INDUSTRY OVERVIEW

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OVERVIEW OF THE GLOBAL MACHINE VISION INDUSTRY

Definition and Application Scenarios of Machine Vision

Machine vision is a method that utilizes computer vision and image processing technologies to achieve automated inspection, automatic positioning, identification, and measurement. It captures product images via high-resolution industrial cameras and then extracts product features using image processing algorithms to conduct quality assessments. Machine vision inspection represents the core application area of machine vision and has extensively permeated various fields, such as lithium-ion battery manufacturing, automotive manufacturing, and electronics production. Machine vision inspection can accurately detect flaws, dimensional deviations, and other defects within an extremely short timeframe, significantly improving product yield rates, safety, and consistency. Compared to application scenarios in general manufacturing, machine vision inspection for lithium-ion batteries imposes extremely high requirements on overall system data algorithms and computing power. Furthermore, since lithium-ion battery defects directly correlate with safety, the industry urgently needs to minimize the rate of missed detections.

Evolution of the Machine Vision Industry

Compared to the global machine vision market, the early machine vision industry in China primarily relied on imported software algorithms and integrated systems. In recent years, Chinese machine vision enterprises have gradually accumulated underlying technologies and deeply cultivated high-precision manufacturing industries, entering an evolutionary stage of closed-loop software-hardware integration. In the future, they aim to achieve a global layout of AI platforms across all manufacturing processes. Notably, leading Chinese enterprises in the lithium-ion battery machine vision inspection sector focus on embedding machine vision systems into lithium-ion battery intelligent equipment, entering a growth cycle of rapid penetration. The core development milestones of the lithium-ion battery machine vision inspection industry are outlined below:

- Inception period from manual replacement to basic inspection (2015 and earlier): Lithium-ion battery inspection production lines primarily relied on manual visual inspection, which was highly inefficient. With the initial introduction of 2D vision technology, machine vision was mainly applied to dimensional measurement and simple positioning correction in front-end processes, such as electrode width measurement and tab cutting alignment;

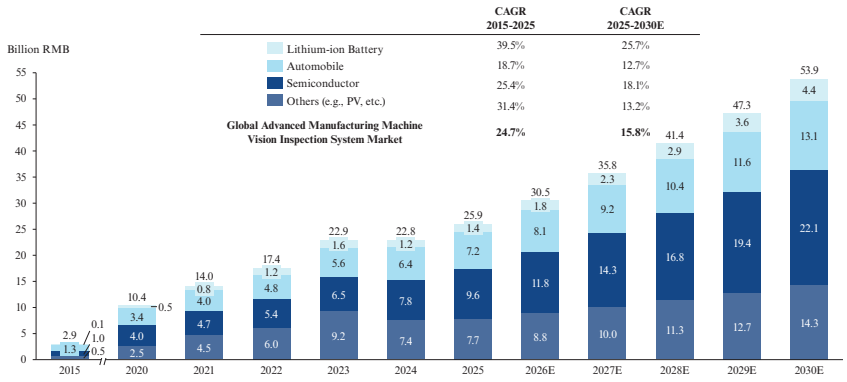
- Domestic enterprise penetration in the lithium-ion battery supply chain (2015 to 2019): As safety requirements for power batteries escalated, lithium-ion battery machine vision inspection rapidly penetrated the battery production lines of leading enterprises. Relying on deep learning models, machine vision inspection gradually expanded from simple contour measurements to complex surface defect detection capabilities, establishing a trend of continuous software iteration;

- Embedding machine vision into lithium-ion battery intelligent equipment (2020 to 2023): With the rapid expansion of lithium-ion battery production capacity, stand-alone lithium-ion battery intelligent equipment hit its limits regarding efficiency and yield rate. This triggered an urgent need for the deep integration of machine vision and lithium-ion battery intelligent equipment to eliminate process errors during the front-stage and mid-stage of manufacturing;
- AI algorithms constructing process control platforms to ensure ultimate yield requirements (2024 to Present): Following the rapid global expansion of power and energy storage battery capacities, the lithium-ion battery industry is transitioning from a stage of extensive scale growth into a refined manufacturing phase centered on safety, product consistency, process stability, and yield improvement. Faced with increasingly complex battery processes and stringent yield goals, stand-alone equipment can only support single-point defect interception, hitting an efficiency ceiling. Empowered by deep AI algorithms, machine vision is driving a comprehensive upgrade of the industry's core capabilities toward cross-process data closed-loops and full-process control. This marks a leap from passively finding defects to actively optimizing processes, constructing an end-to-end intelligent manufacturing system. As national policies place greater emphasis on lithium-ion battery safety, the future popularization of AI algorithms will effectively optimize yield rates and false alarm rates, creating a complete closed loop of manufacturing and inspection.

Market Size Analysis of the Machine Vision Industry

Against the backdrop of accelerated industrial transformation toward automation and digitalization, machine vision, as a key technology for achieving high-precision and high-efficiency quality inspection, is continuously penetrating various advanced manufacturing scenarios. Driven by this, the market size of global advanced manufacturing machine vision inspection solution grew rapidly from RMB2.9 billion in 2015 to RMB25.9 billion in 2025, representing a CAGR of 24.7%. As the intelligent upgrading of manufacturing continues to progress, the market size is projected to further expand to RMB53.9 billion by 2030, with a CAGR of 15.8% between 2025 and 2030. For the downstream application, the importance of machine vision inspection in the field of lithium-ion battery manufacturing is rising rapidly. Its share of applications within advanced manufacturing machine vision inspection solutions is expected to increase from 5.4% in 2025 to 8.2% in 2030, with a CAGR exceeding 25% during this period, making it one of the fastest-growing segments among all application fields.

Market Size of the Global Advanced Manufacturing Machine Vision Inspection Solution, by Application Scenarios, 2015–2030E



Sources: China Machine Vision Industry Union (CMVU), European Machine Vision Association (EMVA), Frost & Sullivan

Note: Integrated machine vision software and hardware components constitute machine vision inspection solutions.

