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In recent years, in response to the challenges posed by global climate change and promoting sustainable development, many countries have formulated strategies and policy initiatives to drive clean energy transition and promote a low-carbon economy. According to Net Zero Tracker, 195 jurisdictions worldwide have declared and adopted Nationally Determined Contributions[1], with a strong emphasis on decarbonizing key sectors such as power, transportation and industrials. Energy systems in these countries are evolving to become greener, more efficient and intelligent.

On the power supply side, renewable energy such as wind and solar power have witnessed rapid expansion globally, with their share of total installed capacity continuously increasing. Energy storage system is set to play an essential role in providing stability and flexibility in power systems as renewables scale up. On the grid side, as power grid becomes more flexible, digitalized and intelligent, its capacity to integrate and accommodate renewable energy is continuously improving. On the load side, the NEV penetration has surged in recent years, with electrification extending further to sectors such as machinery, vessels and aircraft, advancing the transition toward green mobility in phases. Meanwhile, industrial electrification is deepening, driving the adoption of energy storage solutions in commercial and industrial applications to facilitate emission reduction. Upon multi-energy complementarity, generation-grid planning, and source-load interaction, integrated energy system is promoting low-carbon and clean energy transition of the whole society.

High-quality lithium-ion battery, as core energy storage carrier, with advantages such as high energy density, long life cycle, excellent stability and safety features, plays a pivotal role in new electricity system and low-carbon society. A lithium-ion battery primarily consists of cathode, anode, separator, and electrolyte. Its working principle is as follows: during charging, lithium ions migrate from the cathode to the anode, storing electrical energy; conversely, during discharging, lithium ions migrate from the anode to the cathode, releasing the stored electrical energy. The various performance indicators of lithium-ion batteries involve strong interconnection among physical fields such as electrochemistry and thermodynamics, and research on the intrinsic characteristics of materials, structure design, and engineering

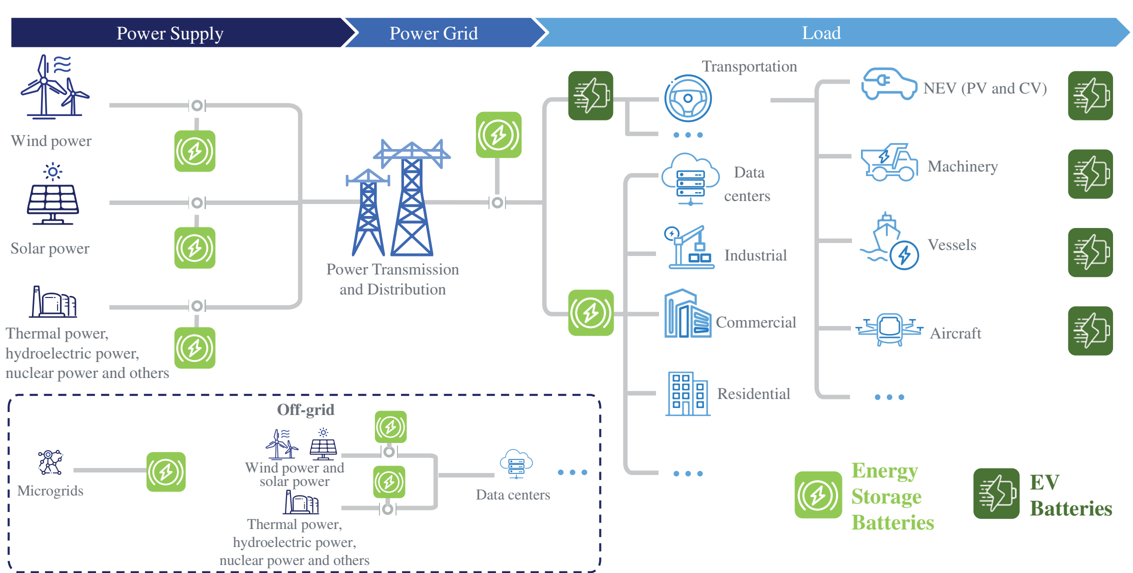
1 Nationally Determined Contributions (NDCs) are national climate action plans by each country under the Paris Agreement, an international treaty on climate change including commitments from each country to reduce emissions and work together to adapt to the impacts of climate change.

manufacturing spans micro-, meso-, and macro-scales. Furthermore, the performance indicators require comprehensive consideration of factors such as application scenario requirements. For example, energy density is mainly influenced by the specific capacity of cathode and anode materials and voltage platform, system structure design, and volumetric utilization efficiency. Life cycle is primarily affected by material stability, side reaction control, and levels of manufacturing technologies. Charging and discharging rate is mainly influenced by factors such as battery material conductivity and electrode structure design. Overall, the design and manufacturing of lithium-ion batteries result from a comprehensive balance of multidimensional performance metrics. Focusing solely on improving a single performance indicator may affect the performance of other indicators.

Lithium-ion batteries are primarily classified by application into three categories: EV batteries, ESS batteries, and consumer electronics batteries. Depending on applications, the general requirements for EV batteries primarily include (1) a life cycle exceeding 1,500 times for ternary batteries or exceeding 4,000 times for LFP batteries, (2) a pack-level energy density exceeding 125Wh/kg, and (3) a C-rate exceeding 1C. For ESS batteries, the general requirements primarily include (1) a longer life cycle and useful life, (2) a stronger environmental adaptability and enhanced safety, and (3) a C-rate exceeding 1C for ESS batteries used in frequency regulation and other purpose.

The mass adoption of lithium-ion battery-powered applications has led to the development of supporting services, electrification ecosystem and infrastructure, such as high-efficiency battery charging and swapping and intelligent energy management solutions.

The Omnipresent Application of Lithium-ion Batteries in Low-Carbon and Clean Energy Transition



Note: Others include geothermal energy, biomass energy, etc.

OVERVIEW OF THE EV BATTERY INDUSTRY

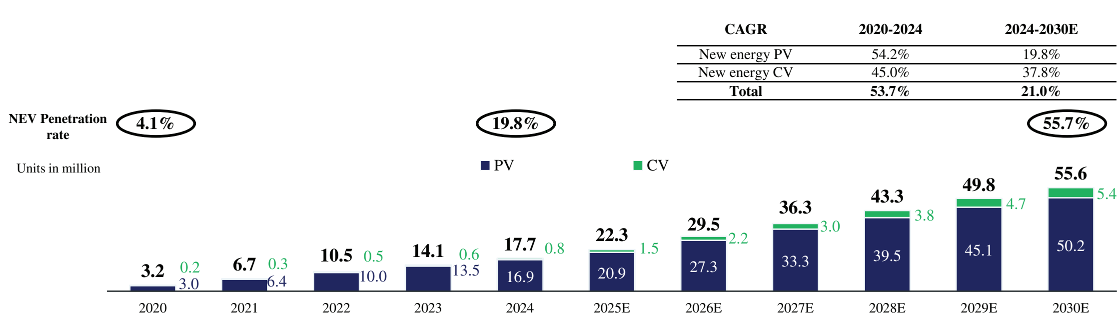
EV batteries are designed to supply energy to power systems in mobility applications. EV batteries can be primarily classified by cathode materials into ternary batteries and LFP batteries. According to the GGII Report, the combined market share of ternary batteries and LFP batteries exceeded 99% of global EV battery shipments in 2024, making them the mainstream EV battery products in the current market. Ternary cathode materials theoretically offer a higher battery energy capacity per gram, enabling greater energy density, higher charging and discharging efficiency, and wide operating temperature range, while LFP batteries exhibit better thermal stability and longer life cycle. Beyond these mainstream technologies, the industry continues to advance through ongoing research and innovation, driving breakthroughs in emerging battery technologies such as sodium-ion batteries, condensed batteries, thereby expanding potential application scenarios.

NEV represent the largest end market for EV batteries globally, which can be categorized into new energy PV and new energy CV. The wide adoption of NEV contributes to the low-carbon development of transportation. In addition, NEV also enhance the overall user experience through improvements in dynamic performance and intelligent vehicle systems. The increasing NEV penetration has driven the growth of global EV battery shipments. Currently, new energy PV primarily utilize both ternary batteries and LFP batteries, while new energy CV mainly use LFP batteries.

Overview of the Global NEV Market

Global NEV Market by Region

Global NEV Sales Volume and Market Penetration



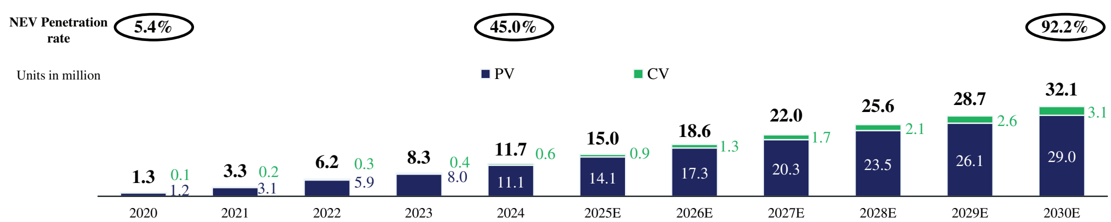
Source: International Organization of Motor Vehicle Manufacturers, China Association of Automobile Manufacturers, European Automobile Manufacturers' Association, GGII Report

Note: The NEV penetration rate is calculated by dividing the annual sales volume of NEV by total vehicle sales volume for the same year. Similarly, the penetration rate of new energy PV/CV is calculated by dividing the annual sales volume of new energy PV/CV by the sales volume in their category for the same year.

