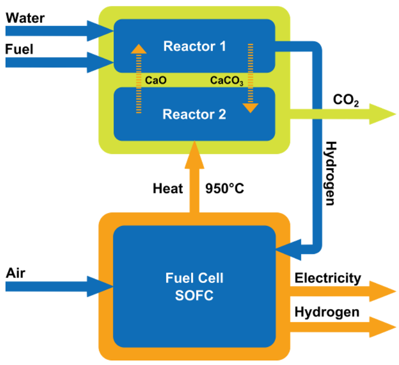
ZEG Power

More energy and less emissions!

The ZEG-technology (**ZEG®** - Zero Emission Gas power) is an innovative, hybrid technology for high efficient co-production of electricity and hydrogen from hydrocarbon fuels, with integrated CO_2 capture.



Electricity is produced by high temperature solid oxide fuel cells (**SOFC**)

Hydrogen is produced in a modified reforming reaction where $\mathbf{CO_2}$ is removed by a high temperature CaO-based sorbent in a carbonation reaction – **S**orption **E**nhanced **R**eforming (**SER**)

A close thermal integration between the **SOFC** and **SER** reactor system provides high overall system efficiency, more than 75%

CO_2 is delivered from the plant as a pure concentrated CO_2 stream and can be pressurized for further industrial use or storage. Pressurized hydrogen can be sold directly to the customer or used in integrated industrial processes.

The BioZEG plant - a 50 kW plant based on biogas; demonstration of green production of electricity and hydrogen

Main components:

20 kW SOFC module — CMR Prototech

SOFC module; delivered by CMR Prototech. The SOFC-module contains 24 SOFC-stacks each made of 30 cell plates (130 x 150 mm) with metallic CFY (chromium-iron-yttrium) interconnects, delivered by Plansee/ Fraunhofer IKTS.

- 750-830°C
- 80-120 DCV operating voltage
- 240 A current output

30kW SER reactor system — IFE

DBFB - SER reactor system; delivered by IFE

Reformer
- 600°C; 0.5 barg max.

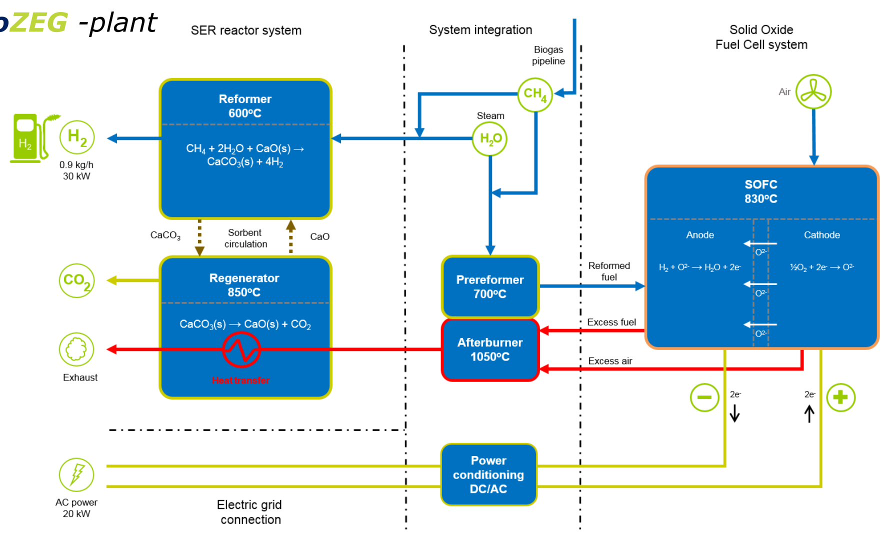
Regenerator
- 850°C; 0.5 barg max.

Solids
- CO_2 sorbent: Dolomite
- Commercial reforming catalyst
- Ratio sorbent/catalyst: 2.5–3 w/w
- Solids circulation rate: 75 kg/h

*Process diagram of the 50 kW **BioZEG** -plant*

Biogas fed to the SOFC is mixed with steam before entering a pre-reformer. This unit is integrated with an afterburner and the combined pre-reformer/afterburner unit yields the required fuel quality for the SOFC-module and boosts the temperature of the SOFC exhaust up to the requirement of the SER regenerator.

A SOFC DC/DC converter allows produced power to be delivered to the grid.

