Electromobility, Supply chains and Dependencies

By the conceptual team of Global Arena Research Institute (published August 2024)

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"Working and conceptual papers" are analytical reviews of existing resources, including academic literature, think tank analyses, and inputs from formal institutions such as the World Bank, European Commission, and OECD. They are not intended to present original research but rather to build a background for developing research concepts used in data-driven analytics. Originally intended as internal working material, these papers are published when they are deemed to be of broader public interest. This paper is part of a series of "conceptual papers" produced as part of a project supported by the International Visegrad Fund and Konrad Adenauer Stiftung in Prague.

Vehicle Battery manufacturing

The manufacturing of vehicle batteries, particularly for electric vehicles (EVs), is a complex and resource-intensive process. The most common types of batteries used in modern electric vehicles are lithium-ion batteries due to their high energy density and long cycle life.

Raw Material Acquisition

Lithium: Often extracted from underground pools of brine or from hard rock, like spodumene. The lithium is processed into lithium carbonate or lithium hydroxide. It can be acquired from:

- South America: The Lithium Triangle, which includes Argentina, Bolivia, and Chile, has large reserves in salt flats where lithium is extracted from brine pools.
- Australia: The world's largest single producer of lithium through hard rock mining, typically from spodumene.
- China: Has both brine and hard rock sources.

Cobalt: Typically mined as a by-product of copper or nickel mining. Cobalt is critical for energy density and battery longevity. It can be acquired from:

- Democratic Republic of Congo (DRC): Holds the largest cobalt reserves and is the leading producer, but there are significant concerns over mining conditions and the use of child labor.
- Canada: Has cobalt mines and is considered a more ethical source compared to the DRC.
- Russia and Australia: Also notable producers of cobalt.

Nickel: Extracted from nickel mines and processed for use in battery cathodes due to its high energy density properties. It can be acquired from:

- Indonesia: One of the largest producers of nickel.

- Philippines: A significant source of nickel.
- Russia: Known for its Norilsk deposit, one of the richest in nickel.
- Australia and Canada: Also have large reserves of nickel.

Manganese: Also used in the cathode of some lithium-ion batteries. It can be acquired from:

- South Africa: Home to a significant portion of the world's manganese reserves.
- Australia, China, and Gabon: Are also key producers of manganese.

Graphite: Used in the anode, it can be mined or synthesised. It can be acquired from:

- China: The largest producer of natural graphite.
- Brazil: Another significant producer.
- Canada and Mozambique: Emerging as potential major suppliers with large deposits being developed.

Copper: Used for the battery's anodes and electrical conductors. It can be acquired from:

- Chile: The largest copper mining country.
- Peru: Also a significant producer.
- United States, Indonesia, and Australia: Have large mining operations.

Aluminium: Used for the cathodes and for battery casing. It can be acquired from:

- China: The largest producer of aluminium.
- Russia, Canada, and India: Also have significant production.

Other materials: Including separators (polyethylene or polypropylene), electrolytes (organic solvents, lithium salts), and various plastics and composites for casing and insulation. These materials can be sourced from chemical companies around the world. Japan and South Korea are known for producing high-quality battery components.

For a visualisation of the material content in different anodes and cathodes, have a look here.

Manufacturing Process

1. Processing of Materials

Refining and processing: The raw materials must be refined and processed into forms suitable for use in battery production, like nickel sulphate or cobalt sulphate.

Synthesis of active materials: Chemicals like lithium cobalt oxide for the cathode or graphite for the anode are synthesised.

Electrode manufacturing: The processed materials are coated onto metal foils to create cathodes and anodes.

Separator placement: A separator is placed between the anode and cathode to prevent electrical shorts.

2. Battery Cell Assembly

Winding or stacking: The electrodes and separators are wound or stacked in a cell assembly.

Electrolyte filling: The electrolyte is added to the cell, which enables the flow of lithium ions between the cathode and anode.

Sealing: The cell is sealed to prevent leakage of the electrolyte and to protect it from outside elements.

3. Formation and Aging

Formation: The first charge/discharge cycles activate the battery materials and form the solid electrolyte interphase (SEI).

Ageing: The batteries are left to rest for a period to ensure stability and performance.

4. Module and Pack Assembly

Module assembly: Cells are assembled into modules by connecting them in series and/or parallel to reach the desired voltage and capacity.

Battery management system (BMS): The BMS is integrated to monitor and manage the battery's health, state of charge, and temperature.

Pack assembly: Modules are then assembled into a pack with all the necessary cooling systems, structural components, and electrical connections.

5. Quality Control and Testing

Inspection: Visual and mechanical inspections are performed to ensure quality.

