostus Oy)	Finland
Fortum Oyj	Finland
Metso Outotec Finland Oy	Finland
Norilsk Nickel Harjavalta Oy	Finland
Terrafame	Finland
Umicore Finland Oy	Finland
Borregaard AS	Norway
Cealtech AS	Norway
Cenate AS	Norway
Elkem AS	Norway
Nordic Mining ASA	Norway
Resitec	Norway
Skaland Graphite AS	Norway
Tiotech AS	Norway
Talga Battery Metals AB	Sweden
Altris AB	Sweden
Bright Day Graphene	Sweden
Dongjin Sweden AB	Sweden
Graphmatec AB	Sweden
Gränges Finspång	Sweden

ACTIVE MATERIALS

Company	Country of operation
Granode	Sweden
Northvolt AB	Sweden
Senior Material (Europe) AB	Sweden
Sicona	Sweden

CELLS

Company	Country of operation
BroadBit Batteries	Finland
TeraFactory (Finnish Batteries)	Finland
Alor	Iceland
Beyonder AS	Norway
Elinor Batteries	Norway
Freyr AS	Norway
Morrow Batteries AS	Norway
Enerpoly AB	Sweden
LifeSize AB	Sweden
Ligna Energy	Sweden
Nilar International AB	Sweden
Northvolt AB	Sweden
NOVO Energy AB	Sweden
SAFT AB	Sweden

Companies in Finland, Norway, Sweden, Denmark and Iceland (2/4)

PACK

Company	Country of operation
Lithium Balance / Senata Technologies	Denmark
WS Technicals A/S	Denmark
Xolta	Denmark
Bamomas	Finland
Celltech	Finland
Geyser Batteries	Finland
JOT Automation Oy	Finland
Corvus Energy AS	Norway
Green waves	Norway
Nordic Batteries AS	Norway
Schive AS	Norway
Siemens	Norway
ZEM Energy	Norway
Alelion Energy Systems AB	Sweden
APR Technologies AB	Sweden
China-Euro Vehicle Technology AB	Sweden
Comsol	Sweden
Echandia Marine	Sweden
Epiroc AB	Sweden
Insplorion	Sweden
Mastervolt Sweden AB	Sweden
Nortical AB	Sweden
Polarium Energy Solutions (Incell)	Sweden
Scania AB	Sweden
Volvo AB	Sweden
Volvo Cars	Sweden
Epec Oy	Finland

APPLICATION

Company	Country of operation
Banke	Denmark
ForSea	Denmark
Maersk Supply Service	Denmark
Midtjyske Jernbaner	Denmark
Molslinjen	Denmark
AuroraPowertrains	Finland
Avant Tecno Oy	Finland
Cargotec Finland Oy (Kalmar)	Finland
Junttan Oy	Finland
Linkker Oy	Finland
Normet Oy	Finland
Ponsse	Finland
Sandvik Mining and Constr. Finland	Finland
Tana Oy	Finland
Tanktwo Oy	Finland
Valmet Automotive Oy	Finland
Valtra Oy	Finland
VEO Oy	Finland
Wärtsilä Finland Oy	Finland
Eimskip	Iceland
Asko Norway AS	Norway
Avinor AS	Norway
Brødrene AA AS	Norway
Evoy	Norway
Fjord1	Norway
Kongsberg Maritime	Norway
Massterly AS	Norway

APPLICATION

Company	Country of operation
Norled AS	Norway
Paxster AS	Norway
Ulstein Group	Norway
Unibuss AS	Norway
Vard Group	Norway
Widerøe AS	Norway
Yara International	Norway
Aktiebolaget Volvo Penta	Sweden
Cake Bikes	Sweden
Candela	Sweden
Einride AB	Sweden
Epiroc AB	Sweden
Heart Aerospace AB	Sweden
Nortical AB (Evledger)	Sweden
Sandvik AB	Sweden
Sandvik Aktiebolag	Sweden
Scania AB	Sweden
VOI Technology AB	Sweden
Volta Trucks AB	Sweden
Volvo AB	Sweden
Volvo Cars	Sweden
Xshore AB	Sweden

Companies in Finland, Norway, Sweden, Denmark and Iceland (3/4)

INTEGRATION

Company	Country of operation
Clever	Denmark
Nerve Smart Systems	Denmark
OK	Denmark
Vestas	Denmark
Ørsted	Denmark
Danfoss Drives (Vacon Oy)	Finland
Ensto	Finland
Fortum Oyj	Finland
Helen Oy	Finland
Hevtec Oy	Finland
Inter Control	Finland
Kempower Oy	Finland
L7 Drive Ltd	Finland
Liikennevirta Oy (Virta)	Finland
Micropower Oy	Finland
Parkkisähkö Oy	Finland
PlugIt Oy	Finland
Proventia Emission Control Oy	Finland
Siemens	Finland
Wapice Oy	Finland
ON	Iceland
Ísorka	Iceland
Orkusalan	Iceland
Virta	Iceland
Circle K	Norway
Easee	Norway
Eidsiva	Norway
Greenely	Norway
Mer Norway AS	Norway
Circle K	Norway

