

FROST & SULLIVAN
BEST PRACTICES



2026

EUROPEAN GRAPHITE
BIPOLAR PLATES

**TECHNOLOGY INNOVATION
LEADERSHIP**



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Best Practices Criteria for World-Class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each recognition category before determining the final recognition recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. Schunk Group excels in many of the criteria in the graphite bipolar plates space.

RECOGNITION CRITERIA	
<i>Business Impact</i>	<i>Technology Leverage</i>
Financial Performance	Commitment to Innovation
Customer Acquisition	Commitment to Creativity
Operational Efficiency	Stage Gate Efficiency
Growth Potential	Commercialization
Human Capital	Application Diversity

Europe’s Graphite Bipolar Plates Market: From Hydrogen Hype to Industrial Discipline

Across Europe, the forces reshaping the broader fuel cell and hydrogen economy are also transforming the graphite bipolar plates market, driving a decisive shift from optimism-driven expansion to execution-focused pragmatism. The exuberance of the 2021–2024 hydrogen growth surge has been replaced by a more disciplined evaluation of where fuel cells deliver irreplaceable value and where economics remain prohibitive. This recalibration has not diminished the long-term importance of graphite bipolar plates; instead, it has clarified the conditions under which meaningful demand will emerge.

Over the past 18 months, the market has undergone a necessary filtration process. High-profile project cancellations, policy reversals, and premature capacity expansions exposed the gap between announced ambitions and bankable demand. Several automotive original equipment manufacturers (OEMs) and Tier 1 suppliers reduced their hydrogen exposure, while investors grew cautious as green hydrogen costs continued to exceed diesel and battery-electric alternatives. In this environment, participants across the fuel cell value chain, including graphite bipolar plate manufacturers, have had to realign expectations, shifting away from reliance on speculative mega-projects or passenger vehicle adoption. Consequently, growth is becoming increasingly anchored in targeted industrial use cases with immediate and tangible decarbonization needs.

This realignment is particularly evident in Europe, where regulatory ambition remains intact, but implementation timelines have slipped, creating uncertainty for both developers and suppliers. Delays in

the transposition of RED III across multiple countries, combined with energy price volatility and inflation in critical material supply chains, have slowed final investment decisions. As a result, the expected ramp-up in fuel cell stack production and, by extension, graphite bipolar plate demand, has not disappeared but has instead moved further toward the end of the decade, with 2030 increasingly viewed as the realistic inflection point.

Importantly, the market is not shrinking; it is concentrating. Demand is consolidating around applications where fuel cells are not merely competitive but indispensable, particularly in heavy-duty transport, maritime propulsion, rail, and mission-critical stationary power environments such as data centers and hospitals. These segments share distinctive characteristics: high energy density requirements, long operating cycles, and limited feasibility for battery-based solutions. In such operating environments, graphite bipolar plates retain significant advantages over metallic alternatives, particularly in corrosion resistance, chemical stability, and long-term durability under harsh conditions.

As demand narrows to these high-value applications, the expectations placed on suppliers are rising in parallel. Leading European graphite specialists are reconfiguring their strategies to align more closely with end-use requirements. Securing growth now depends less on supplying materials alone and more on embedding application-specific engineering within customer programs. Manufacturers must demonstrate stack-level performance optimization through thinner, structurally robust plates, precise flow-field design, advanced composite formulations, and automated production processes that enhance cost efficiency. Early engagement in stack design, close collaboration with system integrators, and the capability to support localized “Hydrogen Valley” initiatives are emerging as key sources of competitive differentiation.

At the same time, capacity planning must reflect realistic adoption trajectories rather than earlier, hype-driven projections. This shift places greater importance on flexible production systems, modular investment strategies, and the ability to serve adjacent graphite applications, all of which help build resilience during this transitional phase. Companies that navigate this period successfully will be those capable of bridging today’s low-volume, high-specification demand with tomorrow’s large-scale industrial requirements.

Schunk Group: Engineering the Materials Backbone of Europe’s Graphite Bipolar Plates Market

Within Europe’s more disciplined hydrogen landscape, Schunk Group (Schunk) distinguishes itself by translating more than a century of carbon materials heritage into a decisive advantage in graphite bipolar plates. Founded in 1913 and active in bipolar plate development since 1996, with scaled production for stationary fuel cells beginning in the early 2000s, the company’s position reflects decades of cumulative materials learning. This history is critical because bipolar plates are fundamentally constrained by materials science rather than simple part manufacturing. Their performance relies on a precise mastery of graphite formulation, polymer chemistry, and processing proficiency—expertise that Schunk has successfully industrialized, as evidenced by a track record of more than one million plates delivered across multiple generations of designs and applications.¹

¹ Frost & Sullivan’s Discussion with Schunk Group, May 2026.