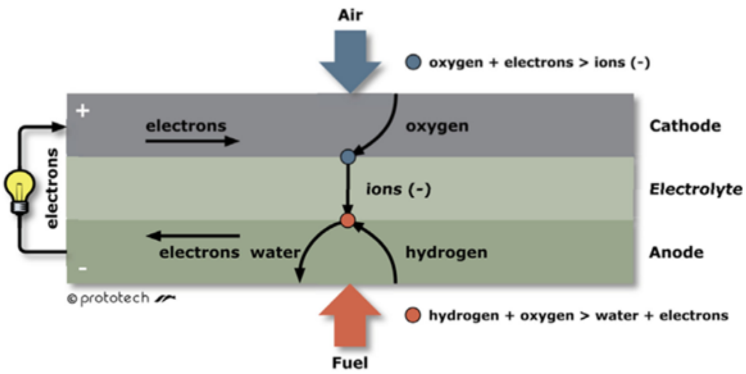


The basic technologies

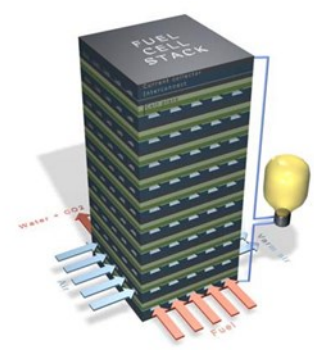
SOFCs for electricity production

In a solid oxide fuel cell (SOFC) the chemical energy is converted directly to electric power. A general fuel cell is made up of an electrolyte placed between two electrodes. For a SOFC, air is led to the porous cathode where each oxygen atom collects two electrons and gets absorbed into the electrolyte. The oxygen ion then travels through the electrolyte to the anode where it reacts with hydrogen to form water. In this reaction the electrons are released again. They travel through an external circuit, driving some electrical load, and back to the cathode where the whole process starts again.

Single fuel cells can be added together in stacks to increase the electric potential and total power output. Interconnects are then added to each electrode. The interconnects separate the anode and cathode gas streams, while at the same time collecting the current and distributing the gases uniformly. Each fuel cell stack can then be connected in series or parallel to make larger power producing units.



Single SOFC-cell running on oxygen and hydrogen

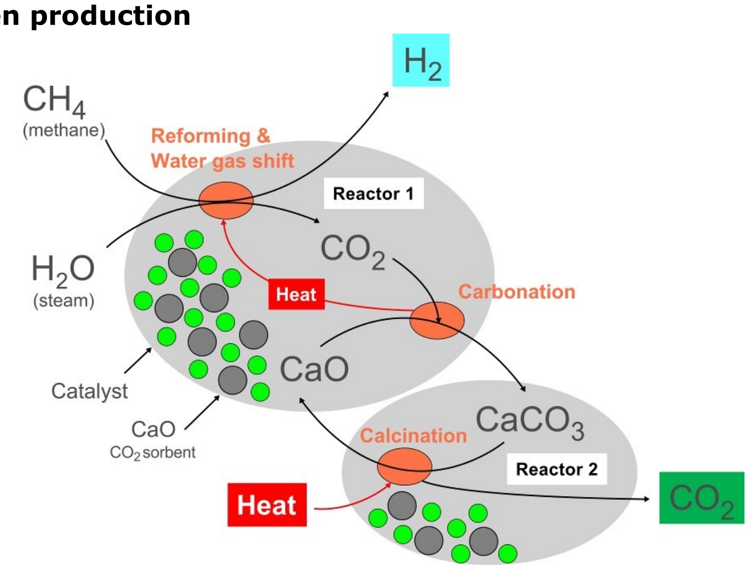


Single SOFC-cells added together in a stack

Chemical reactions in the SOFC; Anode: $H_2 + O^{2-} \rightarrow H_2O + 2e^-$ Cathode: $\frac{1}{2} O_2 + 2e^- \rightarrow O^{2-}$

SER - Sorption Enhanced Reforming for hydrogen production

SER permits hydrogen production and CO_2 capture in one single step. When a CO_2-sorbent, such as calcined dolomite (CaO-MgO), is mixed with a reforming catalyst, the CO_2 in the synthesis gas mixture is removed as it is formed, causing the reforming and water gas shift reactions to proceed simultaneously beyond the thermodynamic limits. Moreover, when CO_2 is captured *in situ*, high purity CO_2 can be obtained from regeneration of the sorbent, eliminating costly separation steps downstream.



The overall SER reaction is:

$CaO(s) + CH_4(g) + 2H_2O(g) \rightarrow CaCO_3(s) + 4H_2(g)$

Advantages with SER compared to conventional methane reforming is:

- Simplified process layout (fewer vessels) and a more flexible process
- Higher H_2-yields (95% +) in one single step, and at lower temperatures (500-600°C)
- No need for shift catalyst
- Reduced needs for downstream H_2-purification
- Potential for lower production costs and energy savings