BATTERY CELL PRODUCTION IN EUROPE: STATUS QUO AND OUTLOOK

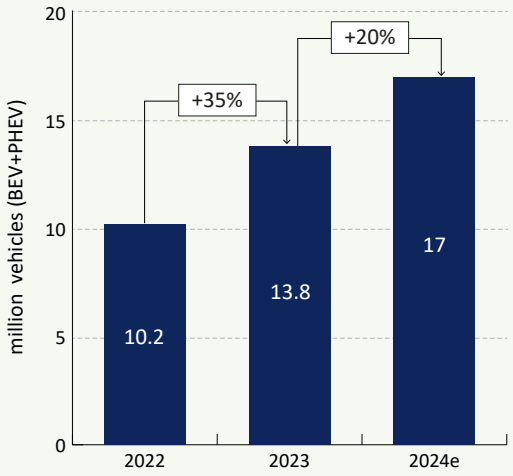
With 14 million electric vehicles sold and 706 GWh of battery energy installed, the global electric vehicle industry and the associated battery market grew by 35% and 44%, respectively in 2023. A growth of 20% is projected for 2024, although the growth rate in Europe could slow down in particular. The cell production sites in Europe now have a nominal production capacity of approximately 190 GWh/a. In the short to medium term, production capacity could be increased to almost 470 GWh/a. In the long term, around 1,500 GWh/a is possible. To utilize a significant portion of this potential, a corresponding ramp-up in electromobility is necessary.

Electric vehicles and battery market: Continuous growth in 2024

According to the EV Outlook 2024, almost 14 million electric vehicles [Battery Electric Vehicles (BEV) + Plug-In Hybrid Vehicles (PHEV)] were sold worldwide in 2023, which corresponds to an increase of 35% or 3.5 million vehicles compared to the previous year. China is the largest sales market with around eight million registrations, followed by Europe with 3.2 million and the USA with around 1.4 million vehicles.

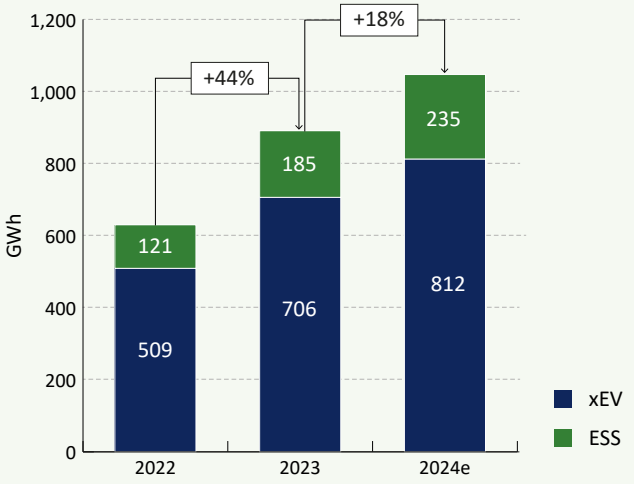
At the same time, the battery market also recorded significant growth in 2023. According to SNE Research, 706 GWh of lithium-ion batteries were installed in delivered electric vehicles [BEV, PHEV and Hybrid Electric Vehicle (HEV)] last year, almost 40% more than in 2022. Not only the application in electric vehicles is growing, but also the market for energy storage systems (ESS). SNE Research estimates that lithium-ion batteries with an energy content of 185 GWh were sold for ESS in 2023, 53% more than in the previous year. The main sales regions for ESS are North America and China.

Figure 1: Global development of electric vehicle registrations (BEV+PHEV) between 2022 and 2023 and forecast for the year 2024.



Source: EV Outlook 2024, IEA

Figure 2: Development of the xEV and ESS battery market between 2022 and 2023 and forecast for the year 2024.



Source: SNE Research

According to the Global EV Outlook 2024, more than three million electric vehicles were sold worldwide in the first quarter of 2024, 25% more than in the same quarter of the previous year. Based on the data from the first quarter and considering political measures, the authors expect sales of around 17 million electric vehicles in 2024, an increase of around 20% compared to 2023. In comparison to the three major sales markets of China, Europe and the USA, the lowest growth is forecasted for Europe. In the first three months, around 5% more electric vehicles were sold compared to the previous year. Stronger growth could resume in Europe from 2025 onwards, as political pressure increases due to the tightening of CO_2 emission targets in Europe.