Market Drivers and Development Trends of the Machine Vision Industry

Technology-Intensive Transformation and Upgrading of Manufacturing

As global manufacturing advances toward intelligent manufacturing, traditional modes can no longer satisfy the speed and precision requirements of modern production lines. Machine vision has become a critical link for replacing manual labor and achieving automated production lines. Enterprises need to introduce machine vision systems to boost production efficiency, enhance yield rates, and achieve 24/7, large-scale continuous operations, ensuring the production line transitions toward a technology-intensive model.

Substantial Incremental Growth from Downstream Emerging Scenarios

Explosive demand from high-growth industries such as lithium-ion batteries, new energy, eVTOL (electric vertical takeoff and landing), and robotics serves as the core engine driving machine vision market expansion. In the field of lithium-ion battery manufacturing, due to exponential increases in safety and consistency demands, machine vision has penetrated the entire process, ranging from electrode coating, calendering, slitting, and winding to module assembly.

Evolution of Machine Vision into Full-Process Control Platforms

Machine vision is undergoing a transition from a single, passive defect detection tool to a core driver of active process control. Relying on the deep synergy of massive data and algorithms, stand-alone equipment is gradually being reshaped into closed-loop empowering platforms capable of real-time feedback and process optimization. This signifies that the entire machine vision industry, spearheaded by lithium-ion batteries, is fully evolving into the digital center and brain driving intelligent production lines.

Deep Integration of Machine Vision and AI Algorithms

Machine vision is evolving from 2D image analysis to 3D perception and AI cognition. The introduction of AI algorithms resolves the pain point of handling non-standard, irregular defects during inspection. Continuous optimization of inspection models significantly lowers the barrier to entry for system debugging and reduces false positive rates.

OVERVIEW OF THE GLOBAL LITHIUM-ION BATTERY INTELLIGENT EQUIPMENT INDUSTRY

Analysis of Lithium-ion Battery Production Process

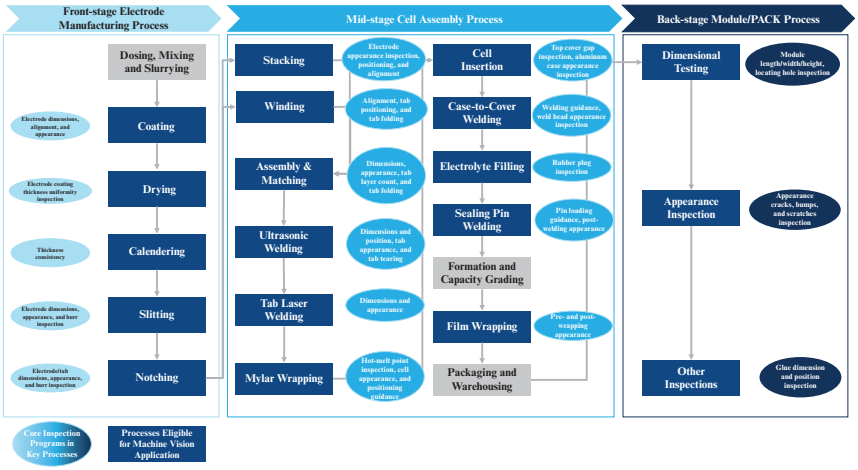
The production process of lithium-ion batteries is typically divided into three stages: the front-end electrode manufacturing stage, the mid-end cell assembly stage, and the back-end module/PACK process stage. Following raw material mixing to generate slurry, the main steps of the front-stage cover coating, drying, calendering, slitting, and notching. The front-end electrode manufacturing stage serves as the foundation of lithium-ion battery manufacturing; its processes dictate the battery's overall consistency, safety, energy density, and cycle life. The mid-end cell assembly stage mainly includes winding/stacking, welding and assembly, electrolyte filling and sealing, formation and capacity grading, etc., which affect battery safety, consistency, and fast-charging performance. The back-end module/PACK process stage primarily encompasses assembly, dimensional inspection, and appearance inspection to guarantee final lithium-ion battery quality requirements.

Definition of Lithium-ion Battery Intelligent Equipment and Analysis of Machine Vision Applications

Lithium-ion battery intelligent equipment primarily refers to automated equipment and systems applied across the front-end electrode manufacturing stage, mid-end cell assembly stage, and back-end module/PACK process stage. Regarding to its high precision and high efficiency, lithium-ion battery machine vision inspection can now be applied to over 80% of the processes in lithium-ion battery production. As the industry transitions from a scale expansion phase to a high-quality development phase, the core competitiveness of lithium-ion battery manufacturing is shifting from capacity scale to high safety, product consistency, process stability, and yield rate improvement. Competition in lithium-ion battery intelligent equipment is shifting from equipment performance to ultimate control over entire-line yield and consistency. Faced with quality transmission and defect amplification effects that become prominent between front-stage, mid-stage, and back-stage processes, traditional single-point inspections and stand-alone equipment can no longer fulfill current lean manufacturing demands. This drives the industry to accelerate its upgrade toward cross-process data closed-loops and global process control. Consequently, machine vision has jumped from a passive defect inspection tool to a core process control capability that drives production line optimization and empowers lifecycle management. Participants who can deeply embed this platform capability into core processes and support full-line quality closed-loops are becoming the primary engines leading the high-quality leap in lithium-ion battery manufacturing.

Electrode manufacturing is the underlying foundation determining cell yield and consistency: Regarding the application of lithium-ion battery machine vision inspection across different production stages, the front-end electrode manufacturing stage requires strict precision. The front-end stage establishes the physical foundation for the battery's electrochemical performance and safety boundaries. Furthermore, defects generated during the front-stage generally cannot be repaired in subsequent mid-stage and back-stage. Defects such as surface flaws, electrode decarburization, scratches, cracks, splicing tape issues, bubbles, electrode damage, pinholes, exposed metal, and particle protrusions will be amplified by mid-stage and back-stage processes, ultimately triggering internal short circuits or severe performance degradation. In addition, changes in electrode microstructure caused by defects drastically affect the battery's electrochemical performance, including battery capacity, internal resistance, and cycle life. Therefore, to prevent occurrences like micro-short circuits, the front-stage is typically the core scenario for lithium-ion battery inspection.

