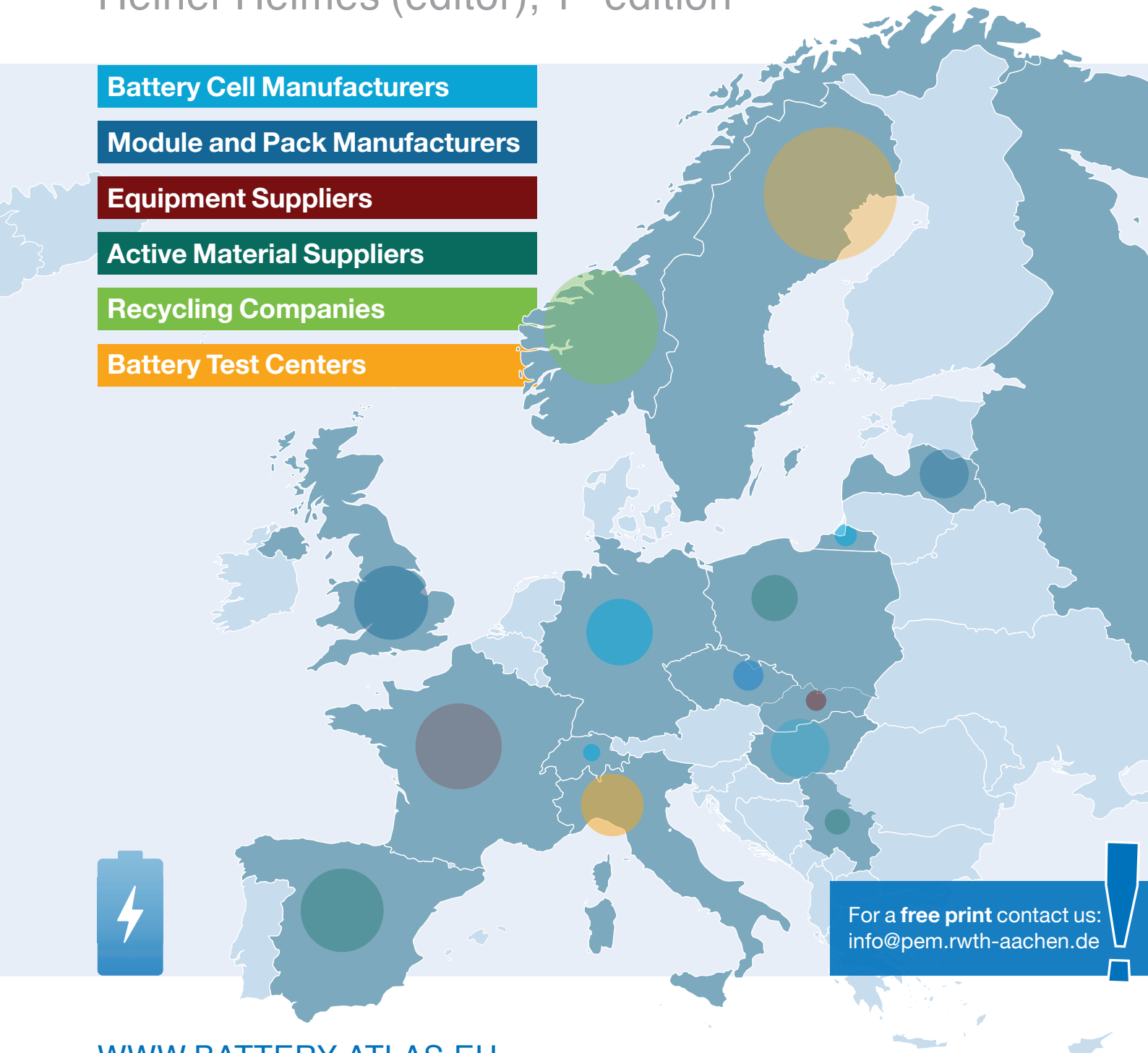
BATTERY ATLAS 2022

SHAPING THE EUROPEAN LITHIUM-ION BATTERY INDUSTRY

Heiner Heimes (editor), 1st edition



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PREFACE

INITIAL POSITION

In 2019, John Goodenough, M. Stanley Whittingham and Akira Yoshino were honored with the Nobel Prize in Chemistry for their work on lithium-ion batteries. These scientists laid the foundation for a “rechargeable world.” Since the development of the operating principle of the lithium-ion battery, both the product and the associated production technology have evolved significantly. In the beginning, lithium-ion battery cells were only manufactured in small formats, which were mainly used in the “consumer electronics” sector. In the past years, further development of the lithium-ion battery has made batteries with larger capacities possible. Due to this further development, the current change from conventional powertrains to electric mobility is taking place at a high speed.

Whereas at the beginning of this change the battery cell was often still regarded as a purchased part, this view has changed fundamentally in the last years. Currently, most vehicle manufacturers see the lithium-ion battery cell as a core component of electric mobility. This is why success in the aforementioned industry will depend on the mastery of the battery cell.

CHALLENGES

Mastering the lithium-ion battery is challenging because a variety of different competencies is required and the lithium-ion battery industry scene is developing at a very rapid pace. As in the past years Europe has been focussing especially on reducing the knowledge gap with the Asian region, it is now increasingly important to successfully meet all the challenges arising from the ramp-up of various battery cell series productions. These challenges include amongst others:

- securing the supply chains of active and passive components of battery cells
- short-term supply of production equipment to set up cell-manufacturing operations and to expand module/pack manufacturing
- access to testing facilities for battery cells and systems
- advance planning of comprehensive dismantling and recycling concepts
- near-term training of specialists and managers in the topic of the lithium-ion battery

These challenges are further complicated by the development of those players in the lithium-ion battery industry, by the constant launch of new companies, and by the fact that additional clusters and alliances are created.

OBJECTIVES

This Battery Atlas aims to meet the challenges described above by providing as detailed as possible an insight into the individual topics of the lithium-ion battery. For this purpose, the Battery Atlas shows the competence carriers and classifies them on the European map. It is important to mention that the Battery Atlas cannot claim to be exhaustive, but does provide an overview that is as comprehensive as possible.

Dear readers, I would like to invite you to use this Battery Atlas to get an overview of the European battery industry. I sincerely hope that this information will help you to orientate yourself in the market and to make the right decisions in the interest of a strong European battery industry.

Let us continue to work towards positioning Europe strongly in the field of lithium-ion batteries for making a great contribution to all industries that depend on this core component.

I also warmly invite you to contribute your experiences. The Battery Atlas is planned as a continuous publication, in which additions and completions are always welcome. Therefore, please do not hesitate to contact us with questions and comments. We will be pleased to be at your disposal.

Best regards,

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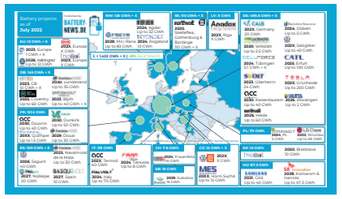
Are you interested in an exchange of ideas? Please feel free to contact us!

