# Application 2053

# Multisource multiproduct energy systems with multifunctional fuel cells.

KAS HEMMES

TU Delft, Technology Policy and Management, Delft

In this project we will study the use of fuel cells in so-called MSMP (Multi Source Multi Product) energy systems. In particular it will built on the

characteristics of high temperature internal reforming fuel cells that are capable of converting methane or other hydrocarbons together with

steam into hydrogen internally in the fuel cell, thereby using waste heat from the fuel-cell for the endothermic reforming process. By operating

this system in such a way that more hydrogen is produced than needed for its own consumption by electrochemical reactions inside the fuel cell,

we can also see the system as a steam methane reformer that also produces electricity.

This is a system that is capable of flexible co-production of hydrogen and power at many different ratios and with high efficiencies. It is perfectly suitable for accommodating fluctuations in for example wind energy and/or solar energy.

As a next step in the development that we want to focus on in this project, we can also operate the fuel cell in reverse mode, thereby it really does convert a surplus of electricity into hydrogen as in an ordinary electrolyzer. However, an interesting modification on this electrolysis operation mode is the simultaneous supply of a fuel to one of the electrodes during operation as an electrolyzer. We call this 'fuel assisted electrolysis'. By applying additional energy in teh form of a fuel next to electricity, the same amount of hydrogen can be produced with less electricity. If the fuel is a mixture of hydrogen and other fuels, like for example is the case in biogas, than in this operation mode we upgrade the biogas into pure hydrogen.

To operate the fuel cell in hydrogen and power co-production mode is relatively straightforward and close to normal operation. However, to operate the fuel cell in reverse brings with it material issues in relation to [electro –]chemical stability and electro catalysis properties of the electrodes. Suitable materials have to be tested in the different operation modes for stability and performance as electrodes in all operation modes.

The access will involve the SOFC (Solid Oxide Fuel Cell) facility at University of Perugia. The tests will be performed by operating commercial high temperature SOFC in reverse mode as SOEC (Solid Oxide Electrolyzer Cell). The experiments will focus on the anode composition. Cathode gas will be kept constant, wile the anode will be fed with several gas compositions. In particular in the reference case we will use nitrogen as a purge gas, while 'real' studies will focus on the effect of fuel ($H_2$ or $CH_4$) introduction for the 'fuel assisted electrolysis' experiments.

The tests will be realized at different operation temperatures to evaluate the effect on the internal reactions and overall performance.

Gas Chromatography (GC analysis), temperature and cell voltage measurements will be performed and considered as direct and indirect indication of gas (equilibrium-) composition. Performance will be evaluated by measuring I-V curves with a standard procedure.

Materials Stability will be tested in endurance experiments and by post mortem analysis.