



**SOFC MARKET AND COST REPORT FOR  
G-VOLUTION BY ADELAN  
15<sup>TH</sup> SEPTEMBER 2023**

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## Solid Oxide Fuel Cell (SOFC) Market Analysis- Current Status, Size, and Geographical Trends

### Executive Summary:

This analysis of the current state of the Solid Oxide Fuel Cell (SOFC) market, emphasising its size and geographical distribution, with a specific focus on the United Kingdom (UK) as of September 2023.

### Market Size:

As of 2022, the global SOFC market has grown significantly, reaching an estimated size of approximately \$1.5bn. This expansion is driven by the escalating demand for cleaner and more sustainable energy solutions across various industries. SOFCs have gained prominence for their efficiency and reduced environmental footprint, fostering their adoption for power generation, transportation, and other applications. The market is to grow to \$9.1bn by 2027

### Geographical Distribution:

The SOFC market exhibits a diverse geographical distribution, with notable activity in various regions:

- **North America:** The United States and Canada have led SOFC technology development and deployment. Strong government support, incentives, and favourable policies have been pivotal in market growth.
- **Europe:** Europe, including Germany, Italy, and the UK, plays a significant role in the global SOFC market. The European Union's commitment to sustainability and initiatives such as the Green Deal are driving SOFC adoption. The UK, in particular, has shown promising advancements in SOFC technology.
- **Asia-Pacific:** Asia-Pacific, led by Japan, South Korea, and China, has experienced rapid growth in the SOFC market. Government initiatives and the pursuit of cleaner energy alternatives are propelling this growth. Asian manufacturers are actively expanding their global presence.
- **United Kingdom:** The UK has emerged as a noteworthy player in the European SOFC market. The government's dedication to reducing carbon emissions and promoting green technologies has led to significant developments in SOFC technology. UK-based companies are actively contributing to the growth of this sector.

### Market Drivers:

Several key factors are fuelling the growth of the SOFC market:

- Rising environmental concerns and the demand for sustainable energy sources.
- The high efficiency and reduced emissions associated with SOFCs.
- Government incentives, subsidies, and regulatory support for clean energy technologies.

- Ongoing advancements in materials and manufacturing processes, leading to cost reductions.
- The growing interest in hydrogen-based energy systems, where SOFCs play a critical role in power generation.

#### Conclusion:

The SOFC market has seen substantial growth, with a diverse global presence. The UK, alongside other regions, is actively contributing to this expansion by leveraging its commitment to clean energy and sustainable technologies. As the world continues its transition toward cleaner energy sources, SOFCs are expected to play a pivotal role in shaping the future energy landscape.

## Solid Oxide Fuel Cell (SOFC) Supply Chain Evolution and Dominant Players: A Forecast for the Next Decade

#### Introduction:

The Solid Oxide Fuel Cell (SOFC) supply chain is on the brink of transformative growth over the next 1-3 years and beyond. As the world embraces cleaner energy solutions, the SOFC industry is experiencing a paradigm shift. This part of the report delves into the anticipated developments in the SOFC supply chain, focusing on both manufacturers and countries poised to dominate this burgeoning space. Of particular interest is the role that the United Kingdom (UK) is expected to play in this evolving landscape.

#### Manufacturers Leading the Charge:

A spectrum of manufacturers will significantly influence the future of the SOFC supply chain. Long-established industry leaders like Adelan and Bloom Energy continue to pioneer innovation and expansion. In parallel, emerging players and startups, particularly in Asia-Pacific and Europe, are poised to disrupt the market. The UK is home to dynamic SOFC companies like Adelan and Ceres Power Holdings, which are making substantial strides in shaping the technology's trajectory.

#### Regional Dynamics:

The SOFC manufacturing landscape is geographically diverse, with several regions emerging as potential powerhouses.

- **Asia-Pacific:** Japan, South Korea, and China lead the charge in Asia-Pacific, buoyed by robust governmental backing for clean energy technology. These nations have invested heavily in research and development, with various companies taking prominent roles in the industry.
- **Europe:** Europe, encompassing Germany, Italy, and the UK, is making substantial strides in SOFC research and development. The European Union's sustainability objectives and carbon reduction initiatives are propelling the growth of SOFC technology in this region.

- North America: The United States and Canada, known for their longstanding commitment to SOFC technology, have a robust research ecosystem, supportive policies, and pioneering companies like Bloom Energy.

### Conclusion:

The outlook for the SOFC supply chain is overwhelmingly positive over the next 1-3 years and beyond. Innovations in materials, manufacturing techniques, and system integration are poised to overcome existing challenges and boost the competitiveness of SOFCs. In a world increasingly focused on sustainability and carbon reduction, SOFCs are set to become a linchpin of clean energy strategies. Global collaboration and partnerships will play a pivotal role in advancing SOFC technology and promoting broader adoption as the world transitions to cleaner, more sustainable energy sources. The UK, with its burgeoning SOFC industry, is well-positioned to be a vital contributor to this global transformation.