The global NEV demand continues to grow. The global sales volume of NEV increased from 3.2 million units in 2020 to 17.7 million units in 2024, and is expected to further increase to 55.6 million units in 2030, representing a CAGR of 21.0% from 2024 to 2030. The global NEV penetration rate is expected to increase from 19.8% in 2024 to 55.7% in 2030. Specifically, the penetration rate of new energy PV is expected to increase from 23.2% in 2024 to 61.0% in 2030, and the penetration rate of new energy CV is expected to increase from 4.8% in 2024 to 31.0% in 2030.

NEV Sales Volume and Market Penetration in China

CAGR	2020-2024	2024-2030E
New energy PV	75.4%	17.4%
New energy CV	47.4%	31.4%
Total	**73.2%**	**18.3%**

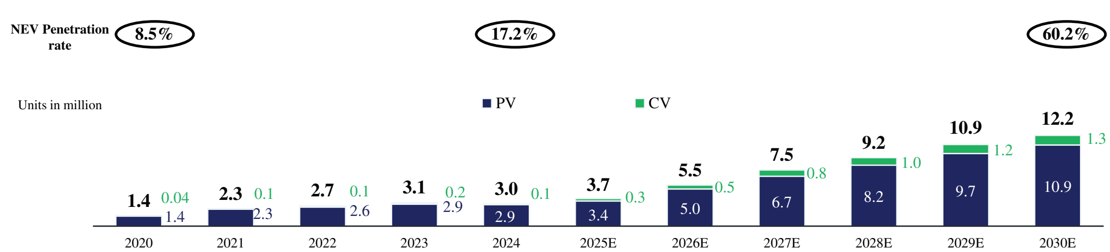


Source: China Association of Automobile Manufacturers, GGII Report

China is the world's largest NEV market by sales volume in 2024, with a total of 11.7 million units sold, and the sales volume is expected to increase to 32.1 million units in 2030, representing a CAGR of 18.3% from 2024 to 2030. The NEV penetration rate in China reached 45.0% in 2024 and is expected to increase to 92.2% in 2030. Specifically, the penetration rate of new energy PV in China is expected to increase from 48.5% in 2024 to 94.5% in 2030, and the penetration rate of new energy CV is expected to increase from 19.4% in 2024 to 75.3% in 2030.

NEV Sales Volume and Market Penetration in Europe

CAGR	2020-2024	2024-2030E
New energy PV	20.7%	24.7%
New energy CV	23.5%	58.0%
Total	**20.8%**	**26.5%**

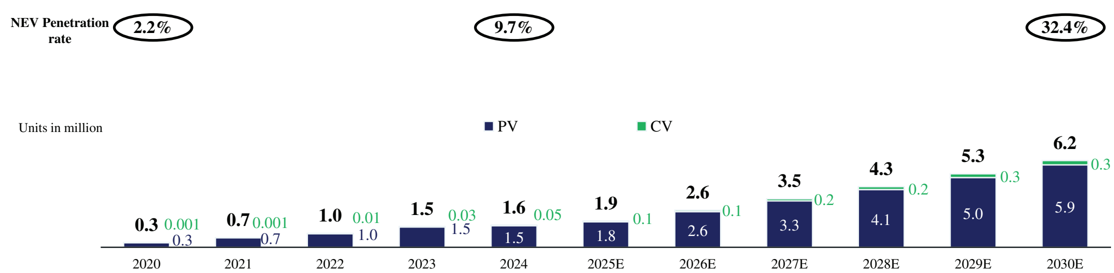


Source: International Organization of Motor Vehicle Manufacturers, European Automobile Manufacturers' Association, GGII Report

In Europe, the NEV penetration rate reached 17.2% in 2024, and the sales volume of NEV is expected to increase to 12.2 million units in 2030, with a CAGR of 26.5% from 2024 to 2030. The NEV penetration rate in Europe is expected to increase to 60.2% in 2030. Specifically, the penetration rate of new energy PV is expected to increase from 20.3% in 2024 to 64.0% in 2030, and the penetration rate of new energy CV is expected to increase from 2.7% in 2024 to 39.8% in 2030.

NEV Sales Volume and Market Penetration in the United States

CAGR	2020-2024	2024-2030E
New energy PV	47.7%	25.0%
New energy CV	152.3%	37.6%
Total	**48.7%**	**25.4%**



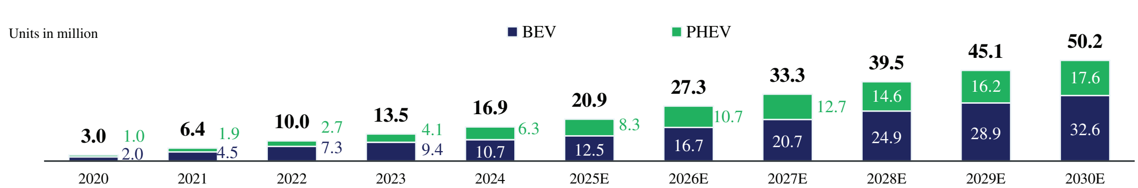
Source: International Organization of Motor Vehicle Manufacturers, GGII Report

In the United States, the NEV penetration rate reached 9.7% in 2024, and the sales volume of NEV is expected to increase to 6.2 million units in 2030, with a CAGR of 25.4% from 2024 to 2030. The NEV penetration in the United States is expected to increase to 32.4% in 2030. Specifically, the penetration rate of new energy PV is expected to increase from 12.2% in 2024 to 39.0% in 2030, and the penetration rate of new energy CV is expected to increase from 1.2% in 2024 to 7.6% in 2030.

Global NEV Market by PV and CV

Global New Energy PV Sales Volume

CAGR	2020-2024	2024-2030E
BEV	51.4%	20.5%
PHEV	59.5%	18.6%
Total	**54.2%**	**19.8%**



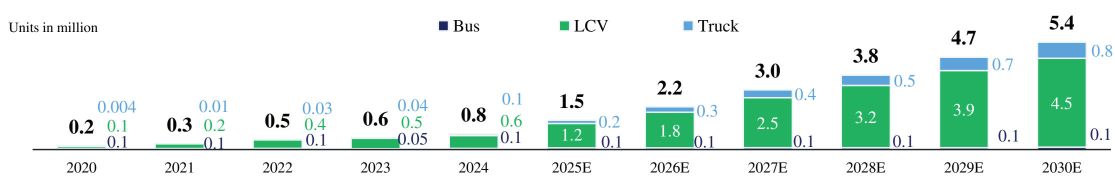
Source: GGII Report

Note: PHEV include REV

New energy PV accounted for approximately 95% of total NEV sales volume in 2024. They can be categorized by powertrain type into BEV and PHEV. In 2024, the average battery energy capacity per vehicle was 63 kWh for BEV and 24 kWh for PHEV. The global sales volume of new energy PV reached 16.9 million units in 2024 and is expected to increase to 50.2 million units in 2030, representing a CAGR of 19.8% from 2024 to 2030. Specifically, the global sales volume of BEV are expected to increase from 10.7 million units in 2024 to 32.6 million units in 2030, with a CAGR of 20.5%, and its market share in new energy PV is expected to increase from 62.9% in 2024 to 65.0% in 2030. The global sales volume of PHEV is expected to increase from 6.3 million units in 2024 to 17.6 million units in 2030 with a CAGR of 18.6%.

Global New Energy CV Sales Volume

CAGR	2020-2024	2024-2030E
Bus	(2.9%)	12.6%
LCV	56.9%	38.1%
Truck	113.8%	45.5%
Total	**45.0%**	**37.8%**



Source: GGII Report

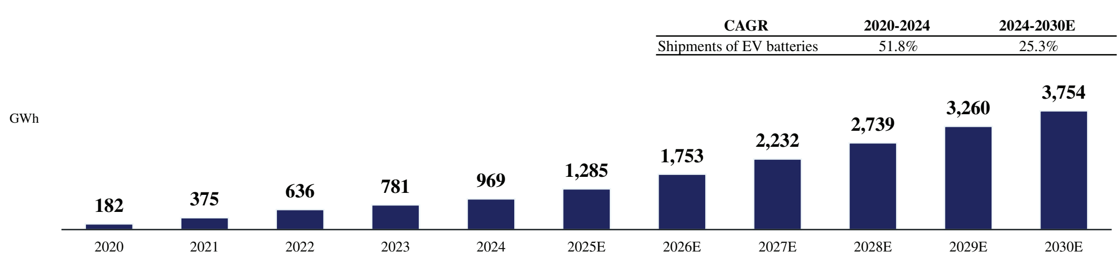
New energy CV primarily include new energy bus, new energy LCV and new energy truck. The new energy CV sector is experiencing rapid growth driven by multiple factors including the support of carbon emission reduction policies, enhanced cost effectiveness, technological advancements, and NEV infrastructure development. CV manufacturers are expediting their transition to new energy and the number of new energy CV models is rapidly increasing. The export of high-quality Chinese new energy CV has further stimulated the development of overseas new energy CV markets. The mass adoption and technological improvements have boosted the cost effectiveness of new energy CV. With more applications of high-capacity battery technologies, the driving range of new energy CV is increasing, and their cost effectiveness is anticipated to be further enhanced. Moreover, the ongoing enhancement of battery charging and swapping infrastructure for new energy CV has also improved the efficiency and flexibility of replenishing solutions.

