MARKET INTELLIGENCE REPORT

COBRA

KEY TECHNICAL, POLICY AND MARKET DEVELOPMENTS INFLUENCING THE ELECTRIC VEHICLE BATTERY LANDSCAPE

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VALUE FROM SCIENCE AND TECHNOLOGY

NEW ANODE TECHNOLOGIES

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INTRODUCTION

Anodes constitute around 20-30% of EV battery mass and typically have a higher specific capacity than cathodes. Yet, negative electrodes have received far less attention than positive ones. For many years, anode technology based on graphite seemed to stagnate, while in fact, there are some exciting developments which are expected to improve battery performance and reduce the dependency of the EU and the US on China's supply chain. **Silicon, lithium metal and anode-free technologies** promise higher energy density, improved sustainability, and lower costs, although they still struggle with volume expansion and low lifetime.

This market intelligence report looks deeper into opportunities and challenges related to new anode technologies, based on the most recent research and commercial developments. We also explore the dynamics of the anode market, explaining the economy of anode active materials, strategic interests of the EU in the graphite supply chain, as well as key global anode producers and innovators. In addition, this edition's contributor ReSiTec gives insights into the production of silicon anodes and how to make them more sustainable by using recycled material from PV panels manufacturing.

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ANODES OVERVIEW

ROLE OF THE ANODE IN EV BATTERIES

To understand how a battery works, it is necessary to understand the role of the anode. A conventional battery has two electrodes and an electrolyte with a separator. The two electrodes are typically made of different materials that hold such different properties, that an interaction between them is inevitable if placed in the right environment. The resulting interaction between them is the release of electrons from one electrode to the other. In a conventional lithium-ion battery, this release occurs in the anode during the discharge of the battery as the cathode more easily will attract and hold the electrons due to the nature of the material, compared to the anode. This electron transfer is what generates the electric energy in the battery. At the same time as the electrons release, lithium ions will also be released. During the charging of the battery, the opposite reaction occurs as the electrons and lithium ions are forced back into the anode. **This process of electrode absorption of lithium ions is known as intercalation**, where the ions are inserted into the crystal lattice of the anode material. M. Stanley Whittingham, Nobel Prize laureate, discovered the concept of intercalation electrodes in the 1970s and created the first rechargeable lithium-ion battery, which was based on a titanium disulphide anode and a lithium-aluminium cathode, although it suffered from safety issues and was never commercialised. As the lithium ions require space, the intercalation leads to volume changes in the electrode which can impact battery performance.

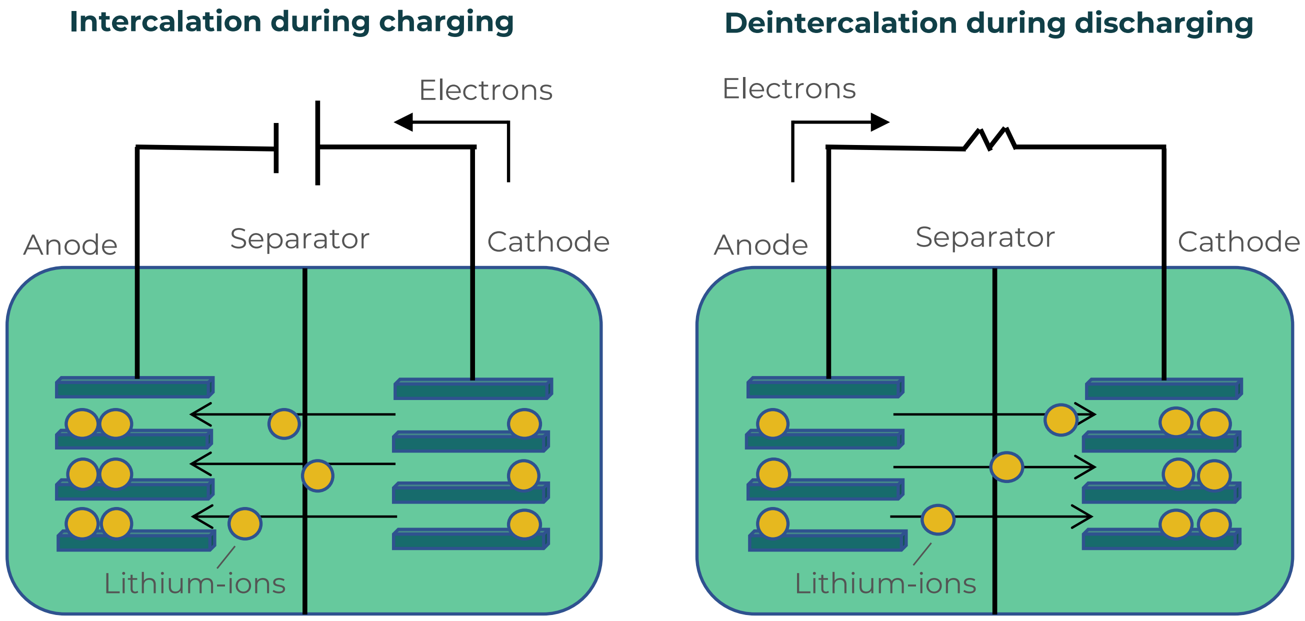


Figure 1: Intercalation and deintercalation of the anode (based on [1])

WHAT MAKES A GOOD ANODE?