INTRODUCTION

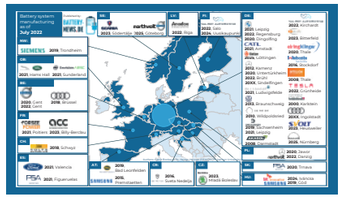
In this Battery Atlas, six areas of consideration are addressed. It starts to outline the situation of the battery cell manufacturers. While in the past many companies decided not to manufacture their own battery cells, from a European perspective it is well known that this situation has changed completely. Currently, many companies see the battery cell as a core component whose production has to be mastered. The battery cell manufacturers also play a key role. It is thanks to them that other industrial sectors such as mechanical and plant engineering (see figure) are establishing themselves in Europe. Mechanical and plant engineering in particular relies on being able to provide appropriate references. These can be built up much more easily if the customers (battery cell manufacturers) are also located in Europe so that the advantages rising from local proximity can be used.

It is also significant that active material suppliers are currently establishing themselves in Europe. These companies have recognized that cell production depends on stable supply chains with active material for anode and cathode. Stability in these supply chains cannot be guaranteed by European locations, but it can be significantly increased. It should also be mentioned that, in addition to active materials, the supply of inactive components such as separators or cell housings is of great importance too. Currently, many recycling companies are being established in Europe. With these companies, it may be possible to establish closed-loop approaches in Europe in the medium term. Companies are looking forward to achieve high recovery rates of materials with efficient recycling processes.

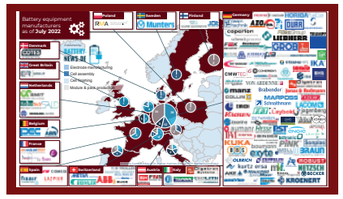
Battery Cell Manufacturers



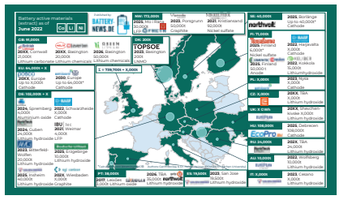
Module and Pack Manufacturers



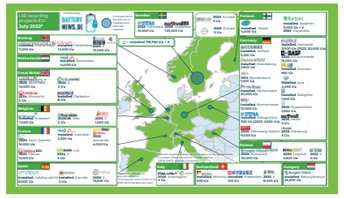
Equipment Suppliers



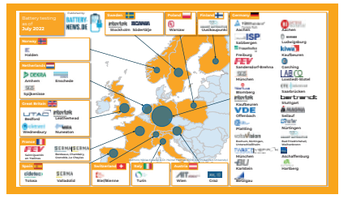
Active Material Suppliers



Recycling Companies



Battery Test Centers

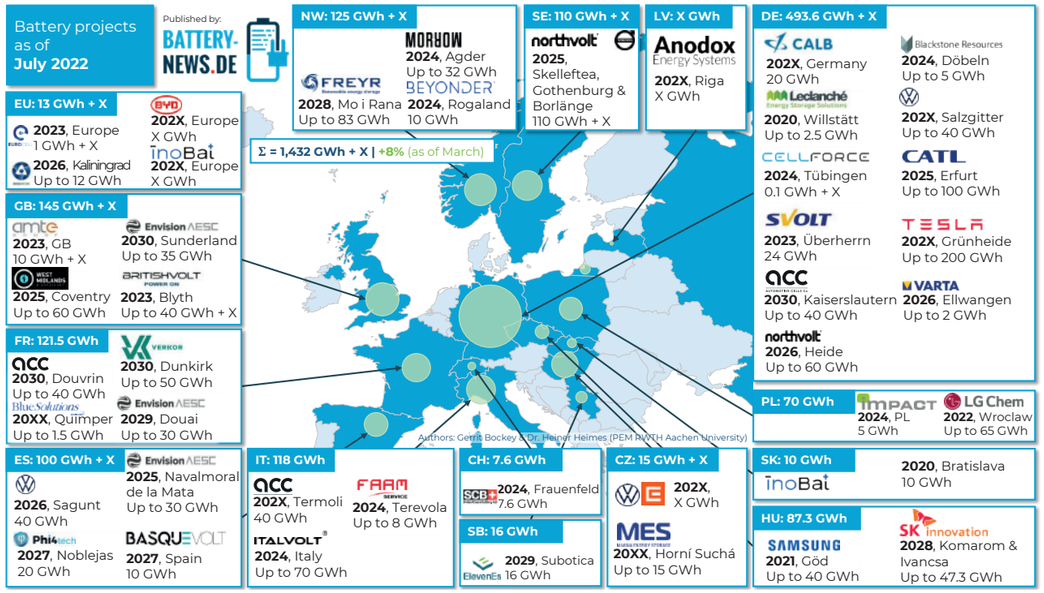


The module and pack manufacturers can benefit from local proximity too. This applies in particular to companies that do not have their own cell production facilities and purchase battery cells to manufacture battery modules. For these companies, supply safety is increased by European cell production. It will be interesting to see whether in the future every cell manufacturer also integrates forward to become a module and pack manufacturer.

Finally, this Battery Atlas focuses on battery test centers. After development, every lithium-ion battery has to pass various acceptance and performance tests before it is approved. As many companies are currently developing batteries at the same time, this results in a very high testing effort. Often, the test requirements exceed the test capacities available on the market. The map of test centers is intended to contribute to the best possible estimation of available test capacities.

The six maps mentioned are part of the present Battery Atlas and can help to answer different questions related to the European battery industry.

BATTERY CELL MANUFACTURERS



Source: www.battery-atlas.eu; abstract, no claim of completeness

INITIAL POSITION

Until recently, Europe has not played a major role as a production location for battery cells – but technical innovation and stable as well as promoting political framework conditions are making Europe more and more attractive as a new market place for battery production. Due to the importance of the battery cell along the process chain of an electric vehicle and Europe's OEM density, Europe will become the next hotspot. In order to meet the increasing demand for battery cells in the automotive sector alone, 900 GWh of battery capacity[1] could be needed in 2030 in the automotive sector.

Therefore, around 40 battery cell production factories are being planned or are already under construction. The planned activities are spread throughout Europe. In addition to European manufacturers, manufacturers from Asia and America also want to help shape the battery world in Europe. Compared to the Asian cell manufacturing companies, who mostly concentrate on the production of cells, the European market sees many collaborations and joint ventures between large car manufacturers and cell producers. In addition, there are new start-ups from Europe. From Asia, it is mainly cell manufacturers already established at home that are entering the European market.

The goal of those newly planned battery cell production factories is to decrease further production costs and therefore the cell costs to improve the competition of the electric vehicle against the internal combustion engine. Important factors are the scrap rate reduction throughout the process, the processing improvement of higher energy material (e.g. nickel-rich cathode material), and the reduction of CO_2 emission within the production process. It is already becoming evident that a characteristic of the European factories will be a high degree of digitization to tackle the addressed goal and to improve the production process.