Due to the positive development of the electric vehicle market, battery sales also saw a positive trend in the first quarter of 2024. SNE Research reports that electric vehicles with an energy storage capacity of around 159 GWh were delivered in the first three months, 22% more than in the previous year. Overall, SNE is forecasting growth of just over 15% to 812 GWh for the automotive sector in 2024. For the ESS market, SNE expects an increase of 25% to 235 GWh.

Battery cell production Europe

The increase in the electric vehicle and battery market are also becoming noticeable in Europe. In Europe, ACC, AESC, CATL, LG Energy Solution, Northvolt, Samsung SDI and SK On produce lithium-ion cells (LIB) for traction batteries at seven locations (see Figure 3). Together, they have a nominal production capacity of almost 190 GWh/a. Due to the anticipated increase in demand, the production capacities of the existing factories are being expanded or ramped up and could reach an estimated 280 GWh/a in the next few years. In the long term, these sites could be expanded to a maximum production capacity of around 340 GWh/a.

In addition, 13 other sites are currently in the construction phase. The companies that have already started the construction phase include AESC, CATL, Cellforce, Eve Energy, Farasis, Morrow, Northvolt, Novo Energy, PowerCo, Rosatom, SK On, Tesla and Verkor. The construction phase of a cell factory takes approximately two years, which means that these projects could be commissioned within the next one to two years. The projects of Cellforce, Morrow and SK On are already at an advanced stage, with commissioning scheduled to begin within this year.

In the long term, the sites currently under construction could provide a maximum production capacity of around 620 GWh/a. However, the sites are generally expanded in phases. For instance, PowerCo will be able to provide a production capacity of 20 GWh/a after completing the first expansion phase, but has long-term plans for up to 40 GWh/a. In addition, the production capacity planned in the first phase is not fully available from the start but will be ramped up gradually. Considering the publicly known announcements, it can be assumed that the sites will be able to provide a production capacity of around 190 GWh/a in the short to medium term.

In addition to the projects in operation and under construction, there are numerous other announcements for cell factories in Europe. Among others, ACC, AESC, AGRATAS (subsidiary of Tata), CALB, Gotion InoBat Batteries, Prologium, Sunwoda and SVOLT have announced plans to manufacture cells for traction batteries in Europe. The aforementioned projects could have a maximum production capacity of around 355 GWh/a in the long term. For the initial phase of expansion, announcements have been made of nearly 100 GWh/a. As these projects are announcements that have not yet started construction, they will not be able to commence cell production before 2027. Furthermore, it should be noted that the announced projects may ultimately not be realised. For instance, Italvolt has decided to abandon its plans for the cell factory in Italy.

A multitude of companies have already positioned themselves to supply the European electric car industry with battery cells produced in Europe. According to the IEA, 80% of European demand was already be covered by cells produced in Europe by 2023. With the reserved expansion potentials of up to 1,500 GWh/a, companies could respond to increasing demand from the automotive industry as needed, ensuring that a local supply of battery cells is possible in the future as well.

Setting up battery cell production involves considerable investment. A comparison of publicly quoted investment sums shows that around 75 to 120 million EUR/GWh are estimated for the establishment of battery cell production in Europe. Since the individual sites may differ in terms of the vertical range of manufacture, and some sites plan to have their own research department or additional processing steps, such as a recycling plant, the investment sums may vary. Approximately 50 to 100 direct jobs are created per gigawatt hour at each site. Here too, the number varies depending on the vertical range of manufacture and possible additional processing steps.