When choosing an anode, it is desirable to find an inexpensive material that has a low reduction potential, high coulombic efficiency, fulfils certain morphological and mechanical material properties, has elevated gravimetric capacity, good conductivity, stability, and rate capability, as is also safe and easy to produce. These properties are summarised in Table 1 **[2]**, **[3]**.

Table 1: Key performance indicators for battery anodes

Reduction potential	The reduction potential is a measure of how easily an electrode material acquires electrons. It is desirable that the anode has a low reduction potential so that the material more easily gives away its electrons during discharge. The lower the reduction potential of the anode, the higher the cell voltage.
Coulombic efficiency	Coulombic efficiency is a ratio between the number of electrons being transferred from the cathode to the anode during charging and the number of electrons transferred back from the anode to the cathode during discharge. Losses may occur due to electrolyte degradation or material ageing, and lower coulombic efficiency is associated with a shorter cycle life **[4]**.
Mechanical and morphological criteria	A good anode material usually has a certain porosity to enhance electrolyte interphase and intercalation, as well as structural integrity for increased safety. The porosity and mechanical properties of the anode can affect the degree of cracking of the SEI layer, which works as a protective layer on the anode formed by electrolyte degradation. Extensive and uncontrolled SEI cracking can lead to dendrite formation.
Gravimetric capacity	A high gravimetric capacity is desirable in anodes as it indicates the charge storage capability of the anode per unit mass. This means that the anode can store and deliver more energy per unit mass, enabling a wider range of battery applications.
Conductivity	To facilitate the transfer of electrons within the anode material to and from the current collector, high conductivity is required.
Stability	A good anode should be chemically and electrochemically stable to prevent undesired side reactions and degradation. Instability can result in excessive SEI growth and dendrite formation, as well as a shorter cycle life.
Rate capability	An anode with good rate capability can efficiently receive and deliver charge at different rates without significant degradation. Rate capability directly affects the charging time, and higher rate capability opens up the possibility of shorter charging times.

MANUFACTURING STEPS

The active anode materials (AAM) used in batteries are typically made of graphite, which can be natural or synthetic. Natural flake graphite is processed into spherical form to ensure homogeneity for its use as an anode material. Synthetic graphite, on the other hand, is produced by refining hydrocarbon materials like coke [5] through a process called graphitization. More advanced anode materials such as silicon and lithium are also used, and their details will be discussed in the following chapter.

Despite the different anode chemistries, there is a **general manufacturing process for conventional anodes** as shown in Figure 2. The manufacturing starts with material preparation where the active anode material is mixed with other components to make up an alloy. During this step, milling or grinding is typically applied to obtain the desired particle size. When this is achieved, binders, additives and solvents are added to form a slurry that is typically mixed for uniformity [6]. The slurry is coated on the current collector, which is usually made of copper for anodes. After this follows the drying and solvent removal to retain the dried anode material adhered to the current collector, and then calendaring and compaction to compact the anode material for higher density and improve the mechanical properties. The final stage includes cutting and cell assembly to acquire the final battery cell [7].

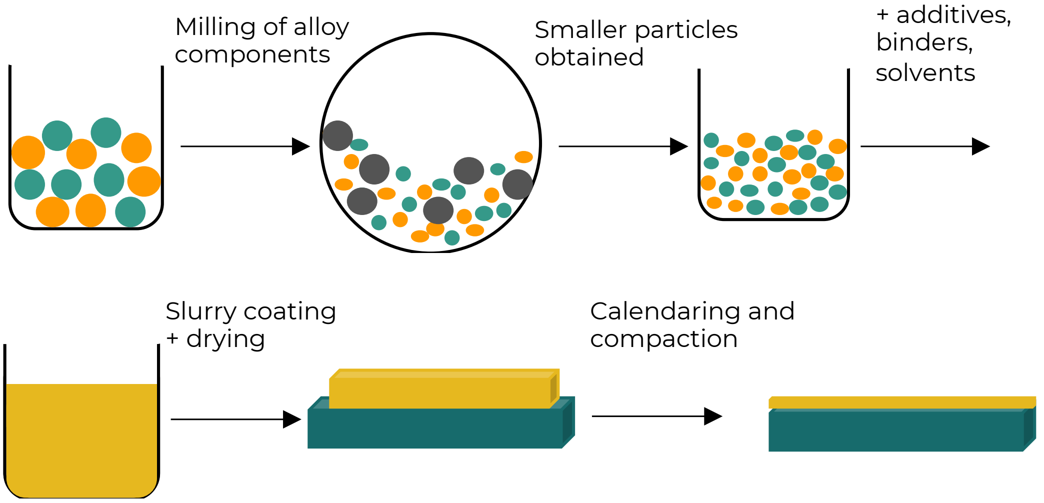
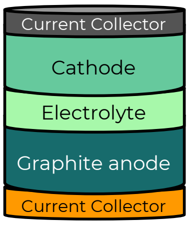
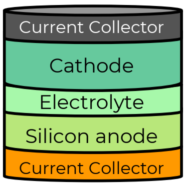
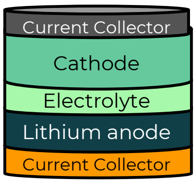
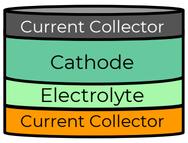