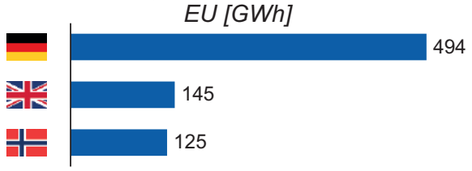
But those planning activities are facing also some challenges during the planning and ramp-up of the production factories. The main challenges regarding building up those battery cell production factories in Europe are the following topics:

- Limited availability of production technologies for a gigafactory
- EU environmental standards to be met, including the use of low-carbon power sources and sustainable production standards
- Raw material supply on the long term in Europe

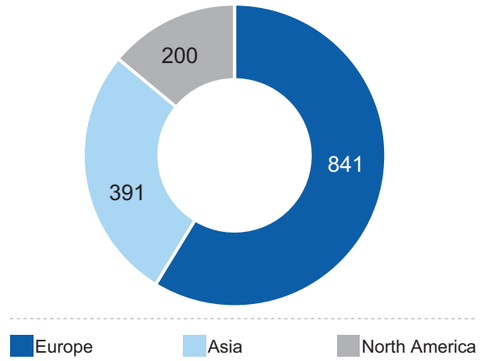
1 www.handelsblatt.com/unternehmen/nachhaltigkeit/elektromobilitaet-europa-droht-eine-batterie-blase/27748868.html?ticket=ST-2064609-P4bVgujytMjMoh6fqdng-cas01.example.org

Growth rate of European battery production capacity [GWh]

Top 3 battery production countries in the EU [GWh]



Origin of company to build up battery production factories in the EU (size in GWh)



ANALYSIS

Compared to 2020 with 25 GWh production volume per year, an increase to approximately. 1,300 GWh is expected to be realized in Europe in 2030. Therefore the production capacity is increasing by a factor of 50 due to the planned activities in Europe.
It can be said that the majority of the planned battery cell capacities will be covered by European players. European projects account for around 725 GWh of the planned activities. In comparison, Asian cell manufacturing companies are planning to install 368 GWh and Americans 200 GWh. Compared to the other areas of origin, Asia and America, the European cell manufacturing companies are planning overall smaller production projects in relation to the total capacity to be produced. The planning projects of the Asian and American cell manufacturing companies are characterized by fewer but larger planning projects. Approximately 25 of the 40 planning projects in Europe are attributable to European, nine to Asian and one to American players.

The top three countries where battery cell production factories are being built are Germany with 462 GWh, followed by the UK with 135 GWh and Norway with 125 GWh. Other activities are planned in Italy, France, Hungary, Spain, Poland, Serbia and Slovakia.

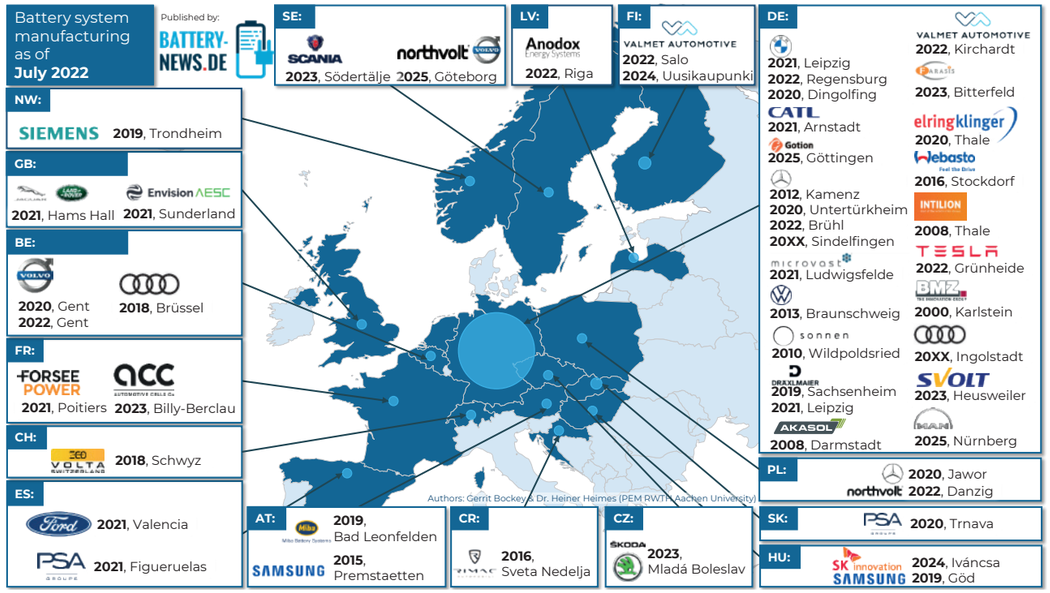
OUTLOOK

Europe is currently in transition on its way to becoming a battery cell production hotspot. In addition to the cell manufacturers and joint ventures already existing in the Asian and American markets, a large number of new companies and joint ventures are being established in Europe. The challenge for European players is to build up the production factories and achieve a fast ramp-up to keep up with the production speed in Asia. A main price reduction of the European battery cell is to be achieved through the design and optimization of the production process. Digitization and process parameter optimization in particular play a decisive role. Therefore the production plants have to be designed by including new digitization concepts and strategies.

So far, only a minority of European companies have produced a battery cell "made in Europe" and some planning projects in Europe have already been cancelled. The coming years are decisive for the development of Europe as a location in the battery sector and thus also for the competitiveness of the battery cell "made in Europe".

Battery cell production in Europe is picking up speed to meet the growing domestic demand for battery cells.

MODULE AND PACK MANUFACTURERS



Source: www.battery-atlas.eu; abstract, no claim of completeness

INITIAL POSITION

European market currently has a growing number of cell manufacturers and battery cell plants. As mentioned before, there is a large gap to the Asian manufacturers. In terms of module and pack production, this gap between Asian and European manufacturers is narrowing.

This is particularly evident in the automotive groups which have active supply contracts for battery cells from Asia to meet the demand for electric vehicles (EVs). When analyzing the registration numbers in relation to the population of electric vehicles, it becomes apparent that Europe allows significantly more EVs.

Since the use of individual cells in electric-powered vehicles is limited, these cells must be bundled into modules and packs. Individual companies, as well as cell manufacturers and direct end users, have specialized in these processes.

In this map, these end users are manufacturers of cars, buses, and trucks as well as stationary energy storages. Accordingly, it is not surprising that a large number of the companies shown here already have existing plants and are not yet in the planning or design phase.

In general, module pack production can be divided into about eleven production steps, ranging from an initial inspection of the cells to an end-of-line inspection.

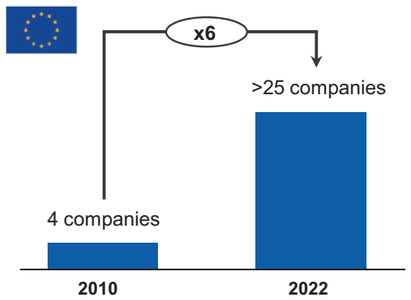
The processes differ depending on the type of battery cell used. Due to regulations, low-voltage modules are usually handled, from which the packs are ultimately assembled by connecting the modules in series and parallel.

In comparison to the cell production, it is recognizable that a large part of these companies operate in the country where they have their headquarters or already had a production factory.