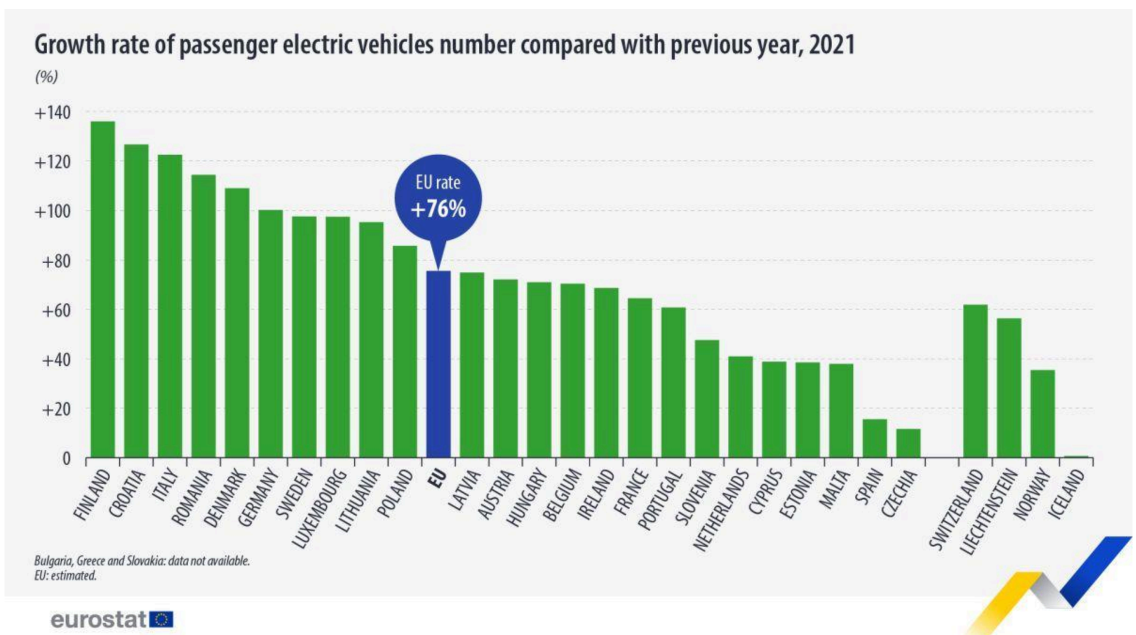
Electrical testing: The battery is tested for capacity, discharge rate, and charge retention.

Safety testing: Tests for thermal stability, short-circuit conditions, and resistance to impact and puncture are conducted.

Battery cell production challenges

The European Battery Alliance (EBA), with significant funding, aims to build a third of global battery cell production capacity in the EU by 2030 which is challenging at the moment. These challenges stem from various areas:

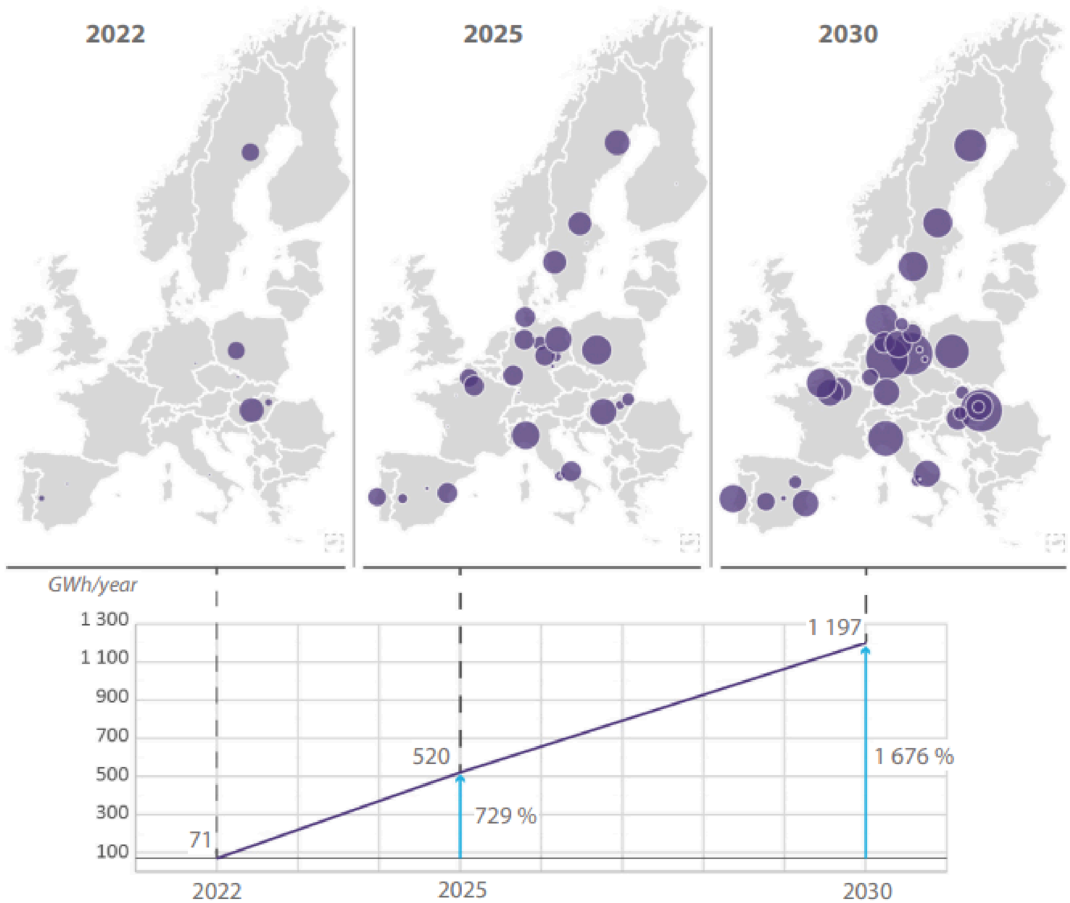
1. Supply and Demand balancing: In 2017, the European Commission had warned about the serious risk for Europe to become irreversibly dependent on battery cell imports. The EBA must then ensure there are enough gigafactories in the pipeline to meet the anticipated surge in EV demand. In 2021, there was a substantial increase in the number of electric passenger vehicles in the EU compared with 2020 (+76%)[1].



