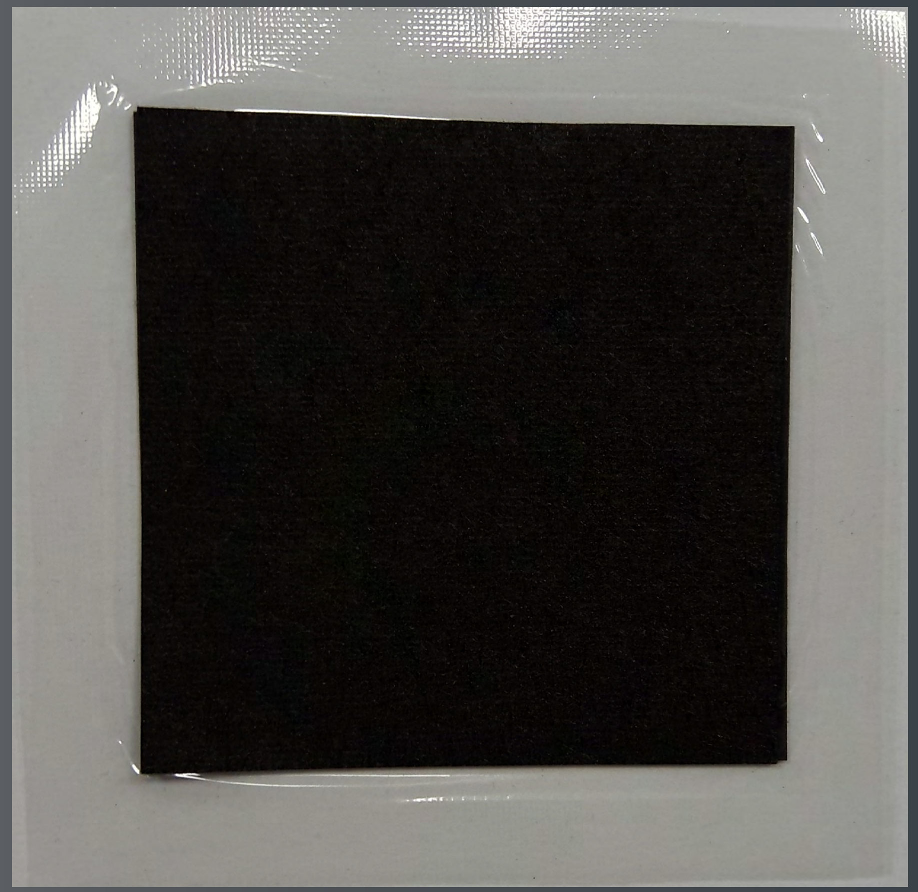


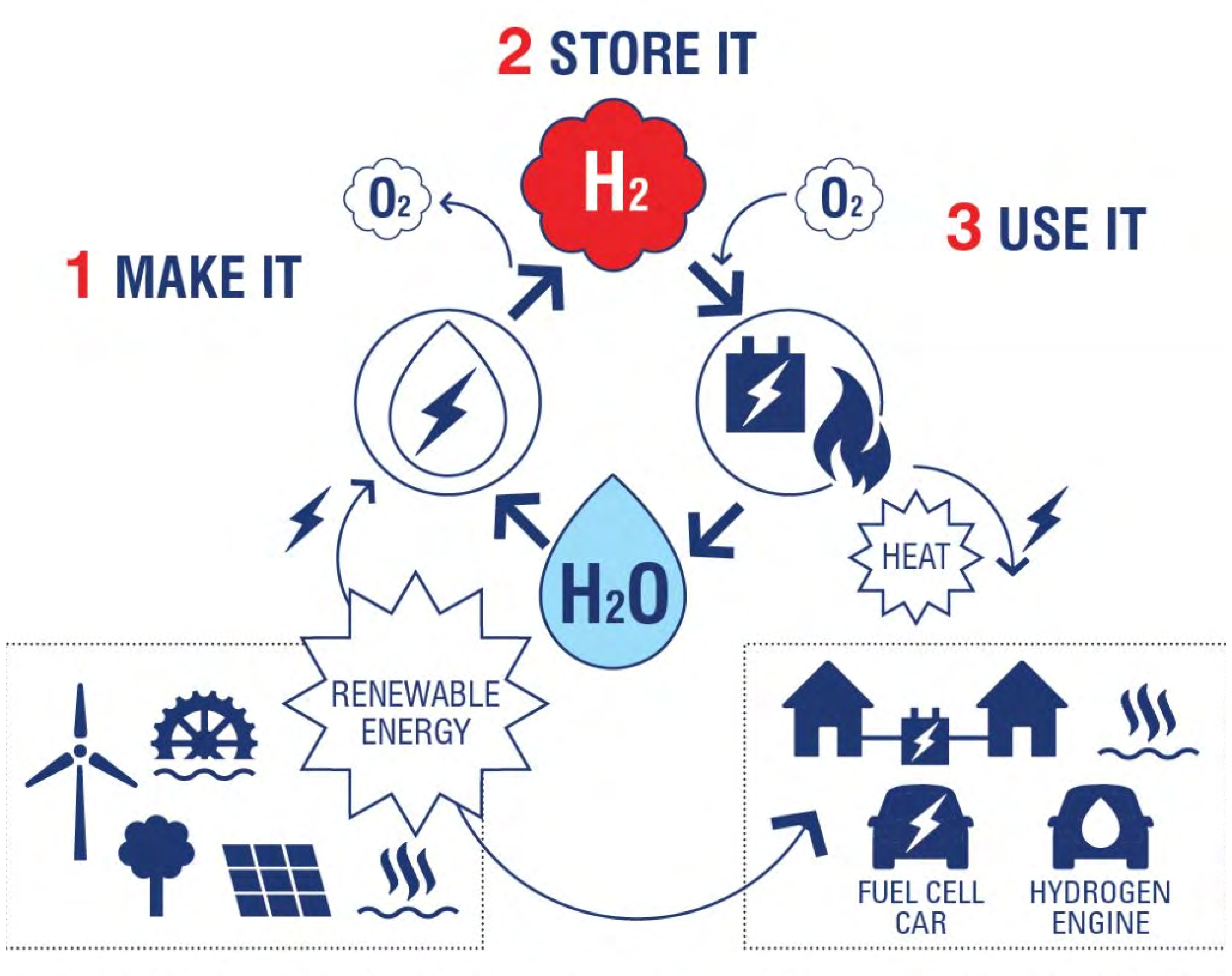
UNLEASH THE POWER OF FUEL CELLS WITH THE NEW MEBIUS MEA

mebius

Introduction to fuel cells

Hydrogen is the single most abundant substance in the universe. Perhaps due to this abundance, we sometimes forget how useful hydrogen is. From being used in the very first internal combustion engines, to powering flight by airships, hydrogen has once again taken center stage in mankind's quest for energy sources in the form of fuel cell applications.

Its attributes guarantee a market for it: it's light, storable, reactive, has high energy content per unit mass, and can be readily produced at an industrial scale. It can also be used without direct emissions of pollutants or GHG, and can also be produced from a diverse range of low-carbon energy sources.



Cycle of renewable hydrogen

Depending on how hydrogen is produced, fuel cells can be completely green by using solar, or wind power and electrolysis. And even when sourcing hydrogen from fossil fuels, by using it in a fuel cell, it is still cleaner than an internal combustion engine (ICE). Any high temperature combustion, such as that which would take place in a spark ignition engine fuelled by oil-derived fuels, produces GHG (CO, CO_2, NOx). Fuel cells also produce power more efficiently than ICE, thereby less fuel is being consumed to produce a given amount of electricity or to travel a given distance, thus also reducing emissions. By using clean hydrogen, fuel cells do not produce any GHG emissions.

