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Solid Oxide Electrolyzer Cell (SOEC) Market - A Global and Regional Analysis: Focus on Application, Product, and Regional Analysis - Analysis and Forecast, 2025-2035

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Abstracts

The solid oxide electrolyzer cell (SOEC) market was valued at $136.9 million in 2024 and is projected to grow at a CAGR of 48.78%, reaching $22,558.3 million by 2035. The solid oxide electrolyzer cell (SOEC) market is an emerging segment of the electrolyzer industry focused on high-temperature water electrolysis (steam electrolysis). SOECs operate at elevated temperatures, which can improve conversion efficiency by using heat as part of the energy input, making them especially attractive for hard-to-abate industrial decarbonization where waste heat or high-temperature process heat is available. The International Energy Agency (IEA) notes SOECs can achieve the highest efficiencies among electrolyzer types, while also highlighting that extending lifetime remains a key development priority.

Introduction of Solid Oxide Electrolyzer Cell

The study conducted by BIS Research highlights that the solid oxide electrolyzer cell (SOEC) market includes stack and system manufacturers, balance-of-plant suppliers, EPC partners, and end users deploying SOEC systems for green hydrogen and e-fuels pathways. It is closely linked to broader electrolyzer deployment momentum (across alkaline/PEM/SOEC), with nearly 700 MW of electrolysis capacity becoming operational in 2023 (all technologies). Unlike low-temperature electrolyzers, SOEC commercialization tends to cluster around industrial hubs (refineries, steel, chemicals, e-methanol/ammonia), where the value of high efficiency and heat integration is highest.

Market Introduction

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The solid oxide electrolyzer cell (SOEC) market covers the development, manufacturing, and deployment of high-temperature electrolyzer systems that produce hydrogen by splitting steam (and, in some configurations, co-electrolyzing steam and CO? to create syngas for e-fuels). Market activity spans SOEC stack suppliers, system integrators, balance-of-plant providers (heat exchangers, power electronics, controls), EPC partners, and end users across heavy industry. Compared with low-temperature electrolyzers, SOEC adoption is most concentrated in industrial hubs such as steel, chemicals, refineries, and e-fuel projects, where access to high-grade heat or steam can improve overall efficiency and economics. As clean hydrogen policies and industrial decarbonization targets expand, the solid oxide electrolyzer cell (SOEC) market is transitioning from pilot-scale installations toward early commercialization, with competition increasingly centered on stack durability, thermal cycling resilience, and scalable manufacturing.

Industrial Impact

SOEC adoption can materially change industrial decarbonization economics by lowering electricity needs per unit of hydrogen when integrated with usable heat, helping industrial sites convert renewable power + heat into hydrogen more efficiently. This supports new value chains, green steel, low-carbon ammonia/methanol, refinery hydrogen replacement, and synthetic fuels while also stimulating localized ecosystems for high-temperature components, ceramics, advanced coatings, and balance-of-plant engineering. At the same time, SOEC's industrial impact is tightly tied to operational durability and thermal management; as the IEA notes, lifetime is still a limitation compared with more mature electrolyzer types, making reliability engineering and stack longevity a major determinant of total cost of hydrogen for real-world deployments.

Market Segmentation:

Segmentation 1: by Application

- Refining Industry
- Power and Energy Sector
- Ammonia Production
- Methanol Production

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Transportation/Mobility

Others

Refining Industry Segment to Dominate Solid Oxide Electrolyzer Cell (SOEC) Market (by Application)

In the solid oxide electrolyzer cell (SOEC) market, the refining industry segment is expected to dominate by application, driven by the industry's increasing focus on sustainability and reducing carbon emissions. The refining industry represents a significant application segment within the global solid oxide electrolyzer cell (SOEC) market, using SOEC technology for hydrogen generation required in refining processes. Growth in this segment has been driven by increasing demand for low?carbon hydrogen to comply with stricter environmental regulations in refining operations. Additionally, the shift toward cleaner fuel production and the decarbonization of industrial processes accelerate the adoption of SOEC systems in the refining sector. As demand for sustainable hydrogen rises, the refining industry application strengthens the overall expansion of the global SOEC market by driving the deployment of electrolyzer systems. Continued focus on environmental compliance and cleaner energy transitions in refineries is expected to boost this segment’s growth further.