INTEGRATION

Company	Country of operation
Pixii AS	Norway
Recharge (Fortum Charge and Drive)	Norway
Skagerak Energi AS	
Statkraft	Norway
Tensio AS	Norway
Tensio TN AS	Norway
Zaptec	Norway
ABB	Sweden, Denmark, Finland, Norway, Iceland
APR Technologies AB	Sweden
Charge4go AB	Sweden
Charge-Amps AB	Sweden
CTEK Sweden AB	Sweden
Ferroamp Elektronik AB	Sweden
Hitachi ABB Powergrids	Sweden
Milence Sweden AB	Sweden
Mälarenergi	Sweden
OK-Q8 AB	Sweden
Vattenfall	Sweden
Volvo Lastvagnar Aktiebolag	Sweden
Zpark Energy Systems Ab	Sweden

RECYCLE AND REUSE

Company	Country of operation
Feasib Oy	Finland
Fortum Battery Recycling Oy	Finland
Metso Outotec Finland Oy	Finland
Suomen Autokierrätys Oy	Finland
uRecycle Group Oy	Finland
Batteriretur AS	Norway
Eco Stor AS	Norway
Evyon AS	Norway
Glencore Nikkelverk AS	Norway
Hagal AS	Norway
Hydro Volt AS	Norway
Norsirk AS	Norway
Yedlik AS	Norway
Cling	Sweden
Elkretsen i Sweden AB	Sweden
Northvolt AB	Sweden
Stena Recycling	Sweden, Denmark

List of battery value chain actors in Finland, Norway, Sweden, Denmark and Iceland - Organisations (4/4)

Organisation	Country
Aalborg University	Denmark
DaCES	Denmark
Danish Technological Institute	Denmark
Danska Batteriselskab	Denmark
Technical University of Denmark (DTU)	Denmark
University of Southern Denmark (SDU)	Denmark
Batteries Europe ETIP	EU
BATTERY 2030+	EU
EuBatIn	EU
Eurogeosurveys	EU
European Battery Alliance	EU
European Green Deal	EU
European Raw Matreials Alliance	EU
FRAME	EU
Aalto University	Finland
BATCircle 2.0	Finland
Battery Recycling Innovation Park	Finland
Business Finland	Finland
Business Tampere	Finland
Center for Non-Ferrous metals Harjavalta	Finland
Centria University of Applied Sciences	Finland
Cursor	Finland
eFlowHub	Finland
EnergyVaasa	Finland
FinnMin	Finland
Finnvera	Finland

Organisation	Country
Geological Survey of Finland (GTK)	Finland
GigaVaasa	Finland
HiQ-CARB	Finland
Kokkola Industrial Park	Finland
Kokkola University Consortium Chydenius	Finland
LUT University	Finland
Metropolia University of Applied Sciences	Finland
Mining Finland	Finland
Pyhäjärven Callio	Finland
Sustainable industry X	Finland
Tampere University of Technology	Finland
Technical Research Centre of Finland (VTT)	Finland
The Finnish Mining Community	Finland
The Finnish Safety and Chemicals Agency (TUKES)	Finland
Turku University of Applied Sciences	Finland
University of Eastern Finland	Finland
University of Oulu	Finland
University of Turku	Finland
Vaasa University	Finland
Åbo Akademi University	Finland
Battery Norway	Norway
Bellona Foundation	Norway
Confederation of Norwegian Enterprise (NHO)	Norway
Enova SF	Norway

Organisation	Country
Eyde-klustret	Norway
Grønn plattform	Norway
Industrial Development Corporation of Norway (SIVA)	Norway
Innovation Norway	Norway
Institute for Energy Technology (IFE)	Norway
Institute of Transport Economics	Norway
Maritime Battery Forum	Norway
Maritime CleanTech	Norway
MoZEES	Norway
NABLA	Norway
Nordic Innovation	Norway
NorGiBatF	Norway
Norways Forskningsråd	Norway
Norwegian University of Science and Technology (NTNU)	Norway
Prosess21	Norway
PROSIN	Norway
SINTEF	Norway
University of Agder (UiA)	Norway
University of Stavanger	Norway
ZERO	Norway
Future Materials	Norway
Norwegian EV Association	Norway
Norwegian Society for the Conservation of Nature	Norway
Rana Utvikling	Norway
Green Flyway	Norway/ Sweden
Confederation of Norwegian Enterprise (NHO)	Norway

Organisation	Country
BASE Batteries	Sweden
Business Sweden	Sweden
Chalmers Tekniska Högskola	Sweden
EIT InnoEnergy	Sweden
Energimyndigheten	Sweden
Environmental Protection Agency	Sweden
Fossilfritt Sweden	Sweden
Geological Survey of Sweden (SGU)	Sweden
Industrial Materials Recycling	Sweden
Invest in Norrbotten	Sweden
Linköping University	Sweden
Luleå University of Technology	Sweden
Mid Sweden University	Sweden
Mobility Sweden	Sweden
Mälardalens University	Sweden
Node Pole	Sweden
Northvolt Labs	Sweden
Region Gotland	Sweden
Research Institutes of Sweden (RISE)	Sweden
Royal Institute of Technology	Sweden
Skellefteå Science City	Sweden
Stiftelsen för miljöstrategisk forskning (MISTRA)	Sweden