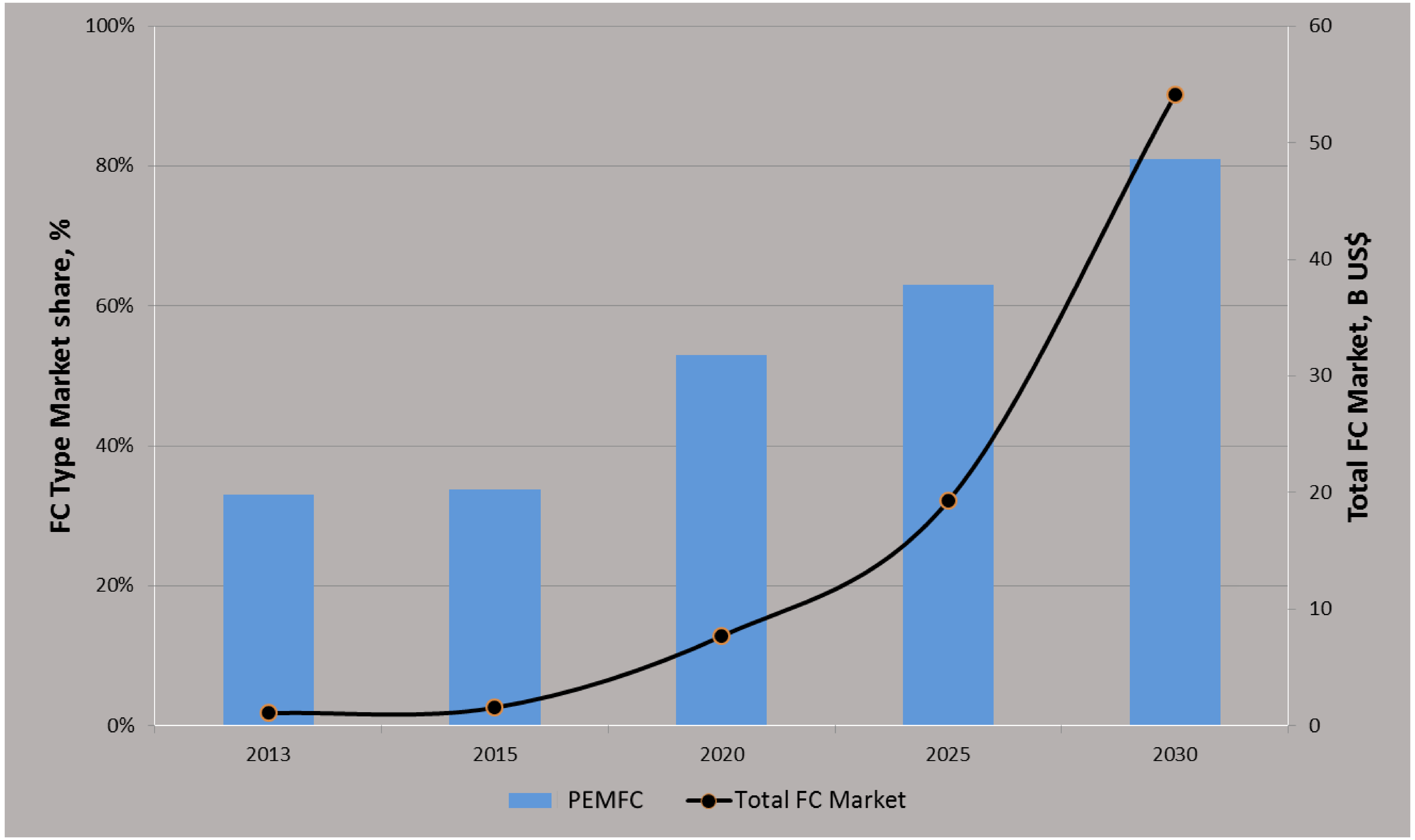
Introduction to fuel cells

Fuel cells can be segmented in several ways: by type, by application, and by power rating. The various types of fuel cells are Solid-Oxide (SOFC), Molten Carbonate (MCFC), Phosphoric Acid (PAFC), and Proton Exchange Membrane (PEMFC).

Of these types, PEMFC are suitable for the most diverse range of applications, from portables (chargers, small devices, backpack power units), stationary applications (backup power, residential CHP, remote power), and transport applications (forklifts, cars, trucks, buses, trains, ships, aircraft).

