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Analysis of the Battery Manufacturing Value Chain

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List of Abbreviations

AV ČR	Czech Academy of Sciences
BESS	Battery Energy Storage Systems
BMS	Battery Management System
CTU	Czech Technical University in Prague
EU	European Union
EUR	Euro
GDP	Gross Domestic Product
IoT	Internet of Things
LFP cells	Lithium iron phosphate (LiFePO4) battery
NRIS3	National Research and Innovation Strategy
RES	Renewable Energy Sources
RIS3	Research and Innovation Strategy for Smart Specialisation
UPCE	University of Pardubice
USD	United States Dollar
R&D	Research and Development
RDI	Research, Development and Innovation
VŠCHT	University of Chemical Technology, Prague
VUT	Brno University of Technology
ZČU	University of West Bohemia in Plzeň

Introduction

Battery manufacturing is a key industry that plays a vital role in the modern economy and technological progress. In Czechia, this sector is becoming increasingly important, particularly in the context of growing demand for electric vehicles, renewable energy sources and other battery-dependent technologies. This analysis of the battery manufacturing value chain in Czechia focuses on five main areas: input and component manufacturing, battery production, battery testing, application (electromobility, BESS and other uses) and battery recycling.

Input and component manufacturing includes the extraction and processing of raw materials such as lithium, cobalt, nickel, manganese and graphite, which are essential for battery production. It also includes their subsequent processing into active materials and the manufacture of other battery components, such as polymer separators and electrolytes. There are several major companies and research institutions in Czechia involved in the development and production of these materials.

Battery production itself is another key step in the value chain. This process includes the manufacture of individual cells, which are subsequently assembled into battery modules and systems where they are used as a power source in a variety of applications, from smaller devices to electric vehicles to large-scale energy storage systems.

Battery testing is essential to ensure safety, reliability and performance. There are several specialised laboratories and test centres in Czechia focused on testing batteries and their components.

Battery recycling is the final, but equally important, step in the value chain. Efficient recycling enables the recovery of valuable materials and minimises environmental impact. Battery recycling technologies and infrastructure are developing in Czechia, contributing to the sustainability of the entire sector.

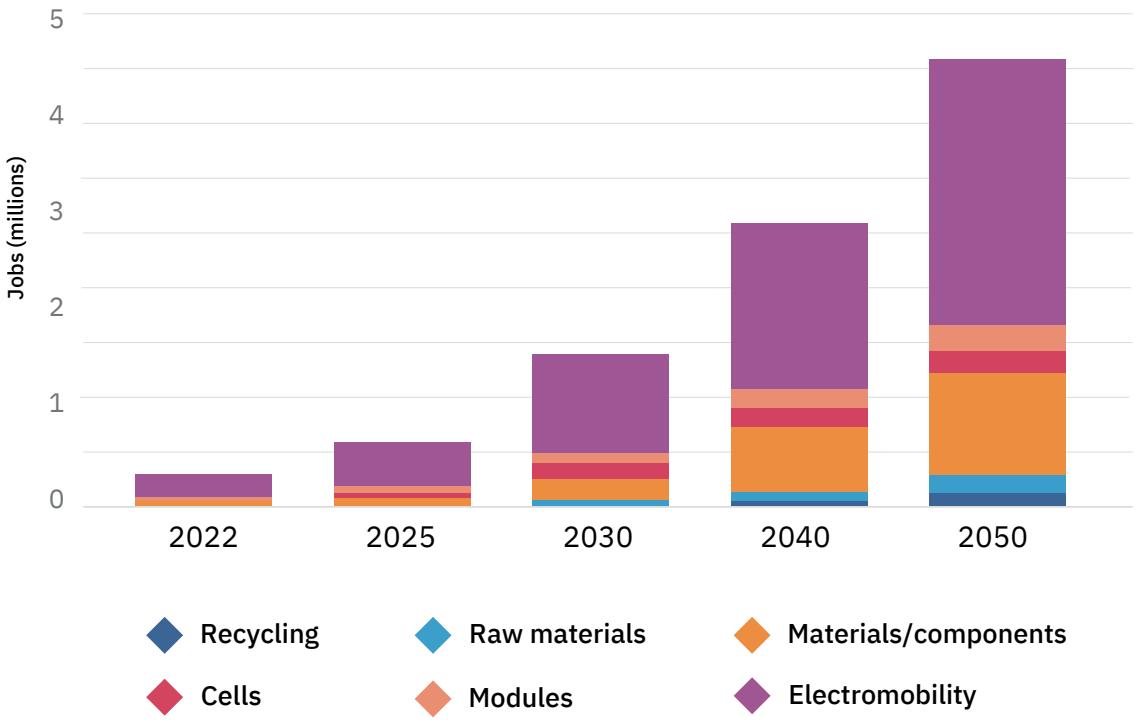
Overall, battery manufacturing in Czechia is a strategically important sector, one that contributes to economic growth, technological progress and sustainability. This topic is also one of the main pillars of the European industrial transformation, alongside the semiconductor industry. According to data from the European Centre for the Development of Vocational Training (Cedefop), over 2.4 million workers in the EU automotive sector will need to be reskilled by 2030. The development of the battery value chain could therefore provide jobs for these workers. At the same time, the development and long-term sustainability of the EU automotive industry are dependent on the supply of batteries. According to the European Battery Alliance, the EU should be able to cover around 70% of its estimated demand of 1,000 GWh from domestic production by 2030. According to the European Battery Alliance, the total production capacity of all gigafactories in the EU in 2023 was 167 GWh, having increased from almost zero since 2017. However, global production capacity in 2023 exceeded 900 GWh. The prospect of achieving at least 70% of the capacity needed for the EU market has recently been challenged by strong competition and pressure on new battery projects, particularly from China. As a result, there are growing efforts within the EU to secure as much of the battery materials supply chain as possible and to encourage material recovery through recycling. These efforts are reflected in the Critical Raw Materials Act adopted in 2024 and in the new EU Regulation on batteries and waste batteries. According to McKinsey, global battery production is expected to increase to 4,700 GWh by 2030, with the market to exceed USD 400 billion. The development of battery technologies and electromobility is also linked to the development of charging infrastructure. According to P3 and ChargeUp Europe, this sector employs approximately 80,000 people in around 3,500 companies in the EU, and the number of employees is expected to rise to approximately 162,000 by 2030. These figures are also consistent with data published by Fraunhofer ISI, which predicts that by 2030 the demand for battery experts will increase to more than 80,000 people in Germany alone and to around 200,000 people in the EU. At the same time, only around 90,000 battery experts will be available in the EU, so more training and reskilling will be needed. Across the entire battery-related value chain, the number of direct and indirect jobs within the EU will increase from approximately 250,000 in 2022 to 1.5 million in 2030, and is expected to grow to more than 4.5 million jobs by 2050, see Fig. 1. In Czechia, a study published by Deloitte in 2021 estimated that the construction of a gigafactory with a production capacity of 40 GWh in Czechia would create more than 6,000 jobs and more than 33,000 jobs in supplier companies. GDP would also increase by CZK 185.9 billion. An example is Poland, where the LG Energy Solution gigafactory was commissioned in 2017, gradually increasing its capacity and reaching a production capacity of 73 GWh in 2022. At the same time, exports of Li-ion batteries from Poland increased from EUR 0.21 billion in 2017 to EUR 8.24 billion in 2022. Exports of Li-ion batteries thus accounted for more than 2% of all Polish exports (Colaluce, 2024; Ptak, 2023; Polish Economic Institute, 2022).