Segmentation 2: by Product Type

Planar

Tubular

Others

Planar Segment to Dominate Solid Oxide Electrolyzer Cell (SOEC) Market (by Product Type)

Planar segment is expected to dominate the solid oxide electrolyzer cell (SOEC) market by type. The planar type is a key segment within the global solid oxide electrolyzer cell (SOEC) market, characterized by its efficient design and high-performance capabilities. The growth of this segment has been driven by advancements in material science and

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manufacturing techniques, which enable higher efficiency and lower production costs. Additionally, the increasing demand for clean hydrogen production and the shift toward sustainable energy sources are accelerating the adoption of planar SOEC systems. This segment's growth positively impacts the overall market, as it contributes to the scaling up of hydrogen production technologies, further driving the expansion of the global SOEC market. Factors such as government support for green technologies and rising investments in clean energy infrastructure are expected to sustain this growth trajectory.

Segmentation 3: by Region

North America: U.S., Canada, and Mexico

Europe: Germany, France, U.K., Italy, and Rest-of-Europe

Asia-Pacific: China, Japan, India, South Korea, and Rest-of-Asia-Pacific

Rest-of-the-World: South America and the Middle East and Africa

Currently, Europe is expected to lead the solid oxide electrolyzer cell (SOEC) market because it combines the strongest "policy pull" with large industrial decarbonization demand and targeted funding that accelerates electrolyzer scale-up. At the EU level, REPowerEU sets a clear demand signal for renewable hydrogen; 10 million tons were produced domestically and 10 million tons imported by 2030, which directly supports deployment of advanced electrolyzer technologies, including high-temperature SOEC systems suited to industrial hubs.

Recent Developments in Solid Oxide Electrolyzer Cell (SOEC) Market

In April 2024, Topsoe revealed that it intends to establish a large-scale solid oxide electrolyzer cell (SOEC) manufacturing facility in Chesterfield, Virginia. The planned plant is designed to localize SOEC production in the U.S. and support the growing demand for clean-hydrogen applications, particularly downstream products such as e-ammonia and e-methanol.

In October 2025, the MultiPLHY project achieved a major milestone at Neste's Rotterdam refinery by commissioning what is recognized as the world's largest solid-oxide electrolyzer operating within an industrial environment, with Sunfire

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contributing the technology and Neste publicly confirming the start-up.

In January 2025, Sunfire announced a significant financing milestone, securing a $234.5 million guaranteed funding package structured and led by a consortium of banks.

Demand - Drivers, Limitations, and Opportunities

Market Demand Drivers: Superior Efficiency and Performance Advantages over PEM and Alkaline Electrolyzers

The solid oxide electrolyzer cell (SOEC) market has been witnessing strong momentum due to its distinct efficiency advantages compared to PEM and alkaline technologies. According to the IEA's 2024 hydrogen outlook, electricity remains the dominant cost driver in clean hydrogen production, making high-efficiency electrolysis technologies increasingly attractive. SOEC systems, which operate at elevated temperatures using steam rather than liquid water, require significantly less electrical input. FuelCell Energy's 2024 demonstrations showcased efficiencies approaching 90% (HHV) when operating solely on electricity and up to 100% when integrated with industrial or nuclear heat sources. In comparison, PEM and alkaline electrolyzers typically operate at 60-70% efficiency, making SOEC an appealing option for markets where electricity prices directly dictate hydrogen cost competitiveness. Industry deployments between 2023 and 2025 further highlight this shift. Bloom Energy's 2024 SOEC units delivered record-low electricity consumption of ~37–39 kWh/kg of hydrogen in industrial pilots, outperforming competing electrolyzer types under similar conditions. CATF's 2023 technology assessment emphasized that SOEC maturity has been underestimated, with many manufacturers leveraging decades of SOFC manufacturing experience. This performance advantage is important in the context of the IEA's updated Net Zero Scenario 2024, which reduced near-term clean hydrogen demand projections but reinforced the need for highly efficient electrolyzers to achieve long-term cost and emissions targets. These characteristics make SOECs particularly compelling for regions aiming to optimize hydrogen production under strict carbon-intensity thresholds.