Our company's field of expertise lies in PEMFC technologies, and our primary market of focus is stationary applications in the 1-10 kW power range.

PEMFC work silently, as there are no moving parts in the system, other than air and gas pumps, their operating temperature is usually between 80-95°C, but they are capable of cold starts, and the ambient temperature does not affect performance (-10 to +50°C).



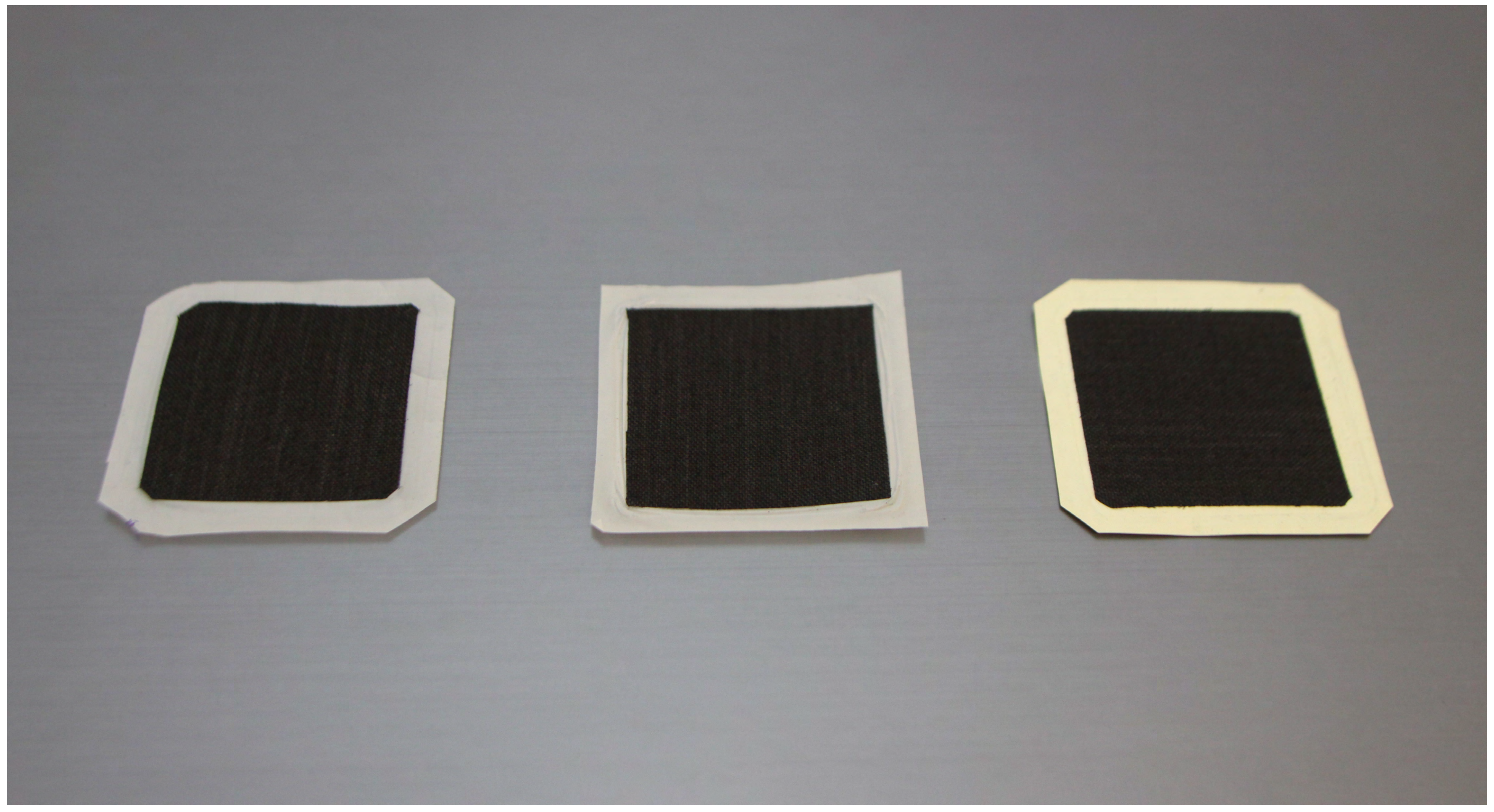
Due to their wide range of possible applications, and in particular transport, PEMFC are the choice of fuel cell technology for all automotive companies today. By 2035, 23% of all vehicles on the road are expected to be powered by fuel cells, thus being the main driving force for growth in this tech sector. The market has seen big growth in 2019 (~40%), and due to continued global disruptions in energy supply and demand, as well as environmental concerns, there are no external reasons for this to slow down any time soon.

