

Global Carbon-based Electrode Materials for Flow Batteries Supply, Demand and Key Producers, 2026-2032

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Abstracts

The global Carbon-based Electrode Materials for Flow Batteries market size is expected to reach \$ 432 million by 2032, rising at a market growth of 23.0% CAGR during the forecast period (2026-2032).

Carbon-based Electrode Materials for Flow Batteries are porous conductive carbon-fiber materials installed in the positive and negative half-cells of flow battery stacks. They provide electrochemically active reaction sites, conduct electrons between the electrolyte and bipolar plates, and create interconnected channels for electrolyte distribution and mass transfer. The market primarily covers carbon felt and graphite felt manufactured from polyacrylonitrile-based, rayon-based or other carbon-fiber precursors through web forming, needle punching, stabilization, carbonization, graphitization, purification, surface activation and precision converting. This market focuses on felt-based porous carbon electrodes commercially supplied for vanadium redox, zinc-bromine, iron-chromium and other flow battery systems.

Key Findings

Global output reached 3.24 million square meters in 2025

The global average selling price reached US\$25.61 per square meter in 2025

Graphite felt represents the principal high-conductivity product category for commercial flow battery stacks

Vanadium redox flow batteries constitute a core application for carbon and graphite felt electrodes

Asia Pacific is a major manufacturing and project-demand center for flow battery electrode materials

Market Trends

Carbon-based flow battery electrodes are evolving from general-purpose industrial felts into application-specific electrochemical materials jointly optimized with stack structure, electrolyte chemistry and operating current density. Product development increasingly emphasizes lower through-plane resistance, improved electrolyte wettability, uniform surface activation, controlled pore structures and stable performance under repeated compression. Graphitization provides conductivity, purity and chemical stability, while subsequent thermal or chemical activation increases surface area and introduces functional groups that promote electrolyte contact and redox reaction kinetics. JNTG supplies graphite felt electrodes with multiple thickness and density specifications and applies combined thermal and chemical activation, while SGL Carbon offers PAN-based, rayon-based and mixed-fiber battery felts designed around conductivity, surface area, impurity control and cycle stability. AvCarb combines PAN-based felt production with activation and lot-level electrochemical performance verification. The market is also moving toward thinner electrodes, narrower thickness tolerances, larger roll widths, continuous roll-to-roll processing and stack-specific precision cutting as manufacturers increase cell area and pursue higher stack power density.

Market Dynamics

Drivers

The principal growth driver is the expansion of long-duration stationary energy storage for renewable-energy integration, grid balancing, peak shifting, capacity support and industrial energy resilience. Flow batteries offer independent scaling of stack power and electrolyte energy capacity, making them suitable for multi-hour storage systems where cycle life, operational safety and flexible discharge duration are important. The U.S. Department of Energy has identified flow batteries as one of the technology pathways for achieving major cost reductions in storage systems providing ten hours or more of discharge. China is also advancing the construction, demonstration and standardization

of diversified new energy storage technologies, supporting demand for flow battery stacks and their electrode materials. Every increase in stack power requires additional porous electrode area, creating a direct relationship between flow battery stack deployment and demand for carbon felt, graphite felt and processed electrode components.

Restraints

Market expansion remains constrained by the relatively limited commercial installed base of flow batteries compared with lithium-ion battery storage, as well as the project-driven nature of utility-scale demand. Lithium iron phosphate batteries continue to dominate global battery storage deployments, while flow battery projects generally require longer development, financing, permitting and grid-connection cycles. Electrode materials also face lengthy customer qualification because variations in precursor fiber, graphitization degree, surface chemistry, thickness, permeability and compression characteristics can materially affect voltage efficiency, pressure drop, pumping consumption and cycling stability. Stack manufacturers therefore tend to retain electrode grades that have completed extended cell and stack validation, slowing the commercial adoption of new suppliers and new material specifications. Uneven project delivery schedules can also create significant annual fluctuations in electrode orders and production-line utilization.

