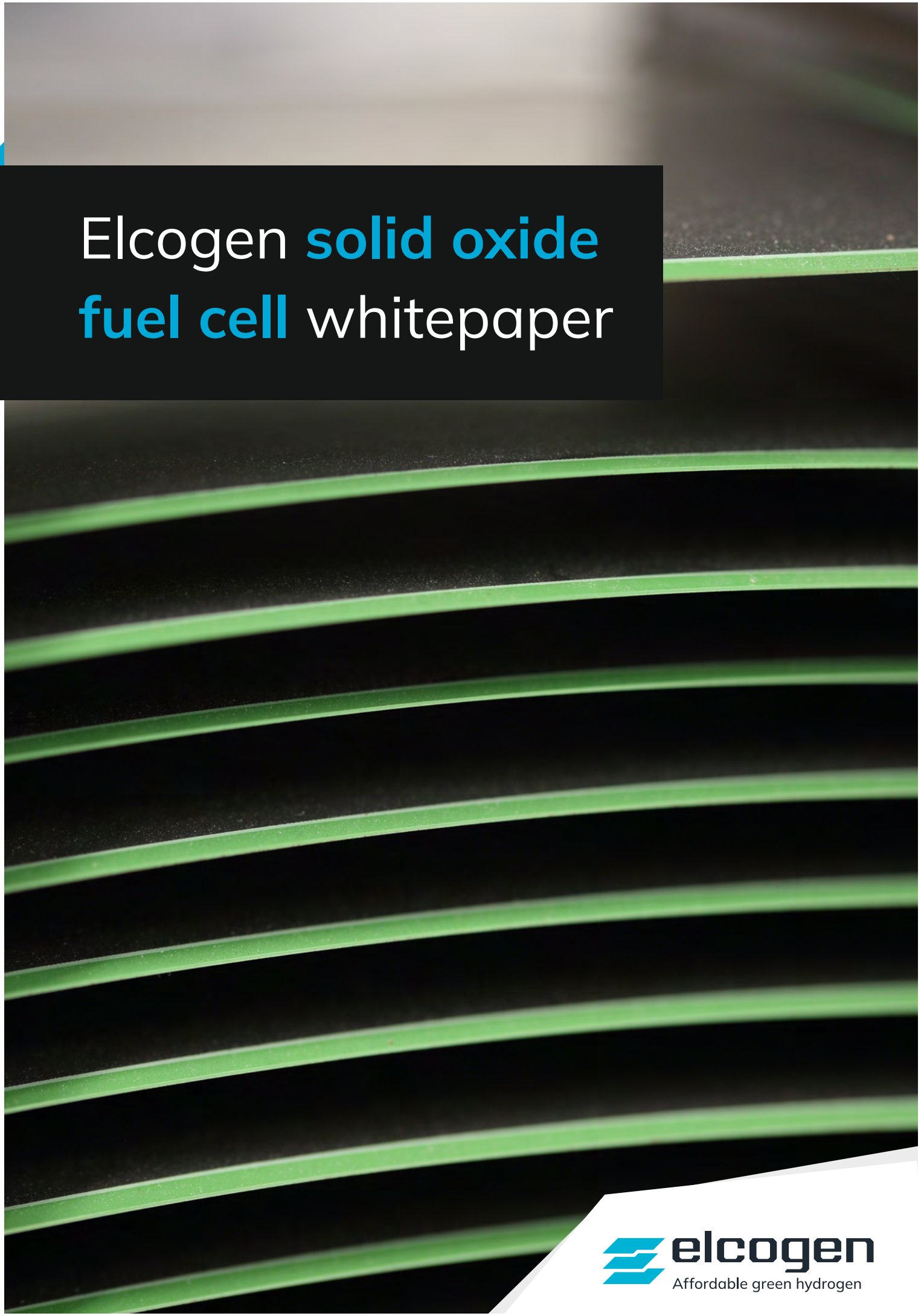
Elcogen **solid oxide fuel cell** whitepaper



elcogen
Affordable green hydrogen

INTRODUCTION

Elcogen's innovative solid oxide fuel cell technology is a game-changer in the global energy landscape, offering a highly efficient, sustainable, and scalable solution for applications of all sizes from small niche projects to megawatt-scale power generation. As the world increasingly shifts toward cleaner, more resilient energy systems, solid oxide fuel cell technology presents a clear pathway to meet the growing demand for low-emission, high-performance power generation. Here's how:

Why solid oxide technology?