This depth of experience enables Schunk to approach bipolar plates not as discrete components, but as engineered material systems whose performance emerges from rigorous control over formulation, shaping, and surface behavior. Unlike competitors that purchase pre-compounded materials and focus primarily on the pressing stage, Schunk maintains command over the entire value chain, from raw carbon powders and proprietary mixing and milling to heat treatment and surface modification. This control over critical material trade-offs, such as balancing conductivity with mechanical strength or gas tightness with extreme thinness, allows the company to solve complex stack-level challenges that many suppliers address only at the component level. By managing these variables in-house, Schunk ensures that surface characteristics like hydrophilicity and corrosion resistance are designed into the material itself rather than added as an afterthought.

“In a market moving from promise to proof, Schunk’s combination of historical depth, formulation-level control, patented surface engineering, and scalable manufacturing positions it as the materials and manufacturing backbone that enables stack developers to industrialize graphite solutions with confidence across fuel cells and broader electrochemical energy systems.”

**- Diksha Nautiyal,
Research Analyst**

These materials capabilities translate directly into two complementary technology platforms tailored to distinct electrochemical demands. For proton-exchange membrane fuel cells, Schunk’s thermoset-based compression molding platform produces dense, stiff, gas-tight graphite composite plates capable of incorporating complex flow fields without deformation and proven to operate beyond 25,000 hours. For flow batteries and harsh electrochemical environments, its thermoplastic extrusion platform produces highly corrosion-resistant graphite foils that can be embossed for flow guidance, surface-treated for higher conductivity, and ultrasonically welded to

plastic frames without adhesives. Together, these platforms allow Schunk to serve fuel cells, redox flow batteries, and emerging electrochemical systems with technologies optimized for each operating environment.

Process innovation reinforces this materials leadership. Schunk’s compression molding capability embeds intricate flow-field geometries and sealing concepts into the plate in a single step, eliminating extensive machining and enabling repeatable, multi-cavity production suitable for future automotive-scale volumes. At the same time, continuous extrusion enables large-format graphite foils with high graphite loading for separator applications where metals fail due to corrosion across pH 0–14 environments. Patented surface treatments complement these shaping technologies by improving interfacial contact resistance, tuning hydrophilic or hydrophobic behavior, removing polymer “skin” to increase conductivity, and enhancing water management and cold-start performance without compromising corrosion resistance.

A defining innovation milestone in this journey has been Schunk’s success in overcoming graphite’s historical thickness disadvantage. Through advances in formulation, press tooling, and curing control, the company has reduced plate thickness by a factor of three compared to earlier generations, achieving total thickness around 500 microns and web thickness below 250 microns.² This breakthrough enables higher energy density stacks and makes graphite viable for buses, trucks, trains, marine vessels, and other heavy-

² Ibid.

duty applications where durability, dimensional stability, and corrosion resistance outweigh the marginal size advantage of coated metal plates.

Complementing this technical depth is Schunk's readiness for high-volume industrialization. Because machining graphite plates is economically unviable at scale, the company has prioritized optimized multi-cavity compression molding and reduced cycle times, capabilities it has already industrialized to ensure true commercial scalability. Schunk's infrastructure is already built for extreme demand; the company has previously demonstrated the capacity to respond to inquiries for up to 15 million plates per year following the investment has to be made.³ By aligning its tooling, automation, and quality systems today, the company is positioned to support the significant market ramp-up that industry observers anticipate toward the end of the decade.

"Through this integrated focus on materials science, process excellence, sustainability, and cross-industry collaboration, Schunk maintains a technology leadership position that is difficult to replicate. As the market shifts from demonstration to industrialization, its graphite bipolar plate solutions evolve in step with application needs, preserving a clear competitive advantage in Europe's maturing hydrogen and electrochemical systems market."

**- Sama Suwal,
Best Practices Research Analyst**

In a market moving from promise to proof, Schunk's combination of historical depth, formulation-level control, patented surface engineering, and scalable manufacturing positions it as the materials and manufacturing backbone that enables stack developers to industrialize graphite solutions with confidence across fuel cells and broader electrochemical energy systems.

Reinforcing Technology Leadership Through Continuous Innovation in Materials, Processes, and Sustainability

Building on its materials and manufacturing foundations, Schunk strengthens its competitive edge through a deliberate innovation focus that responds

directly to changing fuel cell architectures and customer performance targets. Instead of treating graphite bipolar plates as a mature component, the company advances them as an evolving materials platform, refining formulations, flow-field integration, and surface characteristics to meet rising expectations for efficiency, durability, and compact stack design in heavy-duty and stationary applications.