Opportunities

The strongest market opportunities are concentrated in electrodes that increase stack power density, reduce internal resistance and improve electrolyte utilization. Thin graphite felt, uniformly activated felt, graded-pore structures and electrodes with differentiated surface chemistry can shorten ion-transport paths and support higher operating current densities. Vanadium, iron-chromium and zinc-based systems have different electrolyte environments and electrode-reaction characteristics, creating demand for chemistry-specific graphitization, oxidation, catalytic modification and pore-structure control. Additional value can be created through customized thickness and density, asymmetric positive and negative electrodes, pre-cut stack kits, batch-level electrochemical certification and integrated supply of carbon felt with other stack components. As the installed base expands, electrode replacement, stack refurbishment and maintenance demand may supplement new-stack production, while localized continuous carbonization, graphitization and activation capacity can shorten delivery cycles and improve batch consistency.

Challenges

The central technical challenge is balancing conductivity, electrochemical activity, permeability, mechanical integrity and long-term durability within the same porous material. A higher graphitization degree generally reduces electrical resistance and improves chemical stability but may decrease surface functional groups and electrolyte affinity. Stronger activation can increase active surface area and reaction kinetics but may weaken fibers, increase property variation or accelerate surface degradation. Higher compression reduces contact resistance but also decreases pore volume and permeability, increasing pressure drop and pumping energy; insufficient compression can result in poor electrical contact and uneven current distribution. Manufacturers must also control metallic impurities, fiber shedding, thickness deviation, areal-weight variation, activation depth and performance uniformity across wide rolls. These requirements become increasingly stringent as cell dimensions and stack current increase, making continuous process control and electrochemical quality verification key commercial barriers.

Industry Chain Analysis

The upstream segment includes PAN fiber, oxidized PAN fiber, rayon fiber, other carbon-fiber precursors, binders, carbon particles, process gases, activation chemicals and electricity for high-temperature treatment. PAN-based fibers are widely used because they provide a practical balance of mechanical strength, processability, availability and electrical performance, while rayon-based and mixed-fiber materials support differentiated surface area, compressibility and pore structures. Midstream manufacturing covers fiber opening, web forming, needle punching, stabilization, carbonization, graphitization, purification, activation, washing, heat setting, inspection, slitting and precision cutting. Graphitization, surface activation and electrochemical quality control are the principal value-creation stages because they determine conductivity, purity, wettability, reaction activity and batch consistency. Downstream customers include electrode converters, flow battery cell and stack manufacturers, system integrators, energy storage project developers and maintenance providers. Material specifications are increasingly coordinated with flow-field geometry, membrane properties, electrolyte chemistry, compression design and operating current density.

Segment Insights

Graphite felt occupies the principal high-performance segment of the market. High-temperature graphitization gives the material lower electrical resistance, higher carbon purity and stronger chemical stability in demanding flow battery electrolytes.

Commercial graphite felt is differentiated by precursor type, thickness, areal weight, bulk density, resistance, permeability, compressibility, impurity content and activation method. Surface-treated grades combine a conductive graphitized fiber backbone with controlled oxidation or chemical activation, improving electrolyte wettability and electrochemical reaction kinetics while maintaining low internal resistance. Product development is moving toward thinner, more uniform and highly engineered structures rather than relying solely on higher graphitization temperatures.

Carbon felt remains important in cost-sensitive applications and as an intermediate substrate for subsequent graphitization or activation. Compared with graphite felt, it generally has a less ordered carbon structure and higher electrical resistance but may retain more surface functional groups and offer advantages in wettability and processing flexibility. Selection between carbon felt and graphite felt depends on battery chemistry, stack architecture, operating current density, compression ratio, target efficiency and customer qualification requirements. The product structure is consequently shifting from untreated standard felts toward activated, customized and stack-specific electrode grades with controlled electrochemical performance.