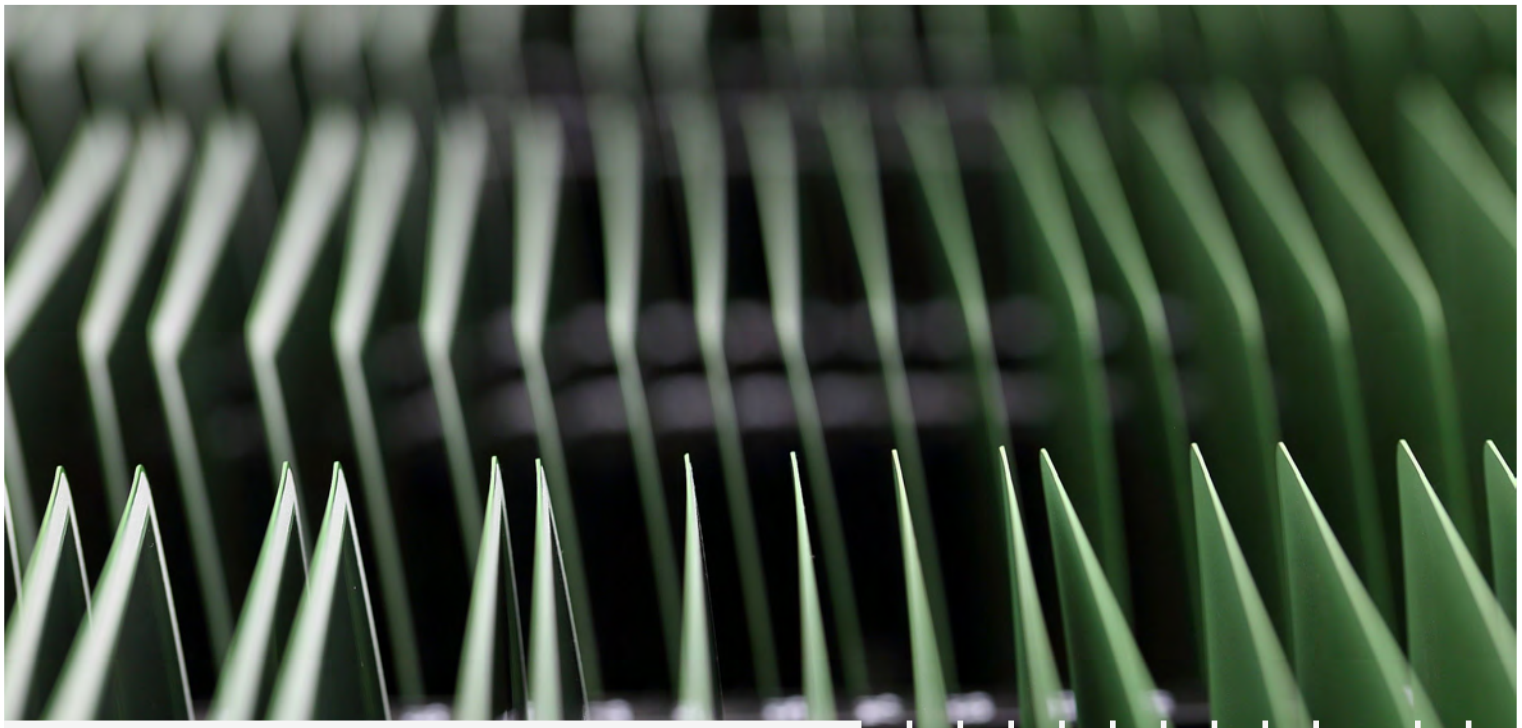
Fuel cells are unique electrochemical devices that provide electricity and heat with superior efficiency and minimal emissions.

All fuel cell types share the same operating principle: fuel and air electrodes in contact with an electrolyte enable electrochemical reactions that produce electricity and heat. Elcogen's solid oxide technology is based on solid ceramic planar cells manufactured from special proprietary materials and inks. Unlike other types of fuel cells, no noble metals or corrosive substances are needed to manufacture and operate Elcogen's solid oxide fuel cells.

Furthermore, Elcogen's cell design enables operation with high efficiency and power output at lower operating temperatures compared to many other solid oxide technologies, providing potential to use materials that are lower in cost and have longer lifespans.

Solid oxide fuel cells hold the greatest potential among all fuel cell technologies due to their highest efficiencies compared to other fuel cell types, with electrical efficiency of up to and over 60% readily achievable with solid oxide technology.

Solid oxide fuel cells also offer many additional benefits over other types of fuel cell technologies, including higher tolerance to impurities, fuel flexibility for various hydrogen and hydrocarbon fuels, and high-temperature operation, which enables the use of exhaust gases for co-generation of heat.