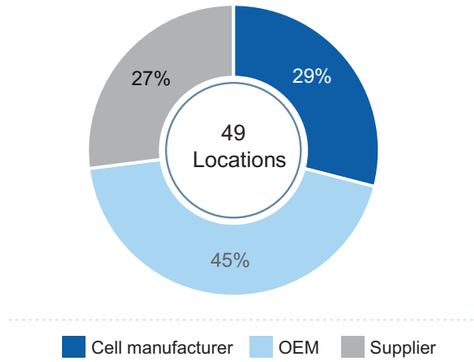
It is difficult to establish a clear measurement parameter due to the data situation, as the companies inconsistently publish information on this. This usually includes the country and location as well as the start of production. Other information includes square meters, number of employees, investment, number of units, annual capacity of modules or packs as well as the origin of the cells and the cell chemistry.

For reasons of clarity and consistency, this has been removed and only a presentation of participating companies and locations is provided.

Growth in battery system production in Europe



Breakdown of module and pack production sites by manufacturer type



ANALYSIS

As mentioned at the beginning of this chapter, some companies already have module and pack manufacturing as they source or have sourced their cells externally and are assembling them into modules and integrating them into packs.

Some of this manufacturing is done by OEMs. However, it should be emphasized that these have only started manufacturing modules and packs in the last few years or will be doing so in the future. Other companies are or were active here earlier. In 2010, only four companies were active in this area. Since then, the demand but also the supply of manufacturing sites has increased significantly. In 2020, there were already 19 that we can identify on this map. By 2024 the total number of manufacturing sites by these companies may grow to over 40. This means that the number of manufacturing sites by these companies has more than quintupled from 2010 to 2020 and more than doubled in the following four years.

When looking at the companies, one not only notices the much talked about OEMs, but also battery cell manufacturers that produce their own modules. This takes place both at the direct manufacturing location of the cells and at other locations in Europe. As in other maps, Germany is a center of concentration for many companies, whereas the Scandinavian countries have high potential and in some cases larger plants with higher capacities.

OUTLOOK

Currently the joining to modules and packs is done one after the other. In addition, the topic of “Cell to Pack” or “Cell to Chassis” or even “Cell to Vehicle” is strongly discussed.

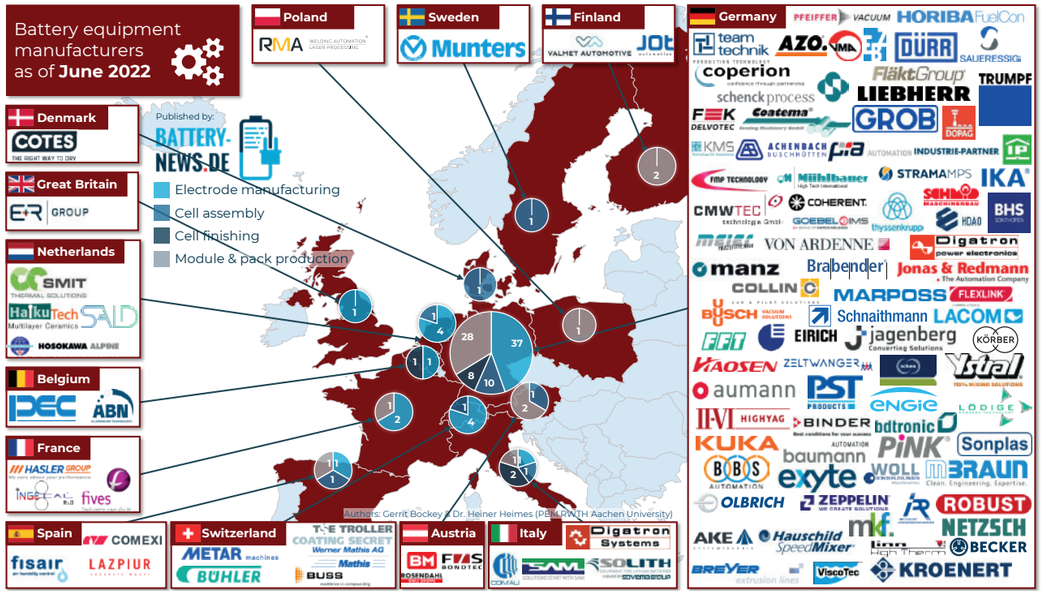
From this the market of module and pack production can change strongly. When considering large volume cells, any interconnection is no longer necessary or is greatly reduced.

The use of cells as an integral component of the electric vehicle can also influence the process sequence and thus affect the market. The direct integration of cells into the vehicle can consolidate the position of the automobile manufacturers, but suppliers could also integrate cells into components and continue to participate in the market.

It therefore remains to be seen which trends will prevail in the cell formats and what changes such a radical development will lead to. There is no doubt that module and pack production is directly dependent on the battery cell and the respective cell chemistry, which in turn has an influence on a large number of components.

The number of production sites for modules and packs of automotive and cell manufacturers is steadily growing and is able to further increase the market shares of OEMs through new cell formats.

EQUIPMENT SUPPLIERS



Source: www.battery-atlas.eu; abstract, no claim of completeness

INITIAL POSITION

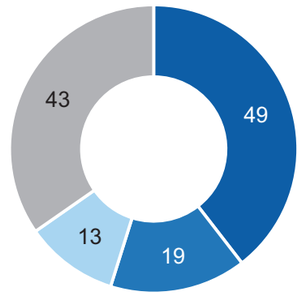
The rising global demand of electric vehicles led to a huge jump in need for batteries. Various battery production sites are ramping up to match these demands. To serve European battery manufacturing, established battery cell companies and emerging start-ups have announced plans to meet the regional growing demands. New battery production facilities will require a large amount of machinery and equipment accounting for about 60% of the total investment. The battery cell production process chain is divided into three sections: electrode manufacturing, cell assembly, and cell finishing. Some of the processes require a high level of technological expertise and high-precision manufacturing equipment.

Beginning with electrode manufacturing, the active material is mixed with the solvent to form a slurry. Subsequent process steps are performed mostly on various role-by-role production systems where large metal foils are coated with the slurry and dried, followed by calendering and cutting the produced electrodes to the desired dimensions.

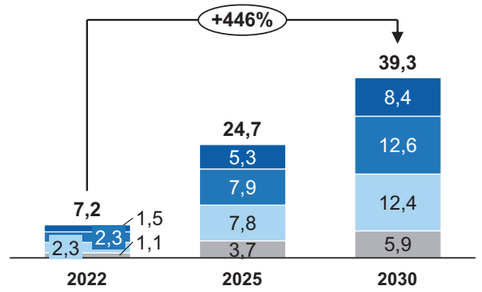
In cell assembly, the fabricated electrodes are formed into a cell roll or stack together with the separator and then placed in the cell housing and wetted with the electrolyte. Given the number of sequential process steps and process atmosphere requirements, the equipment is typically fully interlinked in order to ensure the necessary throughput and product quality. After the battery cell is fully assembled, it is charged for the first time within the formation process and examined in a series of monitoring mechanisms and the end-of-line test. Most electrochemical properties are set during cell finishing, which requires a profound process understanding.