Downstream Market Opportunities

Vanadium redox flow batteries are a core downstream application because porous carbon or graphite felt is used in both half-cells to provide reaction sites and conduct electrons. Large utility-scale and renewable-energy projects generate substantial electrode-area demand through the use of multiple high-power stacks. Iron-chromium flow batteries also require porous carbon electrodes with suitable catalytic activity and durability in acidic electrolytes, while zinc-bromine and other zinc-based systems create demand for carbon materials resistant to bromine-containing environments and compatible with metal-deposition processes. Emerging all-iron, organic and other aqueous flow battery chemistries provide additional opportunities for tailored surface functionalization, asymmetric electrode structures and lower-cost carbon substrates. Utility storage, renewable-energy integration and independent energy storage remain the principal demand scenarios, while industrial microgrids, critical infrastructure and remote power systems provide additional application space.

Regional Insights

Asia Pacific is a major manufacturing and demand center for carbon-based flow battery electrode materials. China has developed an integrated supply chain covering precursor fibers, carbon and graphite felt, surface activation, membranes, bipolar plates, electrolytes, stacks and system integration. Large new energy storage projects and localization of critical stack materials support commercial demand for electrode felts, while Japan and South Korea retain capabilities in carbon-fiber processing, electrochemical material development and high-performance electrode structures. Regional suppliers increasingly compete through continuous production, cost control, rapid customization and proximity to major stack manufacturers.

Europe and North America maintain established expertise in engineered carbon materials, high-purity processing, surface activation and application engineering. Suppliers in these regions emphasize verified electrochemical performance, product traceability, customized dimensions and long-term supply reliability. Long-duration storage demonstrations, renewable-energy integration and grid-resilience projects support market development, although annual demand remains sensitive to project approvals and construction schedules. Competition between international and Asian suppliers is increasingly based on total stack performance, qualification support, production consistency and lifecycle value rather than material price alone.

Competitive Landscape Analysis

Market participants include JNTG, Sichuan Jiangyou Runsheng Graphite Felting, Shenyang Fulai Carbon Fiber, SGL Carbon, Jiangsu Mige New Material, Liaoning JinGu Carbon Materials, Hangzhou Woken New Material Technology, Shanghai Qijie New Materials, Zhejiang Huarong Technology, Toyobo, AvCarb, Chemshine Carbon, Shanghai Carbon Industry, CGT Carbon and CeTech. Competition centers on compressed through-plane resistance, electrolyte wettability, surface-activation uniformity, impurity control, thickness consistency, permeability, roll width, precision converting and long-term electrochemical durability. JNTG, SGL Carbon and AvCarb offer dedicated flow battery electrode materials with differentiated activation, fiber structures and electrochemical performance control. Liaoning JinGu Carbon Materials, Hangzhou Woken New Material Technology and Shanghai Qijie New Materials have developed liquid-flow-battery electrode products and related continuous processing or

electrochemical material capabilities. International suppliers generally compete through established product platforms, application engineering and global customer support, while Chinese suppliers benefit from integrated manufacturing, cost control, proximity to domestic stack manufacturers and rapid customization. Customer qualification and stack-level validation remain more important than conventional physical-property certificates alone.

Report Scope

This report studies the global Carbon-based Electrode Materials for Flow Batteries production, demand, key manufacturers, and key regions.

This report is a detailed and comprehensive analysis of the world market for Carbon-based Electrode Materials for Flow Batteries and provides market size (US\$ million) and Year-over-Year (YoY) Growth, considering 2025 as the base year. This report explores demand trends and competition, as well as details the characteristics of Carbon-based Electrode Materials for Flow Batteries that contribute to its increasing demand across many markets.