This analysis focuses on the development opportunities for the battery-related value chain in Czechia, provides an overview of the individual stages of the value chain, and identifies key stakeholders, challenges and opportunities in this dynamically developing sector. The analysis was prepared with contributions from the Czech Battery Cluster.

The battery manufacturing value chain is closely linked to various specialisation domains under the RIS3 priorities.[1] The “Smart Settlements” domain focuses on the sustainable development of human settlements and reducing the adverse impacts of climate change. Battery manufacturing can play a key role here, as it enables the storage of energy from renewable sources, thus improving the energy efficiency of buildings and infrastructure. The production and use of batteries also support the sustainable management of natural resources and reduce dependence on fossil fuels. In addition, batteries can form part of smart infrastructure that connects different types of infrastructure systems with the natural environment.

[1] RIS3. (2022). *Overview of research and innovation specialisation domains.* https://www.ris3.cz/o-ris3/narodni-dimenze/priority/tematicke-vertikalni-prioritydomeny-specializace/prehled-domen-vyzkumne-a-inovacni-specializace

Figure 1: Number of Direct and Indirect Jobs Linked to the Battery Industry in the EU Across the Entire Value Chain



Source: Czech Battery Cluster 2025, authors' analysis

The "Green Transport" domain focuses on reducing the adverse environmental impact of transport through key technologies and applications. In this context, batteries are essential for electric vehicles and other low-emission means of transport, leading to lower transport emissions. Batteries also enable the storage of energy from renewable sources, increasing the energy efficiency of transport systems. The development and use of advanced materials in battery manufacturing can promote innovation in green transport, while recycling and the sustainable use of battery materials support long-term sustainability.

The "Advanced Materials, Technologies and Systems" domain supports the development of economic sectors and the production of state-of-the-art equipment and technological components. Battery manufacturing requires the development of new materials, including nanomaterials and composites, which can improve battery performance and lifetime. Advanced materials and technologies developed for battery manufacturing can also be used in other sectors such as engineering, energy and industrial chemistry. Research and development in energy efficiency and energy savings can contribute to the production of batteries with higher efficiency and lower costs.

The "Green Technologies and Bioeconomy" domain focuses on the sustainable management of natural resources, smart agriculture and forestry, and sustainable food production. Here, batteries can play a role in storing renewable energy, increasing energy efficiency and promoting the use of green technologies. The use of batteries in transport and industry can help reduce greenhouse gas emissions and improve environmental quality. In addition, the development of environmentally friendly production processes and the recycling of materials used in batteries support sustainability and reduce adverse environmental impacts.

Translated into specific battery value chains, the NRIS3 addresses batteries as follows: the value chain for the synthesis of materials for battery production is mentioned in "DS01KET02 Advanced Materials and Nanotechnologies" in the section New Materials for Transport; the battery modularisation value chain, which also includes thermal simulations of higher-level battery assemblies under development (battery modules and systems), is mentioned under the strategic topic "DS03VVI08 Electronics and Digital Technologies for Industry 4.0" using edge computing as an example; the electromobility value chain is covered in "*DS04KET03 Advanced Manufacturing Technologies"* from the perspective of R&D procedures for the design of vehicles with new powertrains for new energy carriers, such as batteries; the use of batteries in electromobility is also addressed in *"Strategic Topic DS04VVI01 Low-emission Mobility",* with an illustrative example of batteries as key vehicle components or from the perspective of vehicle energy systems and the possibility of bidirectional connection between an electric vehicle and the stationary grid; the value chain of battery reuse and the battery safety chain are addressed in "*DS04SHUV03 Conditions/Barriers to the Application of Innovative Technologies and Procedures",* with an illustrative reference to the legal aspects of using used electric-vehicle batteries in the energy sector. Battery storage systems (BESS) are addressed under the mission objective card of *Decentralization*, which mentions, among the RDI topics in the Local production and hardware for grid stability section, the need for municipalities to develop local storage, where batteries and thermal storage are to increase the stability and self-sufficiency of local energy networks.