Figure 2: Anode manufacturing process

ANODE TECHNOLOGIES

In 1976, the first practical lithium-based battery with a lithium anode was patented. Despite being lightweight and possessing high energy density and good rate capabilities, this battery suffered from dendrite formation and posed significant safety risks [8] As a result, research was conducted to explore alternative anode materials with enhanced safety features. Eventually, thanks to the developments of Nobel Prize laureate Akira Yoshino, **rechargeable lithium-ion batteries with graphite anodes hit the market**. Since then, graphite anodes have become the standard choice for most applications. However, ongoing developments are focused on creating new anode materials that can meet the specific requirements of emerging applications, where the conventional graphite anode may fall short. Table 2 provides a comparison of the main anode technologies, and the explanations of these technologies are provided below.

Table 2: Comparison of battery anode technologies

	Graphite anode	Silicon anode	Lithium anode	Anode-free
				
ADVANTAGES	Low cost Long lifetime Maturity and high knowledge level	Energy density Abundance of silicon Fast-charging capability	Energy density Fast charging capability High voltages	Low cost Energy density Safety Sustainability
DISADVANTAGES	Problematic when fast charging Low energy density	Large volume expansions Short lifetime	High instability and reactivity Short lifetime	Corrosion Short lifetime Low readiness level

GRAPHITE ANODES

The graphite anode, the conventional anode in lithium-ion batteries, has a low cost, high porosity, is lightweight, and has excellent cycling stability [9]. The **low cost** makes it a suitable electrode for lithium-ion batteries which are the most used batteries on a large scale. The **porosity,** along with the additional weak forces between the layers, enables the intercalation process of lithium ions during charging. Due to the nature of the graphite structure which provides good interlayer space, the graphite anodes tend to reach a volume expansion of up to 12% during charging, which is relatively small compared to other anode chemistries [10]. The ease of deintercalation and intercalation, along with electrochemical stability, also results in **relatively high coulombic efficiency**, allowing for a long cycle life for graphite anodes. For electric vehicles, this means a more durable battery that can ensure an extensive vehicle lifespan.

Despite being an appropriate anode for enhancing battery cycle life, the graphite anode exhibits **poor rate capability** due to instability when fast charging, which can significantly shorten the anode's lifespan. This instability consequently leads to dendrite formation that penetrates through the electrolyte and can potentially lead to short-circuiting and explosions [10], [11]. It is therefore desirable to operate graphite anodes at lower charging rates, which poses a limitation for electric vehicles where an increased charging rate is being sought as a holy grail.

Apart from aiding the deintercalation and intercalation, the nature of the graphite structure limits the gravimetric capacity of the graphite anode. This is due to the packing of ions in-between the graphite layers, where six carbon atoms are required for every lithium ion, resulting in poor packing efficiency, and a **low gravimetric capacity** [12]. A low gravimetric capacity of anodes in lithium-ion batteries can accordingly result in a smaller driving range for electric vehicles as less energy can be stored.

SILICON ANODES

Believed to be the next generation of anodes, the silicon anode exhibits **excellent gravimetric capacity, is readily abundant, and has improved fast charging capabilities** compared to the state-of-the-art graphite anode. The nature of the silicon structure facilitates the packing of lithium ions, where it only takes one silicon atom to bond with as many as four lithium ions [12], which gives the outstanding gravimetric capacity of silicon anodes which is usually 10x higher than that of graphite [10].Silicon anodes also demonstrate faster charging compared to graphite, as they have better rate capabilities, allowing for the faster delivery of lithium ions [13].

The silicon anode possesses promising properties for electric vehicles, such as an extended driving range and fast charging possibilities. However, it is also susceptible to some critical disadvantages, including **excessive volume expansion and poor cycle life,** which limits its usage. Due to the high packing density of lithium ions and a less flexible structure compared to graphite, the silicon anode experiences volume expansion of up to 320% during cycling. This expansion leads to stress and cracking of the solid electrolyte interface (SEI) when the volume decreases again (Figure 3). The cracking of exposes the anode to the electrolyte, resulting in side reactions, decreased coulombic efficiency, and the growth of an inhomogeneous and extensive SEI. These factors reduce conductivity and contribute to the anode's poor cycle life [10].

Challenges associated with significant volume expansions present a substantial obstacle to the use of silicon anodes in applications like EV batteries, but some newer innovations are highlighting possible solutions. One approach is the use of specific **electrolyte additives** that enhance the flexibility of the SEI layer, making it less prone to failure [14]. Another more general approach is the use of **Si-C composites** where the surface of silicon nanoparticles is coated with carbon structures like graphite, graphene, and carbon nanotubes. This coating helps mitigate volume expansion and improves the battery's lifespan [15].