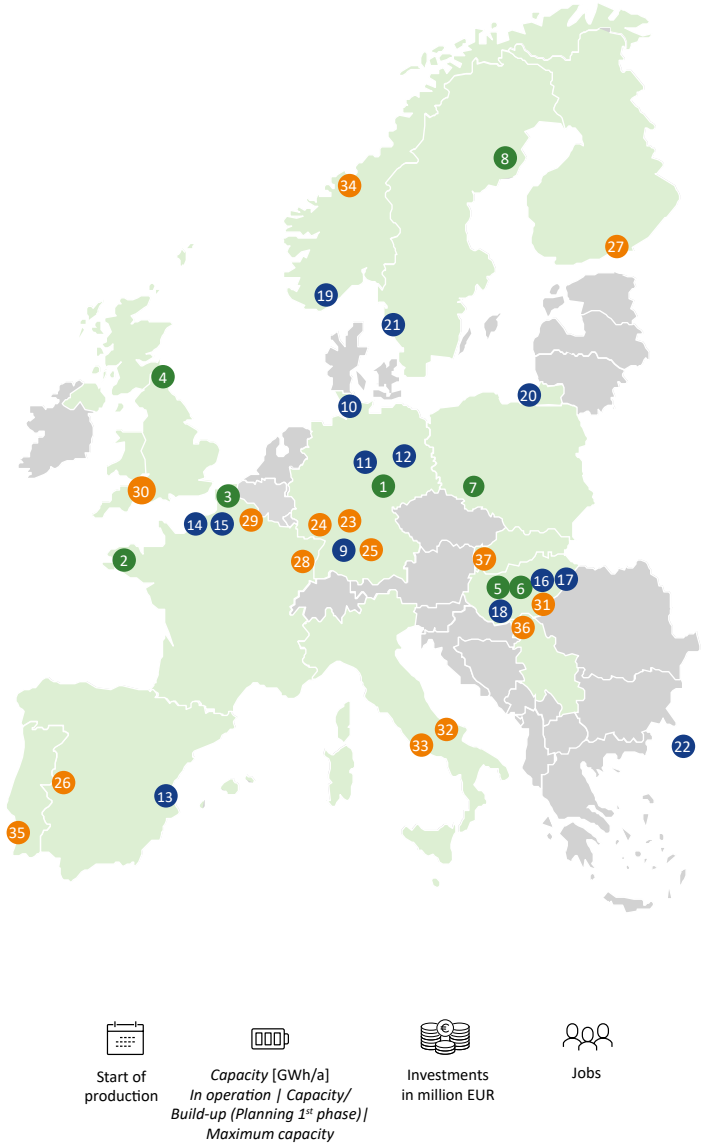
Figure 3: Manufacturing of lithium-ion battery cells for traction batteries in Europe.

In operation

#	company							
1	CATL	DE	2022	14	24	24	2.000	1.800
2	BlueSolutions	FR	2013	1	1	1		
3	ACC	FR	2013	13	26	40	2.000	
4	AESC	GB	2012	2	14	35	1.470	
5	SK on	HU	2020	18	18	18		
6	SAMSUNG SDI	HU	2018	40	50	50		
7	LG Energy Solution	PL	2018	86	90	115		
8	northvolt	SE	2021	16	60	60		

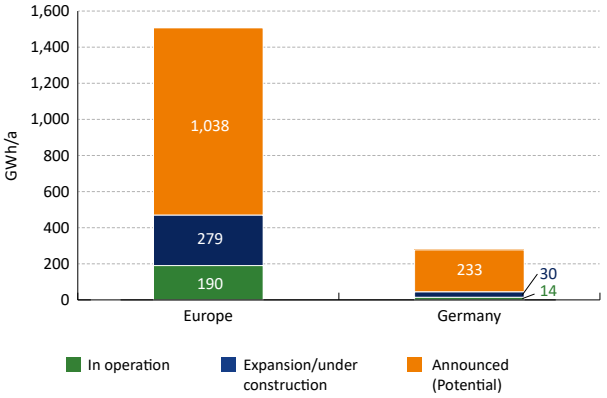
Under construction

#	company							
9	CELLFORCE	DE	2024		0,1	1		
10	northvolt	DE	2026			60	3,000	4,500
11	PowerCo	DE	2025		20	40		2,000
12	Tesla	DE				100		
13	PowerCo	ES	2026		40	60		
14	AESC	FR	2025		9	30		1,300
15	Verkor	FR	2025		16	50	1,200	1,941
16	CATL	HU	2025			100		7,340
17	EVE 亿纬锂能	HU	2026		28	28	1,000	1,000
18	SK on	HU	2024		30	30		2,483
19	MORROW	NO	2024		1	43		
20	Rosatom	RU	2026		4	12		
21	NOVO	SE	2026		18	50		2,965
22	PARASIS	TR	2026		20	50		



Announced (Potential)

#	company						
23	ACC	DE	2026	13	40		
24	SVOLT	DE		6	24		
25	VARTA	DE			2		
26	AESC	ES	2025		50		
27	FINNISH MINERALS GROUP	FI			60		
28	BlueSolutions	FR	2030		25		2,000
29	ProLogium	FR	2026		48		
30	AGRATAS	GB	2026		40		
31	SUNWODA	HU					
32	ACC	IT	2026	26	40	2,000	2,000
33	FAAM	IT	2022	8	8		500
34	elinor.	NO	2026		40		
35	CALB	PT	2025	15	45		
36	ElevenEs	RS	2026	8	48		
37	InoBat	SK	2026	20	40		



This illustration does not claim to be exhaustive.