As global hydrogen markets expand, SOEC's efficiency edge plays a critical role in lowering levelized hydrogen costs and enabling competitiveness in emerging Power-to-X value chains. The EU's Renewable Hydrogen definition under RED III, which emphasizes low-carbon intensity, incentivizes electrolyzer technologies that minimize electricity use. Similarly, U.S. projects under the DOE's Hydrogen Hubs initiative

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2023–2024 have begun incorporating SOEC pilots precisely due to their higher electrical efficiency. These examples underscore SOEC's strategic positioning within the broader green hydrogen market, where performance advantages directly translate to economic benefits.

Market Challenges: High Operating Temperatures and Durability Challenges

SOEC systems operate at 700–900°C, which introduces engineering, materials, and operational challenges that remain more pronounced than in PEM or alkaline electrolyzers. According to Fraunhofer IKTS' 2024 degradation studies, these elevated temperatures lead to several degradation pathways, including chromium volatilization from interconnects, seal cracking, electrode delamination, and thermal cycling fatigue. These challenges are inherent to ceramic-based technologies and demand extremely precise manufacturing control, robust thermal management systems, and consistent operating environments, factors that increase design complexity and limit flexibility for frequent startups and shutdowns.

Compared with PEM and alkaline systems, which typically operate at 60–80°C and 60–90°C, respectively, SOECs are more sensitive to load changes and cannot cycle as aggressively to follow renewable electricity variations without accelerated degradation. This makes SOEC better suited to baseload or semi-continuous operation, especially in settings where waste heat is available. CATF's 2023 comparative assessment highlights that while SOEC has unmatched efficiency potential, stack lifetimes still require improvement to consistently exceed 20,000-30,000 operational hours under real-world industrial conditions. Until these durability thresholds reach the 60,000-80,000-hour expectations witnessed in mature fuel cell markets, some end users, particularly risk-averse industrial operators, may favor established low-temperature technologies.

Thermal integration requirements add complexity to EPC delivery and scale-up. Steam generation, heat recuperation, and temperature uniformity across large stack modules require advanced system engineering. Any deviation in thermal gradients can accelerate degradation, requiring expensive, specialized maintenance. This engineering overhead increases perceived project risk and can affect financing terms, particularly for early commercial deployments without long-term field data. As a result, although SOEC's efficiency benefits are compelling, durability concerns remain a practical barrier to widespread industry adoption until more large-scale plants accumulate multi-year operational track records.

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Market Opportunities: Co-Electrolysis for Synthetic Fuels and Chemical Production

SOEC's ability to perform co-electrolysis of H?O and CO? to produce a tailored syngas mixture represents one of the most compelling technology advantages in the emerging Power-to-X (PtX) economy. Reports such as Delivering Sustainable Fuels 2024 and The Role of E-Fuels in Decarbonising Transport 2023 emphasize that synthetic fuels, particularly e-methanol, sustainable aviation fuel (SAF via Fischer–Tropsch), and synthetic hydrocarbons, will play a critical role in meeting aviation and maritime decarbonization mandates. Co-electrolysis eliminates the need for a standalone reverse water–gas shift (RWGS) reactor, simplifying process flows and reducing both CAPEX and OPEX, especially in large-scale e-fuel plants.

As global demand for e-fuels accelerates, SOEC becomes strategically positioned as a core enabling technology. Coastal e-methanol projects, green shipping fuel initiatives, and aviation SAF mandates in the EU and U.K. increasingly require cost-effective syngas production. The ability to fine-tune H?:CO ratios within the SOEC stack allows downstream processes, such as methanol synthesis or FT synthesis, to operate more efficiently, reducing the overall energy penalty typical of low-temperature electrolyzer pathways. This positions SOEC as a preferred choice for refining, chemical, and e-fuel developers prioritizing both high efficiency and reduced plant complexity.

How can this report add value to an organization?

Product/Innovation Strategy: An effective product and innovation strategy in the solid oxide electrolyzer cell (SOEC) market must be system-centric rather than component-centric, because value is created at the level of integrated hydrogen and e-fuel production, not at the electrolyzer stack alone. Leading players are therefore prioritizing modular, scalable SOEC platforms that can be deployed in 10-50 MW blocks and combined into 100+ MW industrial systems, aligning with how e-methanol, e-ammonia, and refinery decarbonization projects reach final investment decisions.