While only a few years ago the majority of machinery was largely provided by Asian equipment suppliers, more and more experts are establishing themselves in Europe to capture a share of the revenue by becoming a key supplier for battery manufacturers. European players seeking to enter or expand into the battery market can leverage their geographic benefits which facilitates installation and ramp-up times as well as support and service for equipment. Suppliers for industries whose operations are comparable to battery cell production are in a particularly advantageous position to capitalize on technological opportunities. Furthermore, suppliers for module and pack production equipment are also focusing on innovative solutions for high automation, increased productivity and quality management – from cell level all the way to the module and pack.

Number of European equipment suppliers along the battery production process chain



Market demand for production equipment of lithium-ion batteries [billion €]



Electrode manufacturing | Cell assembly | Cell finishing | Module and pack assembly

ANALYSIS

In Europe, more than 100 established and newly emerging equipment suppliers have already successfully entered the battery market.

The market demand for lithium-ion battery production equipment will increase from around €6 billion in 2022 to a projected €33 billion.

Especially in the area of electrode manufacturing, where some processes such as coating are either unique or specific to battery cell manufacturing, more than 40 companies have been able to transfer their expertise from other sectors like the textile and packaging industry to battery cell production. Specific solutions and technological innovations enable various companies to enter the market.

Germany is playing a pioneering role in the development of battery production systems, where numerous companies in a wide variety of formats are involved in the further development of battery production.

The cell assembly and handling processes are often in scope of general automation and manufacturing, allowing established companies to convert and apply their equipment systems here accordingly.[2]

In Europe, only a few companies are currently able to make a name for themselves in the field of cell finishing for productions on a gigafactory scale.

OUTLOOK

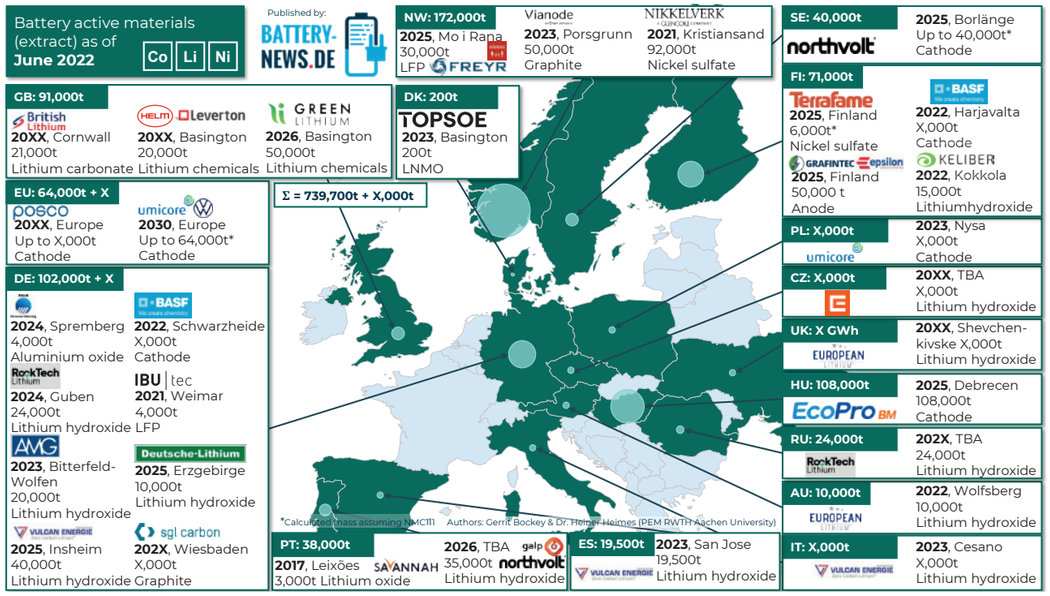
Since most of the Asian battery cell equipment manufacturers are already heavily booked with requests, they may prioritize orders from established customers. As a result, European battery cell manufacturers and OEMs entering the market are likely to face equipment supply shortages that jeopardize their production ramp-up. Securing equipment supplies is a critical success factor while criteria such as sustainability and quality will become more and more important in the procurement process, not just because of the EU Battery Regulation coming into force. The announcements by battery cell and system manufacturers offer great potential for equipment suppliers.

- Cell finishing: This procedure forms a large part of the overall market in cell manufacturing. Only 5-10% of the European companies can serve this market.
- Delivery times: It is expected that equipment manufacturers will not be able to increase their capacities in line with demand. Already now, delivery times for some core processes are more than one year.
- The numerous specialists in the European equipment industry should be able to act as general contractors in the coming years in order not to leave the market to the currently dominant Asian manufacturers.

> The numerous specialists in the European equipment industry should be able to act as general contractors in the coming years and focus on modular systems in order to shorten delivery times.

2 https://www.mckinsey.com/industries/advanced-electronics/our-insights/unlocking-the-growth-opportunity-in-battery-manufacturing-equipment

ACTIVE MATERIAL SUPPLIERS



Source: www.battery-atlas.eu; abstract, no claim of completeness

INITIAL POSITION

A lithium-ion battery consists of several cells, each of which has a negativ anode and positiv cathode. Both, anode and cathode, consist of a current collector which is different for the positiv and negativ electrode (copper or aluminum foil) and an active material. This active material can have different compositions and combined in various ways. Most common material mixtures are Nickel-Manganese-Cobalt (NMC) or Lithum-Iron-Phosphate (LFP) for the cathodes in combination with graphite anodes. The active material combination determines the cell chemistry of a battery and is decisive for the amount of raw material required in production.

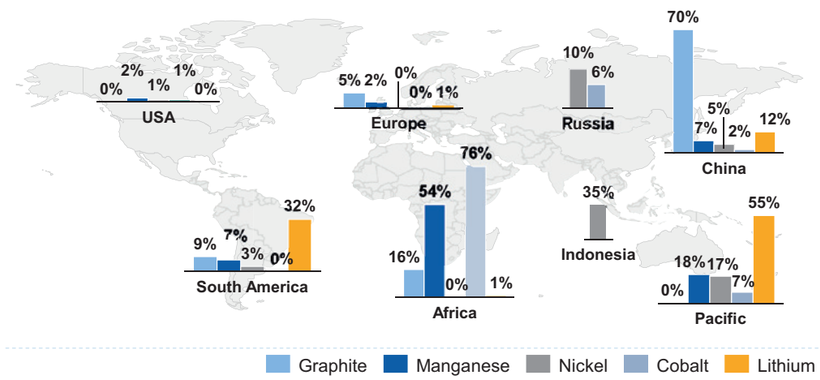
The raw materials used in a lithium-ion battery are among others graphite, manganese, nickel, cobalt, and lithium[4].