Methodology

For the purpose of the analysis, the value chain was divided into eight segments, which are specified in more detail in the following chapters. The list of companies operating in this area was obtained through the Czech Battery Cluster, which divides the value chain into the following segments and classifies companies into the following categories:

- Extraction of basic materials
- Processing, production and development of materials
- Production and development of batteries
- Production and development of BMS modules (battery management systems) and battery energy storage
- Electromobility (including charging infrastructure)
- Safety and storage
- Battery second life
- Recycling

Companies in the battery manufacturing value chain are present in all fourteen regions of Czechia. The highest number of companies are based in Prague, while the remaining thirteen regions are evenly represented (Figure 2). These companies are also evenly distributed in terms of size. Companies involved in battery manufacturing are present across all size categories (Figure 2).

Figure 2: Number of Companies by Region and Size Category

Region	Number of companies
City of Prague	17
South Bohemian Region	1
South Moravian Region	4
Karlovy Vary Region	1
Vysočina Region	2
Hradec Králové Region	3
Liberec Region	2
Moravian-Silesian Region	4
Olomouc Region	3
Pardubice Region	3
Plzeň Region	6
Central Bohemian Region	5
Ústí nad Labem Region	3
Zlín Region	5

Company size category	Number of companies
1–5 employees	6
6–9 employees	3
10–19 employees	7
20–24 employees	1
25–49 employees	8
50–99 employees	5
100–199 employees	7
200–249 employees	2
250–499 employees	4
500–999 employees	3
1000–1499 employees	2
1500–1999 employees	1
2500–2999 employees	1
3000–3999 employees	2
10,000 or more employees	1

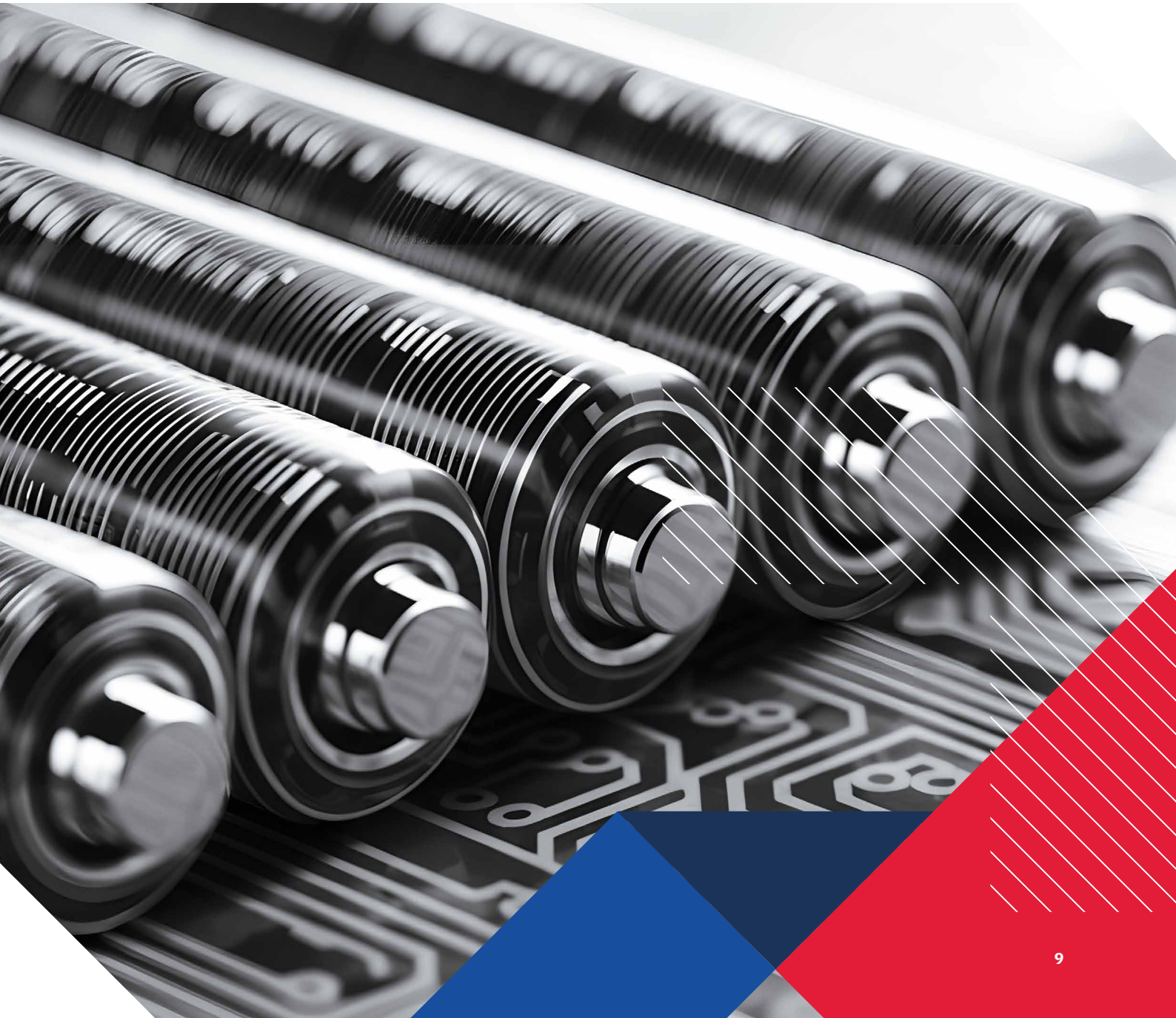
Source: Merk database 2025, CzechInvest 2025, authors' analysis