A central pillar of this effort lies in advanced materials development. Schunk continuously adjusts graphite compositions, binder systems, and composite structures to balance conductivity, strength, thinness, and corrosion resistance for different electrochemical environments. This ability to fine-tune material behavior enables customers to optimize stack performance without redesigning entire systems, reinforcing the company's role as a materials engineering partner embedded in product development cycles.

In parallel, Schunk advances process innovation to translate materials breakthroughs into scalable production. Improvements in compression molding precision, extrusion stability for high-graphite thermoplastic films, and automated finishing techniques allow the company to reduce variability, improve

³ Ibid.

yield, and lower cost per plate as volumes increase. These process refinements ensure that performance gains achieved in the lab can be replicated consistently on industrial production lines.

Sustainability forms a third axis of Schunk's innovation focus. By developing fluoropolymer-free formulations, enabling weldable thermoplastic plates that eliminate sealing materials, and designing products for recyclability at end of life, the company aligns its technology roadmap with the broader environmental objectives driving hydrogen and energy storage adoption. Material efficiency, waste recirculation in extrusion, and long product lifetimes further reinforce the sustainability value proposition of its graphite solutions.

Schunk amplifies these advances by leveraging synergies across Schunk Carbon Technology and the wider group's expertise in ceramics, sintered metals, quartz, environmental simulation, and precision machinery. This cross-disciplinary knowledge accelerates tool design, strengthens quality assurance, and enriches application insight, allowing bipolar plate innovation to benefit from decades of accumulated know-how in high-performance materials and advanced manufacturing.

This innovation culture also supports a broader electrochemical platform strategy beyond fuel cells. Schunk applies its graphite separator and bipolar plate expertise to redox flow batteries across multiple chemistries, selective roles in electrolyzers, and emerging systems such as Power-to-X, carbon capture, hydrogen storage, and other harsh pH electrochemical environments. By positioning graphite as a versatile materials platform rather than a single-use component, the company diversifies technology risk and sustains relevance across the expanding hydrogen and energy storage landscape.

Through this integrated focus on materials science, process excellence, sustainability, and cross-industry collaboration, Schunk maintains a technology leadership position that is difficult to replicate. As the market shifts from demonstration to industrialization, its graphite bipolar plate solutions evolve in step with application needs, preserving a clear competitive advantage in Europe's maturing hydrogen and electrochemical systems market.

Customer-Centric Execution: Converting Technology Leadership into Scalable Growth

Schunk translates its technical leadership into market growth through a structured, customer-centric engagement model designed to lower adoption barriers for fuel cell and electrochemical system developers. By integrating early into customer design cycles, the company works directly from stack requirements and operating conditions to recommend the optimal material formulation and manufacturing route. This consultative approach allows developers to validate performance rapidly while significantly reducing development risk and time-to-market.

A defining element of this model is Schunk's prototype-to-series pathway, which serves as a powerful engine for customer acquisition. New entrants and established OEMs can initiate material qualification with standard plates, progress to machined functional prototypes, and transition seamlessly to compression-molded or extruded solutions for series production. Because the company controls the complete value chain, this pathway ensures total continuity between sampling and scale-up, guaranteeing that the performance achieved in the lab is mirrored in volume production.

Schunk further enhances the customer experience and acquisition potential through application-specific customization. In-house tool design enables tailored flow-field geometries and specialized sealing concepts, while surface optimization allows for performance tuning without requiring a full stack redesign. This flexibility is essential in a maturing market where architectures continue to evolve, and developers seek partners capable of adapting alongside them. Furthermore, by providing “Design-for-Manufacturability” guidance, Schunk helps customers avoid the costly pitfalls of unscalable designs, effectively bridging the gap between theoretical engineering and industrial reality.

Ultimately, Schunk’s industrial discipline provides the reliability required for long-term partnership and sustained growth. Certified production processes, tight manufacturing tolerances, and a robust supply chain ensure that quality remains uncompromising even as volumes scale toward the millions. By simplifying qualification and de-risking the transition to mass production, the company makes it easier for both emerging and established players to industrialize graphite solutions. In a market moving from experimentation to execution, this ability to combine technical depth with a seamless customer journey positions the company to capture a significant share of the expanding hydrogen economy.

Conclusion

Technology is a decisive success factor in Europe’s graphite bipolar plates industry, where manufacturers must prove not only materials expertise but the ability to translate that expertise into scalable, application-ready solutions for fuel cells and electrochemical systems. Through its proprietary graphite composite formulations, compression molding, thermoplastic extrusion platforms, and advanced surface engineering capabilities, Schunk Group (Schunk) delivers thinner, more durable, and corrosion-resistant bipolar plates while enabling higher production repeatability and lower system-level costs for customers.