- Graphite can be obtained either as a by-product of oil refining (synthetic graphite) or in traditional mining operations.
- Manganese is either extracted by open pit mining or deep mining. The ore can be further processed in metallurgical or chemical processes to intermediate products for battery production.
- Class I nickel and Class II nickel are nickel laterite and sulfide, which are required for the cathode and currently the most important material for lithium-ion batteries.
- Cobalt concentrates (hydroxides) are mainly by-products of nickel and copper mining and usually extracted in small mines.
- Lithium can be extracted in two processes that are economically relevant: extraction from hard-rock mines or from salars. Hard rock minerals are further processed to lithium hydroxide, lithium chloride and lithium carbonate. Salar lithium is further processed into lithium carbonate and lithium hydroxide, both of which are used as cathode material.[3]

All these described resources are distributed very unevenly among the different countries of the world, resulting in a global supply chain with few suppliers. Combined with the precarious social and political conditions in some countries, this leads to a vulnerable supply chain. These risks play an important role in the assessment and selection of supply chain stakeholders and determine the ecological and social footprint of the lithium-ion battery production.[4]

3 GIZ + BGR, "Rohstoffe für die E-Mobilität", 2021
4 "Why Europe can secure enough critical raw materials", [Online]. Available: https://is.gd/cYOOsI [Access 06-01-2022].

Supply chain risks: Resource allocation with major political risks
*Supply of new raw materials, 2020 [% share of world market]**



*China is shown separately. Excludes data from countries that contain either low volume or proprietary data.
Source: Metastudy PEM with data from: CATL, Avicenne Energy, IEA Global Electric Vehicle Outlook 2022, United States Geological Survey, Roland Berger, McKinsey

ANALYSIS

The highly unbalanced distribution of raw materials for lithium-ion batteries means that individual states are de facto single source suppliers of certain resources. The global raw material distribution of the most important active materials in 2020 is shown in the figure above.

- According to the data, 72% of the graphite for the world market is extracted in China as natural graphite in traditional mining.
- Manganese ore is mainly mined in South Africa (54%) and Australia (18%) from where it is transported to China for further processing.
- Nickel shows the greatest scatter in resource distribution. Nickel laterite and nickel sulfide are mined in more than 30 countries worldwide.[5]
  However, Indonesia and Russia are the two largest nickel producers with 10% and 35% market share, respectively.
- 76% of cobalt is produced in the Democratic Republic of the Congo, making this nation the world's dominant supplier.
- Lithium is mainly available in Australia (55%) and South America (32%). Australia mainly mines hard rock lithium, while South America extracts it from salars.

OUTLOOK

Due to high demand, global raw material prices for NMC and LFP batteries have increased in the first half of 2022 (NMC by 300% and LFP by 700%). However, as global production volumes increase and new supply chains are established, overall material prices are expected to normalize.[6]

This can be seen, for example, in the market forecast of the European suppliers of active materials. As can be seen in the figure on page 12, the production capacity of active materials in the EU is expected to rise to a total amount of 656,000 tons per year. Main materials are Lithium products with up to 197,500 tons per year and cathode material with up to 212,000 tons per year.

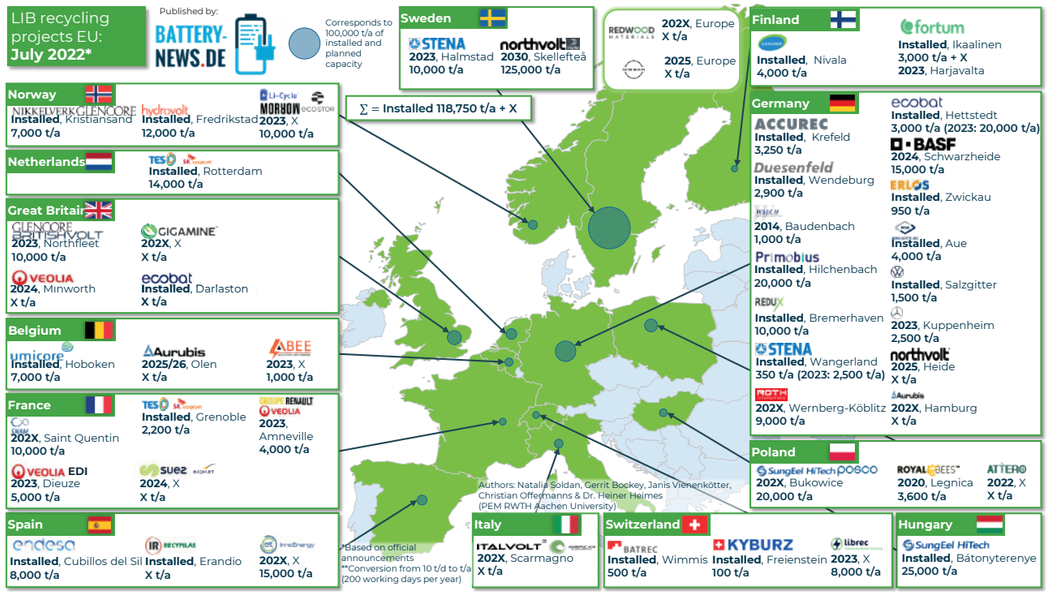
This trend could at least partially reduce the current high risks in the global supply chain and dependence on certain countries. This trend is expected to be further reinforced by technological innovations that will reduce the demand for critical materials.[7]

The currently dominant supplier countries can also benefit from this trend, as they have to comply with higher standards in order to be accepted on the world market. This reduces precarious production conditions and increases the countries' prosperity, of which Botswana or Chile are good examples.[8]

Global raw material distribution for active materials is unbalanced, with individual countries dominating market shares. Production capacity in Europe for active materials will increase in the near future (2025) and will reduce the risks associated with current battery material supply chains.

5 + 8 GIZ + BGR, "Rohstoffe für die E-Mobilität", 2021,
6 "Lithium ion Battery Raw Material Price Index", [Online]. Available: https://is.gd/XnuYRJ [Access 06-01-2022],
7 "Why Europe can secure enough critical raw materials", [Online]. Available: https://is.gd/cYOOsI [Access 06-01-2022].

RECYCLING COMPANIES



Source: www.battery-atlas.eu; abstract, no claim of completeness

INITIAL POSITION

As Europe is undergoing a low-carbon energy transition, the rise of electric and hybrid vehicles has increased to reduce carbon dioxide emissions. As a result, this energy transition has led the demand for lithium-ion batteries to grow in recent years.[9] Europe has responded by investing and building more battery production factories to meet the continuously growing need for batteries in electric vehicles. However, the rise in battery production requires the development of an essential sector: battery recycling facilities.

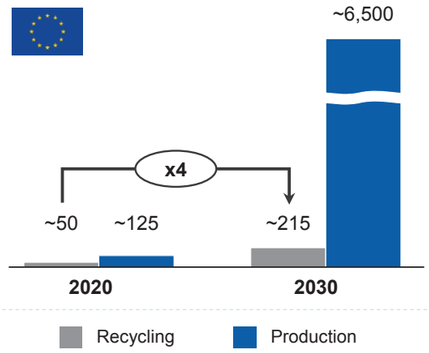
The growth of the recycling market will also allure businesses that want to take advantage of the new market needs. It is anticipated that most battery recycling factories will be built close to European automotive industries to create easy transportation access to production scrap materials.[10] Therefore, there will be an increase in battery recycling facilities in nations like Germany, which currently has the highest number of battery recycling factories, as shown on the map. The nordic countries are also a focal point for recycling plants as Sweden is presently taking the lead, and these nations have the advantage of retaining access to cheap renewable energy and mineral resources.[11]