Figure 3 shows the number of companies identified and assigned to segments of the value chain.

Figure 3: Number of Companies in the Battery Manufacturing Value Chain

Value chain segment	Number of companies
Extraction of basic materials	8
Processing, production and development of materials	9
Production and development of batteries	10
Production and development of BMS modules (battery management systems)	23
Electromobility (including charging infrastructure)	40
Safety and storage	10
Recycling	6
Battery second life	12

Source: Czech Battery Cluster 2025



Battery Manufacturing Value Chain

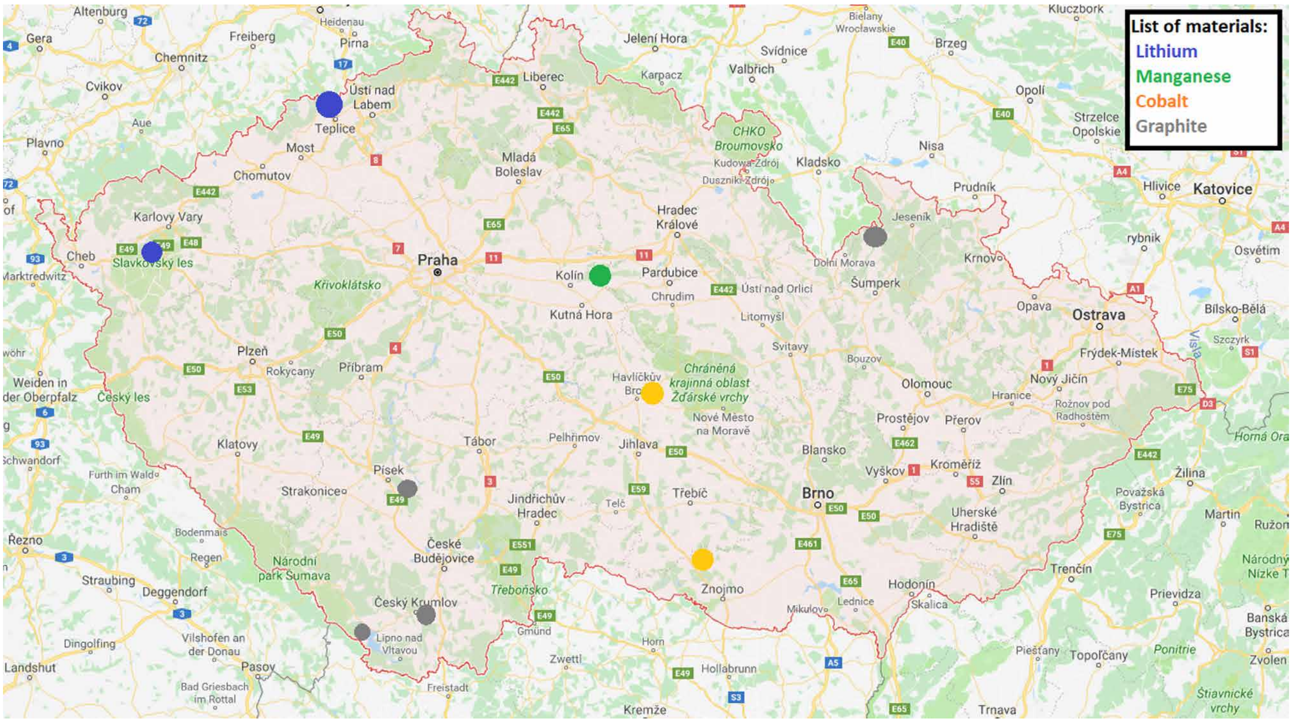
Extraction of basic materials

Czechia has significant resources of lithium and manganese, which are essential for the production of lithium-ion (Li-ion) batteries. Raw materials such as cobalt and graphite are also found in Czechia. These raw materials are mined and processed into precursor forms (carbonates, hydroxides) suitable for the synthesis of commercial Li-ion batteries. These precursors must be synthesised at high purity, which is essential for their use in battery technologies. Czechia therefore has unique starting conditions for the development of the value chain in this sector. At the same time, all these materials are listed as strategic under the EU Critical Raw Materials Act due to their high dependence on China and their necessity for Li-ion battery production.

One of the main projects in this area is lithium extraction at the Cínovec site, which contains one of the largest lithium deposits in Europe. This project is led by Geomet, a subsidiary of ČEZ. Lithium extraction at Cínovec has the potential to reduce Europe's dependence on imports of this key material from abroad and to support the development of the local battery industry.

Another important project is manganese extraction in Chvaletice, carried out by Mangan Chvaletice. This project focuses on recycling old mining waste that contains high concentrations of manganese. Extracting and processing these materials contributes to sustainability and the efficient use of resources. Overall, the extraction of basic materials for battery production in Czechia is strategically important and has the potential to support the development of the entire sector.