2. Financial and Geographical Distribution: Securing financial support and achieving a fair geographical distribution of activities among EU Member States and industry partners is a significant hurdle. Although substantial public finance is available, coordinating and agreeing on the distribution of these resources and projects is complex[2]. The EU automotive maker's primary choice has been to seek East Asia incumbents to invest in battery cell production in Europe, so as to reduce the costs of production.
3. Manufacturing Capacity Targets: According to forecasts, the European EV market would need 500-600 GWh per year by 2030. Though the lithium-ion battery cells production capacity has been developing rapidly, it hasn't reached the desired target, having

[1] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230324-1
[2] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230324-1

subsidiaries of non-EU companies currently owning most of the manufacturing sites. However, it is projected that by 2025, EU-based companies would account for as much as 56% of overall EU production capacity. Below is an analysis showing the planned additional production capacity and how it would spread across the EU member states[3].



Source: ECA, based on data compiled by Germany's Federal Ministry of Economic Affairs and Climate Action and company announcements. Circles are proportionally sized to reflect production capacity in individual locations. Design of the maps: Eurostat.

4. Market Entry Barriers: The European industry faces high barriers to entry due to the lack of experience in large-scale cell manufacturing and the incumbents' established knowledge and partnerships[4]. Building the required know-how and establishing new partnerships, especially international ones, are crucial.

[3] https://www.eca.europa.eu/ECAPublications/SR-2023-15/SR-2023-15_EN.pdf
[4] M. Beuse, T.S. Schmidt and V. Wood, « A Technology-Smart Battery Policy Strategy for Europe », ScienceMag, September 2018, Vol 361, Issue 6407

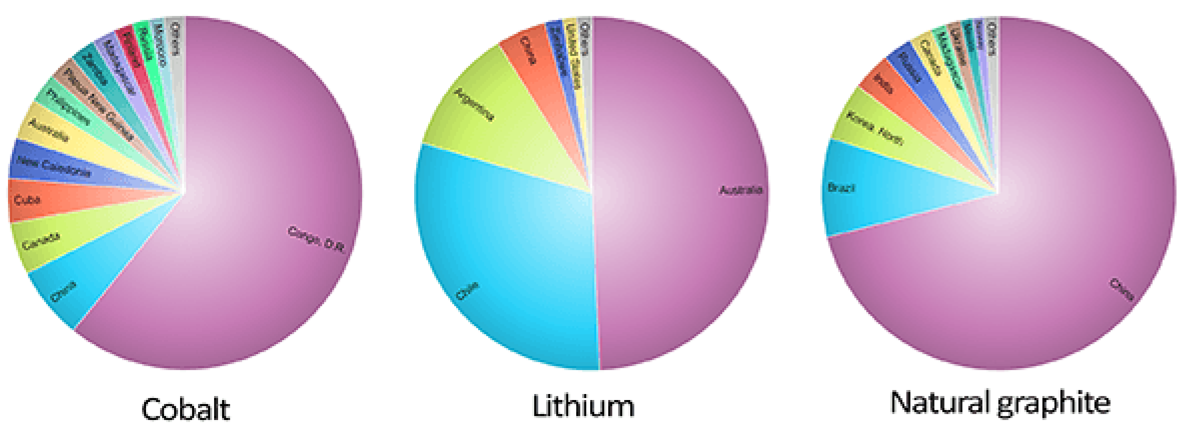
5. Ensuring Ethical and Sustainable Production: Battery manufacturing is energy-intensive (70-80 kWh needed to produce a 1 kWh battery capacity), and it is based on a number of critical raw materials that are predominantly sourced outside of Europe under poor traceability systems[5]. Integrating sustainability and ethical considerations into the production process adds another layer of complexity.

In response to the challenges faced in the battery market, the European Commission has taken measures to boost the electric vehicle (EV) battery industry's growth. This includes a 3.5 billion dollar subsidy to encourage more battery production within Europe and several planned major battery plants to meet anticipated demand. These efforts, alongside the existing production rate increase and the reduction in battery prices, are considered crucial for the continued demand for electric vehicles. Despite the material cost pressures, the EV battery market in Europe is on a rapid growth trajectory, with an expected compound annual growth rate (CAGR) of more than 21% by 2027. This indicates a strong market outlook and the potential for scale economies and technological advancements to help manage and mitigate cost increases over time.