What's New?

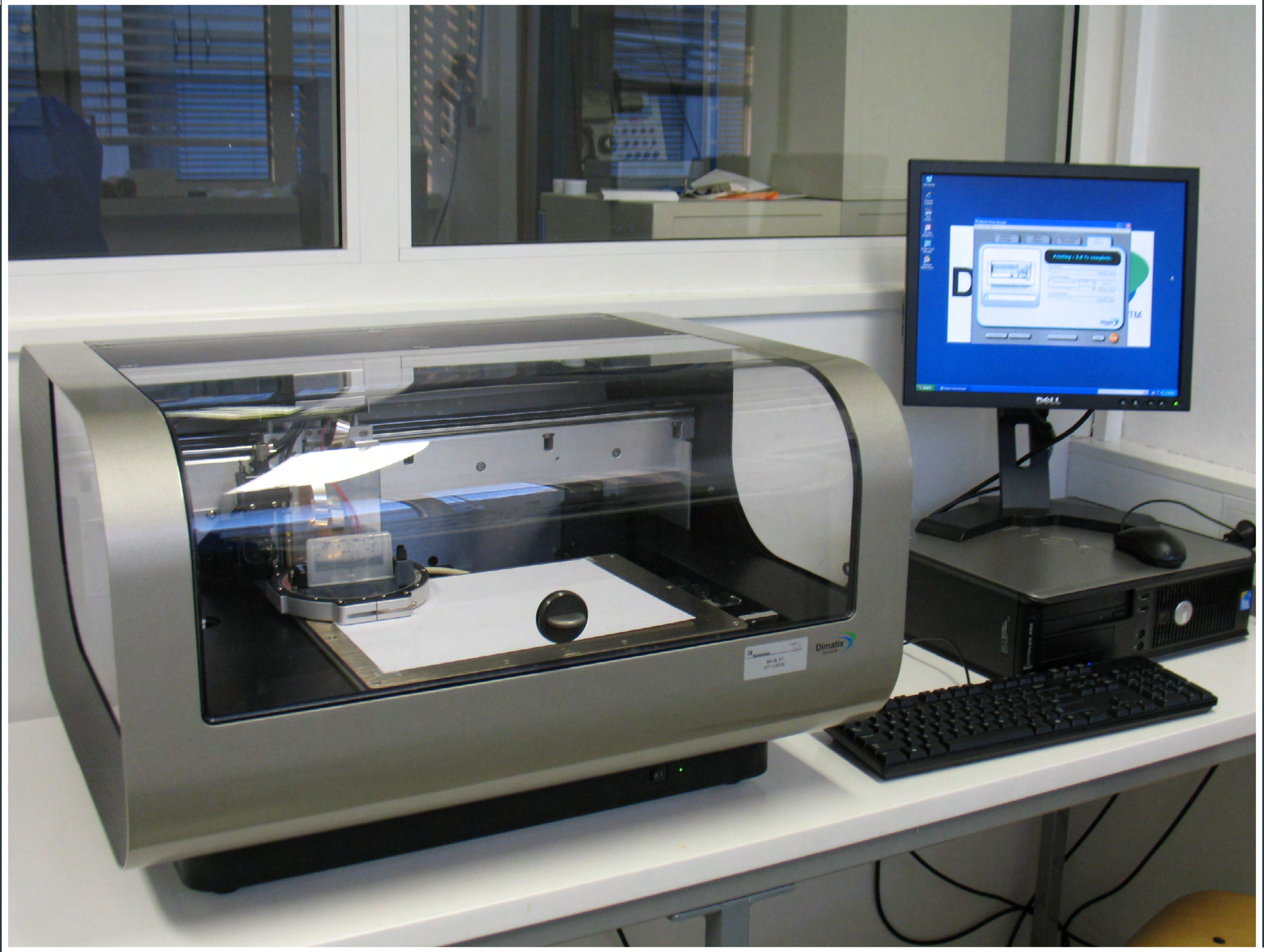
Mebius is a start-up company from Ljubljana, Slovenia, that was founded in 2008. Our core business is the manufacture of PEM FC core components such as catalysts, membranes, GDEs and MEAs.