Driven by the above-mentioned factors, the global sales volume of new energy CV increased from 0.2 million units in 2020 to 0.8 million units in 2024 and is expected to increase to 5.4 million units in 2030, representing a CAGR of 37.8% from 2024 to 2030. In 2024, total global CV sales volume reached 16.5 million units, while new energy CV accounted for only 4.8% of the market, highlighting the significant growth potential in this segment. The penetration rate of new energy CV is expected to increase to 31.0% in 2030. China is currently the largest market for new energy CV. The penetration rate of new energy CV in China is expected to increase from 19.4% in 2024 to 75.3% in 2030. Specifically, the penetration rate of new energy bus is expected to remain at 55.0% to 60.0%; the penetration rate of new energy LCV is expected to increase from 19.5% in 2024 to 79.5% in 2030; the penetration rate of new energy truck is expected to increase from 13.6% in 2024 to 59.6% in 2030.

Overview of Global EV Battery Market

EV Battery Shipments by Region

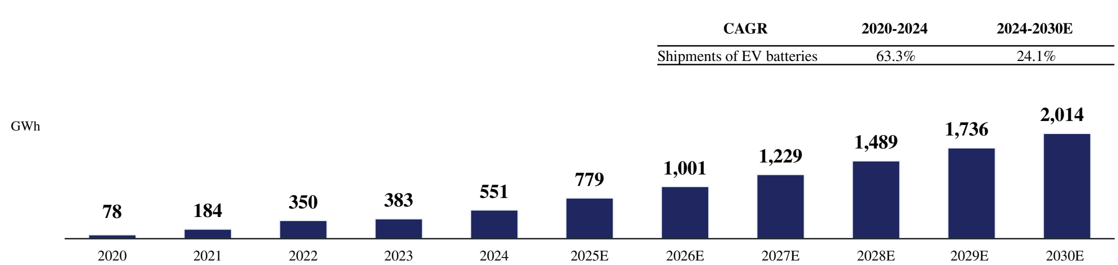
Global Shipments of EV Batteries



Source: GGII Report

The growth in sales volume of NEV is driving and is expected to continue propelling a sustained increase in global EV battery shipments. The global EV battery shipments increased from 182 GWh in 2020 to 969 GWh in 2024 with a CAGR of 51.8%, and are expected to reach 3,754 GWh in 2030 with a CAGR of 25.3% from 2024 to 2030.

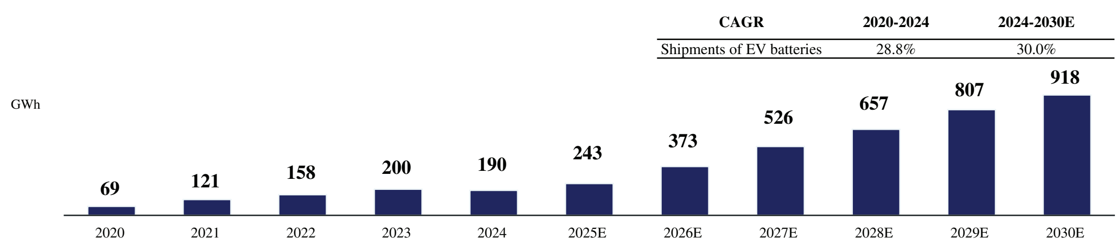
Shipments of EV Batteries in China



Source: GGII Report

In recent years, China's EV battery market has experienced rapid growth and become the world's largest EV battery market. China's EV battery shipments increased from 78 GWh in 2020 to 551 GWh in 2024 with a CAGR of 63.3%, and are expected to grow to 2,014 GWh in 2030 with a CAGR of 24.1% from 2024 to 2030.

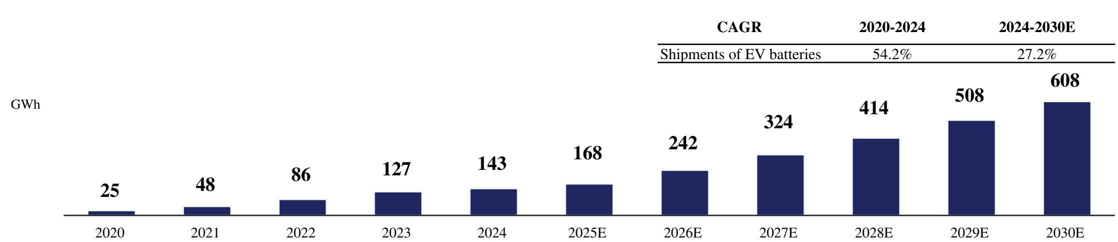
Shipments of EV Batteries in Europe



Source: GGII Report

EV battery shipments in Europe are expected to grow from 190 GWh in 2024 to 918 GWh in 2030, with a CAGR of 30.0%.

Shipments of EV Batteries in the United States

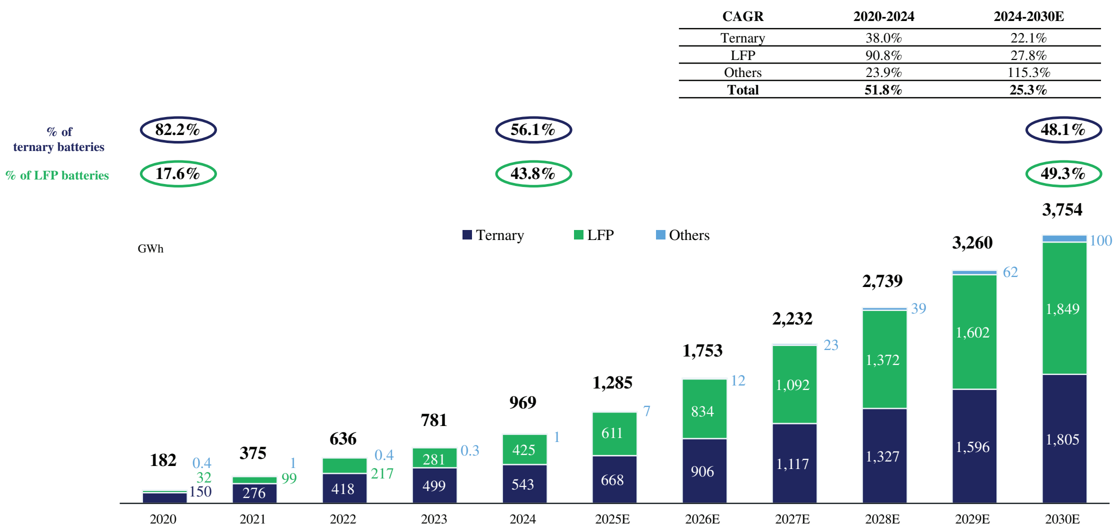


Source: GGII Report

EV battery shipments in the United States are expected to grow from 143 GWh in 2024 to 608 GWh in 2030, with a CAGR of 27.2%.

EV Battery Shipments by Cathode Chemistry

Global Shipments of EV Batteries by Cathode Chemistry



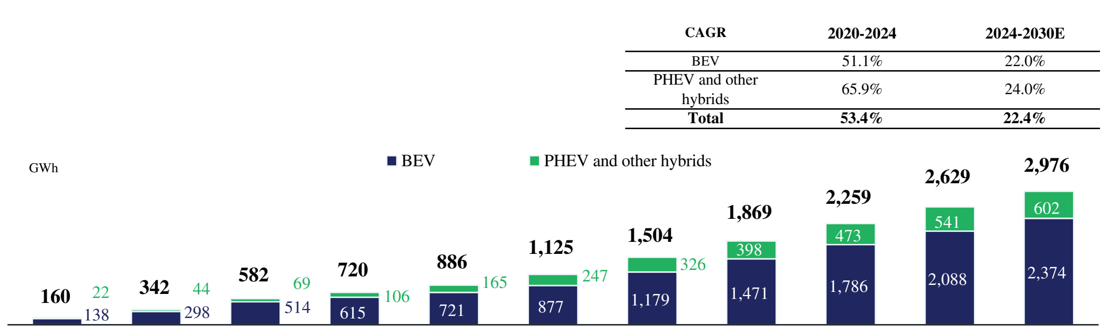
Source: *GGII Report*

Note: Others include sodium-ion batteries and others

In general, ternary batteries offer higher battery energy density, higher charging and discharging efficiency, and higher recycling value. On the other hand, LFP batteries generally have advantages like better thermal stability and longer life cycle. The global shipments of ternary batteries increased from 150 GWh in 2020 to 543 GWh in 2024 with a CAGR of 38.0%, and are expected to reach 1,805 GWh in 2030 with a CAGR of 22.1% from 2024 to 2030, accounting for 48.1% of global EV battery shipments in 2030. The global shipments of LFP batteries increased from 32 GWh in 2020 to 425 GWh in 2024 with a CAGR of 90.8%, and are expected to reach 1,849 GWh in 2030 with a CAGR of 27.8% from 2024 to 2030. Driven by the improved competitiveness of LFP batteries based on enhanced battery performance and increased efficiency of battery system integration, the global market share of LFP batteries increased from 17.6% in 2020 to 43.8% in 2024, and is expected to reach 49.3% in 2030.