Lithium-ion Battery Manufacturing Process and Core Inspection Programs in Key Processes



Sources: CMVU, Frost & Sullivan

As lithium-ion battery manufacturing upgrades to safety, consistency, ultimate yield, and full-line collaborative optimization, downstream customer demand is shifting from single-point inspection equipment to all-process quality management systems. It is upgrading from traditional decentralized system integration modes to equipment integration and platform solutions that are more deeply embedded in production lines. Inspection capabilities have evolved from local functional modules into the core of full-line yield control and data closed-loops for lithium-ion battery equipment. The cross-process stacking effect of technical thresholds further strengthens the advantages of enterprises with full-process layout capabilities, leading to increased industry concentration.

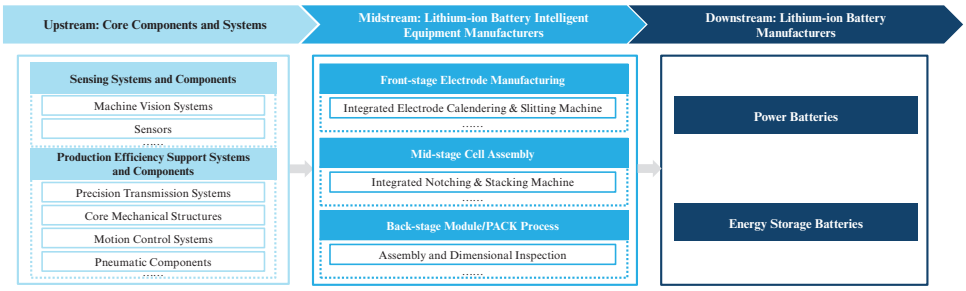
Consequently, very few leading enterprises possess machine vision inspection capabilities across all processes of lithium-ion battery manufacturing. The core reason lies in the extremely high composite technical barriers spanning the entire chain. For instance, high-speed, micron-level defect detection for front-stage electrodes and 3D topography measurement for complex cell structures in the mid-to-back stages exhibit a stark technical chasm in underlying algorithms across different processes. At the same time, constructing full-process capabilities faces two major barriers: first, the accumulation of massive defect data requires continuous supplementation and closed-loop iteration from massive, real production line data; second, the high system integration complexity heavily couples optical, mechanical, electrical, and software elements. This not only demands that suppliers possess a full-stack, self-developed technical foundation but also deep cross-process understanding. This comprehensive barrier, characterized by an exceptionally high degree of non-standard customization and immense trial-and-error costs, ultimately results in most lithium-ion battery machine vision manufacturers focusing only on single-point system applications for specific processes.

Value Chain Analysis of the Lithium-ion Battery Intelligent Equipment Industry

The upstream segment mainly includes sensing systems and components, such as machine vision systems and sensors, as well as production efficiency support systems and components, such as precision transmission systems, core mechanical structures, motion control systems and pneumatic components, which provide fundamental support for safety, consistency, ultimate yield and automation levels in equipment production. The midstream segment mainly consists of lithium-ion battery intelligent equipment manufacturers. Core equipment includes integrated electrode calendering & slitting machines, integrated laser notching & winding machines, etc. Through the deep integration of mechanical equipment, control systems and industrial software, such equipment can realize real-time data collection, process parameter adjustment and equipment status monitoring, thereby improving production efficiency and product yield. The downstream segment mainly comprises lithium-ion battery manufacturers, including power battery and energy storage battery manufacturers. By application scenarios, driven by the increasing penetration rate of new energy vehicles and the technological upgrades towards higher energy density and fast charging, power batteries are accelerating their evolution towards larger capacity and higher consistency, imposing significantly higher requirements on cell defect control and batch stability. Energy storage batteries, driven by surging demand for power system peak shaving and renewable energy grid integration globally, place greater emphasis on long cycle life and large-scale delivery capabilities, thereby imposing systematic requirements on overall production line yield and stability.

As the requirements for battery cell safety and consistency continue to increase across various application scenarios, particularly as the power battery and energy storage battery sectors move towards parts per billion (PPB) level or more stringent defect control standards, downstream manufacturers are imposing higher requirements on the accuracy, response speed and full-process coverage capabilities of machine vision inspection. This trend drives the accelerated upgrading of upstream machine vision applications from single-point deployment to full-line penetration.

Value Chain of the Lithium-ion Battery Intelligent Equipment Industry



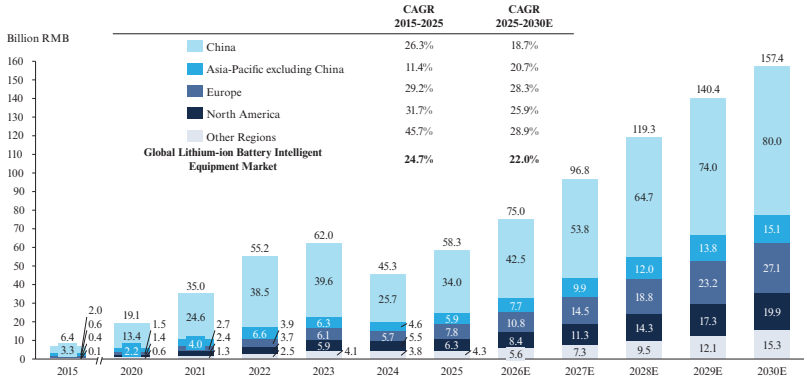
Sources: China Battery Industry Association, Frost & Sullivan

Market Size Analysis of the Lithium-ion Battery Intelligent Equipment Industry

From 2015 to 2025, the market size of global lithium-ion battery intelligent equipment surged from RMB6.4 billion in 2015 to RMB58.3 billion in 2025, representing a CAGR of 24.7%. In 2024, the market size experienced slight fluctuations due to the phased destocking of the battery industry chain and the slowdown in certain capacity investment plans. With the continuous growth of global lithium-ion battery demand, industry capacity utilization recovered significantly in 2025. In 2025, the capacity utilization rate of the top three lithium-ion battery manufacturers in China by shipment volume approached 90%, while the largest lithium-ion battery manufacturer in China experienced a capacity shortage. As equipment investment demand recovers, the market is expected to maintain growth in the future.