Source: Public announcements, own depiction.

Furthermore, it is expected that the demand for labour during commissioning will be higher than during operation.

Due to the high investment sums involved, the existence of a key customer with sufficient cell requirements is an essential factor for the successful initiation and establishment of large-scale battery production. The major projects under construction in Europe generally have at least one key customer. For example, Verkor has concluded a purchase agreement with Renault for 12 GWh/a and Eve Energy will supply BMW in Hungary with cylindrical cells. SVOLT also justifies the cancelation of cell production at the Lauchhammer site with the fact that an extensive customer project will not be realised as planned. The close cooperation between cell manufacturers and key customers can ensure growth in line with the market and prevent overcapacity, as long as the demand for electric vehicles corresponds to the plans of the key customers.

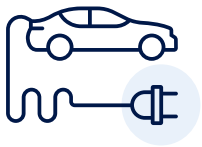
Electromobility ramp-up crucial for the expansion of battery cell production

The main customer of the produced cells and thus the main driver of battery demand is the automotive industry. In this context, light vehicles (vehicles < 3.5 t) with high sales volumes account for the greatest demand. Additionally, the demand from heavy commercial vehicles will also increase by the end of the decade. The expansion of cell production in Europe is closely linked to the ramp-up of electromobility and the corresponding transition from internal combustion engine manufacturing to electric vehicle production.

Germany experienced a decline in vehicle production numbers at the beginning of the Covid-19 pandemic, reaching its lowest point with 3.3 million vehicles (all vehicle classes) in 2021. The market has been recovering since 2022 and an increase in production numbers has been recorded over the last few years. Berylls is forecasting a growth of 2.5%, so that production numbers of over five million vehicles could be reached towards the end of the decade.

Berylls outlines various scenarios for the development of vehicle production numbers in Germany, with production of 3.6 million vehicles being assured and, in a best-case scenario, a figure of six million vehicles could be reached by 2030. The range depends heavily on whether German car manufacturers relocate parts of their production abroad or continue to produce in Germany. If growth remains constant, a production number of 5.3 million vehicles is expected for 2030.

According to Berylls, the electrification rate for Germany should be 75% by 2030. The degree of electrification is the ratio of BEVs produced to total vehicle production. If growth remains constant, around 3.8 million light, battery-electric vehicles will be produced in Germany in 2030, which will be available for both domestic demand and exports.



While global vehicle production has been growing again since 2021, the automotive industry in Europe is recovering more slowly. The pre-crisis level of 2017/2018 with 22 million light vehicles produced is not expected to be reached before the end of the decade. In the following, an estimate of battery cell demand in Europe is made based on the forecast for vehicle production in Europe. For this purpose, three scenarios are assumed:

- **Scenario A (optimistic):** In 2030, 21.1 million light vehicles are produced in Europe and a degree of electrification of 70% is achieved.
- **Scenario B (realistic):** 18 million light vehicles are produced in Europe in 2030 and a degree of electrification of 70% is achieved.
- **Scenario C (pessimistic):** 18 million light vehicles are produced in Europe in 2030 and a degree of electrification of 50% is achieved.

The forecasts and scenarios are based on data from Roland Berger and S&P Global. The development of production depends on how Europe deals with the prevailing challenges. High production costs due to inflation, electricity, high wages, and a shortage of labour will complicate the situation for the European automotive industry.

Based on the assumptions in scenario A, 15 million BEVs could be produced annually in Europe in 2030. Scenario B would lead to 12.5 million BEVs and scenario C to a production of around nine million BEVs.

Cell demand in the automotive industry is estimated using an average battery size and the number of BEVs produced. It is assumed that the average battery size will increase to 70 kWh by 2030.

For Europe, the optimistic scenario A 2030 results in a demand of 1,030 GWh/a. In the pessimistic scenario C, demand is 630 GWh/a and in the realistic scenario B it is around 885 GWh/a.