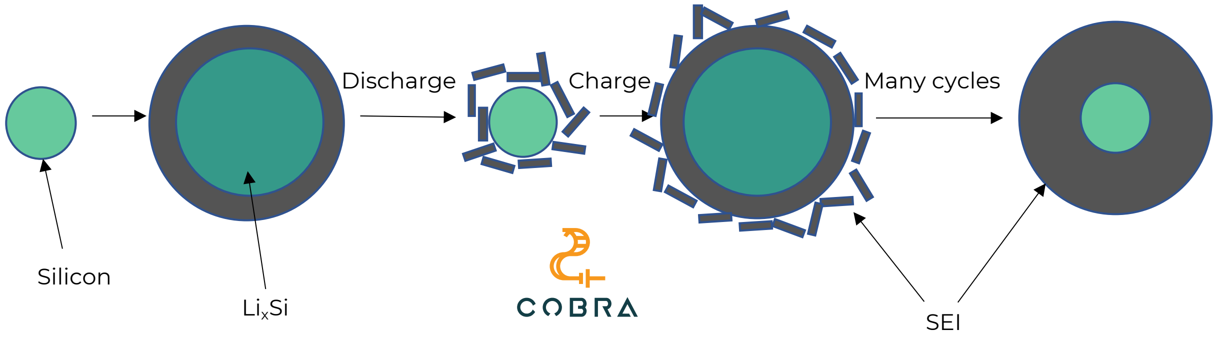


Figure 3: SEI growth in silicon anodes due to volume expansions (based on [10])

LITHIUM METAL ANODES

Being one of the most interesting anode technologies, lithium boasts the **lowest reduction potential, has excellent gravimetric capacity, and can be fast charged** [16], [17]. The low reduction potential of lithium enables the attainment of high voltages, which is highly desirable in electric vehicles as it signifies higher power output and efficiency. Simultaneously, lithium anodes exhibit remarkable gravimetric capacity, close to that of silicon, resulting in a higher driving range compared to graphite-based anode batteries. Moreover, the ease of lithium-ion deposition on the lithium anode offers the possibility of increased rate capability and fast charging [16].

Despite possessing fascinating properties, lithium anodes are **prone to dendrite formation and low coulombic efficiency**, hindering their effective utilisation in electric vehicles. Lithium is a highly reactive material and is thermodynamically unstable with organic solvents. When in contact with a conventional electrolyte, side reactions are triggered giving excessive SEI layer growth which in turn can lead to catastrophic failure of the battery. The induced side reactions will also significantly reduce the coulombic efficiency of the battery and shorten its cycle life [18].

As for silicon anodes, there is a strong emphasis on exploring new solutions to address the challenges associated with lithium anodes. The general approach is is to improve the interphase between the electrolyte and the anode. This can be done by using special **electrolyte formulations that enhance the SEI stability,** making the layer more robust, using **less reactive solid electrolytes**, or by coating the lithium with aluminium oxide techniques like **atomic layer deposition (ALD)**, among others [19], [20].

ANODE-FREE BATTERIES

Due to safety concerns and the accelerated degradation of anodes, anode-free batteries have become a trending topic, offering the potential for simplified cell manufacturing. In anode-free batteries, the anode is eliminated, and the cathode material serves as both the anode and the cathode. During charge and discharge, ions move back and forth between the cathode and electrolyte. However, **achieving high efficiency is currently the main challenge, as corrosion occurs during cell operation**, resulting in low coulombic efficiency, and low cycle life. To address this efficiency loss, an **enhanced cathode-electrolyte interphase** is needed, and the solid-state electrolytes are investigated as a solution giving increased lithium compatibility compared to liquid electrolytes. The adoption of anode-free battery assemblies has the potential to revolutionise lithium-ion batteries, making them **safer, more cost-effective, and with increased energy density** [21].

Another relevant aspect is the **recycling of anodes**, which receives little to no attention. The cathode active material presents more than 40% of the cell's value, while the anode active material is only responsible for around 10% [22]. As a result, recycling the cathode is more appealing for the industry. Still, the continuous development in the EV industry and the high reliance on external graphite supply in the European Union make the transition towards anode-less or anode-free batteries desirable.

UNLOCKING THE POTENTIAL OF SILICON ANODES

CONVERSATION WITH MADS CHRISTENSEN HEINTZ AND ANNE-KARIN SØILAND

RESEARCH & DEVELOPMENT AT RESITEC

What have you achieved so far in the COBRA project?

Our job in the COBRA project is to be a supplier of silicon for the anodes. As different anode manufacturers have different needs, being a partner in the project has allowed us to develop a product for Gen3B battery cells. This has been useful as the partners we have worked with have much knowledge about product behaviour on the cell level, which has made it possible for us to further develop the product for the given specifications to obtain new and more suitable products.

What is the route from raw materials to your finished product?