Environmental and Ethical Considerations

Sourcing of materials: The mining of some materials, especially cobalt, has come under scrutiny for ethical concerns, including labour practices and environmental impact.

Figure 2: Global mine production output shares for cobalt, lithium and natural graphite per country



Source: RMIS raw material profiles

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[5] https://www.ifri.org/en/publications/editoriaux-de-lifri/european-battery-alliance-moving-gear

Manufacturing impact: The production process is energy-intensive and contributes to CO2 emissions. It's estimated that for every tonne of mined lithium, 15 tonnes of CO_2 are emitted into the air.

Recycling and life-cycle management: End-of-life vehicle batteries must be disposed of or recycled responsibly to recover valuable materials and prevent environmental damage.

Efforts for Sustainable Sourcing

Responsible Sourcing: Ensuring raw materials are obtained through ethical and sustainable practices. Organisations such as the Responsible Minerals Initiative (RMI) have developed certification programs to ensure that minerals like cobalt, lithium, and others are sourced responsibly. While in terms of supply chain transparency, companies are increasingly required to disclose their supply chains and sourcing practices, ensuring transparency from mine to market.

Recycling: Developing effective methods for recycling old batteries to recover valuable materials. The European Council adopted a new regulation on batteries and waste batteries in July 2023, with the aim of ensuring the entire life cycle of batteries are safe, sustainable and competitive. The regulation introduced a specific collection target for waste batteries for light means of transportation, the regulation sets targets for producers to collect waste portable batteries. The regulation also provided that by 2027, portable batteries incorporated into appliances should be removable and replaceable by the end-user, leaving sufficient time for operators to adapt the design of their products to this requirement.

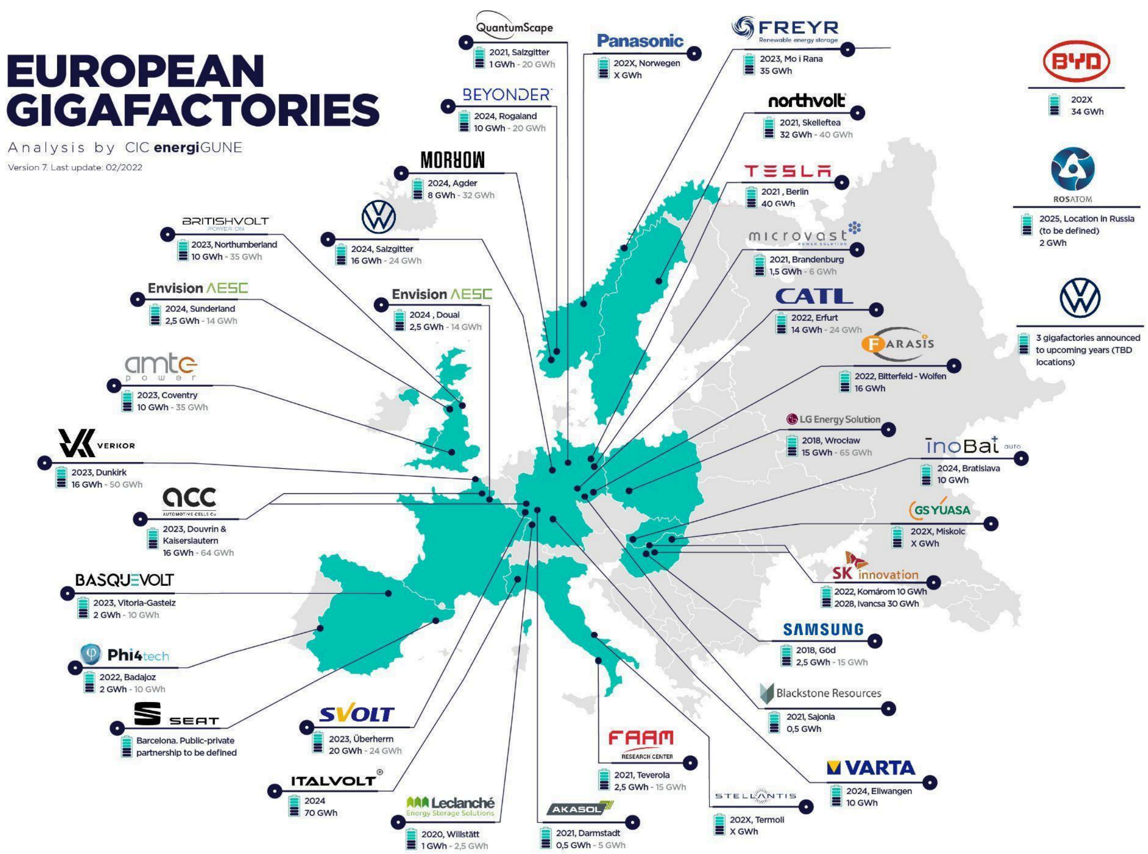
Research: Investing in research to find alternative materials with lower environmental and social impacts. Sodium has a similar chemical make-up to lithium but doesn't carry the same environmental impact for extracting it. This technology is being developed and looks to be making headway, with Tesla's battery supplier CATL starting to produce sodium-ion batteries (2022). General Motors (GM) joined in this effort by developing a new chemistry for a battery pack called Ultium that will be used across a new range of EV that reduces the cobalt content by 70%. Toyota on the other hand, sought out to invest in a more solid-state battery that greatly reduces the risk of fire and allows for a more energy dense battery, thus believed in having a longer-life expectancy and even faster charging.