Figure 4: Map of Czechia Showing the Distribution of Selected Materials Suitable for the Production of Li-ion Batteries



Source: Czech Battery Cluster 2024

Processing, production and development of materials

Czechia has a strong industrial base and research capabilities that enable the efficient processing of raw materials and production of high quality battery materials. These materials can be used for the manufacture of new Li-ion batteries or newer types of batteries. This includes components such as cathodes, anodes, electrolytes, separators, etc. Companies such as Bochemie, Precheza, Draslovka Kolín and Central Glass are involved in or planning the production of electrolytes, electrode materials and other components required for Li-ion batteries or newer battery types.

The development of new materials and technologies is another important aspect of this sector. Czech universities and research centres such as Brno University of Technology, the University of Chemistry and Technology in Prague, the Czech Academy of Sciences and the University of Pardubice are working with industrial partners to research and develop innovative solutions that can improve battery performance and service life. This collaboration includes the development of new materials that can be used in future battery systems.

Overall, the processing, production and development of battery materials in Czechia are important. Investments in research and development, the modernisation of production capacities, support for cooperation between academia and industry, and support for start-ups are key to maintaining competitiveness and technological progress in this dynamically developing sector. At the same time, the training and recruitment of new workers in this area are essential for further development, including within industry.

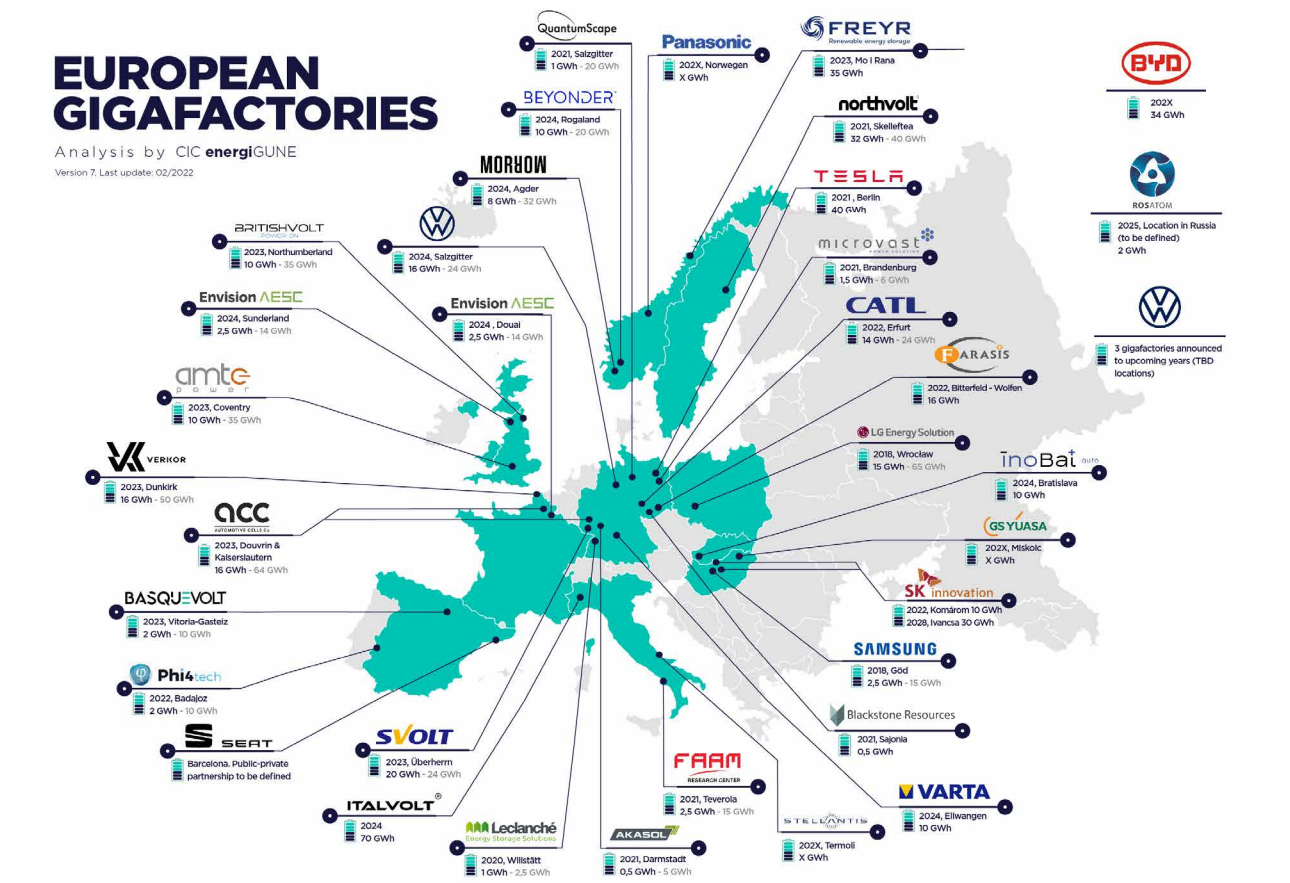
Production and development of batteries

The production and development of batteries is one of the EU's main objectives, and a number of projects have been announced or launched in recent years. Czechia is currently lagging behind this trend, even though, given its highly developed automotive industry, Li-ion battery production is crucial for the further development and retention of this industry in Czechia as it gradually transitions to e-mobility. In Czechia, there was only one company commercially producing and selling Li-ion batteries based on LFP cathodes, with a production capacity of up to 10 MWh per year. However, this company suspended operations at the end of 2024 due to a sharp drop in the price of batteries from China, where the price of input components supplied from China was the same as the price of batteries supplied to the Czech market from China. In the context of alternative systems, the company PinFlow Battery, a spin-off developing vanadium redox batteries, is developing successfully in Czechia. Due to their parameters, these batteries are suitable for stationary applications such as battery energy storage for industrial systems. This company seeks not only to manufacture high-quality vanadium redox batteries, but also invests in research and development to improve their performance and service life.