EV Battery Shipments by PV and CV

Global Shipments of EV Batteries for PV

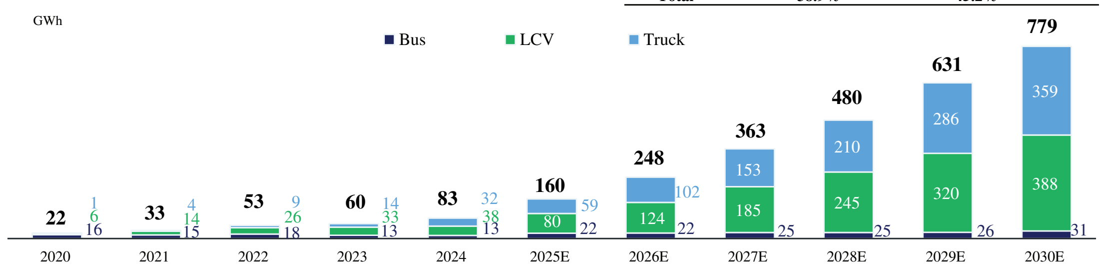


Source: *GGII Report*

The global shipments of EV batteries for PV increased from 160 GWh in 2020 to 886 GWh in 2024, with a CAGR of 53.4%, and are expected to reach 2,976 GWh in 2030. In particular, the shipments of EV batteries for BEV, which feature higher battery energy capacity per vehicle compared to PHEV, are expected to grow from 721 GWh in 2024 to 2,374 GWh in 2030 with a CAGR of 22.0%, while the shipments of EV batteries for PHEV and other hybrids are expected to increase from 165 GWh in 2024 to 602 GWh in 2030 with a CAGR of 24.0%.

Global Shipments of EV Batteries for CV

CAGR	2020-2024	2024-2030E
Bus	(4.1%)	15.4%
LCV	60.8%	47.5%
Truck	131.1%	49.5%
Total	**38.9%**	**45.2%**



Source: GGII Report

The global shipments of EV batteries for new energy CV increased from 22 GWh in 2020 to 83 GWh in 2024 with a CAGR of 38.9%, and are expected to reach 779 GWh in 2030, with a CAGR of 45.2% from 2024 to 2030. In particular, the shipments of EV batteries for E-Bus are expected to grow from 13 GWh in 2024 to 31 GWh in 2030 with a CAGR of 15.4%; the shipments of EV batteries for E-LCV are expected to increase from 38 GWh in 2024 to 388 GWh in 2030 with a CAGR of 47.5%; and the shipments of EV batteries for E-Truck are expected to increase from 32 GWh in 2024 to 359 GWh in 2030 with a CAGR of 49.5%.

Growth Drivers for the EV Battery Market

Rapid Development of the NEV Market: The accelerating electrification of vehicles has contributed to the rapid growth in the EV battery market. This increasing penetration of NEV is driven by the following factors:

- ***Rapid increase in available NEV models:*** The global automobile industry is transitioning toward electrification. Automakers have continuously increased their investments in the R&D and production of NEV, leading to a rapid increase in the number of available NEV models. According to the GGII Report, in 2024, the number of new energy PV models available for sale worldwide exceeded 750 and is expected to reach over 1,500 in 2030; in 2024, the number of new energy CV models available for sale worldwide is approximately 3,000 and is expected to reach over 7,000 in 2030.

- ***Advancement in intelligence:*** The electrical architecture of NEV is more adaptable to the hardware and software systems required for intelligent vehicles. With continuous advancement and wide application of technologies such as smart cockpits and autonomous driving, user experience has significantly improved. Smart cockpit technology enables intelligent human-machine interaction, high-definition displays with immersive experiences, and multimedia interconnectivity, comprehensively enhancing the end-user experience. According to the GGII Report, by 2030, global sales of new energy PV equipped with smart cockpits are expected to reach approximately 43 million, accounting for 85% of the total sales volume of new energy PV. In terms of autonomous driving, by 2030, approximately 38 million new energy PV to be sold globally will feature L2 or higher technologies, accounting for 76% of the total sales volume of new energy PV. As L3 and above autonomous driving technologies mature, autonomous NEV will gradually enter commercialization, further boosting demand for NEV in the future.

- ***Continuous improvement of NEV infrastructure:*** The scale of global battery charging and swapping infrastructure has expanded significantly. The increasingly well-developed charging and swapping network for NEV has significantly enhanced the convenience of using NEV. According to the GGII Report, installed charging piles for new energy PV worldwide exceeded 50 million by the end of 2024, more than three times the number by the end of 2020, among these, the number of public fast-charging piles reached approximately 3 million, and is expected to reach 10 million by the end of 2030; the number of charging piles for E-Truck worldwide reached approximately 30,000, and is expected to reach approximately 150,000 by the end of 2030. In addition, the promotion and adaption of battery-swapping modes have further improved the efficiency and flexibility of NEV replenishing solutions. By the end of 2024, there were over 5,000 battery-swapping stations for new energy PV worldwide, more than seven times the number by the end of 2020, and is expected to exceed 20,000 by the end of 2030; there were approximately 1,000 battery-swapping stations for E-Truck worldwide, and it is expected to increase to over 9,000 in 2030. Increasing intelligent charging piles and battery-swapping stations can realize two-way interaction with the power grid and promote the development of V2G, which can reduce the impact of concentrated charging of NEV on the power grid, and further improve the flexibility of the power grid.

- ***Improved cost effectiveness:*** The continuous advancement in NEV technology, the maturity of the supply chain, and economies of scale have steadily reduced NEV purchase costs. Meanwhile, electricity costs and maintenance expenses of NEV during usage period are significantly lower than those for traditional fuel vehicles, making NEV more attractive to end users. According to the GGII Report, E-Bus, E-LCV and E-Truck used for urban and short-distance transportation scenarios in China have better cost effectiveness in terms of TCO (total cost of ownership).

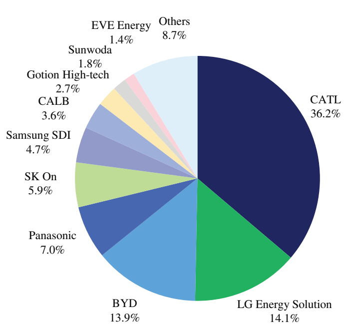
Gradual Increase in Battery Energy Capacity per Vehicle: According to the GGII Report, for passenger vehicles in 2024, the global average battery energy capacity per vehicle for BEV and PHEV was 63 kWh and 24 kWh, respectively, and is expected to reach 68 kWh and 32 kWh in 2030, respectively. Compared with new energy PV, E-Bus and E-Truck have a higher battery energy capacity per vehicle. In 2024, the global average battery energy capacity per vehicle for E-Bus, E-LCV and E-Truck was 199 kWh, 54 kWh, and 349 kWh, respectively, which are expected to increase to 230 kWh, 80 kWh, and 410 kWh in 2030, respectively. The increase in the battery energy capacity per vehicle has contributed to the growth in EV battery shipments.

Emerging Application Scenarios: With technological advancement and innovation, EV batteries have seen continuous improvements in energy density, life cycle, charge-discharge rate, safety and reliability. Their applications have gradually expanded to emerging fields such as machinery, vessels and aircraft, further driving demand in the EV battery market.

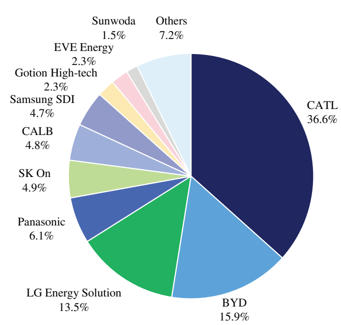
Competitive Landscape of EV Battery Market

Major players in the global EV battery market include companies from China, South Korea, Japan, among others, with a relatively high market concentration due to significant barriers to entry. Based on EV battery usage volume in 2024, the top five and top ten EV battery companies accounted for 74.7% and 89.4% of the global market, respectively. Leading companies dominate the industry, leveraging their technological innovation, strengths in scale and capital resources, customer relationships and supply chain management capabilities.