Technological Advancements: To improve traceability and certification of minerals, blockchain technology is being used to track materials from the point of origin to the final product. AI is employed to optimise supply chains and predict the impacts of sourcing decisions on sustainability.

Can the EU nations break away from its dependency on China?

China is currently dominating in the supply chain for the batteries globally. The stability of the global supply chain is increasingly at danger when an excessive amount of EV battery components are extracted, refined, processed, and assembled in a single nation due to broader geopolitical difficulties that impact trade and economic ties.

Well, thanks to the European Battery Alliance, Europe is now a hub for investments across the whole battery value chain. This places the continent on course to being the world's second-largest producer of battery cells by 2024. There are several companies investing in large-scale battery production facilities, or 'gigafactories', within Europe. Germany, Sweden, Norway, Hungary and Poland are the leading countries, having the leading companies such as Northvolt and Tesla.



Source: CIC energiGUNE

Some of these companies include:

- Northvolt, Sweden. A Swedish battery developer and manufacturer, specialising in lithium-ion technology for electric vehicles. It's one of the most significant players in Europe's battery industry, aiming to build Europe's largest lithium-ion battery cell factory.
- Tesla, Germany. Its Gigafactory Berlin-Brandenburg is intended to produce batteries, battery packs, and powertrains for its electric vehicles, as well as assemble the Tesla Model Y. It's Tesla's first manufacturing location in Europe.
- ACC (Automotive Cells Company), France and Germany. A joint venture between Saft (a subsidiary of TotalEnergies), Stellantis (formed from the merger of PSA Group and Fiat Chrysler), and Mercedes-Benz, aiming to produce battery cells and modules in Europe.
- CATL (Contemporary Amperex Technology Co. Limited), Germany. Chinese battery giant CATL is building its first European factory in Erfurt, Thuringia, Germany. While it's a Chinese company, this factory represents a significant local investment in European battery production.
- LG Chem, Poland. South Korean company LG Chem operates a battery factory in Wroclaw, Poland, which is one of the largest lithium-ion battery factories in Europe.
- SK Innovation, Hungary. The company, another South Korean company, has invested in production facilities in Hungary, serving European automotive manufacturers.
- Britishvolt, United Kingdom. The company has plans to build the UK's first gigafactory in Northumberland, focusing on the production of lithium-ion batteries for electric vehicles.
- Verkor,France. A French start-up partnering with EIT InnoEnergy, Schneider Electric, and other organisations, planning to build a gigafactory for high-performance batteries.
- Volkswagen Group, Germany. The company has announced plans to build six gigafactories in Europe by 2030 to secure battery capacity for its ambitious electric vehicle production targets.
- Freyr Battery, Norway. The company is planning to build one of the largest battery gigafactories in Europe in Mo i Rana, Norway, using clean Norwegian energy.

These companies, among others, are part of a growing ecosystem aiming to establish a competitive and sustainable battery production industry in Europe. This in turn strengthens the local manufacturing capacity within the EU.

Europe is seeking to diversify its sources of critical raw materials by investing in mining projects in Europe, Africa, and elsewhere. Some European countries like Portugal, Finland, and Sweden have lithium reserves and are exploring the potential of mining and processing lithium locally.

European institutions and companies are heavily investing in research into next-generation battery technologies that may be less reliant on the materials currently dominated by Chinese supply chains. The continent is also at the forefront of research into battery recycling technologies, aiming to recover raw materials from spent batteries.

Europe is forming partnerships with countries like Canada, Australia, and Chile to secure a stable supply of raw materials. Encouraging collaboration between European automotive manufacturers and technology firms to develop in-house battery technology and production. An example is the Northvolt and Volvo cars joint venture in building the next generation of pure electric Volvo cars.

Some European car manufacturers are considering or already implementing vertical integration, taking control of their supply chain from raw material to finished product. A good example of this is Volvo's reorganisation of its global operations by combining its supply chain logistics and procurement functions.

Negotiating trade agreements that include provisions for raw materials and battery components. Balancing economic ties with China while strengthening internal capabilities and alliances with other regions. For a comprehensive overview of the EU-China relations, you can take a read here.

Companies investing in EV battery factories in Europe

With Europe seeking to lure electric vehicle battery makers to build gigafactories in the region, below is an overview of factories in Europe. It includes annual capacity and production timelines where available.

BELGIUM

Planned

- Seneffe-manage: Avesta Battery and Energy Engineering expects its 40-million-euro ($43.7 million) plant to be fully operational before 2030, with an aimed capacity of 3 GWh.

