

F R O S T & S U L L I V A N

2024 ENABLING TECHNOLOGY LEADER

*IN THE EUROPEAN
SOLID OXIDE
ELECTROCHEMICAL CELL
INDUSTRY*

F R O S T & S U L L I V A N

2024
BEST
PRACTICES
AWARD

 **elcogen**
Affordable green hydrogen

Best Practices Criteria for World-Class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each award category before determining the final award recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. Elcogen AS excels in many of the criteria in the solid oxide electrochemical cell space.

AWARD CRITERIA	
<i>Technology Leverage</i>	<i>Customer Impact</i>
Commitment to Innovation	Price/Performance Value
Commitment to Creativity	Customer Purchase Experience
Stage Gate Efficiency	Customer Ownership Experience
Commercialization Success	Customer Service Experience
Application Diversity	Brand Equity

SOEC and SOFC Leading the Global Energy Transition

The European solid oxide electrolyzer cell (SOEC) industry is at the forefront of the global energy transition, spearheading the development of high-efficiency technologies for green hydrogen production and emission-free electricity generation. With strategic investments from energy giants such as Baker Hughes and Hyundai, along with partnerships with key system integrators like AVL and Convion, the industry is rapidly expanding its manufacturing capacity to meet the rising demand for sustainable energy. Backed by European Commission grants and collaborations across the value chain, the SOEC sector will play a pivotal role in Europe’s pursuit of net-zero emissions and hydrogen economy.

Electrolyzers and fuel cells are integral to the development of the hydrogen economy, providing the necessary infrastructure for both the production and utilization of green hydrogen. SOECs play a critical role by producing hydrogen with higher efficiency and lower energy consumption than other types of electrolyzers, such as proton-exchange membrane or alkaline systems. Meanwhile, solid oxide fuel cells (SOFCs) enable the efficient conversion of hydrogen into electricity, offering superior fuel flexibility and durability. The European SOFC market for combined heat and power (CHP) applications is also experiencing robust growth as the region focuses on clean energy solutions. SOFCs offer advantages like high efficiency, fuel flexibility, and lower emissions than traditional power generation technologies. The push for renewable energy, especially the hydrogen economy, drives widespread interest and investment in SOFC technologies across residential, commercial, and industrial sectors. European projects focused on advancing SOFC technology further fuel momentum in the market, improving its durability and making it more cost-effective.

The growing demand for continuous power supply, particularly in key markets like Germany, the United Kingdom, and France, accelerates the adoption of SOFC systems, positioning Europe as a critical hub for fuel cell innovation and the clean energy transition. Within this context, companies like Elcogen AS (Elcogen) are leading this transformation with advanced SOFC and SOEC technologies that provide scalable, cost-effective solutions for both residential and industrial applications.

Elcogen AS: A Foundation of Strength and Innovation

Elcogen is a global leader in clean energy, specializing in SOFC and SOEC cells, stacks and modules. The company supports the energy transition by providing core technology that delivers affordable green hydrogen and emission-free electricity. Elcogen supplies solid oxide electrochemical cells that power the development of electrolyzers for renewable hydrogen production and fuel cells that convert hydrogen into electricity. The company's technology uniquely meet today's energy demands while being future-ready for biofuels and carbon-free energy, paving the way for a sustainable, hydrogen-powered future.

Delivering High-Efficiency, Emission-Free Power and Green Hydrogen

Elcogen's value proposition lies in its ability to provide high-efficiency, emission-free power, and green hydrogen production through solid oxide technology. It provides three core product lines (planar ceramic anode-supported cells, low-cost stacks designed for mass manufacturing, and stack modules equipped with gas manifolds and air distribution systems), ensuring seamless integration into third-party systems.

"Elcogen's value proposition lies in its ability to provide high-efficiency, emission-free power, and green hydrogen production through innovative solid oxide technology. It provides three core product lines (planar ceramic anode-supported cells, low-cost stacks designed for mass manufacturing, and stack modules equipped with gas manifolds and air distribution systems), ensuring seamless integration into third-party systems."

- Manuel Alborno
Best Practices Research Analyst

Plus, the company's flexible product lines serve various industries, from residential to large-scale industrial applications.