We produce our silicon product from solar cell manufacturing in the PV industry, by recycling the silicon sawdust that comes from cutting the silicon ingots into wafers. With today's wafering technique utilising a diamond wire, approximately 40% of the ingot becomes sawdust, also known as kerf waste. This wet waste stream is filtered and sent to us from the PV manufacturer as moist filter cake. In the powder recycling, processes to purify, shape, and adapt the powder for anode use are carried out. The particle size is already relatively small but can be further processed to fit the destined application. Using our silicon powder, partners from the COBRA project have made the anode foil, mixed with graphite and binders.

What are issues related to silicon anodes, and how can these be minimised?

One problem related to anodes containing silicon is the reduced lifetime of the battery, and the challenges increase in severity with higher percentages of silicon. For this reason, we aim to use 10% silicon in the anodes where silicon works as the active material together with graphite. The main challenge with silicon is its significant volume expansion on lithiation, causing cracking and formation of a new surface which leads to continuous loss of lithium. A common strategy to reduce this effect is to use nanoscale silicon particles, as stresses developed are less significant with smaller particles. Kerf is naturally very fine-grained, making the material very low footprint compared to production routes where the material must be ground in energy intensive processes.

What will happen in ReSiTec in the coming years?

We will continue working with customers, which can be an anode or battery cell manufacturers, to develop products suitable for their cell chemistries. Taking COBRA as an example, we have delivered more than 100 different samples for incremental improvements and final verification in the selected COBRA cell design. We will continue the same way with other customers, collaborating with manufacturers to shape silicon powders tailored for their application. This way we ensure that we meet the needs of our customers.

ReSiTec

ReSiTec AS was founded in 2012 and is located in Kristiansand, Norway. ReSiTec has two large processing plants in the Kristiansand area where they produce valuable metals and powders for industrial purposes. Currently, ReSiTec recycles 1000-2000 tons of Si, along with various other specialty products, annually. Resitec's engineers have a broad experience in the R&D of silicon powders and an industrial background.

ANODES MARKET ANALYSIS

ACTIVE ANODE MATERIALS

The market for anodes is strongly driven by the increasing EV demand and battery industry growth. Anodes are crucial for EV batteries, with each battery requiring 50 to 100 kg of anode material. In 2021, the global anode demand doubled to 300 kt, while cathode demand was 520 kt (anodes have higher energy density, requiring less material for battery production) **[5]**. **By 2030, the demand for anodes will increase tenfold, reaching 3500 kt** (approximately 900 kg of anode material needed for 1 GWh of battery production).

Currently, China (73%), Japan (16%) and South Korea (9%) produce most battery active anode materials (AAM) **[23]**. Synthetic graphite dominates (63% of global production in 2022), followed by natural graphite (35%) and silicon (1%) **[24]**. By 2030, market share changes are expected: synthetic graphite 41%, natural graphite 50%, and silicon 5% **[25]**. These changes reflect by environmental, social, and governance (ESG) concerns regarding the carbon footprint of synthetic graphite production and the emerging commercialisation of silicon anodes.

Natural graphite is considered a critical raw material in the EU, with 10% needing domestic mining and 40% requiring processing within the EU by 2030 **[26]**. **The EU will need to increase its anode production capacity and develop graphite mining operations.** However, establishing new mining operations can be a time-consuming process, taking anywhere from 5 to 20 years due to feasibility studies and obtaining environmental permits. In 2021, the major natural graphite suppliers in Europe were Norway (13 kt), Ukraine (17 kt), and Russia (27 kt). Ukraine, once the ongoing conflict ends, has the potential to help the EU achieve its strategic targets, as it possesses an estimated graphite deposit of roughly 18 Mt **[27]**.