Another essential factor are the new regulations in Europe that impact the lithium battery market. The regulation proposed by the European Commission aims to target challenges, initiate supply chain investigations, and thus create the conditions for green and sustainable batteries. In addition, it regulates the use of recycled materials for batteries over two kilowatt-hours to become less dependent on raw materials. Since Europe heavily relies on global markets, regulations address responsible sourcing, a vital aspect of ensuring a sustainable and ethical supply chain. When it comes to regulations regarding recycling batteries, Europe wants to increase the battery collection rate and recycling efficiency by refining recovery rates and requiring recycled raw materials to be reused in new batteries.[12]

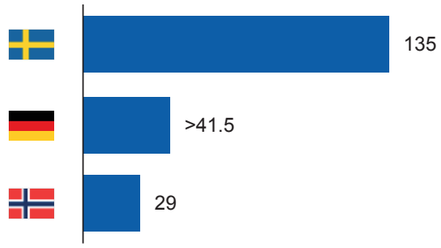
Nonetheless, these regulations also raise uncertainties. They mainly stem from the fact that the market is young yet growing extensively, creating vagueness on how it will develop, so current regulations are not guaranteed to meet the market's future needs. Further uncertainties derive from stricter regulations limiting companies' options to source batteries, hindering market competition and consequently obstructing innovations.[13]

9 Vivienne Halleux (New EU regulatory framework for batteries). 2022. Pg. 2.
10 Rodrigo P Navarro et al. 2022.
11 Ibid
12 Hans Eric Melin et al (Global Implications of the EU battery regulation). 2022. Pg. 384
13 Hans Eric Melin et al. 2022. Pg. 385.

Growth in EU battery recycling compared to EU battery production [thousand t/a]



Top 3 recycling markets in the EU [thousand t/a]



ANALYSIS

There is an evident market for battery recycling facilities, and the market in Europe is growing. With a suspected 2.5 megatons of new batteries in the EU by 2030, there is a rise in environmental unease if the number of produced batteries does not have enough recycling facilities to recover them.[14] There is also the concern of shortages in raw material supply chains if the prior material from secondhand batteries is not reused.[15] National governments are investing heavily in recycling plants to increase their processing capacity. All factories in Europe are forecast to reach more than 1,100 GWh of annual recycling capacity by 2030, when full build-out levels are reached.[16] However, there is currently insufficient recycling capacity to handle the anticipated battery production.

Germany has the most battery recycling facilities. In the next years it will produce the second greatest total amount of recycled batteries. Hungary comes in third, recycling 50,000 t/a of batteries.
Sweden tops the list with 135,000 t/a of recycled batteries. Although Germany owns the most battery recycling facilities, it only produces the third greatest total amount of recycled batteries. On the lower end of the scale are nations like Switzerland and Finland. However, it is essential to mention that there are some gaps in the data, as the number of recycled batteries in nations such as Spain and Italy remain unclear.

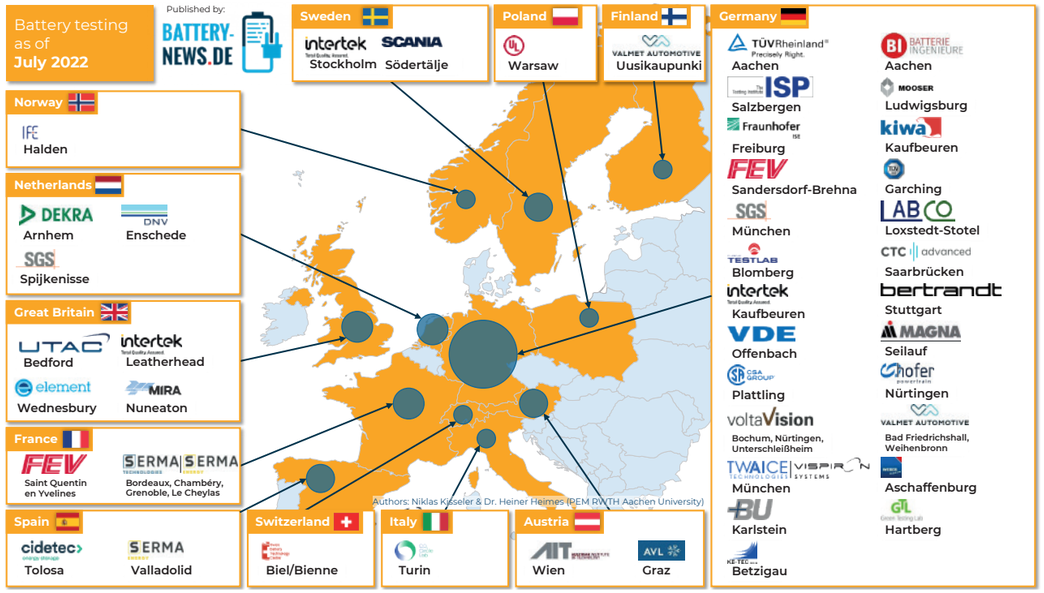
OUTLOOK

It has become evident that there is an urgency to address and adequately handle the rise in lithium-ion batteries produced. As electric mobility is expanding, Europe can set the benchmark and effectively lead the way in battery recycling. The goal is to establish a circular economy to ensure that waste from batteries is reused in a way that makes battery production overall less resource-intensive. For this to happen, battery manufacturers must also partake in battery return systems to ensure battery materials are not lost and collected efficiently. Furthermore, there is a need for battery recycling facilities to have access to all necessary materials in order to undergo recycling processes successfully. Some necessary materials are considered critical raw materials due to potential supply risk shortages, such as Nickel.[17] These concerns will have to be addressed if Europe were to meet its estimated recycling battery goals successfully. If European nations can establish a circular economy where lithium-ion batteries are reused and reapplied, we can expect an increase in jobs within the sector, a lower environmental footprint, and overall economic growth.

As electric mobility is expanding, Europe can set the benchmark and effectively lead the way in battery recycling. The goal is to establish a circular economy to ensure that waste from batteries is reused in a way that makes battery production overall less resource-intensive.

14 Christoph Neef (What is the market potential for sustainable battery recycling in Europe). 2021.
15 Vivienne Halleux (New EU regulatory framework for batteries). 2022. Pg. 3.
16 Rodrigo P. Navarro et al (European battery recycling: an emerging cross-industry convergence). 2022.
17 Roland Berger (The lithium-ion (EV) battery market and supply chain). 2022.

BATTERY TEST CENTERS



Source: www.battery-atlas.eu; abstract, no claim of completeness

INITIAL POSITION

Each lithium-ion battery must pass various abuse and performance tests after completion of its initial development before it is approved for use within specific applications. These tests are performed depending on the respective performance and safety requirements from standards or additional extensive manufacturer requirements at battery cell, module, and/or system level.