We have developed, produced, tested, and patented a new type of electrocatalyst for PEM fuel cells. It boasts with a increase in specific and mass activity, while at the same time having 75% less platinum compared to pure platinum catalysts.

Mebius is also one of the earliest adopters of ink-jet technology (IJP) for the purpose of depositing catalysts and electrolytes onto various substrates. This allows us to produce various types of MEA with minimal re-tooling, whether 5-layer, CCM, the novel Direct Membrane Deposition (DMD) MEAs.



Previous page: Mebius DMD MEA with internal gasket; Above: Mebius 5-layer MEAs.



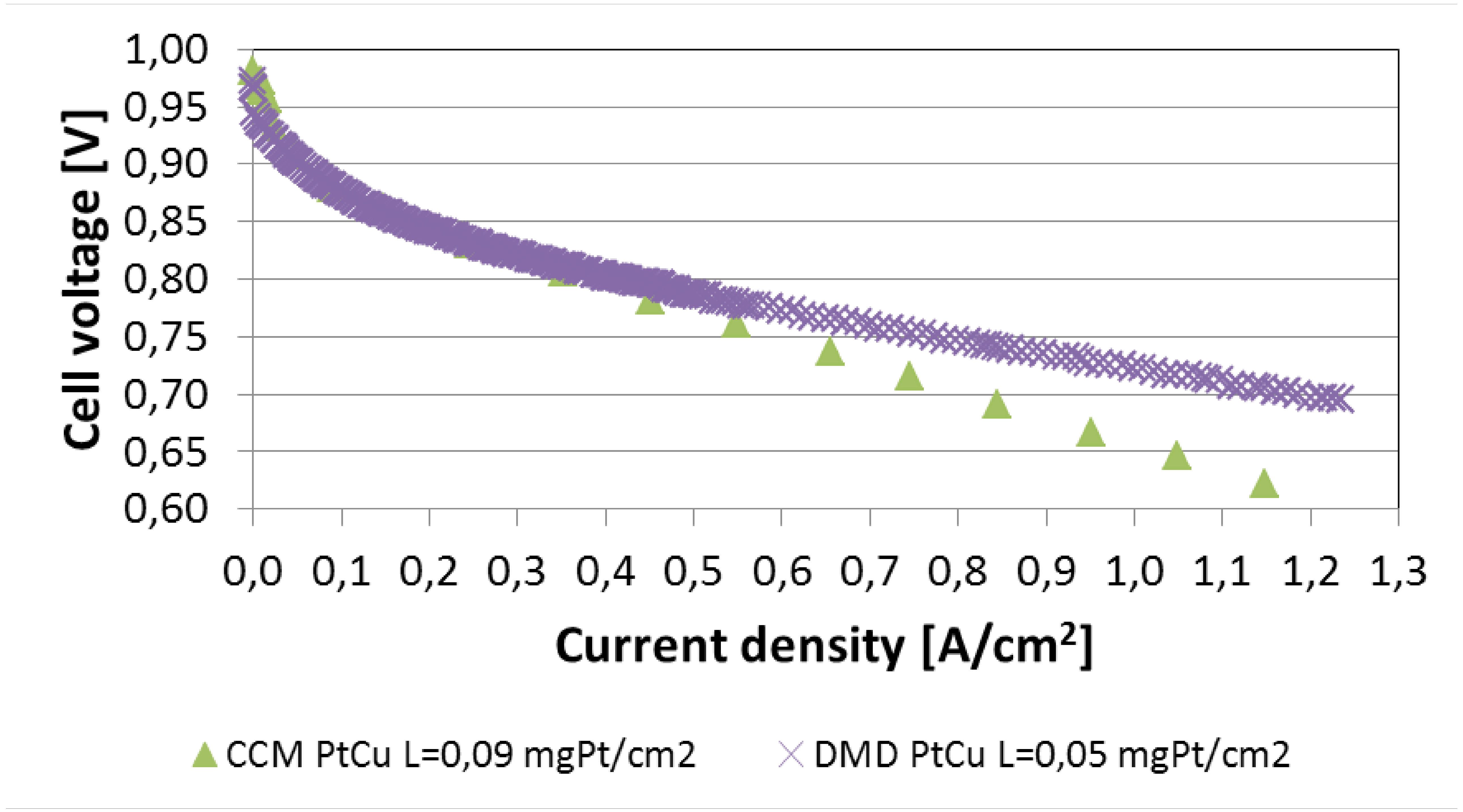
Ink-jet Materials Deposition Printer Fujitsu Dimatix DMP-2831during operation.