Cooperation between universities and industrial partners is another important aspect of battery development in Czechia. Brno University of Technology, the Czech Technical University in Prague, the Technical University of Liberec and the University of West Bohemia in Pilsen play a key role in researching new materials and technologies that can improve battery efficiency and safety. They also focus on testing commercial battery types and verifying their properties under various operating conditions. This collaboration includes not only academic research, but also practical testing and implementation of innovations in real-world conditions. There are also several private entities in Czechia that are able to test cells, modules and batteries, such as TIYO.

Battery production and development are strategically important in Czechia and have the potential to support economic growth and technological progress. Supporting the creation of battery production, innovation and R&D activities is desirable in order to make Czechia more self-sufficient and reduce its dependence on battery imports from Asian countries. At the same time, there is a major shortage of workers trained in battery production and testing across the EU, so one of the key challenges to creating and maintaining this operational capacity is to train or reskill a sufficient number of workers.

Figure 5: Map of Gigafactory Projects (Announced, Planned and Operational) in the EU



Source: Czech Battery Cluster 2024

Production and development of BMS modules (battery management systems)

The production of modules and BMS (Battery Management Systems) for ESS and other applications involves assembling battery systems from individual cells, including control electronics and thermal management. These assemblies are designed for various applications outside the automotive sector, with the most important area being energy storage. There are a number of companies in Czechia active in this area, but not all of them have their own know-how and often use systems imported from Asia. One of the main challenges in this area is integrating advanced technologies such as artificial intelligence and the Internet of Things (IoT) into BMS modules. These technologies enable better prediction and prevention of potential problems, increasing the overall reliability and lifetime of battery systems. BMS modules are essential for the proper control and monitoring of battery systems, including charge and discharge control, thermal management and ensuring battery safety. BESS (Battery Energy Storage Systems) are then essential for the further development of renewable energy sources (RES), as they make it possible to bridge the drops in output from sources such as photovoltaic plants or wind farms when the sun is not shining or the wind is not blowing. Czechia has a great opportunity to become an energy storage hub, particularly for the German economy, which has a large number of installed RES in the north of the country and frequent significant surpluses of electricity produced in this way. The Czech transmission system is capable of transferring and storing these surpluses at times when prices are low or negative, with the possibility of resale during peak demand. BESS are also important, and will remain important, in the residential sector, where they will help store local RES at the level of individual households, apartment buildings, and even islanded municipalities.

Notable companies include AERS, which focuses on battery storage for residential and industrial applications. Agile Europe provides battery storage for industry and has customers at home and abroad. EVC Group manufactures custom industrial battery modules and battery storage systems with its own control systems. Other manufacturers of battery storage systems include ABB, which focuses on markets outside Czechia, and Siemens. This area also includes companies like BatteryCheck, which focuses on mathematical modelling and simulations used to predict the lifetime of battery systems. A separate area is battery testing, which is carried out both by universities and some companies in Czechia.

Electromobility (including charging infrastructure)

Electromobility in Czechia is on the rise as a result of growing interest in sustainable transport and efforts to reduce greenhouse gas emissions. According to AutoSAP, in 2024 a record number of passenger cars were produced, totalling 1.453 million, by brands such as ŠKODA Auto, Hyundai and Toyota. Battery-powered vehicles accounted for 7.8% of production, with more than 113,000 fully electric vehicles and nearly 38,000 plug-in hybrid vehicles produced. At the same time, almost 4,500 buses were produced, including 245 battery buses, as well as more than 1,500 trucks and other means of transport, such as trams and trains (SOR Libchavy, Škoda Transportation, Tatra). All these sectors will need to be transformed to zero-emission transport in the coming years. The production of battery packs for these applications is therefore a very important industrial area linked to the transition to e-mobility. Major car manufacturers handle this in-house, while some manufacturers of other means of transport, such as buses, vans or trains, outsource the production of these components to specialist companies such as EVC Group, which supplies assemblies designed specifically for the relevant application.

Charging infrastructure is a key element in supporting electromobility. In Czechia, the network of charging stations needs to be significantly expanded to ensure availability and encourage greater user interest in electric vehicles. State support for charging infrastructure and funding for development are essential for the successful implementation of electromobility. In addition, it is important to communicate with companies supplying the automotive industry in order to identify options for transforming their operations into new sectors.

In the future, other transport sectors will also need to be electrified, including aviation and shipping, as well as heavy machinery. There are a number of companies in Czechia that focus on the development and production of electric vehicles, such as Zebra (small trucks), Tatra, Pure Flight, Evektor and Zuri (aviation). At the same time, battery systems are also essential for satellites and probes, a sector that has seen significant development in Czechia in recent years.