China remains the largest lithium-ion battery intelligent equipment market globally, with its market size expected to increase from RMB34.0 billion in 2025 to RMB80.0 billion by 2030. Meanwhile, the European and North American markets are expected to record more significant growth, maintaining CAGRs of approximately 28.3% and 25.9% from 2025 to 2030, respectively. This growth is mainly driven by the localization of the battery value chain and the expansion of demand from NEVs, energy storage and other downstream applications, providing important market opportunities for Chinese lithium-ion battery intelligent equipment enterprises in overseas production line supporting services and project implementation.

Market Size of the Global Lithium-ion Battery Intelligent Equipment Industry by Revenue, Classified by Regions, 2015–2030E

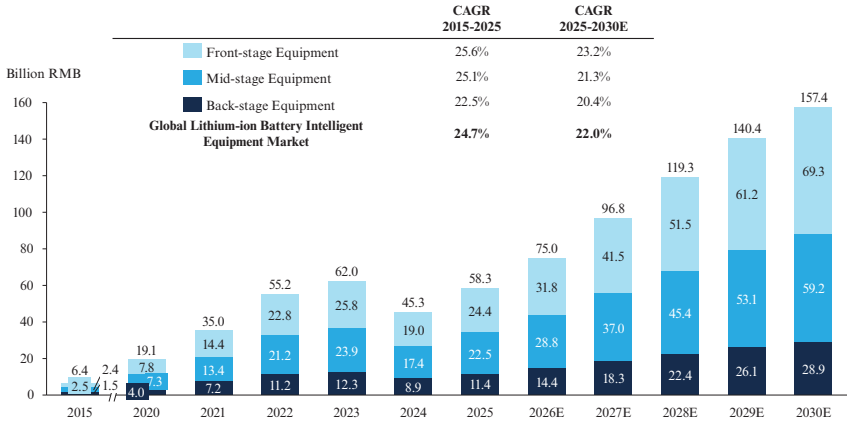


Sources: China Battery Industry Association, Frost & Sullivan

Note: Lithium-ion batteries only include power batteries and energy storage batteries.

By equipment types, in 2025, the market sizes of front-stage equipment, mid-stage equipment and back-stage equipment in the global lithium-ion battery intelligent equipment market reached RMB24.4 billion, RMB22.5 billion and RMB11.4 billion, respectively. Front-stage and mid-stage equipment together accounted for more than 80% of the market, reflecting the high dependence of the front-stage and mid-stage processes of battery production on high-precision and highly automated equipment. Front-stage equipment plays a key role in controlling electrode coating uniformity, thickness and calendering precision, ensuring process consistency, and improving cell performance and yield. The global front-stage equipment market is expected to grow to RMB69.3 billion by 2030, representing a CAGR of 23.2% from 2025 to 2030.

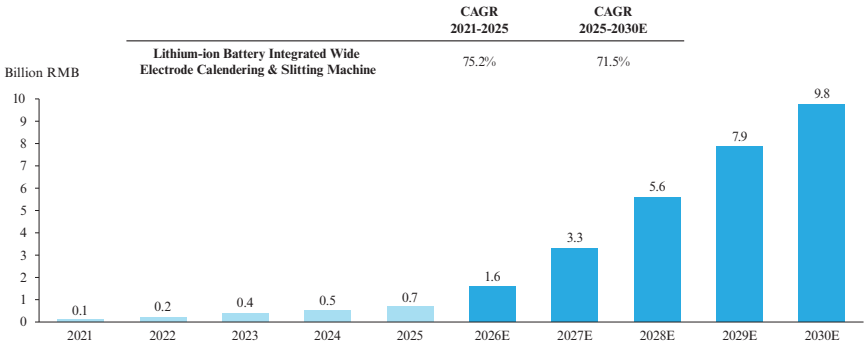
Market Size of the Global Lithium-ion Battery Intelligent Equipment Industry by Revenue, Classified by Front-stage, Mid-stage and Back-stage Equipment, 2015–2030E



Sources: China Battery Industry Association, Frost & Sullivan

Front-stage equipment covers key processes such as calendering and slitting. With the increasing demand for production line integration and process optimization, calendering and slitting integration has become a key trend. As core process equipment for controlling the consistency of electrode thickness and density, integrated electrode calendering & slitting machines play a critical role in ensuring cell performance and safety. Against the backdrop of power batteries and energy storage batteries entering the large-scale TWh era, a wider roller width enables the electrode area processed through calendering and slitting per unit of time to increase proportionally, thereby improving production efficiency. Therefore, the evolution towards wide-width equipment has become an inevitable trend for the technological iteration of integrated electrode calendering & slitting machines and the improvement of single-line output. Based on the value of newly signed orders by integrated electrode calendering & slitting machine manufacturers in 2025, more than 70% of orders were for integrated wide electrode calendering & slitting machines, covering product deliveries over the next several years. The global lithium-ion battery integrated wide electrode calendering & slitting machine market by revenue based on deliveries is expected to grow rapidly from RMB0.7 billion in 2025 to RMB9.8 billion by 2030, representing a CAGR of 71.5% during the period. Going forward, lithium-ion battery integrated wide electrode calendering & slitting machines are expected to become the mainstream application in lithium-ion battery calendering and slitting processes.