BRITAIN

Planned

- Coventry: The city approved a site for a potential plant but an investor is yet to be found. The pitch includes a 60 GWh output with production starting in 2025.
- Somerset: India's Tata Group (TAMO.NS) will build a 4 billion pound ($5.2 billion) gigafactory to supply its Jaguar Land Rover factories. The plant will have an initial output of 40 GWh and create up to 4,000 jobs. Production is due to start in 2026.
- Sunderland: China's Envision is building a factory near Nissan's plant. It will start operation in 2025 with a capacity of 12 GWh.
- N/A: Nanotech Energy plans to build a 1-billion-pound ($1.3 billion) factory and is investigating seven sites in the UK as a final location.

CZECHIA

Operating

- Hornì suchà: MES targets a capacity of 15 GWh at the plant worth 1.4 billion Czech crowns ($64.8 million). It opened in September 2020 with an initial production capacity of 200 MWh per year.

FINLAND

Planned

Kotka: Finnish Minerals Group in April signed a Memorandum of Understanding with a potential partner for a cell production plant. Environmental impact assessment for the plant, based on two options with 27 GWh and 40 GWh capacity, is expected to be completed by summer 2024.

FRANCE

Operating

- Quimper: Blue Solutions's factory in Ergue-Gaberic, near Quimper, was inaugurated in 2013. The company, a subsidiary of Bollore SE (BOLL.PA), says on its website its two factories, located in France and Canada, have an annual capacity of 1.5 GWh. It was not immediately clear how much of this was in France.

Planned

- Douai: China's Envision is investing up to 2 billion euros in an AESC gigafactory near the "Renault ElectriCity" EV hub. The plant will have a capacity of 9 GWh in 2024 and targets 24 GWh by 2030.
- Douvrin: Automotive Cells Company (ACC) - a joint venture of Stellantis , Mercedes Benz (MBGn.DE) and TotalEnergies (TTEF.PA) - plans to spend over 7 billion euros on three gigafactories in Europe, with capacity of 40 GWh each by 2030. The Douvrin plant was inaugurated on May 30, with operations starting in the second half of 2023.
- Dunkirk: Taiwan's ProLogium is working with the French government to secure subsidies for a 5.2-billion-euro battery factory. Production is slated to begin in 2026, with an aimed capacity of 48 GWh.
- Dunkirk: French start-up Verkor plans to build a factory in Dunkirk with targeted capacity of 12 GWh. Renault (RENA.PA) would be its biggest client.

GERMANY

Operating

- Dobeln: Launched by Swiss Blackstone Resources (4BRN.D) at the end of 2021, the plant will scale up to 5 GWh capacity between 2023 and 2024.

- Erfurt: CATL (300750.SZ), which has been expanding rapidly outside its home market China, is ramping up production at its plant near Erfurt, aiming to raise the capacity from 8 GWh to 14 GWh.
- Ludwigsfelde: U.S.-based Microvast's (MVST.O) plant has capacity of 1.5 GWh and targets up to 6 GWh.

Planned

- Heide: Northvolt will invest 3-5 billion euros in a plant as long as subsidies are approved. One source estimated the subsidies at more than 600 million euros.

- Kaiserslautern: One of ACC's three 40 GWh gigafactories is expected to start operations in 2025 in Kaiserslautern.
- Lauchhammer, Uberherrn: China's Svolt will invest up to 2 billion euros in two plants. The first one in Uberherrn is set to start production at the end of 2023, with an aimed capacity of 24 GWh. The second one in Lauchhammer will be operational in 2025, with a targeted capacity of 16 GWh.
- Salzgitter: Volkswagen (VOWG_p.DE) plans to build six plants in Europe totaling 240 GWh capacity by 2030. Production at the first plant will start in 2025 with a target capacity of 40 GWh.
- Tubingen: Cellforce plans to launch a 100 MWh plant in 2024.

HUNGARY

Operating

- Goed: Samsung's 1.2-billion-euro factory with capacity of 30 GWh has been in operation since 2018.

Planned

- Debrecen: China's CATL is building a 7.3-billion-euro plant with an aimed capacity of 100 GWh. Construction started in 2022 and should last no more than 64 months.
- Debrecen: China's EVE Power will spend 1 billion euros to build a 28 GWh plant, Hungary's foreign minister said in May.

ITALY

Planned

- Scarmagno, Romano Canavese: Italvolt expects the 3.5-billion-euro plant to be operational by 2024, with an aimed capacity of 45 GWh.

- Terevola: FAAM expects its 570-million-euro plant to be operational by 2024, with targeted capacity of 8 GWh per year.
- Termoli: ACC will spend more than 2 billion euros to build the 40 GWh plant, set to open in 2026 and to reach full capacity in 2030, under its plan for three gigafactories.

LATVIA

Planned

- Riga: Anodox had said its 50-million-euro plant should be fully operational by 2022. Reuters was unable to immediately confirm its status.