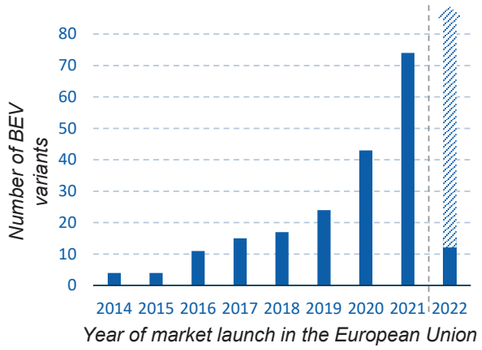
For example, the approval of energy storage systems for electrically powered vehicles according to ECE-R100 (from revision 3) requires the successful completion of a total of ten tests including thermal, mechanical, and electrical stress investigations. These include vibration and mechanical shock tests, tests to ensure thermal shock and fire resistance, and verification of protection against overcurrent, overcharging and deep-discharging.

A selection of other standard specifications particularly relevant to battery storage applications include UN T 38.3 as a requirement for transporting battery storages by road, rail, sea or air, and IEC 62133-2, which defines safety requirements for portable gas-tight lithium-ion secondary cells and batteries for use in portable devices. In addition to the tests defined in standards and homologation requirements, test capacities are also needed to carry out further quality-relevant performance tests on battery systems. This includes, for example, the (long-term) characterization of battery systems during different product development phases.

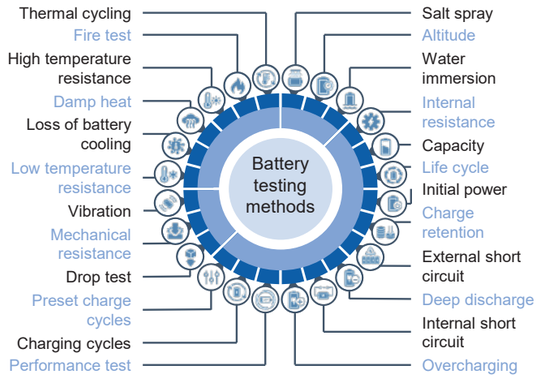
At the current time, it can be observed that the number of companies that are simultaneously developing new lithium-ion battery systems are increasing rapidly. As a direct consequence, there is a correspondingly high demand for testing capacities. Often the required test capacities exceed those available on the market. There is a risk that a lack of testing capacity will result in inefficiencies in the product development. In addition to fulfill the test scopes required for the approval of battery systems in Europe, there is also a need to cover additional test requirements in order to be able to approve products in other regions of the world (e.g. China).

In this context, the map of test centers is intended to help visualize the availability of potential test capacities as well as the establishment of upcoming service providers in Europe.

Development of the number of BEV variants introduced annually on the European market



Overview on test methods for battery homologation



ANALYSIS

The existing test capacities for lithium-ion battery systems are currently concentrated in central Europe, especially in Germany. In direct comparison, there are significantly fewer test capacities in Southern Europe and Eastern Europe.

The expected growth in demand for battery testing within Europe results in a forecast growth in sales of battery electric test equipment of up to 24% to approximately €148 million by 2027 compared to 2022.[18]

A variety of different battery tests exists for electrical, thermal or mechanical stress scenarios. A predominant share of the currently available test capacity is limited to the testing of battery cells and small format battery modules. In particular, abuse testing of large-format battery packs with high energy content has so far only been possible at a comparatively small number of test centers due to the high performance and safety requirements for the test infrastructure and test environment as well as the high initial investment costs required.

Against the background of the expected further increase in energy content at system level, challenges arise here in particular for the existing test capacities, which are limited in their applicability to battery systems with comparatively low energy content. Another challenge is the centralized availability of test capacities in order to be able to perform all test scopes of corresponding standards bundled in one place.

OUTLOOK

The foreseeable increase in demand for test infrastructure for lithium-ion battery systems represents a central requirement along the development of a fully integrated battery value chain in Europe.

Due to the rapid development in the field of battery technology and the updating of standards, this trend is foreseeably intensified. This opens up the opportunity for companies to position themselves strategically within this field and to build up know-how, as can already be increasingly observed at the present time. In this context, it is important for existing and upcoming test centers to anticipate developments in the product area as well as to be able to design test capacities that meet requirements and are economically efficient. This requires intensive monitoring of developments on the market for battery system applications as well as cooperations between battery test centers and manufacturers of battery systems in order to be able to address future demands efficiently.

The further development of the relevant standards for testing battery systems represents an additional challenge for the operators of battery test centers. Thus, the supraregional expansion of the applicability of the Chinese standard GB 38031-2020 and the thermal propagation test contained therein is to be expected.

The increasing number of battery development projects in Europe requires the establishment of sufficient test infrastructure in order to be able to cover the demand efficiently and to meet developing requirements from safety standards.

18 Business Market Insights (2022): Europe Battery Testing Equipment Market Forecast to 2027

SUMMARY

BATTERY CELL MANUFACTURERS

1. To meet the demand for battery cells in the automotive sector in Europe, 900 GWh of battery production capacity are needed in 2030.
2. Main players on the European cell production market are Asian cell manufactures, European cell manufacturers/start-ups and joint ventures between car manufacturers and cell producers.
3. To improve the production process, digitalization will be an important characteristic of European factories.

MODULE AND PACK MANUFACTURERS

1. The module and pack manufacturer market consists of cell manufacturers, automotive manufacturers, and suppliers.
2. Cell manufacturers are planning to increase module and pack production, while automotive manufacturers are converting existing production facilities.
3. In module and pack production, vertical integration is currently taking place in some cases, but classic supplier relationships still exist.

EQUIPMENT SUPPLIERS

1. Germany is playing a pioneering role in the development of production equipment for future battery production.
2. European equipment manufacturers should focus on modular systems in order to shorten delivery times and adapt to customer demands.
3. The numerous specialists in the European equipment industry should be able to act as general contractors in the coming years.

ACTIVE MATERIAL SUPPLIERS

1. The worldwide geographic and company owned battery raw material distribution is unbalanced.
2. Battery manufacturers are striving to further reduce costs, which means that active materials with good availability and low costs are attracting attention.
3. The production capacity of active materials in the EU is expected to rise to a total amount of over 656,000 tons per year.

RECYCLING COMPANIES

1. There is no standardized process chain for battery recycling established on the market.
2. Battery capacities are growing, but many of the existing recycling companies only recycle up to the black mass.
3. The recycling capacities announced in Europe are still mainly pilot lines in terms of battery volume and will have to be scaled up in the near future to cope with the fast growing EV market.

TEST CENTERS

1. The high demand for battery test capacities leads to capacity bottlenecks and delays in the battery development process.
2. The increasing number of battery development projects and evolving battery standards require additional testing capacity.
3. At the present time, there are only a few test centers that can offer all the necessary certification tests from a single source.

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The chair "Production Engineering of E-Mobility Components" (PEM) of RWTH Aachen University has been active in the field of battery production of lithium-ion battery technology for many years. PEM's activities cover both automotive and stationary applications. Due to a multitude of national and international industrial projects in companies of all stages of the value chain as well as central positions in renowned research projects, PEM offers extensive expertise.

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VDMA Battery Production addresses the production technology of batteries, with focus on lithium-ion technology. Our member companies supply battery production solutions along the entire process chain (for electrodes, cell, modul/pack and battery components). For an overview of the expertise of our member companies see our industry guide "Keys to Battery Production" on our website. It also includes companies which offer components for machinery and plants.

WWW.VDMA.ORG/BATTERIEPRODUKTIONSMITTEL

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