Market Size of the Global Lithium-ion Battery Integrated Wide Electrode Calendering & Slitting Machine Market by Revenue Based on Deliveries, 2021–2030E



Sources: GGII, Frost & Sullivan

Notes: 1. Lithium-ion batteries only include power batteries and energy storage batteries; 2. integrated wide electrode calendering & slitting machines refer to integrated electrode calendering & slitting machines with roller width of 1,200 mm or above; 3. Integrated electrode calendering & slitting machines do not include integrated coating, calendering & slitting machine series.

Market Drivers Analysis of the Lithium-ion Battery Intelligent Equipment Industry

Lithium-ion battery safety policies driving the development of intelligent equipment and lean manufacturing processes

As China's lithium-ion battery safety regulatory system continues to evolve towards mandatory national standards and system-level thermal runaway management, such as the implementation in August 2025 of the first "Secondary lithium cells and batteries used in electrical energy storage systems — Safety requirements" in the energy storage sector, which strictly defines the safety bottom line for thermal abuse, the industrial tolerance for manufacturing defects is narrowing rapidly. Coupled with the mandatory process indicators set out in the latest "Specifications for the Lithium-ion Battery Industry" issued by the Ministry of Industry and Information Technology (MIIT), compliance pressure is driving lithium-ion battery manufacturing to evolve from pure capacity expansion towards highly refined lean manufacturing processes. To meet mandatory policy requirements for extremely high cell consistency and full-lifecycle safety, downstream battery manufacturers are accelerating the adoption of lithium-ion battery intelligent equipment with AI-based cognitive capabilities and full closed-loop control, enabling micron-level precise screening and dynamic correction of core microscopic processes such as electrode calendering & slitting, and stacking alignment. Stringent safety regulation is therefore becoming a core driver for the intelligent upgrading of entire production lines.

Continuous expansion of downstream terminal applications

The growth of the global lithium-ion battery intelligent equipment industry benefits from the continued expansion and penetration of downstream application scenarios. In the power battery sector, the global NEV market continues to expand, leading automakers are increasing their presence in the battery sector, and high-performance battery technologies such as ultra-fast charging and long driving range continue to develop. Global power battery shipments are expected to exceed 3,700 GWh by 2030. In the energy storage battery sector, the rapid growth of global renewable energy installed capacity, together with rising power demand from data centers driven by the development of the artificial intelligence industry, has significantly increased demand for large-capacity and highly safe energy storage batteries. Global energy storage battery shipments are expected to exceed 2,500 GWh by 2030, while lithium-ion battery shipments for data centers are expected to reach approximately 300 GWh. Together with the diversified growth of emerging segments such as electric vessels, power tools, eVTOLs and robots, global lithium-ion battery shipments are expected to exceed 6,500 GWh by 2030. Multi-layered market demand is imposing

production requirements on production line equipment in terms of extreme capacity delivery efficiency, high product consistency and flexible manufacturing capability compatible with multiple specifications, thereby driving a new round of technological iteration and market expansion for highly automated, digitalized and intelligent lithium-ion battery manufacturing equipment with lithium-ion battery machine vision inspection capabilities from the demand side.

Capacity expansion by lithium-ion battery manufacturers accelerating the demand for lean manufacturing

The surge in terminal demand is driving lithium-ion battery companies into a capacity expansion cycle, thereby supporting the expansion of the machine vision inspection market. In 2025, the capacity utilization rate of the top three lithium-ion battery manufacturers in China by shipment volume approached 90%, while order schedules of certain companies have extended to 2027. In the same year, overall capital expenditure in China's lithium-ion battery industry increased by nearly 30% year-on-year, indicating a significant acceleration in capacity expansion. Against the backdrop of lithium-ion battery manufacturing entering a stage of large-scale and lean production, newly built production lines generally adopt online full inspection and AI vision systems as standard configurations, while existing production lines continue to unlock quality and efficiency potential through intelligent upgrades and the installation of inspection systems, thereby creating both incremental and replacement opportunities for the machine vision inspection market.

Development Trend Analysis of the Lithium-ion Battery Intelligent Equipment Industry

Wide electrode calendering and slitting integration becoming standard configuration for front-stage lithium-ion battery processes in the TWh era

Driven by the accelerated transition of the global lithium-ion battery industry towards TWh-scale mass production, the evolution of front-stage core calendering and slitting processes is showing clear characteristics of technological integration and scale-up. Calendering and slitting integration has become a mature and inevitable development path for optimizing production line layout, as it significantly reduces electrode transfer between different processes and the frequency of unwinding and rewinding, while lowering the risks of physical damage and dust contamination. Meanwhile, the wide-width development of integrated electrode calendering & slitting machines can effectively break through the capacity bottleneck of traditional stand-alone equipment, multiply electrode output throughput at the same line speed, and significantly dilute unit manufacturing costs through economies of scale. Based on the value of newly signed orders by integrated electrode calendering & slitting machine manufacturers in 2025, more than 70% of orders were for integrated wide electrode calendering & slitting machines, covering product deliveries over the next several years. These two major trends jointly provide a solid foundation for battery manufacturers to address large-scale delivery demand and stringent cost control requirements.

Increasing demand for lithium-ion battery safety and consistency

Modern electric vehicles typically contain thousands of battery cells. Even when the yield rate of individual cells reaches the parts per million (PPM) level, the battery pack failure may still exist after cells are assembled into packs. During long-term charge-discharge cycles, vibration and temperature changes in vehicles, minor defects may gradually lead to issues such as micro-short circuits, eventually causing thermal runaway and vehicle fires. Therefore, parts per billion (PPB)-level or higher standards are required to ensure the safety of mass-produced vehicles at scale. Only by combining high-precision industrial cameras with AI algorithms can micron-level defects be accurately intercepted and identified on high-speed production lines, thereby ensuring the safety and consistency of lithium-ion battery delivery.