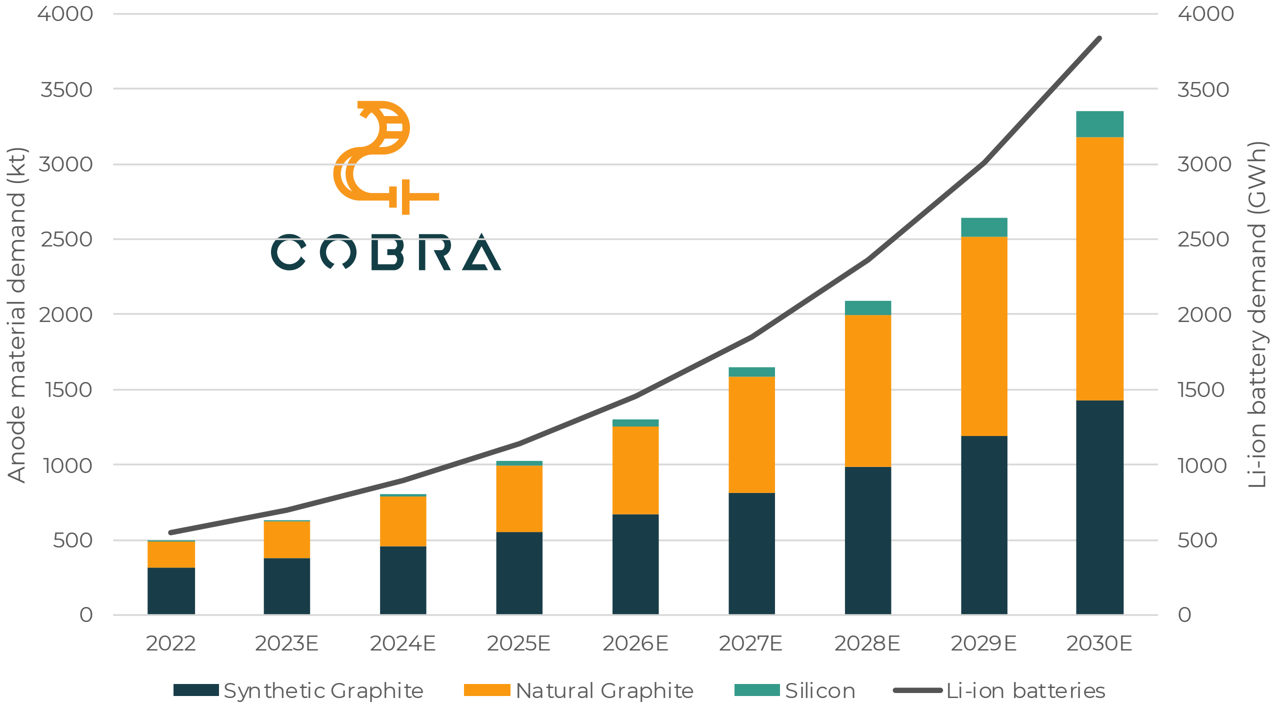


Figure 4: Anodes material demand forecast (based on [5], [28] and own analysis)

ECONOMIC ASPECTS OF ANODE PRODUCTION

Anodes account for approximately 12% of the total battery cell cost ($13-15/kWh), four times less than the cost of cathodes [29]. The cost of anodes highly depends on the type of active material used: **synthetic graphite prices at the end of 2022 stood at 1,400 $/tonne, while the natural flake graphite price was 815$/tonne** [30]. These prices fluctuate due to several reasons. First of all, the demand for batteries is growing which drives the prices of graphite up due to limited increase in supply. In general, synthetic graphite has been the preferred option for most producers because, despite higher prices, it offers reliable quality, more consistent end-product, and high feedstock availability. On the other hand, the production of **natural graphite is around 55% less carbon-intensive compared to the average synthetic graphite anode produced in China** [31], primarily due to the high energy intensity of the graphitisation process. The demand for natural graphite, along with synthetic graphite produced using renewable energy, is driven by the more stringent environmental, social, and governance (ESG) standards in battery production.

The costs of silicone anode production are not yet well established due to the low maturity of this anode technology. A few leading EV manufacturers (such as Tesla, and Porsche) have started including a small fraction of silicon oxide additives (3-8%) mixed with the graphite to increase the cell's energy and power density when compared to graphite-only cells [32]. This percentage is expected to grow to 10-20% by 2025. Although the cost of this material itself is not a problem (silicon is one of the most abundant materials on the Earth), **additional processing expenses have to be considered: adding silicon nanowires (5% SiO) can cost around $2 per kWh** [33]. The lithium metal anodes are also expected to be more expensive initially, due to complicated processing techniques. The cost of making the thinnest layer of lithium metal anode (20 μm) exceeds $1000 per kg when compared to the $300-400 per kg of a thicker lithium foil [33].