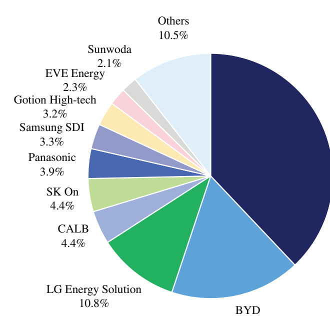
Global EV Battery Market Share in 2022



Global EV Battery Market Share in 2023



Global EV Battery Market Share in 2024



Source: GGII Report, SNE Research

OVERVIEW OF THE ESS BATTERY INDUSTRY

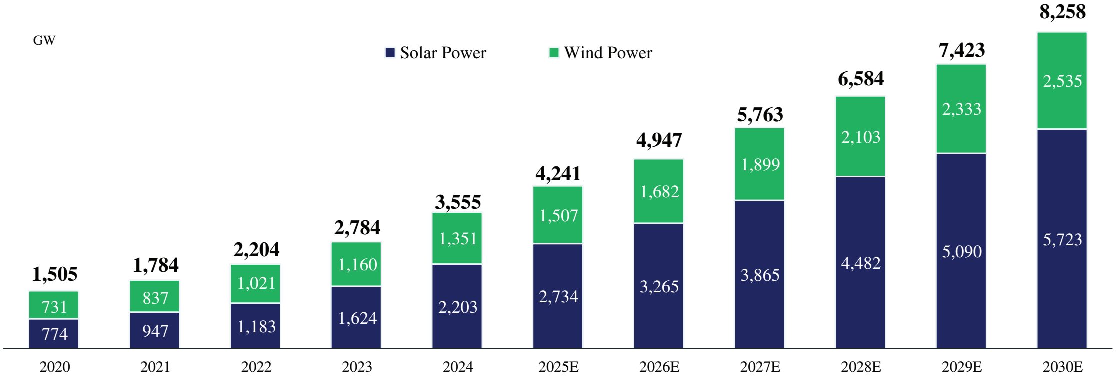
Electrochemical energy storage, exemplified by lithium-ion batteries, enables the storage, conversion, and utilization of electrical energy, with a vital role in stabilizing power output, peak-shaving and valley-filling, as well as regulation of system frequency. Currently, electrochemical energy storage systems mainly use LFP batteries. ESS batteries can be used for FTM energy storage and BTM energy storage based on their application scenarios. FTM energy storage offers a wide array of services for the power system. For example: (1) FTM energy storage ensures power generation capacity, maintains grid stability, and improves renewable energy integration. Wind and solar power have become the primary approach of global clean energy transformation, however, their power generation are unstable and volatile. FTM energy storage can store or release wind and solar power generated according to the grid capacity and the power demand, achieving flexibility in energy release; (2) FTM energy storage can charge during low-power-demand period and discharge during peak-power-demand period to ensure power supply and demand balance; (3) FTM energy storage can alleviate grid congestion by storing power that cannot be transmitted when the grid is clogged and releasing such power when the grid load is below capacity. BTM energy storage encompasses various applications, including industrial and commercial energy storage, data center energy storage, residential energy storage, and telecommunications energy storage, primarily serving functions include: (1) BTM energy storage can provide users with stable and reliable power supply; (2) BTM energy storage can charge and discharge during off-peak-rate period and peak-rate period, respective, to save electricity expenses; (3) BTM energy storage can be used as an emergency backup to reduce the impact of sudden power restriction and blackout, and (4) BTM energy storage can supply power during peak-power-demand period and reduce the demand for transformer capacity expansion. Additionally, advancements in energy storage technology and integrated applications have led to the development of innovative power system applications such as microgrids and virtual power plants.

The energy storage sector is still in the early stage of development. It receives guidance and support from various countries worldwide through top-level policy planning, improvements in electricity market, and the establishment of incentive mechanisms. By advancing and optimizing various market mechanisms, including the electricity spot market, medium and long-term market, ancillary service market and capacity market, the energy storage industry anticipates more diversified profitability models from multiple revenue sources. In recent years, along with the low-carbon transition and continuously increasing penetration of renewable energy of the power industry, regions like China and Europe have seen a general rise in peak-valley price difference, with possibility of further widening in the future. This trend expands the potential for energy storage in peak-shaving and valley-filling and price arbitrage, as the business model of energy storage gradually mature. Furthermore, with the robust development of intelligent application, computing power and electricity demands of data centers have increased significantly. Guided by the carbon reduction goals of technology companies and data center operators, renewable energy paired with ESS has become an effective solution to meet data centers' substantial urgent new electricity demands, ensuring a stable, low-carbon energy supply for their operations.

Overview of the Global Renewable Energy Market (Wind and Solar Power)

Global Cumulative Installed Capacity of Wind and Solar Power

CAGR	2020-2024	2024-2030E
Solar Power	29.9%	17.2%
Wind Power	16.6%	11.1%
Total	**24.0%**	**15.1%**

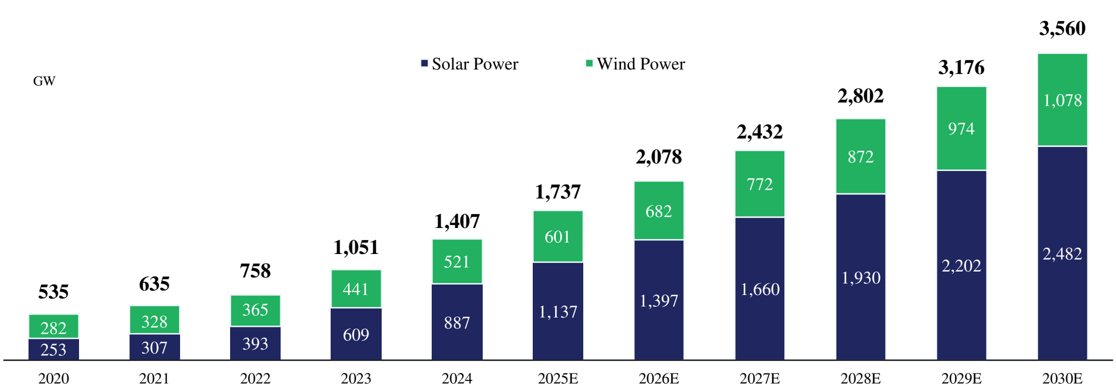


Source: International Energy Agency, DNV, GGII Report

Global cumulative installed capacity of wind and solar power grew from 1,505 GW in 2020 to 3,555 GW in 2024 with a CAGR of 24.0%, and is expected to reach 8,258 GW in 2030, with a CAGR of 15.1% from 2024 to 2030. Wind and solar power is estimated to account for 2.5 TW and 5.7 TW of the global cumulative installed power capacity in 2030, representing 16% and 36% of the total, respectively.

Cumulative Installed Capacity of Wind and Solar Power in China

CAGR	2020-2024	2024-2030E
Solar Power	36.8%	18.7%
Wind Power	16.6%	12.9%
Total	**27.4%**	**16.7%**



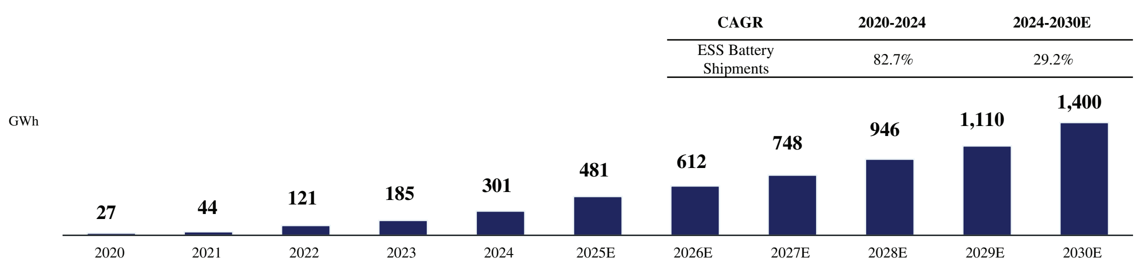
Source: NEA, China Photovoltaic Industry Association, GGII Report

The cumulative installed capacity of wind and solar power in China reached 1,407 GW in 2024, accounting for 40% of the global cumulative installed power capacity, with a CAGR of 27.4% from 2020 to 2024. It is expected to further increase to 3,560 GW in 2030 with a CAGR of 16.7% from 2024 to 2030. Wind and solar power is estimated to account for 1.1 TW and 2.5 TW of China's cumulative installed power capacity in 2030, accounting for 18% and 42% of the total, respectively.

Overview of the Global ESS Battery Market

ESS Battery Shipments by Region

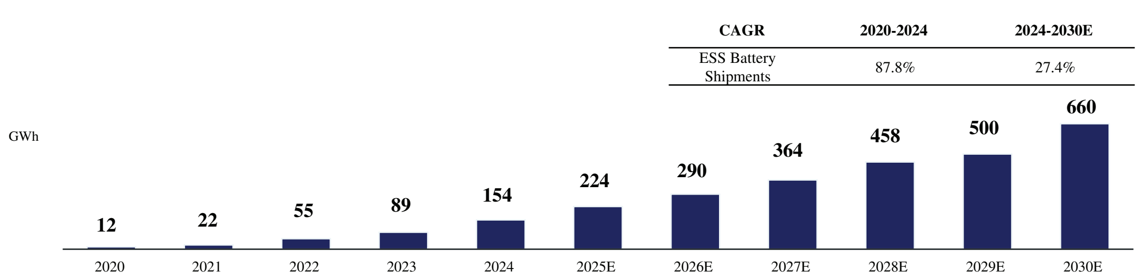
Global ESS Battery Shipments



Source: GGII Report

The cumulative installed capacity of wind and solar power globally continues to grow, highlighting the significant regulatory role of FTM energy storage. Combined with the widespread application of BTM energy storage in industrial and commercial application and data centers, the global ESS battery shipments has grown from 27 GWh in 2020 to 301 GWh in 2024 with a CAGR of 82.7%, and are expected to increase to 1,400 GWh in 2030, with a CAGR of 29.2% from 2024 to 2030.