NORWAY

Planned

- MO I RANA: FREYR expects its $1.7-billion plant to be fully operational by 2028, with an aimed capacity of 83 GWh.
- Arendal: Morrow expects the first of four expansion stages of its 470-million-euro plant to be operational by 2024, with an aimed capacity of 32 GWh.
- Haugaland: Beyonder expects its plant to be fully operational by 2024, with an aimed capacity of 10 GWh.
- Trondheim: Elinor invested 10 billion Norwegian crowns ($939.3 million) in a plant set to be operational by 2026, with targeted capacity of about 40 GWh by 2030.

POLAND

Operating

- Wroclaw: LG Chem's (051910.KS) plant started production in 2017, with a capacity of 100,000 batteries. It aims to reach a capacity of 115 GWh by 2025.

PORTUGAL

Planned

- Sines: China Aviation Lithium Battery Technology (CALB) expects its factory to start operating by end-2025 at 15 GWh capacity, which it may increase to 45 GWh in a second phase in 2028.

SERBIA

Planned

- Subotica: ElevenES expects its 1-billion-euro plant to be fully operational by 2027, with an aimed capacity of 48 GWh.
- N/A: InoBat plans to build a gigafactory with funding of 419 million euros from the government. It will be operational by 2025, with initial capacity of 4 GWh and aimed capacity of 32 GWh.

SLOVAKIA

Planned

- Bratislava: InoBat's 45 MWh pilot line will open later in 2023.

SPAIN

Planned

- Basque Country: BASQUEVOLT plans to invest more than 700 million euros for a plant, aiming to produce 10 GWh by 2027.
- Navalmoral De La Mata: Spain signed a deal in July 2022 with China's Envision to build a plant worth 2.5 billion euros, with planned capacity of 30 GWh.
- Sagunto: Volkswagen and partners said in 2022 they would invest 10 billion euros in a 40 GWh plant with production set to start by 2026.
- Valladolid: InoBat said in October 2022 it had signed a declaration of intent with the Spanish government to set up a 32 GWh factory worth 3 billion euros.

SWEDEN

Operating

- Skelleftea: Northvolt's factory has been operating since 2021 and aims to achieve a capacity of 40 GWh by 2025.
- Planned
- Borlange: Northvolt expects its plant to start production in 2025 and be fully operational by 2030, with a capacity of 150 GWh.
- Gothenburg: Northvolt spent 30 billion Swedish crowns ($2.8 billion) in a plant set to start production by 2025, with an aimed capacity of 50 GWh.

SWITZERLAND

Planned

- Frauenfeld: SCB expects the plant worth 775 million Swiss francs ($868 million) to be fully operational before 2030, with an aimed capacity of 7.6 GWh.

Brexit in relation to the automotive sector

The European automotive industry is highly integrated, with complex supply chains that stretch across the continent, and that benefits from border and tariff free access across the Single Market. Production often relies on 'just-in-time' delivery, which could have been severely disrupted by a no-deal Brexit[6]. Fortunately, the last-minute trade deal between the UK and the EU provided some relief by preventing the imposition of 10% tariffs on exports and imports that would have been catastrophic for the industry[7]. However, three of the world's largest carmakers are calling for a renegotiation of the Brexit deal because they are struggling to meet the TCA 's "rules of origin" which require 40% of an electric vehicle's parts by value to originate in the UK or EU in order for it to qualify for trade without tariffs.This threshold is due to rise to 45% next year and then in 2027 it will increase to 55% and the battery pack will have to come from the UK or EU.

The price of materials has soared especially for electric car batteries thus making carmakers unable to afford the planned UK and EU production minimums. One statement from Stellantis was that if the industry is unable to rely on sufficient UK or European batteries, they will be at a major disadvantage in the market[8]. In 2021, there was a notable increase in the prices of battery metals, which persisted toward the end of the year, particularly for lithium, nickel, and graphite. Original Equipment Manufacturers (OEMs) have been impacted by these surging raw material costs, which have influenced the market and led companies like Ford and BYD to commit to iron-based Lithium Iron Phosphate (LFP) technology due to strong lithium and nickel prices[9]

This means that their cars won't be able to compete with cheaper rival models from east Asia. Which in turn makes the UK lag behind EU countries in attracting battery.making capacity investments. This has been seen by a marked reduction in investment in the UK automotive industry post-Brexit, dropping from an average of £4 billion a year between 2012-2015 to only £1.1 billion between 2016-2019. This in turn makes the employment sector vulnerable too, for the automakers can choose to relocate to continental Europe if they can't comply with the local content requirements or lack the necessary battery capacity in the UK[10].

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6 https://www.acea.auto/fact/fact-sheet-brexit-and-the-auto-industry/#:~:text=The%20impact%20of%20a%20no,time%E2%80%99%20delivery

7 https://ukandeu.ac.uk/the-brexit-deal-and-uk-automotive/#:~:text=That%20a%20trade%20deal%20has,potentially%20%E2%80%98devastating%E2%80%99%20for%20the%20sector

8 https://www.theguardian.com/business/2023/may/17/why-is-a-leading-carmaker-urging-uk-to-overhaul-brexit-deal-stellantis

9 https://www.woodmac.com/news/opinion/EV-battery-supply-chain-2023-outlook/#:~:text=Last%20year%20also%20saw%20the,pressure%20at%20the%20year%E2%80%99s%20end

10 https://internationalfinance.com/transport/will-brexit-bring-doom-uk-automobile-sector/

Academic articles

Köllner, C. (2018). What Brexit Means for the Automotive Industry. ATZ worldwide, 120(3), 10-15.