## Solid Oxide Fuel Cell (SOFC) System Cost and Future Drivers for Cost Reduction

### Introduction:

The cost of SOFC systems has been a significant consideration in their adoption and integration into various applications. Understanding the factors influencing SOFC system costs and the dynamics driving future cost reductions is crucial for realising the full potential of this clean energy technology. This part of the report examines the current state of SOFC system costs and identifies key drivers that will contribute to cost reduction in the future.

### Factors Influencing SOFC System Costs:

The cost of SOFC systems today is influenced by several factors, including materials, manufacturing processes, economies of scale, and system integration. High-temperature materials such as ceramics and precious metals contribute to the initial cost, while manufacturing complexity and low production volumes can also result in higher costs. System integration challenges and balance of plant components further impact the overall cost. It's important to note that these factors have already started evolving, leading to gradual cost reductions in SOFC systems.

### Future Drivers for Cost Reduction:

Several drivers are expected to lead to cost reductions in SOFC systems over the coming years:

1. **Economies of Scale:** As demand for SOFC systems increases, economies of scale will come into play. Higher production volumes will lead to cost efficiencies in manufacturing, component sourcing, and system assembly. Volume break points will be achieved as production scales up, driving down the cost per unit.

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2. **Supply Chain Optimisation:** A well-optimised global supply chain can help reduce costs by sourcing materials and components from regions with competitive advantages. International collaborations and efficient logistics solutions will contribute to overall system cost reduction.

3. **Advancements in Materials and Manufacturing:** Ongoing research and development efforts are leading to innovations in SOFC materials and manufacturing techniques. New materials, coatings, and fabrication methods are being explored to enhance efficiency, durability, and cost-effectiveness.

4. **System Integration and Balance of Plant:** Improvements in system integration and balance of plant components will lead to more efficient and cost-effective SOFC systems. Advanced control systems, better heat management, and simplified manufacturing processes will enhance overall performance and reduce operating and maintenance costs.

### Conclusion:

The future outlook for SOFC system cost reduction is promising, with various factors at play, including economies of scale, supply chain optimisation, materials innovation, and system integration improvements. As these elements continue to evolve, SOFCs are expected to become increasingly competitive with conventional energy sources, making them a vital component of the clean energy landscape. Understanding these cost dynamics is essential for stakeholders in the energy industry to make informed decisions and accelerate the adoption of SOFC technology.

## Solid Oxide Fuel Cell (SOFC) System Future Drivers for Cost Reduction Impact

### Introduction:

As stated in the previous section of the report, various factors will impact the dynamics to improve future costs. All of these factors will come together to impact the affordability of SOFC technology in differing applications, with the initial biggest impact coming from Economies of Scale and Supply Chain Optimisation. Further engineering System Integration, Balance of Plan and Manufacturing developments will also show initial smaller incremental benefits, with further ongoing benefits expected. Longer term Advancements in Materials will continue to drive further cost reductions.

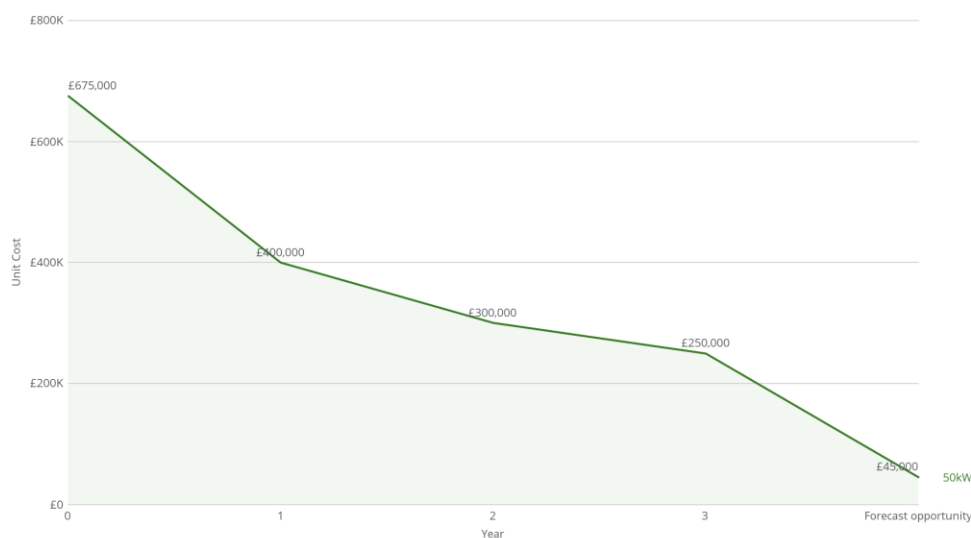
### Cost Reductions:

Detailed below we have shown how the forecast cost of a 50kW unit could reduce of the next 1-3 years, using annual volumes of 250 (Year 1), 500 (Year 2), 1,000 (Year 3).