Growth/Marketing Strategy: Growth and marketing in the solid oxide electrolyzer cell (SOEC) market must be account-based and ecosystem-driven, reflecting the fact that demand is created by a limited number of large, capital-intensive projects rather than by high-volume transactional sales. Unlike PEM or alkaline electrolysis, SOEC adoption is typically triggered at the project concept and front-end engineering (FEED) stage, making early technical influence a primary growth lever. Successful players, therefore, focus on embedding their technology into feasibility studies, consortium bids, and industrial decarbonization roadmaps well before final investment decisions are made.

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Competitive Strategy: A winning competitive strategy in the solid oxide electrolyzer cell (SOEC) market is built less on price competition and more on defensible differentiation through system performance, reliability, and integration depth. Unlike PEM and alkaline electrolysis, where scale and cost curves dominate competitive positioning, SOEC competes on its ability to deliver superior end-to-end efficiency in complex industrial environments. As a result, leading players position themselves not as equipment vendors, but as technology partners embedded in hydrogen-to-molecule value chains.

Research Methodology

Factors for Data Prediction and Modelling

The base currency considered for the solid oxide electrolyzer cell (SOEC) market analysis is the US$. Currencies other than the US$ have been converted to the US$ for all statistical calculations, considering the average conversion rate for that particular year.

The currency conversion rate has been taken from the historical exchange rate of the Oanda website.

Nearly all the recent developments from January 2021 to October 2024 have been considered in this research study.

The information rendered in the report is a result of in-depth primary interviews, surveys, and secondary analysis.

Where relevant information was not available, proxy indicators and extrapolation were employed.

Any economic downturn in the future has not been taken into consideration for the market estimation and forecast.

Technologies currently used are expected to persist through the forecast with no major technological breakthroughs.

Market Estimation and Forecast

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This research study involves the usage of extensive secondary sources, such as certified publications, articles from recognized authors, white papers, annual reports of companies, directories, and major databases to collect useful and effective information for an extensive, technical, market-oriented, and commercial study of the solid oxide electrolyzer cell (SOEC) market.

The market engineering process involves the calculation of the market statistics, market size estimation, market forecast, market crackdown, and data triangulation (the methodology for such quantitative data processes has been explained in further sections). The primary research study has been undertaken to gather information and validate the market numbers for segmentation types and industry trends of the key players in the market.

Primary Research

The primary sources involve industry experts from the solid oxide electrolyzer cell (SOEC) market and various stakeholders in the ecosystem. Respondents such as CEOs, vice presidents, marketing directors, and technology and innovation directors have been interviewed to obtain and verify both qualitative and quantitative aspects of this research study.

The key data points taken from primary sources include:

validation and triangulation of all the numbers and graphs

validation of report segmentations and key qualitative findings

understanding the competitive landscape

validation of the numbers of various markets for the market type

percentage split of individual markets for geographical analysis

Secondary Research

This research study involves the usage of extensive secondary research, directories, company websites, and annual reports. It also makes use of databases, such as Hoovers, Bloomberg, Businessweek, and Factiva, to collect useful and effective

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information for an extensive, technical, market-oriented, and commercial study of the global market. In addition to the data sources, the study has been undertaken with the help of other data sources and websites, such as the IEA Hydrogen Production & Infrastructure Projects Database, EU CORDIS.

Secondary research has been done to obtain crucial information about the industry's value chain, revenue models, the market's monetary chain, the total pool of key players, and the current and potential use cases and applications.

The key data points taken from secondary research include:

- segmentations and percentage shares
- data for market value
- key industry trends of the top players in the market
- qualitative insights into various aspects of the market, key trends, and emerging areas of innovation
- quantitative data for mathematical and statistical calculations

Key Market Players and Competition Synopsis

The companies that are profiled in the solid oxide electrolyzer cell (SOEC) market have been selected based on inputs gathered from primary experts and by analyzing company coverage, product portfolio, and market penetration.

Some of the prominent names in the solid oxide electrolyzer cell (SOEC) market are:

- Elcogen AS
- Bloom Energy
- Nexceris
- FuelCell Energy, Inc.

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OxEon Energy, Inc.

Sunfire SE

Ceres Power Holdings plc

Topsoe A/S

H2E Power

MITSUBISHI HEAVY INDUSTRIES, LTD.

Toshiba Energy Systems & Solutions Corporation

Companies that are not a part of the aforementioned pool have been well represented across different sections of the solid oxide electrolyzer cell (SOEC) market report (wherever applicable).

This report can be delivered within 1 working day.

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