Offering fuel-flexible, scalable solutions for both power generation and electrolysis, Elcogen's SOECs are among the most efficient methods for producing green hydrogen, facilitating emission-free energy storage and power-to-fuel conversion. Its modular systems help customers meet sustainability targets while minimizing capital expenditures and operational costs. Moreover, the company has achieved nearly 100% thermodynamic efficiency and can reduce energy requirements for hydrogen production by up to 33%.¹ Such results relate to Elcogen's ability to

harness heat from downstream processes like green ammonia or methanol production. With an anode-supported cell that becomes active at 580°C, Elcogen achieves comparable performance to competitors who typically require temperatures of 650°C or higher.²

The company collaborates with numerous industrial partners and leading universities across Europe, leveraging a vast research and development network. By working closely with component suppliers and system integrators, Elcogen adapts its technology to industrial applications. Frost & Sullivan praises this

¹ Frost & Sullivan Interview with Elcogen AS (Frost & Sullivan, October 2024)

² Ibid.

collaborative approach, as it strengthens the company’s leadership within the solid oxide sector.

Overcoming Commercialization Challenges with Strategic Partnerships

Elcogen’s primary markets include steam electrolysis, biogas applications, CHP systems, and stationary power generation. The company is also gaining traction in emerging fields such as the maritime industry, off-grid electric vehicle supercharging stations, carbon dioxide electrolysis, and nuclear-powered hydrogen production. Across these industries, Elcogen practices efficient production processes and modular stack assembly. To this end, it has developed replaceable, modular units to streamline

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- Raj Chawla
Senior Research Analyst

maintenance and minimize the complexity of replacing thousands of smaller stacks in large-scale installations. Production processes remain optimized by controlling cell production in-house and collaborating with suppliers to scale other components. Finally, human and robotic methods ensure flexibility based on volume needs, while the lower material costs of solid oxide technology further enhance its cost-effectiveness.

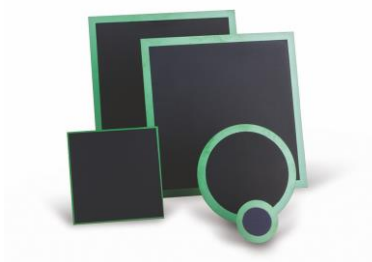
Elcogen’s strategic partnerships are instrumental in commercializing and scaling its SOEC technology. For example, the company has a long-standing collaboration with Convion, which plays a key role in system integration. Specifically, Convion incorporates

Elcogen’s fuel cell stacks into its systems, providing valuable data to optimize performance on a commercial scale.³

ElcoStack



ElcoCell



ElcoModule



³ Ibid.

Moreover, the company partnered with AVL to co-develop modular solutions for large-scale energy systems, with Elcogen supplying cells and stacks and AVL focusing on system design and integration.⁴ This initiative receives the support of the European Important Projects of Common European Interest program, ensuring that both companies can move proof-of-concept systems to megawatt-scale solutions.⁵

Ensuring Customer Success through Flexibility and a Strong Company Culture

Through a flexible, component-based approach, Elcogen delivers exceptional customer value, uniquely supplying critical elements for solid oxide technology. The company caters to diverse markets by partnering with system integrators and engineering firms. It empowers its collaborators to design customized systems, further expanding its reach across multiple market segments. This approach enables greater versatility, allowing customers to easily integrate the technology. Furthermore, Elcogen roots its core values in the well-being and empowerment of its employees. The company sets an example for best practices in employee care, going beyond legal requirements. By fostering a culture that values contributions at every level, Elcogen strengthens its objectives and strategies.

Success Stories

Driving the Circular Economy with Renewable Energy in Estonia: Elcogen’s cutting-edge SOFC and stack technology was integrated into Convion’s C60 fuel cell system, delivering renewable power and heat to Biometaan OÜ in Estonia. Installed at Siimani farm, the biogas-powered system generates 60 kilowatts (kW) of electricity and over 20 kW of heat from locally produced biogas, achieving an impressive 60% electrical efficiency and 80% total efficiency through waste heat recovery.⁶ This project showcases how Elcogen’s technology can drive the circular economy by converting agricultural waste into energy and biofertilizers, with zero harmful emissions and broad fuel flexibility.