These costs, which are based on known costs today and the result of previous studies, the cost of a 1 off 50kW would be c£675,000, but even initial lower volumes in Year 1 reduce this to c£400,000 with further reductions to £250,000, a reduction of c63%.

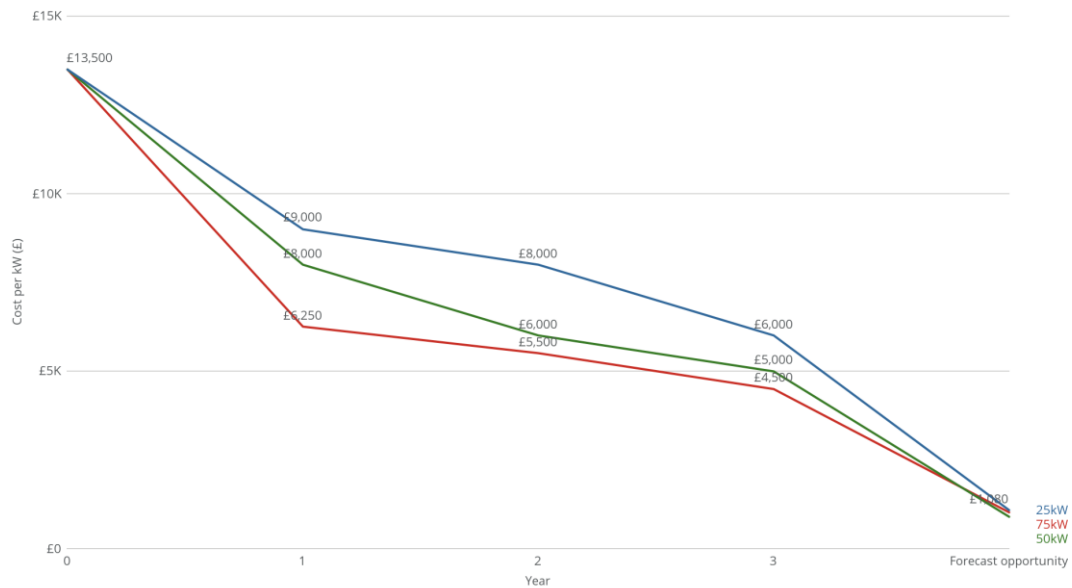
Future reductions would be expected to deliver reductions by a factor of at least x10 and there is evidence of early prototypes seeing a reduction factor by up to x100 with volume. The total market aggregation of sales within multiple sectors will drive the economies of scale benefit with forecast costs expected to reduce down to c£45,000, a reduction of 93%.

50kW SOFC Unit cost



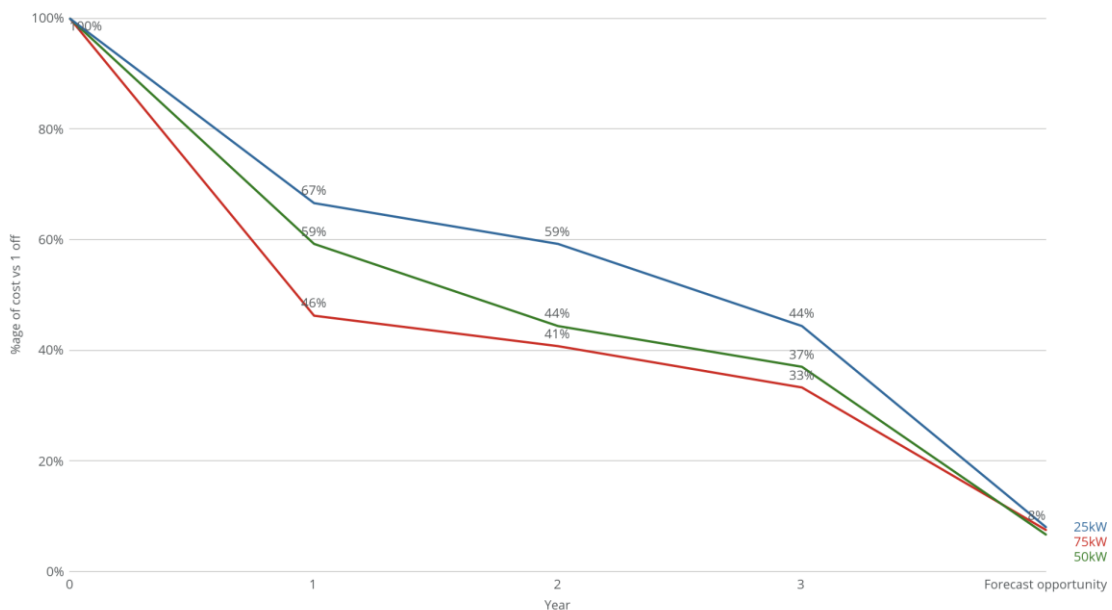
The chart below shows the cost comparison of a 50kW SOFC unit against 25kW and 75kW units measured in cost (£) per kW. All 3 show significant levels of cost reduction over the next 1-3 years, with the biggest incremental benefit being achieved in the initial phase of volume manufacture and assembly. However, the benefits of economies of scale achieved through aggregated demand across multiple sectors, along with the advancement of materials and manufacturing mean that all unit sizes can achieve at least £1,000 per kW.