Lithium-ion battery technology iteration and AI algorithms driving the upgrading of intelligent equipment and machine vision inspection

As lithium-ion battery technology rapidly evolves towards higher energy density, enhanced safety and new packaging forms, the complexity of manufacturing processes has increased significantly, imposing micron-level or even higher-precision inspection standards on core processes such as electrode coating uniformity, stacking alignment and tab welding quality. Against the backdrop of production line speed increases and capacity expansion, the application of core intelligent equipment, such as integrated electrode calendering & slitting machines, is accelerating towards wide-width processing, ultra-high-speed operation, full closed-loop control and high integration across multiple processes, supporting high-pressure electrode densification to improve volumetric energy density and enabling continuous and precise cutting to the required width. To ensure the yield rate of lithium-ion battery products, machine vision systems need to achieve 100% full inspection during high-speed electrode transfer, and accurately identify minor foil exposure, dark spots, roller marks and scratches generated after compaction, while the introduction of AI algorithms supports the upgrading needs of production lines and intelligent equipment. Meanwhile, across front-stage, mid-stage and back-stage lithium-ion battery production lines, AI algorithms enable generalized adaptation and agile deployment across multi-process scenarios, building a next-generation intelligent production line quality inspection system with adaptive perception and self-optimization capabilities, and providing solid computing power support for manufacturing quality in the TWh era.

Globalization and compliance jointly driving high-standard overseas expansion of intelligent equipment

As leading downstream battery companies accelerate the construction of overseas gigafactories, the localized demand for rapid cross-regional replication of mature capacity is driving lithium-ion battery intelligent equipment companies to expand overseas alongside full production lines. At the same time, global compliance regulation represented by the European Battery Regulation is further reshaping barriers to overseas expansion. In particular, full-lifecycle traceability systems such as battery passports are being transformed into core competitive advantages for enterprises. By embedding underlying data recording and quality traceability systems at the equipment construction stage, leading companies can seamlessly assist customers in addressing overseas regulatory risks. Under the dual drivers of capacity localization and compliance upgrading, the capability to integrate physical processes with digital compliance enables leading companies to build overseas competitive barriers through standardized global delivery and full-lifecycle services.

Entry Barriers Analysis of the Lithium-ion Battery Intelligent Equipment Industry

The lithium-ion battery intelligent equipment industry faces comprehensive barriers built on AI algorithms, technological accumulation, product performance, global customer resources, as well as capital strength and delivery capabilities. First, as battery manufacturing involves complex material optical properties and process changes, general-purpose algorithms are highly prone to failure, while the core capability of AI models depends on massive real-defect data sample libraries. Mature companies, leveraging large-scale data assets accumulated through years of service to major customers, are able to train highly adaptive specialized models, whereas new entrants often struggle to achieve accurate judgment and stable delivery within millisecond-level intervals. Second, in high-speed continuous production environments, systems must have extremely high repeated positioning accuracy and speed adaptability. Mature manufacturers can continue to achieve breakthroughs in technology and product performance under such high standards, while new entrants, due to the lack of technological accumulation and multi-scenario validation in the short term, find it difficult to meet the stringent acceptance standards of leading battery manufacturers for final yield and safety. In addition, leading battery manufacturers have long certification cycles and stringent access requirements. Once cooperation is established between such manufacturers and qualified suppliers, they will frequently and closely collaborate on R&D efforts to ensure ongoing supply stability. Existing mature and well-known suppliers, supported by long-term process know-how and comprehensive global networks, can obtain capacity expansion orders on a priority

basis and collaborate with their customers as they expand into new areas, forming solid customer barriers. Finally, amid the centralized delivery characteristics brought by rapid capacity expansion, new entrants often lack the management capabilities required to complete large-scale parallel installation, commissioning and ramp-up of entire production lines within a very short period, making it difficult for them to scale.

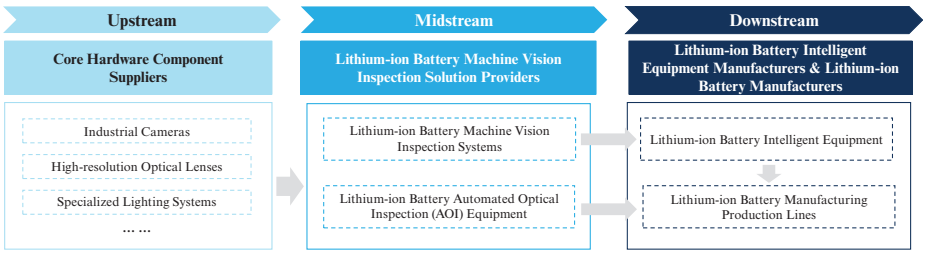
OVERVIEW OF THE GLOBAL LITHIUM-ION BATTERY MACHINE VISION INSPECTION SOLUTION INDUSTRY

Definition and Value Chain Analysis of Lithium-ion Battery Machine Vision Inspection Solutions

Lithium-ion battery machine vision inspection solutions refer to intelligent quality control and process optimization systems that cover the full process of lithium-ion battery manufacturing. The core product categories include lithium-ion battery machine vision inspection systems and lithium-ion battery automated optical inspection (AOI) equipment. Among them, machine vision inspection systems usually integrate software, algorithms and hardware to enable multi-process collaborative inspection and data linkage. AOI equipment mainly refers to standardized inspection units, which are typically deployed at specific processes or key nodes to achieve high-speed and highly stable online defect identification. On this basis, the overall solutions deeply integrate advanced optical imaging, image processing, AI algorithms and automation control technologies. Through micron-level online full inspection and data closed-loop management, they systematically improve the precision and consistency of various processes, from electrode coating, electrode calendering and slitting to battery cell assembly, thereby supporting the large-scale mass production of high-safety lithium-ion batteries.

The value chain of lithium-ion battery machine vision inspection solutions consists of upstream core hardware components, midstream lithium-ion battery machine vision inspection systems and AOI equipment, and downstream application scenarios. Upstream hardware components mainly include industrial cameras, high-resolution optical lenses and specialized lighting systems, which form the foundation of visual inspection capabilities. The midstream segment is the core of the industry. Lithium-ion battery machine vision inspection systems emphasize multi-process data linkage and overall quality control. By contrast, AOI equipment usually exists in the form of standardized stand-alone machines, focusing on a single process or key inspection processes. Downstream application pathways show differentiated characteristics. AOI equipment is mainly deployed directly for lithium-ion battery manufacturers' production lines. Machine vision inspection systems can directly serve the full-line quality management systems of battery manufacturers, or be embedded as functional modules into the production equipment of lithium-ion battery intelligent equipment manufacturers and delivered together with the full production line to lithium-ion battery manufacturers.