Comparison of cell demand and cell production in Europe

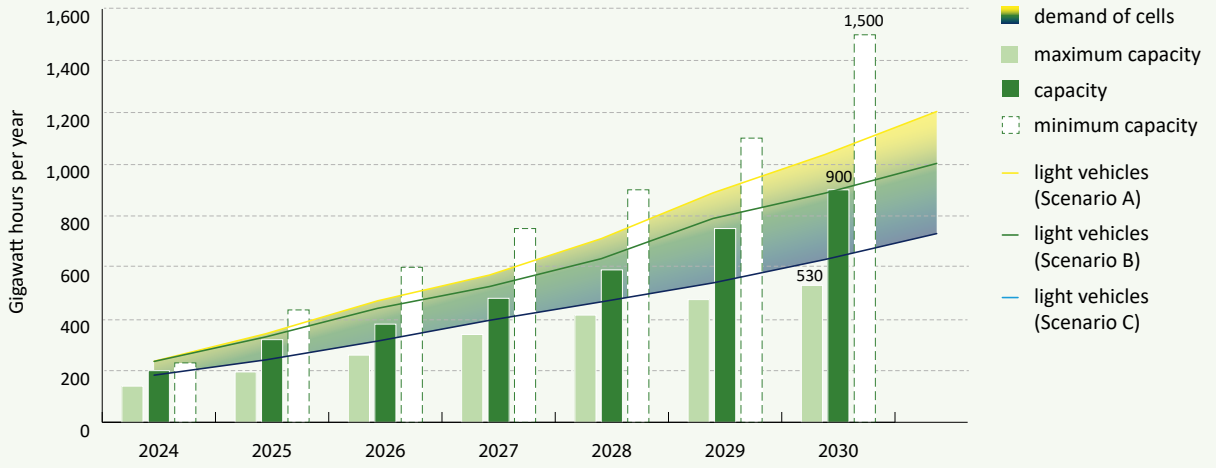
A comparison with the announced cell production capacities in Europe (Figure 4) shows that the demand for European automotive production could be met by the announced cell production capacities in Europe. Based on the announcements of cell manufacturers, Europe has an expansion potential of up to 1,500 GWh/a, which even in the optimistic scenario for 2030 would not be fully utilised by the production of light vehicles. However, if the degree of electrification continues to rise and additional potential customers, such as heavy commercial vehicles, are added, this potential could be fully utilised in the future.

Cell manufacturers therefore need a certain degree of flexibility to be able to react dynamically to the demand from car manufacturers. The situation is further complicated by the fact that individual car manufacturers use different cell formats and different active materials as technology develops. In Europe, the focus has so far clearly been nickel-containing cathode active materials. However, going forward, lithium iron phosphate (LFP) could play a greater role due to its cost advantage. Vehicle manufacturers also generally use customised formats for the cell housings. While Volkswagen relies on prismatic cells, BMW intends to use round cells with two different heights in the future. These individual requirements create a close supply relationship between cell manufacturers and carmakers and the capacity utilisation of a cell production line is usually directly linked to electric vehicle sales. If the demand for electric vehicles does not rise as anticipated, the excess cell production might not be absorbed by other market players, or if so, only after a considerable delay, due to their unique specifications.

Accordingly, underutilised production capacities in China can only be absorbed by the global market if the cells meet the requirements of the customers. The production facilities in China, which are underutilised by 40%, are nevertheless exerting high competitive pressure on Europe, as they are causing battery prices to fall sharply. This applies in particular to LFP-based batteries, which play the dominant role in China. Unlike Europe, China has a fully developed LFP value chain. In the course of the competitive market, CATL and BYD announced at the beginning of the year that they would have their prices in China for LFP battery cells to the equivalent of around EUR 50/kWh.

The low prices are attracting the interest of European car manufacturers, as they can offer cheaper electric cars as

Figure 4: Comparison of the projected demand for scenarios A (yellow), B (green) and C (blue) of European automotive production of LIBs for light vehicles (< 3.5 t), the expected battery cell production capacities (green), the theoretical expansion potential (white) and expected minimum capacities (light green) for LIBs in Europe.



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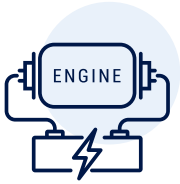
Scenario C (pessimistic): 18 million light vehicles are produced in Europe in 2030 and a degree of electrification of 50% is achieved.