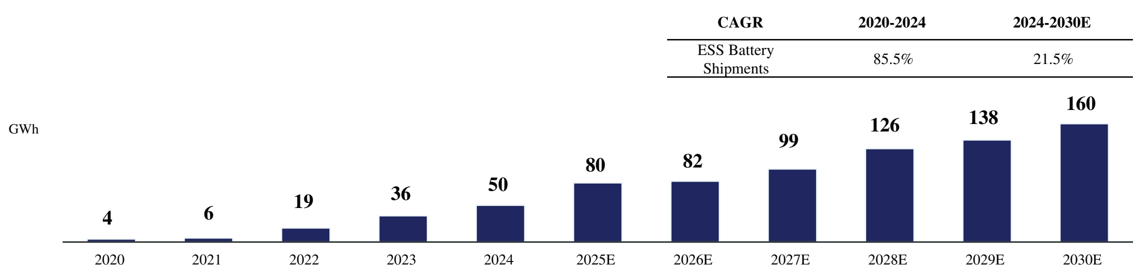
ESS Battery Shipments in China



Source: GGII Report

Supported by policies promoting energy conservation, carbon reduction and renewable energy, the cumulative installed capacity of wind and solar power in China has been consistently increasing. As an important flexible adjustment resources, the demand for energy storage is rapidly growing. The ESS battery shipments in China grew from 12 GWh in 2020 to 154 GWh in 2024, with a CAGR of 87.8%, and are expected to increase to 660 GWh in 2030, with a CAGR of 27.4% from 2024 to 2030.

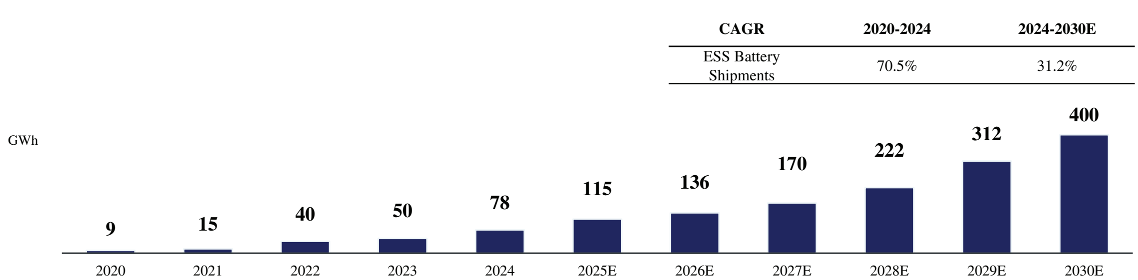
ESS Battery Shipments in Europe



Source: GGII Report

In Europe, with the transformation of clean energy and the promotion of power reform, the cumulative installed capacity of wind and solar power in Europe has been increasing, and the FTM and BTM energy storage markets have experienced rapid development. ESS battery shipments in Europe are expected to increase from 50 GWh in 2024 to 160 GWh in 2030, with a CAGR of 21.5%.

ESS Battery Shipments in the United States



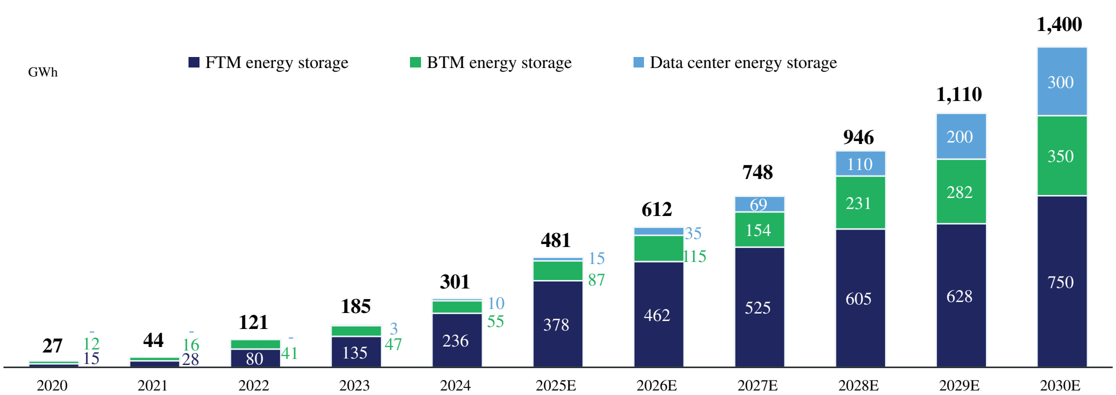
Source: GGII Report

In the United States, driven by factors such as policy reforms to accelerate the process of connecting renewable energy to the power grid and increasing power demand from data centers, the installation of energy storage in the United States has accelerated. In the United States, ESS battery shipments are expected to increase from 78 GWh in 2024 to 400 GWh in 2030, with a CAGR of 31.2%.

ESS Battery Shipments by Application

Global ESS Battery Shipments by Application

CAGR	2020-2024	2024-2030E
FTM energy storage	99.2%	21.3%
BTM energy storage	45.8%	36.2%
Data center energy storage	N/A	76.3%
Total	**82.5%**	**29.2%**



Source: GGII Report

Note: BTM energy storage mainly includes industrial and commercial energy storage, and residential energy storage

In 2024, FTM energy storage accounted for over 75% of global ESS battery shipments. The shipments of FTM energy storage batteries grew from 15 GWh in 2020 to 236 GWh in 2024, with a CAGR of 99.2%, and are expected to increase to 750 GWh in 2030, with a CAGR of 21.3% from 2024 to 2030.

The shipments of BTM ESS batteries grew from 12 GWh in 2020 to 55 GWh in 2024, with a CAGR of 45.8%, and are expected to increase to 350 GWh in 2030, with a CAGR of 36.2% from 2024 to 2030. In the coming years, the shipments of ESS batteries in data centers are expected to increase from 10 GWh in 2024 to approximately 300 GWh in 2030, with a CAGR of 76.3%.

Drivers for the ESS Battery Market

Global Electricity Demand Growth: The global demand for electricity continues to rise, driven by global economic development, population growth, and accelerating electrification. According to the GGII Report, global electricity demand reached approximately 30,000 TWh in 2024, and is expected to increase with a CAGR of 4.5% from 2024 to 2030.

Policy Support: Many countries have introduced policies to guide and support the development of renewable energy and energy storage industries. In China, government authorities including the NDRC and the NEA have issued multiple policy initiatives, such as the 14th Five-Year Plan for Renewable Energy Development (《「十四五」可再生能源發展規

劃》), the Notice on Promoting the Grid Integration and Dispatch of New Types of Energy Storage (《關於促進新型儲能並網與調度運用的通知》), and the Implementation Plan for the Special Action on Optimization of Power System Regulation Capacity (2025-2027) (《電力系統調節能力優化專項行動實施方案(2025-2027年)》), to support the development of renewable energy and energy storage industries, and to improve power system and market development. The EU published the REPowerEU plan in 2022, and established a target to increase the share of renewable energy in the power mix to 42.5% by 2030, with the aspiration to reach 45%. This plan emphasizes the critical role of energy storage in facilitating the EU's energy transition and climate goal. Under this framework, a series of incentive programs for renewable energy and energy storage have been introduced. In addition, the EU proposed the Clean Industrial Deal in 2025, which plans to raise the economy-wide electrification rate from 21.3% to 32% by 2030 while deploying an additional 100 GW of renewable energy capacity per year up to 2030, in order to gradually reduce the reliance on traditional energy sources.

Development of Renewable Energy: According to the GGII Report, the share of renewable power generation in the global power mix has been steadily increasing. Wind and solar power's share increased from 9% in 2020 to 17% in 2024, and is expected to reach approximately 31% in 2030. Energy storage, serving as a flexible grid-balancing resource in power systems, has become increasingly critical for renewable energy integration, power supply-demand balancing, and grid stability, which drives rigid demand for storage growth.

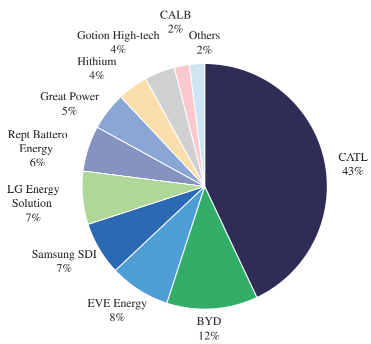
Demand from Data Centers: The rapid advancement of applications of intelligent technologies is driving a significant increase in the demand for computing power and electricity consumption of data centers. According to the GGII Report, global data center electricity consumption is expected to reach approximately 1,900 TWh in 2030. Many leading technology companies and data center operators have established and implemented definitive carbon reduction targets. Renewable energy equipped with ESS batteries has become an effective solution that can be rapidly deployed to provide clean energy for data centers to meet their substantial new electricity demands, making it a key driver for the energy storage market growth.

Improved Cost Effectiveness: The costs of ESS have declined significantly in recent years, driven by technology advancement, supply chain maturity, and economies of scale, enhancing the cost effectiveness of energy storage applications, thus contributing to the rapid growth in demand for ESS batteries.

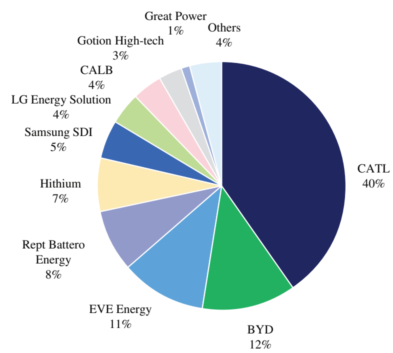
Competitive Landscape of ESS Battery Market

The competitive landscape of the global ESS battery market is similar to that of the EV battery industry, with relatively concentrated market share. In terms of shipment volume, in 2024, the top five and top ten energy storage battery manufacturers accounted for 73% and 96% of the global market, respectively. There is notable overlap between the global top ten companies in EV batteries and ESS batteries.