Value Chain Analysis of Lithium-ion Battery Machine Vision Inspection Solutions Industry

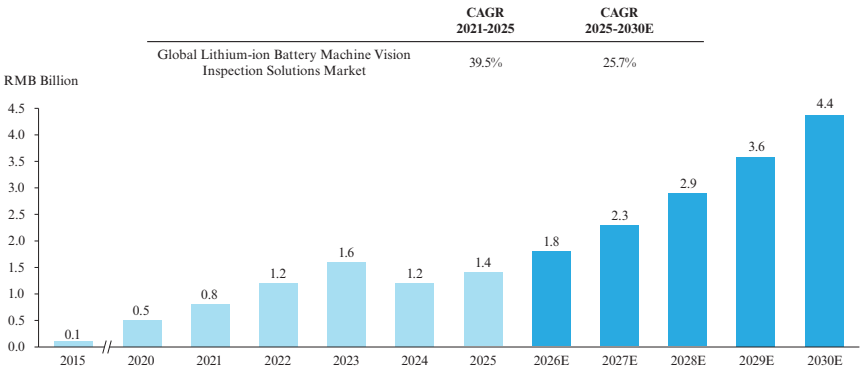


Sources: Machine Vision Industry Alliance, Frost & Sullivan

Market Size Analysis of the Global Lithium-ion Battery Machine Vision Inspection Solutions Industry

The global lithium-ion battery machine vision inspection solutions market increased rapidly from RMB0.1 billion in 2015 to RMB1.4 billion in 2025. Looking ahead, driven by the recovery of global lithium-ion battery capacity utilization, the continued growth in demand for high-precision online inspection across all manufacturing processes, and the deep integration of machine vision with AI algorithms and automation control technologies, the global lithium-ion battery machine vision inspection solutions market is expected to reach RMB4.4 billion by 2030, representing a CAGR of 25.7% from 2025 to 2030.

Market Size of Global Lithium-ion Battery Machine Vision Inspection Solutions, by Revenue, 2015–2030E



Sources: Machine Vision Industry Alliance, GGII, Frost & Sullivan

Competitive Landscape Analysis of the Global Lithium-ion Battery Intelligent Equipment and Machine Vision Inspection Solutions Industry

In 2025, the global lithium-ion battery integrated electrode calendering & slitting machine market reached RMB1,320 million in total. The global top five lithium-ion battery integrated electrode calendering & slitting machine manufacturers together accounted for 92.4% of the market, indicating a concentrated market structure. Among them, the Company ranked third globally in the corresponding business segment in 2025, with a market share of 21.1%.

As lithium-ion battery manufacturing accelerates into the TWh era, integrated wide electrode calendering & slitting machines have become a core pathway for optimizing manufacturing efficiency and significantly increasing single-line production capacity. Meanwhile, most new orders for integrated electrode calendering & slitting machines are wide-width products, confirming the development direction of advanced processes in front-stage lithium-ion battery manufacturing. In 2025, the global lithium-ion battery integrated wide electrode calendering & slitting machine market reached RMB660 million in total. Due to the high-precision process requirements and relatively long customer validation cycles, the global top three lithium-ion battery integrated wide electrode calendering & slitting machine manufacturers together accounted for 95.1% of the market, indicating a highly concentrated market structure. Among them, the Company ranked first globally in the corresponding business segment in 2025, with a market share of 42.1%.

Global Top 5 Lithium-ion Battery Integrated Electrode Calendering & Slitting Machine Manufacturers, by Revenue, 2025

Ranking	Company	2025 Revenue *(RMB Million)*	Market Share *(%)*
1	Company A[2]	380	28.8%
2	Company B[3]	310	23.5%
3	**The Company**	**278**	**21.1%**
4	Company C[4]	150	11.4%
5	Company D[5]	100	7.6%
Top 5		1,218	92.4%
Total		1,320	

Global Top 3 Lithium-ion Battery Integrated Wide Electrode Calendering & Slitting Machine Manufacturers, by Revenue, 2025[1]

Ranking	Company	2025 Revenue *(RMB Million)*	Market Share *(%)*
1	**The Company**	**278**	**42.1%**
2	Company A	200	30.3%
3	Company B	150	22.7%
Top 3		628	95.1%
Total		660	

Sources: Annual reports of listed companies, Frost & Sullivan

Notes:

1. The market share of global integrated wide electrode calendering & slitting machine manufacturers is mainly concentrated among the top three players;
2. Company A was established in 2006 and is headquartered in Guangdong, China. The company is listed on the Shenzhen Stock Exchange, with core business covering integrated lithium-ion battery intelligent equipment solutions and E-vapor;
3. Company B was established in 2000 and is headquartered in Hebei, China. The company is listed on the Beijing Stock Exchange, with core business covering calendering machine and integrated electrode calendering & slitting machine;
4. Company C was established in 2002 and is headquartered in Jiangsu, China. The company is listed on the Shenzhen Stock Exchange and the Hong Kong Stock Exchange, with core business covering integrated lithium-ion battery intelligent equipment solutions, photovoltaic (PV) intelligent equipment, 3C intelligent equipment, etc.;
5. Company D was established in 2016 and is headquartered in Guangdong, China, with core business covering calendering machine and integrated electrode calendering & slitting machine.

In 2025, the market size of lithium-ion battery machine vision inspection solutions in China reached approximately RMB1,400 million. Among them, the global top five lithium-ion battery machine vision inspection solution providers generated combined revenue of approximately RMB436 million, representing an aggregate market share of 31.2%, indicating a relatively fragmented market structure. Among them, the Company recorded revenue of over RMB71 million from lithium-ion battery machine vision inspection solutions in 2025, ranking second with a market share of 5.1%.