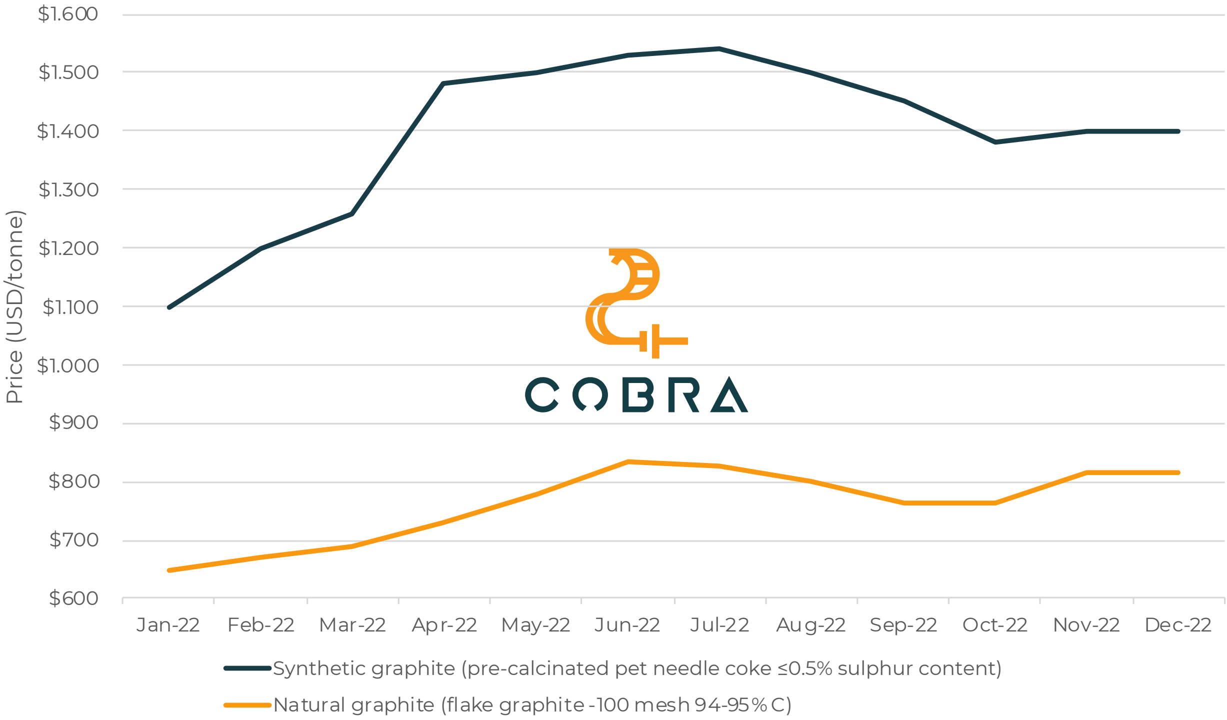


Figure 5: Price developments of synthetic and natural graphite (based on [28])

KEY STAKEHOLDERS IN THE ANODES MARKET

Three Chinese companies produce approximately 43% of battery anodes globally: Ningbo Shanshan, BTR New Energy Materials and Shanghai Putailai New Energy Technology. The latter company announced in May 2023 its plans to invest $1.5 billion in building Europe’s largest factory for anode manufacturing in Sundsvall, Sweden [34].

Several European companies aim to produce anode active materials on a mass scale. **Due to the energy intensity of AAM production, most of them are located in Northern Europe where the electricity is relatively cheap and comes from renewable sources**. In 2021 three Norwegian companies Elkem, Hydro and Altor launched a joint venture called Vianode which plans to produce synthetic graphite materials for 20,000 EV batteries by 2024 [35]. ReSiTec signed an MoU for the development and supply of silicon-based anode materials to Morrow Batteries’ planned lithium-ion battery cell facility in Eyde Energy Park, Arendal, Norway [36]. In 2022, a Swedish company Talga deployed a graphite anode plant EVA in Luleå, which will be fed by natural graphite mined as part of the Vittangi project, which obtained an environmental permit in April 2023 [37]. Talga is also developing a composite of graphite, graphene and ~50% silicon with the pilot plant operating in Rudolstadt, Germany.

The start-up scene has been very active in the development of silicon anodes, mostly in the US. Some companies like Amprius, Enovix or LeydenJar promise to deliver anodes made of up to 100% silicone, which would be possible thanks to various innovations such as 3D cell architecture, nanowires/ nanoparticles wrapped in silicon oxide and coating with thin metal semiconductor layers. Silicone anode start-ups are backed by large investors like Mercedes and BASF [38].

Table 3: Key companies in the anodes market

BIGGEST ASIAN ANODE MANUFACTURERS	EMERGING ANODE PRODUCERS IN EUROPE	PROMISING SILICON ANODE DEVELOPERS
杉杉股份 Shanshan CHINA	Vianode NORWAY	Sila UNITED STATES
BTR® Better our world CHINA	talga SWEDEN	amprius UNITED STATES
璞泰来 PUTAILAI CHINA	TOKAI COBEX FRANCE	ENOVIX UNITED STATES
SHOWA DENKO JAPAN	GRAFINTEC FINLAND	LeydenJar ENERGISING TECHNOLOGIES NETHERLANDS
posco SOUTH KOREA	sgl carbon GERMANY	ReSiTec NORWAY

TECHNICAL DEVELOPMENTS

NEW SOLVENT-FREE ELECTRODE MANUFACTURING

Traditionally, toxic, flammable, and expensive solvents have been used in the manufacturing of electrodes for lithium-ion batteries. A research group from Worcester Polytechnic Institute has pioneered a new solvent-free dry-print manufacturing methodology, where dry, electrically charged powders are mixed and then electrically adhered to a metal substrate upon application. The mixture is then heated and compressed. This technique **cuts the energy and solvent consumption, at the same time allowing to produce electrodes that can be charged faster**. Yan Wang, WPI's Dean's Professor, stated that this innovative process is scalable and could potentially decrease electrode production expenses by as much as 15%.

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ALL-SOLID-STATE RECHARGEABLE AIR BATTERY DEVELOPED

All-solid-state batteries are under continuous investigation due to their promising properties. Recently, a group of Japanese researchers have developed an all-solid-state rechargeable air battery and investigated its capacity and durability. They used a chemical called 2,5-dihydroxy-1,4-benzoquinone (DHBQ) and its polymer (PDBM) as an active material for the negative electrode, and a proton-conductive solid polymer called Nafion as the electrolyte. Compared to typical air batteries consisting of a liquid electrolyte and a metallic negative electrode, **the solid-state battery was more stable in the presence of water and oxygen, and the electrode seemed to have better properties, with an increased gram-discharge capacity**. Still, further developments are needed to enhance properties like coulombic efficiency.