MANY ADVANTAGES:

60% **superior electrical efficiency,** surpassing other technologies across a wide power range

90% **total efficiency** when utilizing exhaust heat for co-generation

Fuel flexibility (hydrogen, ammonia, natural gas, biogases etc.) and better tolerance to impurities compared to other fuel cell types.

Simple and abundant materials: no use of noble metals or other rare matierials causing risk of raw material shortgages.

Emission free: Close to zero particulate emissions and nitrogen oxides

Low cost potential with use of simple materials and lower operating temperature compared to many other solid oxide fuel cell types.

How does solid oxide technology work?

A well-engineered solid oxide fuel cell system does not produce harmful emissions, such as particles, nitrogen oxides, or sulfur dioxide during operation. This is due to its direct electrochemical conversion of fuel to electricity, in contrast to traditional combustion-based technologies.

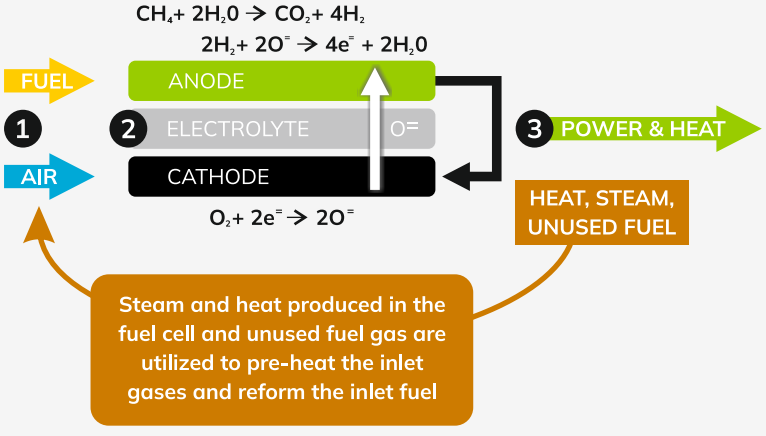
In a solid oxide fuel cell, air is supplied to the air electrode (cathode) and fuel to the fuel electrode (anode). When air comes in contact with the air electrode, oxygen ions are formed and transported through the dense, solid electrolyte. On the other side of the cell, the hydrogen-containing fuel gas sweeps over the surface of the fuel electrode and reacts with oxygen ions, producing electricity, heat, and steam.
The heat generated in the fuel cell is used to pre-heat the inlet gases close to the operating temperature (650°C) of Elcogen's solid oxide fuel cell. Additionally, the steam produced in the fuel cell reactions is utilised to reform inlet fuel into hydrogen-containing syngas with a suitable composition for the fuel cell operation, eliminating the need for an external water supply for the fuel cell system.

By recycling unused fuel back to the system inlet, the conversion efficiency of the final fuel cell system can be improved up to and beyond 60% electrical efficiency.

In addition to electricity generation, Elcogen's solid oxide technology can be used in electrolysis mode. This means it is possible to generate hydrogen by supplying steam and electricity to the cell.

How a solid oxide fuel cell works?

1. Fuel and air are supplied to anode (fuel electrode) and cathode (air electrode)
2. Oxygen ions pass the solic electrolyte and react with the fuel
3. Electrochemical reactions produce electricity and heat