Top 5 Lithium-ion Battery Machine Vision Inspection Solution Providers in China[1], by Revenue, 2025

Ranking	Company	2025 Revenue *(RMB Million)*	Market Share *(%)*
1	Company E[2]	180	12.9%
2	**The Company**	**71**	**5.1%**
3	Company F[3]	70	5.0%
4	Company G[4]	65	4.6%
5	Company H[5]	50	3.6%
Top 5		436	31.2%
Total		1,400	

Sources: Annual reports of listed companies, Frost & Sullivan

Notes:

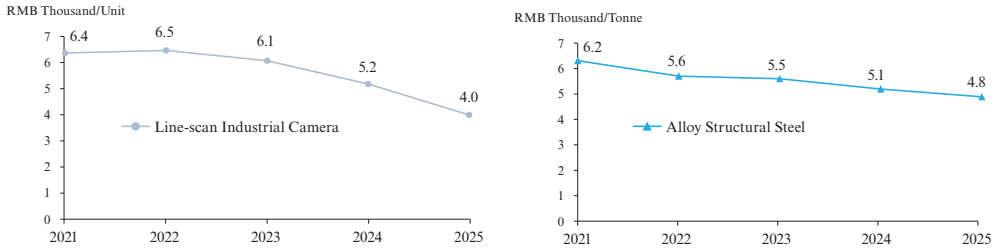
1. Lithium-ion battery machine vision inspection solution providers only include revenue generated by independent third-party lithium-ion battery machine vision inspection enterprises;
2. Company E was established in 2020 and is headquartered in Fujian, China, with core business covering lithium-ion battery machine vision inspection solutions, industrial information software, and industrial big data and artificial intelligence applications;
3. Company F was established in 2006 and is headquartered in Guangdong, China. The company is listed on the Shanghai Stock Exchange, with core business covering machine vision software and hardware products, industrial cameras, lenses, light sources, vision systems, 3D sensors, and industrial AI solutions;
4. Company G was established in 2015 and is headquartered in Guangdong, China, with core business covering machine vision algorithms, 2D and 3D vision systems, industrial AI inspection systems, and integrated machine vision solutions;
5. Company H was established in 2011 and is headquartered in Fujian, China, with core business covering AOI equipment, intelligent equipment, AI image platforms, and 2D/3D vision algorithm software platforms.

Raw Material Price Analysis

Line-scan industrial cameras are one of the core components of machine vision inspection systems. They are mainly used for high-precision imaging and defect identification, and play a key role in the inspection of lithium-ion battery electrodes, separators and battery cells. From 2021 to 2022, affected by tight supply of upstream image sensors and core chips, the average price of line-scan industrial cameras in China increased slightly. Starting from 2023, with the gradual recovery of the semiconductor supply chain, the acceleration of domestic substitution, and a temporary slowdown in downstream demand, product prices gradually declined. In 2025, the average price of line-scan industrial cameras decreased to approximately RMB4.0 thousand per unit.

Alloy structural steel is widely used in key load-bearing and transmission components of lithium-ion battery intelligent equipment, such as rollers, shafts and high-strength structural parts, and has an important impact on the strength, wear resistance and service life of the equipment. From 2021 to 2022, driven by rising prices of iron ore and alloy materials, the average price of alloy structural steel in China remained at a relatively high level. Starting from 2022, with the decline in upstream raw material prices and the recovery of the overall supply chain, the price of alloy structural steel gradually decreased. In 2025, the average price of alloy structural steel declined to approximately RMB4.8 thousand per tonne.

Average Prices of Line-scan Industrial Cameras and Alloy Structural Steel in China, 2021–2025



Sources: China Optics and Optoelectronics Manufacturers Association, Shanghai Futures Exchange, Frost & Sullivan

Notes:

1. Line-scan industrial cameras refer specifically to 8K line-scan cameras, which are mainly used in high-precision machine vision inspection processes;
2. Alloy structural steel mainly refers to molybdenum steel, which is widely used in key load-bearing and transmission components of lithium-ion battery intelligent equipment.

INDUSTRY OVERVIEW

SOURCE OF INFORMATION

We commissioned Frost & Sullivan to conduct market research on the global machine vision, global lithium-ion battery intelligent equipment and global lithium-ion battery machine vision inspection solution industry to prepare the Frost & Sullivan Report. Frost & Sullivan is an independent global consulting firm founded in New York in 1961, providing industry research and market strategies. We have entered into an agreement to pay Frost & Sullivan RMB550,000 for the preparation of the Frost & Sullivan Report.

In preparing the Frost & Sullivan Report, Frost & Sullivan conducted detailed research, including discussions with several leading industry participants regarding industry conditions and interviews with relevant individuals. Frost & Sullivan also conducted secondary research, including reviewing company reports, independent research reports, and data from its own research database. Frost & Sullivan derived the estimated statistics of total market size based on historical data analysis incorporating macroeconomic data, taking into account the aforementioned main industry drivers. Its market engineering forecast methodology combines multiple forecasting techniques with a system based on market engineering measurements and relies on the expertise of the analyst team to integrate the key market elements investigated during the project research phase. Such elements primarily include expert opinion forecasting methods, integration of market drivers and constraints, integration of market challenges, integration of market engineering measurement trends, and integration of econometric variables.

The Frost & Sullivan Report was prepared based on the following assumptions: (i) the social, economic, and political environments globally and in Chinese mainland are likely to remain stable during the forecast period; and (ii) the key relevant industry drivers may drive the market during the forecast period.

This section and other chapters of this document excerpt portions of information from the Frost & Sullivan Report, aiming to provide [REDACTED] with a more comprehensive introduction to the industry in which we operate. The Directors confirm that, to the best of their knowledge and after making reasonable enquiries, there have been no material adverse changes in overall market information since the date of the release of the Frost & Sullivan Report which are sufficient to make material corrections, contradict or have an impact on such information.