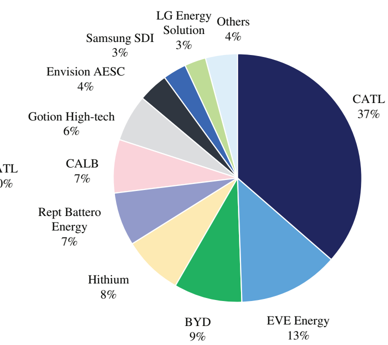
Global ESS Battery Market Share in 2022



Global ESS Battery Market Share in 2023



Global ESS Battery Market Share in 2024



Source: GGII Report, SNE Research

OVERVIEW OF BATTERY RECYCLING INDUSTRY

As more lithium-ion batteries reach the end of their life cycle, the demand for effective battery recycling solutions is growing. Battery recycling is particularly crucial as these batteries contain heavy metals and hazardous substances that, if not properly recycled, could pose significant environmental risks. Lithium-ion battery recycling involves recovering and processing valuable metals such as nickel, cobalt, manganese and lithium, along with other materials from retired batteries, enabling the closed-loop utilization of critical resources required for battery manufacturing. Moreover, battery recycling helps reduce the overall life cycle carbon footprint of lithium-ion batteries compared to using raw mineral materials. The battery industry needs to build a closed-loop industrial ecosystem of battery production, usage, cascade utilization and recycling to achieve sustainable development of resources.

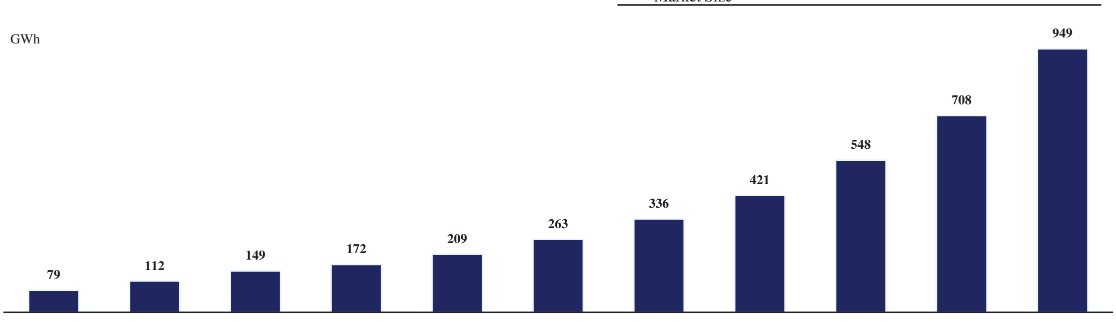
The lithium-ion battery recycling process primarily consists of discharging the batteries, followed by dismantling and crushing, and then separating different materials. These extracted materials are further processed using various technologies, including pyrometallurgical and hydrometallurgical methods. Continuous advancements in lithium-ion battery recycling technologies have significantly improved recovery rates and cost effectiveness, reducing reliance on raw mineral materials and mitigating the constraints caused by regional scarcity of resources.

The lithium-ion battery recycling industry remains in its early stages of development, with countries worldwide implementing policies and regulations to support market growth and establish industry standards. Governments are strengthening industry oversight by imposing strict entry requirements on recycling companies, particularly regarding safety and environmental compliance. For example, China has introduced a series of policy initiatives aimed at building a comprehensive, efficient, and standardized waste recycling system, advancing the R&D and application of recycling technology, and improving traceability management. Key regulations include the Guidelines on Accelerating the Construction of Waste Recycling Systems (《關於加快構建廢棄物循環利用體系的意見》) and the Industry Standards for Comprehensive Utilization of Used Power Batteries from New Energy Vehicles (《新能源汽車廢舊動力電池綜合利用行業規範條件》). They require recycling companies to meet specific standards in areas such as site selection, equipment and processes, resource utilization and energy efficiency, and environmental protection. The EU Battery Regulation established specific targets for EV battery recycling, outlining clear requirements for overall battery recovery rates, material recovery rates, and the minimum proportion of recycled content. Starting from 2025, all collected waste batteries must be recycled, with high recovery rates, particularly for critical materials such as cobalt, lithium, and nickel. Furthermore, the regulation specifies that EV batteries must contain a certain proportion of recycled materials – for example, the proportion of recycled lithium must reach 6% by 2031 and 12% by 2036.

The battery recycling market continues to attract diverse participants, including traditional scrap and waste recycling companies, battery manufacturers, battery materials companies and mining companies. These industry participants are establishing recycling service networks through independent initiatives and collaborative partnerships, gradually forming a structured and comprehensive battery collection and recycling ecosystem. The global battery recycling market is expected to continue expanding, with its total market size projected to reach 949 GWh by 2030.

Global Battery Recycling Market Size

CAGR	2020-2024	2024-2030E
Battery Recycling Market Size	27.4%	28.7%



Source: *GGII Report*

Note: Including retired batteries, as well as waste materials generated from battery and materials production

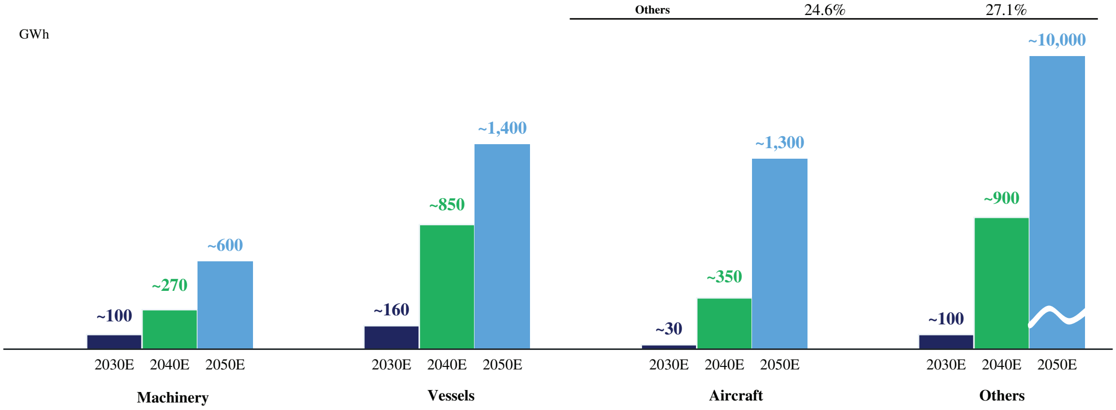
EMERGING APPLICATIONS

The application of lithium-ion batteries in NEV and energy storage sectors are becoming increasingly mature. Continuous technological innovations have enabled the use of lithium-ion batteries in more diverse scenarios, thereby accelerating electrification across all sectors of the society. Next-generation EV batteries are driving the electrification of machinery, vessels and aircraft, further reducing carbon emissions. Moreover, with the introduction and wide adoption of emerging technologies, the demand for EV batteries in intelligence-driven application is expected to be immense.

Based on these four major applications, market demand for lithium-ion batteries in emerging fields is expected to surge beyond 13 TWh by 2050.

Battery Shipments in Emerging Applications

CAGR	2030E-2040E	2040E-2050E
Machinery	10.9%	8.4%
Vessels	18.2%	5.1%
Aircraft	27.7%	13.4%
Others	24.6%	27.1%



Source: GGII Report

INDUSTRY OUTLOOK

The wide adoption of EV batteries and ESS batteries has gradually fostered the development of an industrial ecosystem, creating demands for related services, such as the construction and management of battery charging and swapping stations, the operation and maintenance of energy storage facilities, V2G (two-way interaction between NEV and the power grid), energy internet platforms, and intelligent energy management systems, which plays an important role in promoting the development of the new energy industry and improving the flexibility of the power system. The industry is evolving from simply offering products to providing services, then to delivering comprehensive solutions, and ultimately achieving deep integration. This progression enables the intelligent interconnection, dispatch and management of green energy, establishes a safe, efficient, flexible and intelligent new energy system, and contributes to the wide adoption of zero-carbon solutions and the realization of a zero-carbon society. According to the GGII Report, between 2020 and 2050, the total investments required to achieve net-zero targets is expected to exceed US$275 trillion globally.

KEY ENTRY BARRIERS FOR THE LITHIUM-ION BATTERY INDUSTRY

Technology: Lithium-ion batteries are essential components in low-carbon and clean energy transition. The development and large-scale production of lithium-ion batteries that combine high safety, high performance, superior quality, and low cost face exceptionally high entry barriers. Battery technology requires a profound understanding and comprehensive application of electrochemistry, thermodynamics, and molecular dynamics, spanning multiple principles and fundamental theories across micro-, meso-, and macro-scales. The R&D and manufacturing of high-quality batteries encompass materials, product design, processes, engineering design, testing and analysis, and intelligent manufacturing, each of which demands an extremely high level of technical precision. These technologies must not only be validated in laboratory environments but also undergo long-term refinement and optimization in real-world production and application scenarios.

Scale and Capital: The battery industry exhibits characteristics of being technology-intensive, capital-intensive, and labor-intensive simultaneously. Its highly complex technologies rely on cutting-edge innovations in materials and processes, necessitating substantial R&D investments and cross-disciplinary technical expertise. Moreover, the industry demands sustained and large-scale capital investments, from experimental research and development to mass production, as well as the construction, maintenance, and continuous upgrading of large-scale production lines to ensure product quality. Additionally, battery assembly, quality inspection, and post-production maintenance still rely heavily on manual operations and precision management. Only battery companies that possess all three competitive advantages — technological strength, financial resources, and labor expertise — can establish a sustainable competitive edge in the industry.