Looking at the complex interrelationships when it comes to car manufacturing, those manufactured in the UK, 60% of its components are imported. In the case of Germany, the industry also is dependent on imports and its partnership with the UK. The researcher pointed out that without a good free trade agreement, Brexit will affect the close cooperation between the EU and Britain negatively. Britain is observed to be a significant contributor in the industry to the EU member states, especially Germany. The researcher analysed that with a hard Brexit, the sales and turnover would plummet and the car manufacturers would face major challenges.

The significance of the UK in the automotive industry is highlighted by it being the second-largest European market for passenger cars and light commercial vehicles. The production of motor vehicles and car parts in Germany is particularly closely intertwined with the UK, given that around 20% of all German automobile exports end up in the UK.

Holweg, M. (2019). Death by a thousand cuts: The strategic outlook for the UK automotive industry beyond Brexit. University of Oxford. Dostupné z.

By 2019, the UK car industry has already lost 9% of its volume due to Brexit. These disinvestments are likely to be irreversible. The researcher forecasted that production of manufacturers going forward would be down by 17% compared to pre-referendum levels. The researcher pointed out that the damage to manufacturing would be induced by the friction in the supply chain stemming from the Brexit agreement. The strategic danger is a continued loss of scale in UK automotive manufacturing that will lead to a slow "hollowing-out" of the skill and supply bases.

Yi, C. D. (2022). Economic impacts of UK's free trade agreements with Korea, Japan, and EU as a breakthrough of Brexit. The Manchester School, 90(5), 541-564.

With the UK-Korea-EU Free Trade Agreement (FTA) and the UK-Japan-EU FTA, the gross domestic products of the UK, Korea, Japan, and the EU will increase. The UK's exports to Korea and Japan, and Korea's exports to the UK, Japan, and the EU will increase in some manufacturing sectors, particularly the automotive sector. Likewise, Japan's manufacturing exports to the UK and the EU will grow. However, UK and Japanese exports to the EU and Korea, respectively, will decline in this sector. There will be positive welfare effects on the UK, Korea, and Japan, but negative welfare effects on the EU, China, and the rest of the world (ROW). While UK imports from Korea and Japan and Korean imports from the UK and the EU will both increase and have mixed trade creation and diversion effects, UK imports from the EU will decrease in the manufacturing sectors. Korea's imports from Japan will decline, but Japan's imports from the UK, Korea, and the EU will increase due to trade creation and diversion effects. China's imports from Korea and Japan will decline, whereas China's imports from the UK and the EU will increase. EU imports from Korea and Japan will increase due to trade creation and diversion effects, but EU imports from the UK, China, and the ROW will decline in most manufacturing sectors.

Bridge, G., & Faigen, E. (2023). Lithium, Brexit and Global Britain: onshoring battery production networks in the UK. The Extractive Industries and Society, 16, 101328.

As demand for electrical energy storage scales, production networks for lithium-ion battery manufacturing are being re-worked organisationally and geographically. The UK - like the US and EU - is seeking to onshore lithium-ion battery production and build a national battery supply chain. Governmental, industrial and research actors are engaged in securing battery mineral materials and developing battery manufacturing capacity, in the context of the country's exit from the EU and a perceived 'global battery race' in which geopolitical goals shape links with new and old partners.The researchers identified the primary global networks of lithium mining and refining, battery chemical production, technology development and finance in which the UK's battery manufacturing capacity are increasingly embedded. They foreground the role of the UK state, and how it has sought to assemble discrete capacities in automobile manufacturing, battery R&D, materials chemistry, minerals exploration, mining and green finance into a national battery sector. The researchers mobilised a Global Production Network (GPN) perspective to highlight the cross-border geographical and organisational structures through which onshoring is taking place. The GPN research extended to the role of the state by showing how the UK's growing lithium networks intersect with a plural and differentiated state accumulation project of green industrial transformation. The paper outlines the selective nature of this state accumulation project, highlights instances of coupling creation as the state seeks to strategically couple regional assets with firms in GPNs, and points to a convergence of industrial and innovation policy characteristic of the entrepreneurial state.

Bailey, D. (2020). Brexit, Batteries and Building Cars: Rules of Origin in the Auto Industry after Brexit.

The European Automobile Manufacturers' Association (ACEA) – the trade body that represents major EU auto makers – has pressed the EU to "reconsider its position" on the Rules of Origin that will be used to decide whether goods will qualify for tariff-free trade, and has warned that elements of the EU's current position are "not in the long term interests of the EU automotive industry". In particular, ACEA has requested that the EU reduces the percentage of components in a car that must be either European or British for the vehicle to qualify for the benefits of any EU-UK trade deal. The UK requested special arrangements for BEVs whereby 70% of parts could come from non UK and EU sources with only 30% 'local' content.

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