An incremental increase from 62 kW/h (2024) to 70 kW/h (2030) is assumed for the average battery size.

a result. For instance, Citroën uses an LFP traction battery from SVOLT for the ë-C3 produced in Slovakia. However, the LFP cells for the traction battery must be imported from China, as SVOLT has no cell production facilities in Europe. In general, Europe currently has only limited LFP production capacities.



However, in the future the LFP value chain in Europe could be completed, enabling local production. For example, the leading Chinese LFP manufacturer Hunan Yuneng announced that a LFP cathode active material factory will be built in Spain with a capacity of 50,000 t/a. In addition, Stellantis and CATL have signed a strategic letter of intent for the local supply of LFP cells for the European market. Local production will strengthen the close link between cell manufacturing and electric vehicle production. Particularly for high-volume models that may require millions of cells, spatial proximity to pack and vehicle production reduces logistical effort, lowers the CO_2 footprint, minimises supply chain risks and thus leads to increased resilience.

Cell requirements in Germany

Proximity does not mean that battery cells must be produced in the same country. According to the VDA, Germany is the world's second-largest production location for electric cars. In 2023, 930,000 BEVs and 290,000 PHEVs were produced in Germany. Assuming an average battery size of 60 kWh for BEVs and 12 kWh for PHEVs, this would correspond to a total demand of around 60 GWh. However, CATL was the only manufacturer producing battery cells for traction batteries in Germany in 2023. CATL's production started in 2023 with an initial capacity of 8 GWh/a, meaning that only a fraction of the demand in Germany was covered by cells produced in Germany.

The situation could improve in the future if all announced projects are realised. Based on Berylls' assumptions on vehicle production, the demand for cells in Germany could be 180 to 300 GWh/a by 2030. If all active, under construction and announced German cell sites reach their maximum production capacity by then, around 290 GWh could be produced in Germany. Nevertheless, it should be noted that currently only three additional sites are under construction with Cellforce, PowerCo and Northvolt. With a planned production capacity of maximum 1 GWh/a, Cellforce would make a marginal contribution. Furthermore, Tesla's contribution to German cell production is unclear. Grünheide could potentially achieve a production capacity of up to 100 GWh/a. A first building complex for the production of battery components has already been opened, but complete cells have not yet been produced in Grünheide. Tesla is currently focussing on establishing its own cell production in the USA and it is unclear when and to what extent cell production will begin in Germany. In addition, the example of SVOLT has shown that announced production capacities can also be cancelled again. Accordingly, only a small part of the expansion potential has been secured in Germany. In order to create jobs and strengthen the industrial location, it is important that as much of the existing potential as possible is realised in Germany.

Production of anode active material in Europe

Not only cell production, but also the production of cell components takes place in Europe. As already shown in the Market Update Q2 2023, cathode active material, separators and electrolyte, among other things, are manufactured in Europe. Anode active material (AAM) has so far only been produced on a small scale in Europe.

This could change in the future. Chinese companies Putailai and Shanshan, among others, have announced plans to produce AAM in Scandinavia. Putailai is planning to build a factory in Sweden near Sundsvall. The annual capacity is expected to be 50,000 t/a in the first expansion stage and will supply the Northvolt factory, among others. In the long term, the capacity could be increased to 100,000 t/a. Shanshan has set its sights on Vaasa in Finland as a location for AAM production. Here too, a production capacity of 50,000 t/a is planned in the first expansion stage, which could be increased to 100,000 t/a in the long term. Besides the Chinese companies, there is also a European player, Vianode, which is planning to produce AAM in Norway. Starting in 2024, an initial facility is expected to produce AAM for up to 20,000 electric vehicles. By 2030, the plant could be expanded by 2030 and produce AAM for up to two million electric vehicles.

SGL Carbon, Imerys and Tokai Cobex are companies that produce synthetic graphite for AAM in Poland, Switzerland and France, respectively. In this case as well, production could be expanded in the future depending on demand. In addition, Epsilon Advanced Materials is planning to produce AAM in Europe together with the Finish Minerals Group. Like Shanshan, this company has set its sights on

Vaasa in Finland as a production location. In an initial phase, up to 10,000 t/a could be produced there.

The companies examined so far use synthetic graphite to produce AAM. It is also possible to produce AAM using natural graphite. For example, Mineral Commodities mines natural graphite in Norway. In the future, this graphite could be processed into AAM. For this purpose, Mineral Commodities is cooperating with Mitsubishi Chemicals, who are already successfully marketing AAM based on natural graphite. A potential site for AAM production could be Mo I Rana in Norway.