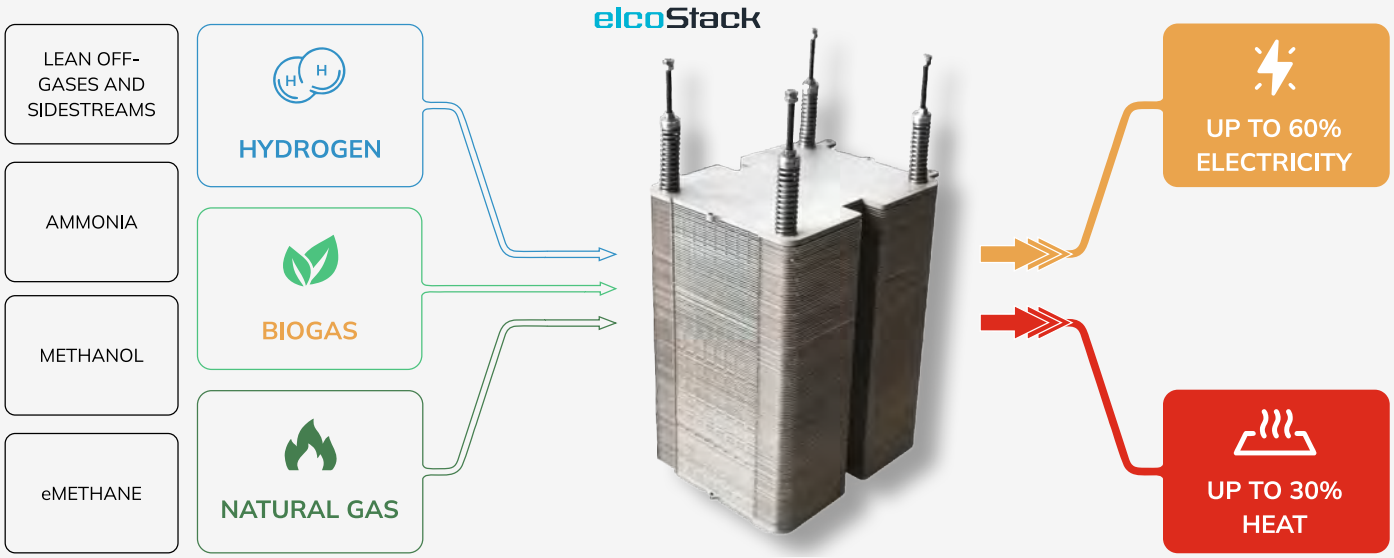


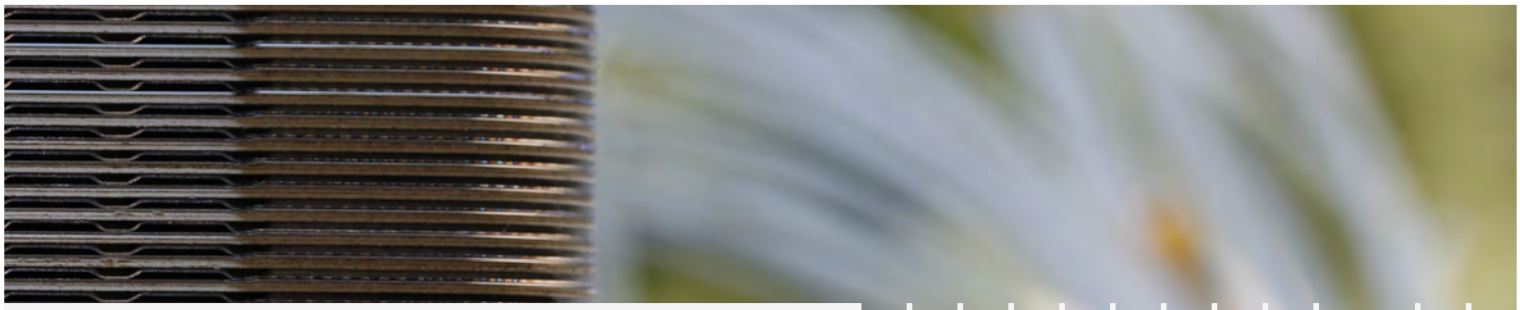
Wide range of possible applications from kW to MW scale

The fuel cell market is steadily growing, with increasing demand for more affordable and cleaner energy from various fuel feedstocks. Elcogen's solid oxide technology offers the necessary characteristics to meet this emerging demand, including high efficiency, fuel flexibility, minimal emissions, and use of simple, low-cost materials.

Solid oxide technology provides a modular approach to building energy systems in various power capacities, up to several megawatts of electric power.

Modular systems serve as essential building blocks for the distributed generation of electricity and heat, tapping into local fuel feedstocks sources of varying capacity such as biogas from agriculture or flammable industrial off-gases. The unique capabilities of solid oxide technology enable the use of lean fuel gases for electricity production with superior efficiency and fewer emissions compared to existing technologies like combustion engines.





Resilient power for industry and data centers

SOFC systems are ideal for various microgrid and backup power applications. Their combination of high efficiency and reliable operation can provide a resilient backup power supply in the event of grid failures, protecting critical assets in banks, data centers, or providing life-saving electricity for hospitals. SOFC systems provide operational lifetimes that are hundreds of times longer than batteries by using on-site gas or liquid fuel storage and leveraging existing gas supply infra-structure instead of relying on the grid for electricity.

Clean power for shipping and off-grid power

Emerging regulations for carbon-neutral and emission-free shipping are driving global changes in deep-sea marine transport applications. SOFCs are fully compatible with future green fuel options for deep-sea marine transport: ammonia, methanol, hydrogen, and emethane are all suitable fuels for SOFCs. Modular solid oxide electricity and heat producing power systems can be used to retrofit existing vessels to meet regulatory targets with lower fuel costs, or to realise completely new designs for powertrains and ships.

Elcogen provides cells, stacks, and modules for fuel cell and electrolyser system integrators and developers

Elcogen is a leading component supplier for solid oxide fuel cell and electrolyser applications, providing the essential core components needed in every fuel cell or electrolyser system: solid oxide cells and stacks, and stack modules.