Cost per kW by SOFC size



The chart below shows the cost reduction comparison of 25kW, 50kW and 75kW units over 1-3 years, using the same volume assumptions. This demonstrates that cost reductions of between 56% and 67% can be achieved in the near term, with further reductions of up to 90% to 95% expected to be achieved as the differing cost drivers mature and develop.

Percentage of cost vs 1 off unit by SOFC size





### Conclusion:

The future costs for SOFC systems are promising, with various factors at play which will drive cost reduction. The main cost drivers will be the benefits in Economies of Scale from total aggregated demand across all sectors and applications, and the Advancements in Materials and Manufacturing.

System Integration and Balance of Plant will drive further benefits which will be further enabled through future market consolidation. Based on the analysis, it is expected that the cost of a unit would reduce by 90%-95% to achieve a cost per kW of at least £1,000.

## Unlocking the Full Potential of Solid Oxide Fuel Cells (SOFCs): Beyond Power Generation

### Introduction:

Solid Oxide Fuel Cells (SOFCs) have long been recognised for their efficient electricity generation capabilities. However, their potential extends beyond power production, offering a range of additional benefits that are worth considering as the world seeks sustainable and versatile energy solutions. In this report, we explore some of these supplementary advantages, including heat recovery from combined heat and power (CHP) systems, and highlight other pertinent benefits that underscore the versatility of SOFC technology.

### Heat Recovery from CHP Systems:

One of the most notable supplementary benefits of SOFCs is their capacity to operate in CHP systems, allowing for the simultaneous generation of electricity and useful heat. This co-generation process significantly enhances overall energy efficiency by capturing waste heat that is typically lost in traditional power generation systems. This surplus heat can then be utilised for various purposes, including space heating, domestic hot water production, or industrial processes. The integration of SOFCs into CHP systems not only reduces energy costs but also lowers greenhouse gas emissions, making it an appealing solution for industries, commercial buildings, and residential applications.

### Additional Relevant Benefits:

Beyond CHP and heat recovery, several other benefits make SOFCs an attractive choice for a wide range of applications:

- **Fuel Flexibility:** SOFCs can operate on a variety of fuels, including hydrogen, natural gas, biogas, and ammonia. This adaptability ensures their viability in diverse energy environments and makes them suitable for transitioning to cleaner energy sources.

- **LPG, CNG, and LNG Integration:** LPG, CNG, and LNG are widely used as cleaner and more environmentally friendly alternatives to traditional fossil fuels like gasoline and diesel. SOFCs

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can be configured to run on these alternative fuels, offering multiple advantages. When combined with SOFCs, these fuels can undergo efficient electrochemical conversion to produce electricity with minimal emissions. Moreover, the utilisation of alternative fuels in SOFC systems can contribute to reducing the carbon footprint across diverse sectors, including transportation, residential power generation, and industrial processes. This adaptability to alternative fuels expands the potential applications of SOFCs, enabling them to contribute to a cleaner and more sustainable energy landscape.

- **Grid Support and Decentralisation:** SOFCs can provide grid support by contributing to distributed energy generation and grid-balancing services. Their ability to accommodate intermittent renewable energy sources, such as solar and wind power, aids in grid stability and promotes energy decentralisation.

- **Zero-Emission Operation:** SOFCs can operate with minimal emissions of pollutants, including nitrogen oxides (NOx) and particulate matter, making them environmentally friendly and compliant with stringent air quality regulations.

- **Resilience and Backup Power:** SOFCs offer reliable backup power in critical applications, ensuring uninterrupted electricity supply during grid outages or emergencies.

### Conclusion:

SOFCs offer a spectrum of benefits beyond their primary role as electricity generators. These advantages include enhanced energy efficiency through CHP and heat recovery, fuel flexibility, grid support, minimal emissions, and reliability. Recognising and leveraging these benefits can help stakeholders in various industries harness the full potential of SOFC technology for a sustainable and resilient energy future.