Powering Finland’s Low-Carbon Future with SOFC Technology: Convion’s C60 system, powered by Elcogen’s SOFC technology, plays a pivotal role in Finland’s LEMENE Energy Community Project. This innovative system provides clean, reliable energy to a low-carbon, self-sufficient business district, delivering 60 kW of electricity and 25 kW of heat with 60% electrical efficiency and 80% total efficiency through waste heat recovery.⁷ By integrating renewable resources like biogas and solar, the hybrid micro-grid displays the potential of Elcogen’s SOFC technology to modernize energy infrastructure while significantly reducing emissions. Recognized by the Finnish Ministry of Economic Affairs and Employment, the project contributes to the European Union’s 2030 climate goals.⁸

Poised for Significant Growth

Elcogen collaborates with major industry players (such as Hyundai and AVL) to accelerate its growth, enable large-scale system designs for electrolyzers, and advance its solid oxide technology for hydrogen production. Hyundai’s investment underscores the commitment to leveraging Elcogen’s technology, while

⁴ “Elcogen partners with AVL to develop cutting-edge megawatt scale solid oxide electrolyser stack modules” (Elcogen AS press release, July 2024)

⁵ Ibid.

⁶ “Biogas fuel cell cogeneration system in Estonia” (Elcogen AS website: <https://elcogen.com/casestudies/biogas-fuel-cell-cogeneration-system-in-estonia/>)

⁷ “LEMENE– fuel cell system to be commercialised in Finland” (Elcogen AS website: <https://elcogen.com/casestudies/lemene-fuel-cell-system-to-be-commercialised-in-finland/>)

⁸ Ibid.

the partnership with AVL strengthens system integration capabilities.

In line with these alliances, the company plans to increase production capacity by developing a new facility in Estonia. This project involves the mass-production of up to 3.6 million cells, with a potential scalability of up to 4 million, with operations scheduled to commence mid-2025.⁹ This boost will reduce costs while maintaining high performance. Additionally, the company practices responsible sourcing and maximizing recycling efforts to minimize environmental impact throughout production. The new production facility highlights a solid commitment to scalability and sustainability, reducing costs by 60% while minimizing environmental impact.¹⁰ Elcogen's new production facility reinforces the company's leadership in green hydrogen and emission-free electricity markets.

€140 million in funding from strategic investors like HD Hyundai, Baker Hughes and other key players further position Elcogen to scale its technology and meet growing demand.¹¹ This funding will support the construction of the new facility and advance Elcogen's role in driving the hydrogen economy. Frost & Sullivan finds that the investments, along with ongoing product development initiatives, allow Elcogen to continue innovating over the next five years, strengthening its position as a key player in the industry.

Conclusion

While technology integration is crucial for success in the energy industry, the many options available force market players to choose the most suitable solutions to maximize their impact. Elcogen AS addresses the challenge of clean energy transition with its solid oxide fuel cell and solid oxide electrolyzer cell technologies. It provides flexible, efficient, and cost-effective solutions for power generation and green hydrogen production, positioning the company as a key contributor to sustainable energy. Elcogen's ability to deliver high efficiency at lower operating temperatures sets it apart by reducing energy costs without sacrificing performance. On top of the previous, strategic partnerships with industry leaders fuel the company's growth, expanding its production capacity and market reach within the hydrogen economy. Finally, by focusing on responsible sourcing, recycling efforts, and advanced technology, Elcogen exemplifies a thoughtful and environmentally conscious approach to energy production, making it a top contender in the green hydrogen and emission-free electricity markets.

For its strong overall performance, Elcogen AS is recognized with Frost & Sullivan's 2024 European Enabling Technology Leadership Award in the solid oxide electrochemical cell industry.

⁹ "Elcogen's new production facility to expand manufacturing capacity to 360 MW" (Elcogen AS press release, May 2024)

¹⁰ Ibid.

¹¹ Frost & Sullivan Interview with Elcogen AS (Frost & Sullivan, October 2024)

What You Need to Know about the Enabling Technology Leadership Recognition

Frost & Sullivan's Enabling Technology Leadership Award recognizes the company that applies its technology in new ways to improve existing products and services and elevate the customer experience.

Best Practices Award Analysis

For the Enabling Technology Leadership Award, 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 Success: 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

Customer Impact

Price/Performance Value: Products or services provide the best value for the price compared to similar market offerings

Customer Purchase Experience: Quality of the purchase experience assures customers that they are buying the optimal solution for addressing their unique needs and constraints

Customer Ownership Experience: Customers proudly own the company's product or service and have a positive experience throughout the life of the product or service

Customer Service Experience: Customer service is accessible, fast, stress-free, and high quality

Brand Equity: Customers perceive the brand positively and exhibit high brand loyalty