The company stands apart through a sustained commitment to innovation that integrates materials science, process excellence, sustainability, and customer-centric engineering into a single industrial platform. This approach is reinforced by more than two decades of operational deployment, extensive production experience, and established series manufacturing capabilities that bridge today’s low-volume requirements with tomorrow’s industrial-scale demand. As hydrogen, fuel cell, and broader electrochemical markets move from demonstration to disciplined execution toward 2030, Schunk’s materials platform, manufacturing maturity, and cross-application relevance position it for sustained growth and long-term leadership in Europe’s evolving energy landscape.

For its strong overall performance, Schunk Group is presented with Frost & Sullivan’s 2026 European Technology Innovation Leadership Recognition in the graphite bipolar plates industry.

What You Need to Know about the Technology Innovation Leadership Recognition

Frost & Sullivan's Technology Innovation Recognition identifies the company that has introduced the best underlying technology for achieving remarkable product and customer success while driving future business value.

Best Practices Recognition Analysis

For the Technology Innovation Leadership Recognition, Frost & Sullivan analysts independently evaluated the criteria listed below.

Technology Leverage

Commitment to Innovation: Continuous emerging technology adoption and creation enables new product development and enhances product performance

Commitment to Creativity: Company leverages technology advancements to push the limits of form and function in the pursuit of white space innovation

Stage Gate Efficiency: Technology adoption enhances the stage gate process for launching new products and solutions

Commercialization: Company displays a proven track record of taking new technologies to market with a high success rate

Application Diversity: Company develops and/or integrates technology that serves multiple applications and multiple environments

Business Impact

Financial Performance: Strong overall business performance is achieved in terms of revenue, revenue growth, operating margin, and other key financial metrics

Customer Acquisition: Customer-facing processes support efficient and consistent new customer acquisition while enhancing customer retention

Operational Efficiency: Company staff performs assigned tasks productively, quickly, and to a high-quality standard

Growth Potential: Growth is fostered by a strong customer focus that strengthens the brand and reinforces customer loyalty

Human Capital: Leveraging innovative technology characterizes the company culture, which enhances employee morale and retention

Best Practices Recognition Analytics Methodology

Inspire the World to Support True Leaders

This long-term process spans 12 months, beginning with the prioritization of the sector. It involves a rigorous approach that includes comprehensive scanning and analytics to identify key best practice trends. A dedicated team of analysts, advisors, coaches, and experts collaborates closely, ensuring thorough review and input. The goal is to maximize the company's long-term value by leveraging unique perspectives to support each Best Practice Recognition and identify meaningful transformation and impact.

VALUE IMPACT			
STEP		WHAT	WHY
1	Opportunity Universe	Identify Sectors with the Greatest Impact on the Global Economy	Value to Economic Development
2	Transformational Model	Analyze Strategic Imperatives That Drive Transformation	Understand and Create a Winning Strategy
3	Ecosystem	Map Critical Value Chains	Comprehensive Community that Shapes the Sector
4	Growth Generator	Data Foundation That Provides Decision Support System	Spark Opportunities and Accelerate Decision-making
5	Growth Opportunities	Identify Opportunities Generated by Companies	Drive the Transformation of the Industry
6	Frost Radar	Benchmark Companies on Future Growth Potential	Identify Most Powerful Companies to Action
7	Best Practices	Identify Companies Achieving Best Practices in All Critical Perspectives	Inspire the World
8	Companies to Action	Tell Your Story to the World (BICEP*)	Ecosystem Community Supporting Future Success

*Board of Directors, Investors, Customers, Employees, Partners

About Frost & Sullivan

Frost & Sullivan is the Growth Pipeline Company™. We power our clients to a future shaped by growth. Our Growth Pipeline as a Service™ provides the CEO and the CEO's growth team with a continuous and rigorous platform of growth opportunities, ensuring long-term success. To achieve positive outcomes, our team leverages over 60 years of experience, coaching organizations of all types and sizes across 6 continents with our proven best practices. To power your Growth Pipeline future, visit Frost & Sullivan at <http://www.frost.com>.

The Growth Pipeline Generator™

Frost & Sullivan's proprietary model to systematically create ongoing growth opportunities and strategies for our clients is fueled by the Innovation Generator™.

[Learn more.](#)

Key Impacts:

- **Growth Pipeline:** Continuous Flow of Growth Opportunities
- **Growth Strategies:** Proven Best Practices
- **Innovation Culture:** Optimized Customer Experience
- **ROI & Margin:** Implementation Excellence
- **Transformational Growth:** Industry Leadership



The Innovation Generator™

Our 6 analytical perspectives are crucial in capturing the broadest range of innovative growth opportunities, most of which occur at the points of these perspectives.

Analytical Perspectives:

- **Megatrend (MT)**
- **Business Model (BM)**
- **Technology (TE)**
- **Industries (IN)**
- **Customer (CU)**
- **Geographies (GE)**