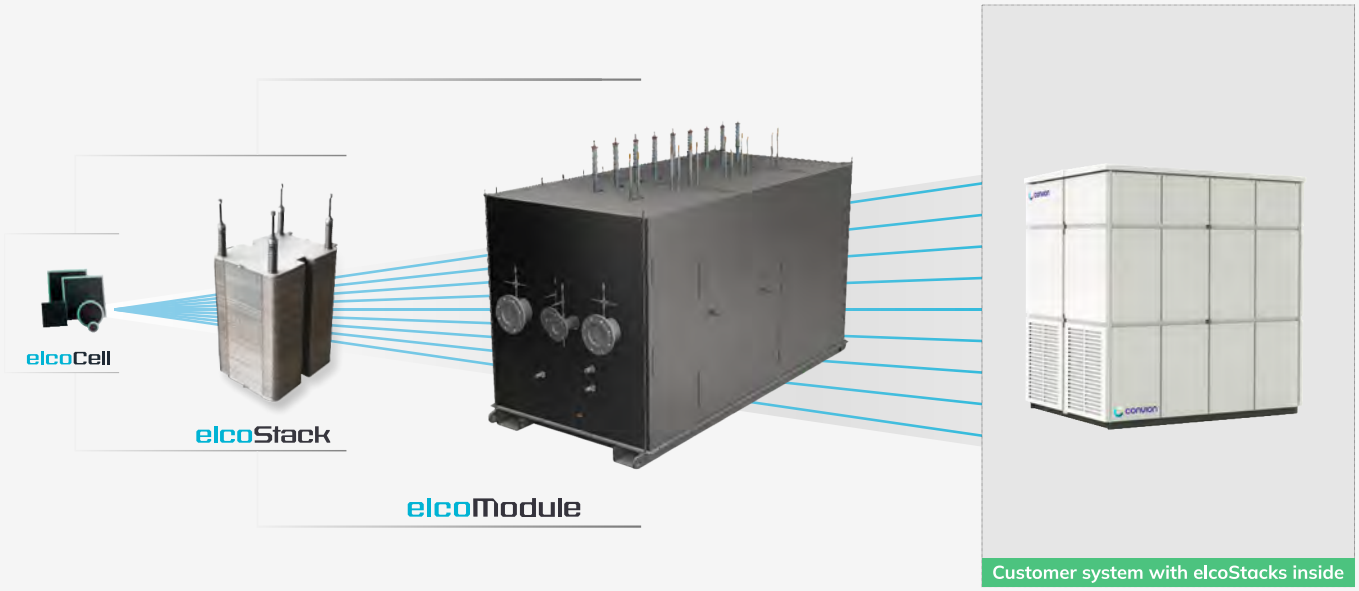
A solid oxide cell is the smallest component that Elcogen manufactures. A single standard-sized **elcoCell**® can produce ca. 25W of electric power.

In order to achieve sensible power levels and to supply fuel and air to the cell, the individual cells are electrically assembled in a series to form a fuel cell stack.

Elcogen's **elcoStacks**® consist of over 100 single cells, producing 3 kW of electric power. Elcogen has demonstrated record-high electrical efficiencies, 75%, for a solid oxide fuel cell stack, measured with an Elcogen E3000 stack.

For larger fuel cell systems, the stacks are bundled together into larger **elcoModules**® modules to reach practical power and voltage levels, and to provide simpler process interfaces for preheated air and fuel supply.

Elcogen provides both stacks and stack modules for system integrators developing their own fuel cell or electrolyser systems. The modularity of these products enables applications for different power capacities.



How can we help you?

Founded in 2001, Elcogen is today headquartered in the UK, which serves as the corporate headquarters, with advanced manufacturing facilities in Tallinn and R&D Centers of Excellence in both Estonia and Finland. We have a global presence with many projects in Combined Heat & Power systems, EV charging, SOFC systems for backup power, stationary power generation, and maritime applications, to name a few.

In addition to the supply of components, we offer comprehensive services to support technology integration, ensuring seamless adoption and optimal functionality of our solutions in various applications. We offer pre-sales and integration support covering consultancy on process and system design, advice on Balance of Plant (BOP) component and material selection, simulations, and process calculations with consultation on testing and operation procedures, including HAZOP studies. Our after-sales services include onsite support for testing, commissioning, first start-up, first shutdown cycle and stack replacements. We also offer stack performance simulations, process reconciliations, and consultancy on practical operational procedure optimisation. Everything you need to succeed.

If you are interested in learning more, get in touch with us!

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