Highlights and key features of the study

Global Carbon-based Electrode Materials for Flow Batteries total production and demand, 2021-2032, (K Sqm)

Global Carbon-based Electrode Materials for Flow Batteries total production value, 2021-2032, (USD Million)

Global Carbon-based Electrode Materials for Flow Batteries production by region & country, production, value, CAGR, 2021-2032, (USD Million) & (K Sqm), (based on production site)

Global Carbon-based Electrode Materials for Flow Batteries consumption by region & country, CAGR, 2021-2032 & (K Sqm)

U.S. VS China: Carbon-based Electrode Materials for Flow Batteries domestic production, consumption, key domestic manufacturers and share

Global Carbon-based Electrode Materials for Flow Batteries production by manufacturer, production, price, value and market share 2021-2026, (USD Million) & (K Sqm)

Global Carbon-based Electrode Materials for Flow Batteries production by Type, production, value, CAGR, 2021-2032, (USD Million) & (K Sqm)

Global Carbon-based Electrode Materials for Flow Batteries production by Application, production, value, CAGR, 2021-2032, (USD Million) & (K Sqm)

This report profiles key players in the global Carbon-based Electrode Materials for Flow Batteries market based on the following parameters - company overview, production, value, price, gross margin, product portfolio, geographical presence, and key developments. Key companies covered as a part of this study include JNTG, Sichuan Jiangyou Runsheng Graphite Felting, Shenyang Fulai Carbon Fiber, SGL Carbon, Jiangsu Mige New Material, Liaoning JinGu Carbon Materials, Hangzhou Woken New Material Technology, Shanghai Qijie New Materials, Zhejiang Huarong Technology, Toyobo, etc.

This report also provides key insights about market drivers, restraints, opportunities, new product launches or approvals.

Stakeholders would have ease in decision-making through various strategy matrices used in analyzing the World Carbon-based Electrode Materials for Flow Batteries market

Detailed Segmentation:

Each section contains quantitative market data including market by value (US\$ Millions), volume (production, consumption) & (K Sqm) and average price (US\$/Sq m) by manufacturer, by Type, and by Application. Data is given for the years 2021-2032 by year with 2025 as the base year, 2026 as the estimate year, and 2027-2032 as the forecast year.

Global Carbon-based Electrode Materials for Flow Batteries Market, By Region:

United States

China

Europe

Japan

South Korea

ASEAN

India

Rest of World

Market Segmentation

Global Carbon-based Electrode Materials for Flow Batteries Market, Segmentation by Type:

Carbon Felt (CF)

Graphite Felt (GF)

Global Carbon-based Electrode Materials for Flow Batteries Market, Segmentation by Base Material:

PAN-based

Rayon-based

Others

Global Carbon-based Electrode Materials for Flow Batteries Market, Segmentation by Thickness:

Thickness <3mm

Thickness 3mm–6mm

Thickness >6mm

Global Carbon-based Electrode Materials for Flow Batteries Market, Segmentation by Application:

Vanadium Redox Flow Battery

Zinc-Bromine Flow Battery

Iron-Chromium Flow Battery

Others

Companies Profiled:

JNTG

Sichuan Jiangyou Runsheng Graphite Felting

Shenyang Fulai Carbon Fiber

SGL Carbon

Jiangsu Mige New Material

Liaoning JinGu Carbon Materials

Hangzhou Woken New Material Technology

Shanghai Qijie New Materials

Zhejiang Huarong Technology

Toyobo

AvCarb

Chemshine Carbon

Shanghai Carbon Industry

CGT Carbon

CeTech

Key Questions Answered

1. How big is the global Carbon-based Electrode Materials for Flow Batteries market?
2. What is the demand of the global Carbon-based Electrode Materials for Flow Batteries market?
3. What is the year over year growth of the global Carbon-based Electrode Materials for Flow Batteries market?
4. What is the total value of the global Carbon-based Electrode Materials for Flow Batteries market?
5. Who are the Major Players in the global Carbon-based Electrode Materials for Flow Batteries market?
6. What are the growth factors driving the market demand?

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