Safety and storage

Proper storage is essential to ensure long battery life and safe operation. These measures include monitoring temperature, humidity and other environmental factors affecting battery performance and safety. The main issues associated with battery storage include the risk of fire or explosion caused by overheating or mechanical damage. Unsuitable storage conditions can also lead to cell degradation and a shorter service life in subsequent applications. It is therefore essential that batteries are stored in an environment that minimises these risks, including the use of special storage containers and systems for monitoring battery condition. There are several companies and research institutions in Czechia specialising in the development and implementation of safety measures for battery storage, including storage containers and systems used to detect critical conditions, as well as fire suppression systems. Equally important is safe transport (in road transport, this involves ADR legislation), which is linked to an ever-evolving range of protection requirements both in terms of the transported materials and the safety of workers and the surrounding area. Planning and the successful implementation of transport, particularly of damaged batteries, significantly increases costs (packaging materials, driver training, fire suppression equipment). In addition, there are continuing concerns about safety and increasing restrictions on international transport. The industry for passive and active battery safety elements is a separate component and sector. This applies not only at the point of use, but is present from battery production through to recycling. Passive elements include the manufacture and use of batteries in accordance with experience and the legal framework so as to prevent hazardous situations. Active safety elements include cooling and fire suppression systems that reduce the extent of damage if risk events occur. In both areas, companies operate in Czechia, including developers and manufacturers of industrial cooling and fire suppression systems (Glaspo Trade, Ases Group), as

well as companies active in passive safety, such as the integrator firms and testing institutes mentioned above). Knowledge and the development of battery safety and proper handling are also essential in terms of the broader social acceptance of Li-ion cell technology and applications, as demonstrated by the heated debate over excessive prevention measures in relation to installing charging points for electromobility.

Battery second life

Battery second life is a concept focused on the reuse of batteries after the end of their primary life cycle. After the end of their service life in the original device, such as electric vehicles, batteries may still be able to retain a significant proportion of their original capacity, which can be used in other applications. This approach not only extends battery life, but also contributes to sustainability and reduces the environmental impact associated with the production of new batteries.

One of the main applications for second-life batteries is their use as backup power sources or in energy storage. For example, electric-vehicle batteries can be integrated into home or commercial energy storage systems, where they can help balance fluctuations in energy supply from renewable sources such as solar panels or wind turbines.

Optimisation for second-life use involves not only technical modifications and testing, but also the development of software and hardware solutions that enable the safe and efficient use of these batteries in new applications. This approach requires collaboration between battery manufacturers, research institutions and industrial partners to develop and implement innovative solutions that maximise battery value and service life.

In Czechia, companies in this area include battery storage manufacturers and energy companies (ČEZ, PRE, E.ON), as well as AERS, which tests pilot systems in cooperation with Škoda Auto.

Recycling

Battery recycling has several key benefits that are essential for protecting the environment, saving raw materials and promoting sustainability, with a positive impact on the economy, energy efficiency and the overall environmental footprint. The European Union also requires that an increasing percentage of new batteries be produced from recycled materials.

The first benefit lies in environmental protection. Battery recycling reduces the amount of hazardous waste that would otherwise end up in landfills or in the environment, and prevents the leakage of toxic substances such as heavy metals into soil and water, contributing to a healthier and safer ecosystem.

Another important aspect is saving raw materials. Recycling enables the reuse of rare and precious materials such as lithium, cobalt and nickel and reduces the need to mine new raw materials. This conserves natural resources and the energy that would otherwise be needed to extract and process these materials. At the same time, it can help recover elements that are mostly unavailable in the EU from primary sources.

The economic benefits of battery recycling include reducing the cost of manufacturing new batteries through the reuse of recycled materials, as well as creating jobs in the recycling and waste treatment sectors. Recycling and the proper end-of-life processing of batteries are key to minimising environmental impacts. The first step is the collection and sorting of used batteries by type and chemical composition, which is important to ensure an efficient and safe recycling process. Batteries are then dismantled into individual components such as electrodes, electrolytes and casing materials, which are processed separately to recover valuable materials.

The recovered materials, such as metals and chemicals, are recycled and reused in the manufacture of new batteries using chemical and physical methods. Battery recycling requires strict safety precautions due to the risk of fire and the leakage of toxic substances. Ensuring worker safety and environmental protection is a priority.

Ultimately, battery recycling supports the circular economy, a model in which materials and products are kept in circulation for as long as possible. In terms of energy efficiency, recycling batteries is less demanding than extracting and processing new raw materials and makes energy resources more sustainable. In this way, we save energy and reduce the ecological footprint associated with the production of new batteries. Recycling also takes place not only at the end of battery life, but also during the battery manufacturing process, as manufacturing generates production waste, non-conforming battery units and ordinary manufacturing waste. This waste is particularly significant during ramp-up as production processes are being set up, and it can even be said that without recycling arrangements for this production waste, a battery manufacturing plant cannot be launched at all.

In Czechia, companies such as Kovohutě Příbram recycle lead-acid batteries and operate a prototype line for recycling Li-ion batteries. Other important entities include Dekonta, which is preparing a prototype line for recycling Li-ion batteries, and EcoBat and REMA, which focus on collective battery collection within Czechia.

Strengths and Weaknesses

The Czech battery manufacturing value chain has several strengths and weaknesses that affect its competitiveness and sustainability.