Mebius has developed its own capabilities and knowledge base while working on various projects for the Slovenian Technology Agency (P-SRRP-09/I/73), the Slovenian MoD (VTSklad) and others.

We were awarded the US and Japanese patents for our catalyst synthesis process in 2015 and 2016 respectively. In 2018 first examples of DMD MEAs were produced in our laboratory, since then we have continuously developed this technology to a market ready state, along with our catalyst IP. Both innovations combined have exhibited the potential to increase the power density of our MEAs by 100% compared to current state-of-the-art on the market.

Improving Fuel Cell Stack Performance

For system builders, what matters is the efficiency of their system, and sometimes even a percentage point or two can make a big difference. Mebius is producing MEAs, that are significantly better at lower power densities in terms of efficiency, as we can achieve 427mA/cm^2 at 0.8V of cell potential, while the US Department of Energy has set the develoment goal for year 2025 at above 300mA/cm^2.



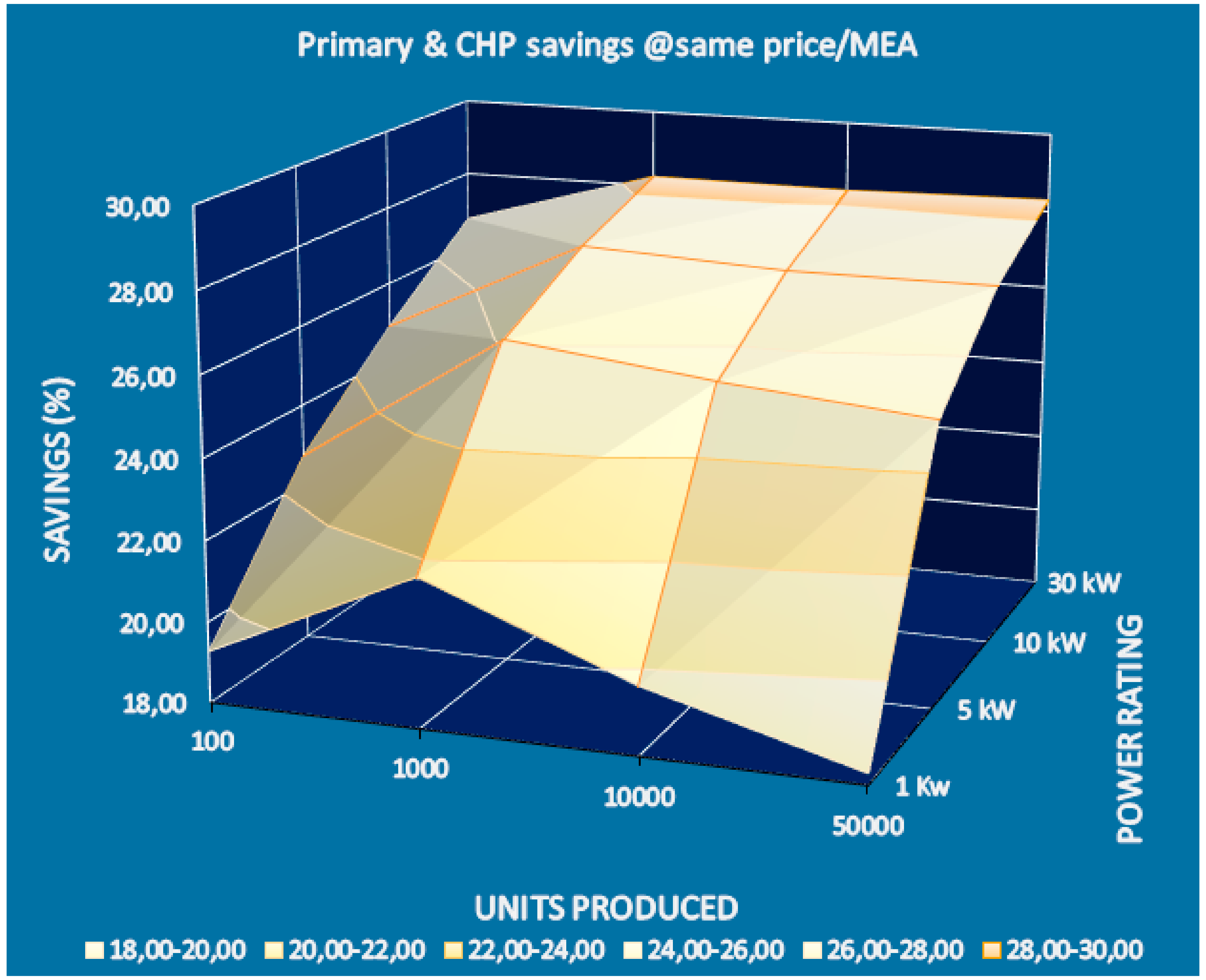
Mebius CCM and DMD MEA polarization curves measured in single cell at 80°C.

- Our MEA power density at 0.8V of cell potential is 30% higher than state-of-the-art MEAs
- Since MEAs represent 42% of the cost of a 1kW stack, the reduction of the stack's cost would be 12.6%
- Stack efficiency at 80°C (LHV) and 0.8V is 68%.

Making Fuel Cell Stacks More Affordable