Customer Relationship: Customers require a long period to accurately assess the performance and quality of battery products, leading them to be highly cautious when selecting new battery suppliers. For example, EV batteries are core components of NEV, accounting for 30% to 60% of total vehicle costs. Given the lengthy development cycle of new vehicle models, battery manufacturers must engage in long-term joint development with automakers and undergo multiple rounds of validation before securing nomination. Considering the sales cycle of vehicle models, automakers are reluctant to change the suppliers for core components such as batteries. As a result, customers tend to choose battery suppliers with strong technological capabilities, stable partnerships, and large-scale delivery capacity to ensure reliability and continuity.

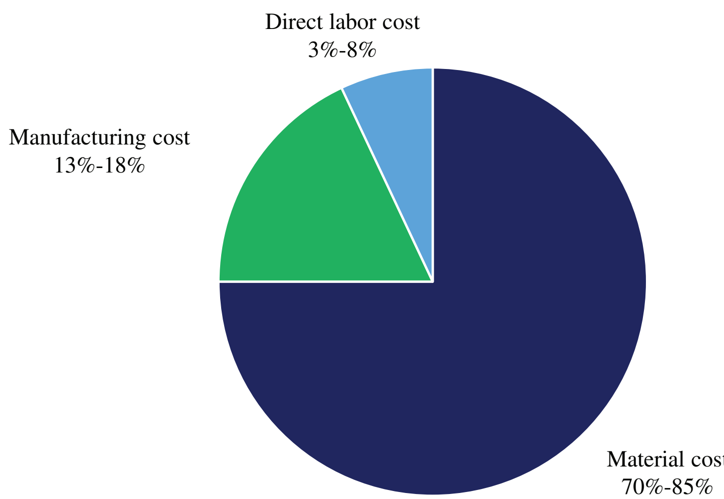
Supply Chain Management: The cost of materials accounts for a significant proportion of the total cost of EV and ESS batteries, and price fluctuations in certain materials can have a substantial impact on overall battery costs. Material supply directly influences production planning for battery manufacturers, while material quality affects both manufacturing consistency and product delivery to customers. As a result, securing low-cost, stable, and high-quality materials is one of the key competitive advantages for battery companies. Battery manufacturers that establish deep collaboration with upstream material suppliers — ensuring both technological compatibility and a stable supply chain — can effectively control costs, drive technological innovation, and maintain strong market competitiveness.

ANALYSIS OF LITHIUM-ION BATTERY PRICE AND COSTS

Major Cost Components

Lithium-ion battery cells mainly consist of cathode, anode, separator, and electrolyte. In the cost structure of lithium-ion cells, material costs account for approximately 70% to 85% of the total cell cost, with cathode materials constituting the largest cost component.

Cost Structure of Lithium-ion Batteries in 2024



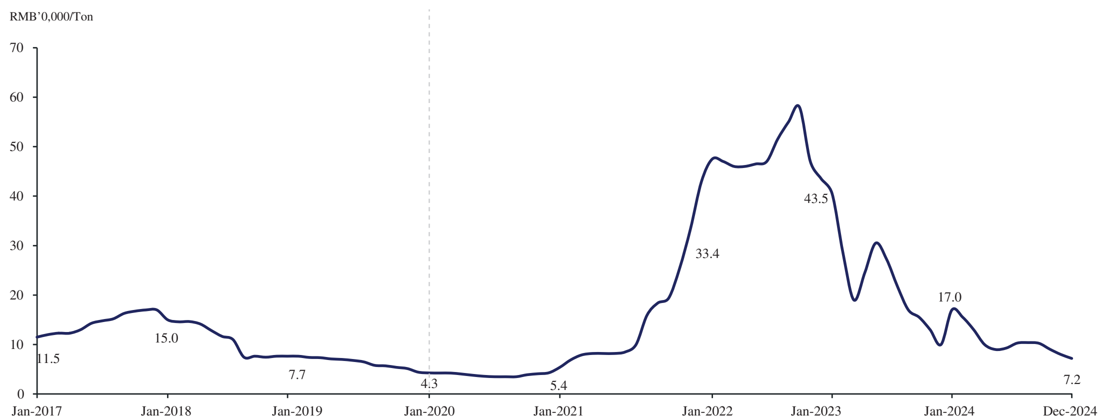
Source: GGII Report

Price Analysis of Key Raw Materials

The price of lithium carbonate, a key raw material influencing lithium-ion battery cathode price, responds sharply to industry supply-demand fluctuations. Both new production and capacity expansion of lithium carbonate, involves multiple stages, including extraction, beneficiation, and refining, which requires a prolonged processing period, typically taking two to three years. Since 2020, the rapid expansion in NEV and energy storage market demand coupled with limited incremental supply of lithium carbonate, has resulted in a supply shortage and a sharp price surge. Price of lithium carbonate reached a peak of over RMB600,000 per ton in the fourth quarter of 2022. As supply gradually increased, price began to decline. By December 2024, lithium carbonate price has drop to RMB72,000 per ton.

The following chart sets forth the trend of average lithium carbonate prices:

Global Monthly Average Price for Lithium Carbonate (VAT Included)



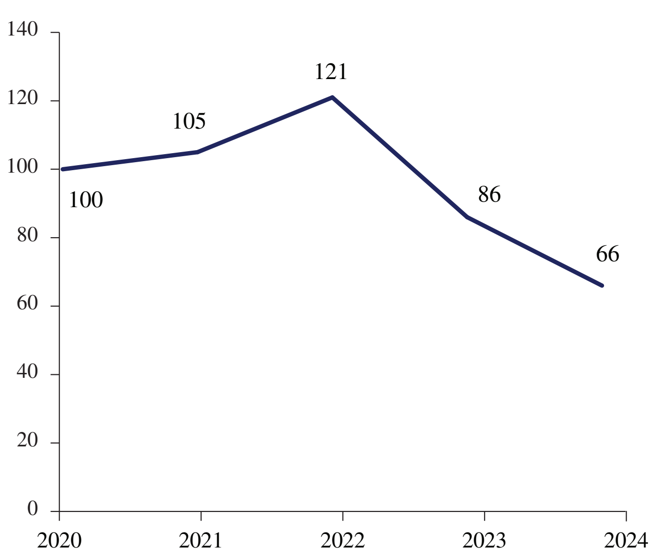
Source: GGII Report

Cost Analysis

Due to technological advances and economies of scale, lithium-ion battery cell costs have shown a downward trend. In 2021 and 2022, as lithium carbonate price rapidly increased, battery cell costs rose accordingly. Subsequently, as lithium carbonate price fell, lithium-ion battery cell costs gradually decreased throughout 2023 and 2024.

The following chart sets forth the trend of average battery cell costs in the global market:

Global Industry Average Battery Cell Costs Index



Note: The data in the chart above is based on the year 2020, with the global average battery cell costs in 2020 adjusted to 100 for statistical analysis and calculation.

Source: GGII Report

DATA SOURCES AND RESEARCH METHODOLOGY

The information and statistics set out in this section and other sections of this document are derived from various official government publications, publicly available market research, and other information sourced from independent providers. In addition, we have engaged GGII to prepare the GGII Report in connection with the [**REDACTED**]. The information provided by GGII and disclosed in this document is extracted from the GGII Report, which was commissioned by us for a fee of RMB550,000. The GGII Report is independently prepared by GGII and is not subject to any influence from us or other interested parties.

Established in 2017, GGII's predecessor was a business unit under Shenzhen Gaogong Consulting Co., Ltd. GGII has been focusing on market research and consulting for emerging industries such as lithium-ion batteries, sodium-ion batteries, solid-state batteries, new energy storage, hydrogen energy and hydrogen fuel cells for more than 10 years. GGII publishes annual market research and analysis reports on lithium mines and lithium carbonate, cathode materials (including precursors), anode materials, electrolytes, diaphragms, electrolytic copper foil, lithium-ion battery recycling, EV batteries, ESS batteries, solid-state batteries, sodium-ion batteries, flow batteries, NEV, light vehicles, engineering machinery, track vehicles, hydrogen fuel cells, hydrogen energy and other industrial chains and various segments.

In preparing the GGII Report, data was primarily sourced from two categories: data obtained by GGII through market research, cross-validation and prediction based on certain assumptions; as well as reference and citation of official websites of global government agencies, public company reports (including prospectuses, transfer instructions, annual reports, semi-annual reports, inquiry reports), and public reports issued by or authorized by other third-party institutions. Due to the research methods and data effectiveness, there may be discrepancies between the data collected by GGII and other third-party sources and the actual industry data.

The GGII Report was compiled based on the following assumptions: (i) Chinese and global economy will experience stable growth from 2025 to 2030, without the impact of financial crises, wars, epidemics, earthquakes or other force majeure factors; (ii) the global economic order will develop steadily, with no major disruptions caused by significant geopolitical events that could materially impact tariffs, imports, or exports; and (iii) major countries and regions worldwide will not introduce substantial adverse adjustments to policies, requirements, or standards related to carbon neutrality initiatives.