Strengths:

- Geographical location and availability of raw materials: Czechia is strategically located in the heart of Europe and has resources of key raw materials such as lithium and manganese, which are essential for battery production.
- Strong industrial base: Czechia has developed industrial infrastructure and know-how in materials manufacturing and processing, which facilitates the integration of new technologies into existing production processes.
- Research and development: Czech universities and research institutions, such as the University of Chemistry and Technology and Brno University of Technology, are actively involved in the research and development of new battery materials and technologies. This collaboration between academia and industry promotes innovation and technological progress.

Weaknesses:

- Lack of human resources: the Czech battery industry faces a shortage of skilled workers, particularly in research and development. This shortage may limit the ability to respond quickly to technological change and innovation.
- Insufficient infrastructure: the infrastructure for battery production and recycling is not sufficiently developed, which may slow the growth of the sector. Investment is needed to modernise and expand production capacity and recycling facilities.
- Dependence on foreign technologies: the Czech battery industry is largely dependent on technologies and know-how from abroad. This dependence may limit the ability of domestic firms to compete in the global market and reduce their innovation potential.

These strengths and weaknesses are key factors affecting the development and competitiveness of the Czech battery manufacturing value chain. Further development requires focusing on strengthening strengths and overcoming weaknesses through investment, education and support for innovation.

Challenges

The development of the battery-related value chain in Czechia faces several major challenges that must be addressed in order for the sector to continue to develop and become competitive in the global market.

One of the main challenges is the **production and recycling of lithium batteries**. This process has a significant environmental impact, so it is essential to develop sustainable methods of production and recycling. A combination of factors, such as the global boom in the extraction of raw materials for Li-ion cells and current economic pressure from China, which not only has some deposits of battery-critical raw materials, but also most of the processing industry for these materials, has led to a sharp drop in their prices over the past few years. This has a direct impact on the value of the material purchased in used batteries, meaning that in particular LFP cells, containing few so-called target metals, are no longer worth recycling. However, processing not only LFP cells is very important for all the above reasons. To ensure that battery cells do not become an environmental burden and that the materials they contain are captured, it will be necessary to financially incentivise their collection beyond their residual value, as is known for other strategic items. This instrument must be decided in the short term, as the first large quantities of batteries for recycling, particularly from electric vehicles, are expected by 2030, while the process of building and ramping up recycling technologies takes many years.

The second challenge is the **development of new technologies and innovations**. Research and development in battery technologies must be intensified in order to achieve longer driving ranges for electric vehicles on a single charge, and potentially to enable other types of mobility requiring high battery energy density, reduce battery costs and improve sustainability. At the same time, the production of conventional Li-ion batteries will enable the development of new advanced battery types.

The third challenge is the **development of education in the fields linked to the battery industry**. Across the EU, there is a severe shortage of people with the necessary skills in battery technology, and the availability of skilled workers is essential for the development of this industry and achieving independence from foreign suppliers.

Another challenge is the **extraction and processing of raw materials**. Czechia has lithium and manganese resources that are crucial for battery production. However, methods need to be developed to extract these materials and produce them at battery-grade purity. It is also necessary to accelerate and support the creation of new mining and processing capacities, including in connection with the EU Raw Materials Act.

Another challenge is **cooperation between universities and companies**. For the successful development of the battery industry, it is essential to connect academic research with industrial practice and support the creation of start-ups that can deliver innovative solutions.

The final challenge, which is indirectly related to the development of battery manufacturing, is to **ensure a well-developed charging station infrastructure.** To support electromobility, it is crucial to have a sufficient charging network that enables convenient and fast charging of electric vehicles.

Conclusion

These challenges represent key areas that must be addressed in order for battery manufacturing in Czechia to further develop and contribute to sustainable development and technological progress.

Overall, it can be said that there are entities operating in Czechia across all parts of the battery value chain. Developing and connecting these parts could lead to a significant multiplier effect. A questionnaire survey conducted by the Czech Battery Cluster showed that there is a major opportunity to integrate companies operating in sectors threatened by industrial transformation into new areas of the battery value chain. Czechia has an advantage due to its local raw material resources. It will be essential to support the training of current workers as well as education for new students in the fields required for new areas of industry.

Within the National RIS3 Strategy, the individual stages of the battery manufacturing value chain are distributed across multiple domains of specialisation. Research and innovation topics comprising selected phases of battery production are therefore represented across different specialisation domains. Given the existence of significant raw material resources for Li-ion battery technologies, a strong historical tradition in chemical R&D and production, as well as a strong electrical or automotive industry, no particular sector can currently be prioritised. Instead, a schematic phasing of support for the development of individual sectors can be recommended, in line with the time required for their establishment in our economy, so that the battery economy can, at a certain point, be established as a self-contained discipline, which would bring the greatest synergies and support the emergence of a high value-added industry.

Czechia has the potential to become a major player in the global battery manufacturing market, but it must overcome several key challenges. These include the sustainable production and recycling of lithium batteries, intensive research and development of new technologies, efficient extraction and processing of raw materials, support for the development of energy storage in parallel with the development of renewable energy sources, and improved cooperation between universities and industry.

Emphasising solutions to these challenges could significantly strengthen battery manufacturing in Czechia and contribute to sustainable development and technological progress. Developing and connecting all parts of the battery value chain could lead to a multiplier effect that would boost the overall economy and innovation in the country.

There is a major opportunity to integrate companies threatened by industrial transformation into emerging areas of the battery value chain. Given the local raw material resources and the need to train workers and educate students in the fields required for this industry, Czechia is well positioned to succeed. It is essential to continue to support education and research, as well as the development of industrial and scientific cooperation, to enable Czechia to become a leader in battery technologies.

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