SOLAR UPGRADING OF FUELS FOR GENERATING OF ELECTRICITY

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The reforming process is a catalytic reaction between low hydrocarbons, like methane, with steam or carbon dioxide. The product is a gaseous mixture of primarily CO and H_2 (called synthesis gas or syngas). This endothermic reaction is the basis for upgrading the calorific value of the hydrocarbons feed by roughly 25%, using solar energy.

The product syngas can be combusted in a conventional gas turbine (GT) or a combined cycle (CC) and therefore, the solar energy share in the product fuel is converted to electricity at higher efficiency (up to 55% in a modern, large CC), compared to conversion efficiency in a regular steam turbine (ST). If the storage of the product syngas is not feasible at a specific case and the GT is operated for 4000 hours per year, the solar contribution is reduced to about 15%.

Another future potential utilization of the product syngas from the solar upgrading process is in fuel cells (FC). Coupling of solar reforming with FC, like solid oxide fuel cell (SOFC) may lead to small- and medium-size systems with high conversion efficiency, higher than GT or CC of similar sizes.

Furthermore, the hydrocarbon feed is not necessarily natural gas (methane), naphtha, or liquid petroleum gas (LPG). It can be landfill gas, which contains approximately 55% methane and 45% CO_2, or biogas with 65–70% methane, and the balance is CO_2. It can also be the product gases of a pyrolysis process of biomass or low-grade coal.

In summary, the solar reforming is an attractive option because of:

- potentially higher conversion of solar energy to electricity;
- the ability to generate electricity at high efficiency over wide range of sizes;
- the ability to integrate the product syngas into existing GT and CC systems;
- the ability to have physical separation of many kilometers between the solar part and the power block subsystem and therefore, place them in the most suitable locations;
- increase of fuel source flexibility by using fuels that regularly are not used for GT.

As a result if these potential benefits, a joint project was commenced, aiming at the demonstration of a complete system at WIS. The partners are DLR, ORMAT and WIS. The project is supported by the EC and is named by the acronym SOLASYS.

The paper describes briefly the project, as well as some economical evaluations and potential markets and applications.

One example of cost evaluation, based on a 3.5-MWe plant, is described, assuming an existing gas turbine. The purpose is to study the trends of influence of various parameters on the plant and the syngas price. At today's natural gas prices and without environmental incentives, the solar energy cannot compete. However, in other cases, e.g., where municipal solid waste (MSW) can be used as a source for biogas, the economical picture can be different, primarily, because of the tipping fee for each ton of MSW that is processed.

A case study with a similar 3.5-MWe plant was analyzed. In this case, biogas is produced from MSW by anaerobic digestion. This can represent other sources of gas as well. The emissions of CO_2 to the atmosphere are much lower in this case and can reach zero if biomass is used as a feed to the solar reformer.

In the case of the MSW it was assumed that either syngas or biogas are combusted in the GT during 3900, 4500 or 8100 operating hours per year (an average of 185 m^3 of biogas per one ton of MSW was assumed). The solar contribution in each case was a variable parameter.

The results show that if MSW is used assuming a tipping fee ranging from 20 to 50 \$/ton, depending on plant size and other factors, such as time of operation, solar parameters, etc., the plant can be economical competitive.

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