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NEW CHEMISTRY TO MAKE EV BATTERIES FOR ALL SEASONS

A common worry for EV owners living in countries with distinct seasonal variations is how the battery will perform during the winter season. This is because conventional lithium-ion batteries used in EVs contain a liquid electrolyte that typically starts to freeze at sub-zero degrees. As a result, the ionic conductivity decreases significantly and affects the overall battery performance. In a new study, scientists from the U.S. Department of Energy have developed a new **fluorine-containing electrolyte that has enhanced performance, as compared to other electrolytes, at sub-zero degrees**. This enhanced performance comes from the fluorine solvent having a lower energy barrier for releasing lithium ions that have been transported from the cathode to the anode during charging compared to other solvents. Additionally, this new electrolyte seems to be safer as it won't catch fire.

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MARKET DEVELOPMENTS

EUROPE'S BIGGEST ANODE PLANT TO SWEDEN

The Chinese battery materials supplier Putailai New Technology recently revealed their plans to build Europe's biggest anode plant in Sundvall, central Sweden, worth $1.3bn. **The construction is expected to start in 2024 and when finished, the plant will have an annual capacity of 50,000 tons of lithium-ion anodes in the first stage, and 100,000 tons in the second stage**. Northvolt will be the first customer of the plant – for the Swedish battery OEM this means high reductions of carbon footprint compared to importing anode materials from China.

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TOYOTA MOTOR WITH ALL-SOLID-STATE EV BATTERIES

In a recent briefing at a research base in Shizuoka prefecture, Toyota Motor revealed their plans to release an all-solid-state battery EV as early as 2027. They say that their technology can more than double the car's driving range from just one single charge, where **10 minutes of charging time can give a driving range of 1200 kilometres**. Additionally, they claim that they have overcome the issues related to the battery lifetime of solid-state batteries, making them all-over more suitable than conventional lithium-ion batteries.

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GRAPHITE RECYCLING MARKET STARTS TO DEVELOP SLOWLY

The Critical Raw Materials Act proposed earlier this year by the European Commission includes voluntary targets for recycling at least 15% of the annual consumption of strategic raw materials by 2030. One of these materials is battery-grade natural graphite. Because of this, market analysts believe that the recycling of graphite may soon start getting traction. For example, France-based Orano is developing a process to extract graphite in the first mechanical pre-treatment phase of recycling process. **The biggest challenges are believed to be the residual metal content in the graphite after processing, which excludes it from being used for batteries again**. One possible application for recycled battery graphite can be the (non-battery) anode industry, steelmakers and lubricant or brake-pad makers.

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HIGH-END MERCEDES-BENZ EVS WITH SILICON ANODES FROM SILA

Mercedes-Benz has announced that their 2024 EQG model will be the automaker's first EV to feature silicon anode technology. The new anode type has been developed by Sila Nanotechnologies, a company in which Mercedes-Benz invested in 2019. The addition of graphite nanotubes is believed to **boost the vehicle's range by 20%, while reducing a 60-minute charge time down to as few as 20 minutes**. Sila is not the only silicon anode partner of Mercedes-Benz. The automaker has collaborated also with ProLogium which recently presented their '100% silicon oxide anode' at the Paris Auto Show.

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POLICY DEVELOPMENTS

NEW BATTERY REGULATION ACCEPTED BY THE EU PARLIAMENT

The EU Parliament recently approved an update to the battery regulation, which still must be endorsed by the Council before its publication in the EU Official Journal. The regulation aims to make batteries more sustainable, durable, and high performing. To achieve this, there will be **stricter targets for waste collection, improved recycling efficiency, and material recovery. Additionally, there will be more stringent requirements for sustainability, performance, and labelling**. The emphasis on addressing social and environmental risks will be heightened, and portable batteries in appliances will be easier to replace. New rules will be implemented for the design, production, and waste management of all types of batteries sold in the EU.

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CHINA LAUNCHED ANOTHER EV TAX BREAK

Since 2014, China has introduced a series of tax breaks for buyers of EVs, and they have recently launched the largest package yet, amounting to an estimated $72.3 billion over four years. **Buyers of new energy vehicles (NEVs) purchased in 2024 and 2025 will pay up to 30,000 yuan ($4,170) less in purchase tax per vehicle**. After two years, the tax break will be halved and kept at 15,000 yuan for 2026 and 2027. China is the world's biggest electric car market accounting for 60% of global EV sales of the last year. This move aims to stimulate demand in various sectors to compensate for an overall declining economy.

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UK EXPLORES COMPULSORY SOH MONITORS FOR EVS

The UK government is considering the implementation of compulsory battery state-of-health (SOH) monitors for electric vehicles (EVs) to provide accurate information about the condition of EV batteries when purchasing used cars. The monitors aim to enhance consumer confidence, promote transparency, and encourage the adoption of EVs. This measure will address concerns in the second-hand EV market and support the country's decarbonization efforts. **The government's proposals are based on The Global Technical Regulations on EV batteries developed at UNECE**. In addition to SOH monitor installation, the regulations recommend setting minimum performance standards for batteries: 80% SOH from 0-5 years old or 100,000km, whichever comes first, and 70% SOH for vehicles between 5-8 years old or 100,000 to 160,000km, whichever comes first.

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