**Biogas exploitation**

Biogas is a promising renewable resource for near-future production of hydrogen. It is generated by an anaerobic digestion of agricultural and animal waste, could contain methane concentrations of until 80% in volume and its quality depends on its origin.

There are several advantages to using BMG as a feedstock for hydrogen production: (i) it is a renewable energy resource, which can be used to partially offset hydrocarbon fuel imports, (ii) it is a local resource, thus, there would be no need for an expensive expensive fuel transport infrastructure, (iii) it is a dangerous gas in confined spaces. For the future of the worldwide energy supply three goals must be fulfilled: security in the energy supply, environmental protection and the utilization of energy sources that promote the economic growth of societies.

**DR of Biogas for H₂ production**

DRM is a strongly endothermic reaction, carried out catalytically at the temperature range of 800-1500 °C and producing syngas, with the H₂/CO molar ratio of 1.1. This is because methane is the most stable among hydrocarbons. The advantage of DRM is that the biogas can be converted to synthesis gas without the requirement of CO₂ separation.

The technical issues related to the DR of biogas stem from the fact that this gas tends to produce carbon via methane decomposition that deactivates the catalyst. The problem of deactivation can be overcome either (i) by developing catalysts that minimize the coke formation, (ii) by adding steam or oxygen or (iii) by working at low temperature (< 550 °C), as coke deposition via methane decomposition is thermodynamically limited under these conditions.

**Fuel Cell micro-CHP system**

Fuel cells are devices that can convert the chemical energy of a fuel directly into electricity, without combustion, with high overall efficiency (lower than 60%) and with lower polluting emissions than conventional equipment/techniques. In a fuel cell the power supply is uninterrupted while it is fed with the fuel and the oxidant.

PEMFC (Proton exchange membrane FC), stands out as a key option, for small scale power generation facilities (homes). Fig.1

A simple estimate for a low-temperature PEMFC CHP system from the reformer to the stack would reveal that the electrical efficiency is approximately maximized around 30-35%. Taking into account parasitic consumptions would only decrease the efficiency and make it closer to the efficiency with which we normally receive power from the grid. Heat generated by the fuel-cell stack is recovered by circulating cooling water through it.

Reformer is a necessary subsystem of the PEMFC cogeneration system that is to be utilized without concern for the hydrogen supply infrastructure. The function of a reformer is to transforms hydrocarbons into a hydrogen-rich gas containing CO concentration less than 10 ppm. Durability of the fuel cell stack is one of the major technical issue, which is mainly linked with the reformer operation.

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**References**


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**Hydrogen Economy**

Hydrogen is an ideal energy carrier and can play a very important role in the energy system, since the depletion of petroleum reserves and stringent regulations regarding CO₂ emissions. The so-called hydrogen economy is an effort to change the current energy system to one that combine the cleanliness of hydrogen as an energy carrier with the efficiency of fuel cells (FCs) as devices to transform energy into electricity and heat.

As an energy carrier, hydrogen must be obtained from other energy sources, consequently it is as clean as the method employed for its production. The main advantage of hydrogen as a fuel is the absence of CO₂ emissions, as well as other pollutant emissions (thermal NOₓ), if it is employed in low temperature FCs. Today its transport and storage is expensive and difficult due to its low energy density on a volume basis. As it is highly inflammable, H₂ is a dangerous gas in confined spaces. For the future of the worldwide energy supply three goals must be fulfilled: security in the energy supply, environmental protection and the utilization of energy sources that promote the economic growth of societies.

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**Industrial and Academic R&D**

Another strategy to avoid catalyst deactivation by coke could be the decomposition of methane using a non-thermal plasma, more specifically a DBD reactor. The non-equilibrium character of such plasma could overcome thermodynamic barriers in chemical reactions and enable thermodynamically unfavourable reactions to occur at atmospheric pressure and low temperatures. In this process, energetic electrons and species are generated during gas ionization, which is the key to stimulate the chemical reactions.

Plasma processes are often less selective than catalytic processes, therefore a combination of plasma and catalytic processes is expected to be a promising way to enhance traditional catalytic processes. With plasma alone during the DR it is possible to have a hydrogen yield between 30% and 35%, with a supplied power in the range of 65-130 W [1]. In order to increase the H₂ production, Lee et al. [2] presented an exciting synergistic effect of Ni/Al₂O₃ catalyst with the low-temperature plasma, where the conversion of reactants at 573 K reached the same results with pure catalytic reaction at 1073 K.

In order to upgrade the H₂ content of the syngas obtained during DR, a WGS reaction is required. Since this is an exothermic equilibrium reaction, it is favoured at low temperature. This means that working with a low-temperature plasma it could be possible to couple the DR with the WGS step in a single reactor made up of two sections, possibly avoiding the use of the Preferential Oxidation step to decrease the CO content in the gas fed to the FC, for the good of apparatus’ dimensions.

In order to investigate about the catalytic phenomena inside the reforming reactor, one useful technique could be represented by SpaciMoS, a spatially resolved capillary inlet mass spectrometry. This technique is characterized by a proven high sensitivity and low invasiveness, allowing for obtaining useful information about the process to understand, for example, the deactivation process during operation.