Our MEA technology offers the stack builder an unprecedented opportunity. Some applications strive to deliver a given amount of power via ever lighter and more compact products, and by needing fewer MEAs in their stacks than they previously did, this reduces the amount of other components needed in the stack, thus reducing the stack's weight and volume significantly.

COST POSITION	Cost structure for 1-kW Stack at 1,000 stacks / year		
	Benchmark the current cost structure	With Mebius[1] at the same MEA cost per stack	With Mebius[1] at the same price per unit
MEA	$ 559.99	$ 559.99	$ 391.99
Anode / Cooling Gasket	$ 36.93	$ 25.85	$ 25.85
Cathode Gasket	$ 17.06	$ 11.94	$ 11.94
Anode Bipolar Plate	$ 75.43	$ 52.80	$ 52.80
Cathode Bipolar Plate	$ 71.37	$ 49.96	$ 49.96
End Plates	$ 46.04	$ 46.04	$ 46.04
Assembly Hardware	$ 41.36	$ 41.36	$ 41.36
Assembly Labor	$ 16.57	$ 16.57	$ 16.57
Test and Conditioning	$ 187.59	$ 187.59	$ 187.59
Total Cost per STACK	**$ 1,052.35**	**$ 1,002.10**	**$ 824.10**
% Saving Compared to Benchmark	**N/A**	**4.78%**	**21.69%**



An improved MEA has the following benefits for fuel cell stack users:

- Reduced number of cells by 30%
- Connected Lower Weight and Volume of Stack (manufacturer dependant)
- Lower Costs of Production by 18%-29%

Cost Breakdown of a 1kW stack with savings (left); combined savings plot at various power and production levels (right).
Benchmark stack data source: Batelle, January 2017.

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