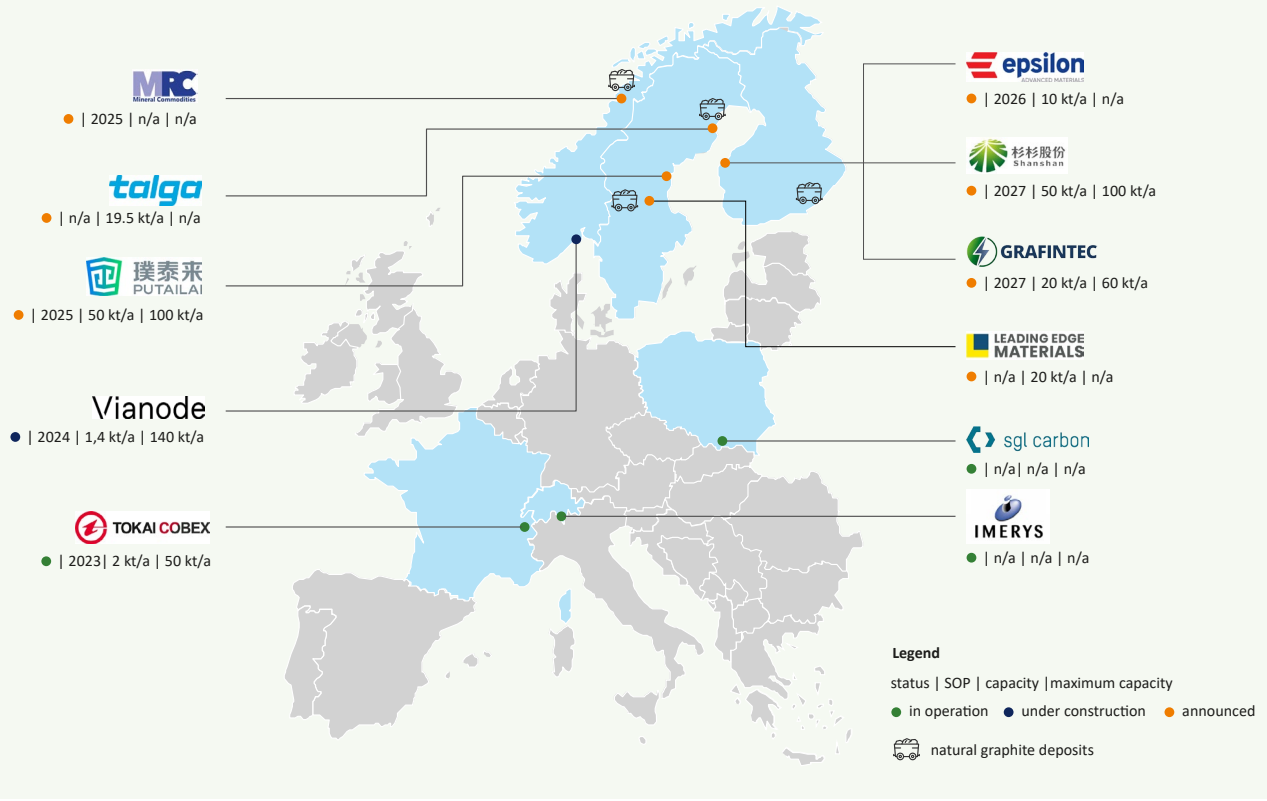
As another company, Talga Resources has a graphite deposit in northern Sweden that is intended to be developed in the future. At the same time, Talga Resources is planning an AAM production facility in Luleå, where up to 19,500 t/a of AAM are to be produced.

Grafintec is also planning an AAM production facility in Finland, which will process natural graphite. A production capacity of 20,000 t/a is planned here. In future, the natural graphite could be extracted from a deposit that is also located in Finland. However, feasibility studies must first be completed for this purpose.

After all, Leading Edge owns a mine in Sweden that was already producing graphite. However, this is currently shut down for economic reasons. Depending on future demand and the associated price trend, production could become economically viable again.

The current developments in the European production of AAM are a positive signal for strengthening local value chains in the battery industry. With the involvement of both international and European companies, a foundation could be laid for a diversified and robust production chain. Investment in manufacturing of AAM is a step towards reducing import dependency. To realise the full potential, supply relationships with cell manufacturers must be established.

Figure 5: AAM production in Europe.



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