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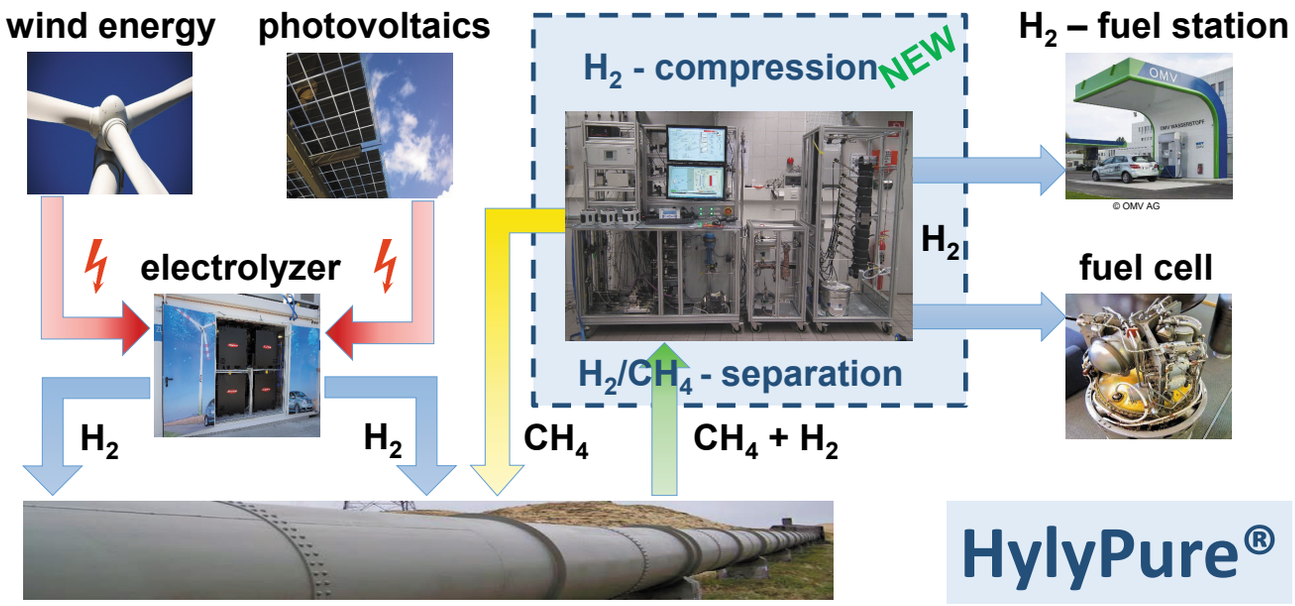
Decentral Supply of Green Hydrogen

HylyPure® NEW - innovative system component for
H_2 transport through the natural gas grid



The storage of excess electricity produced from alternative resources (eg. wind, solar) is a key challenge of the energy transition. The Power-to-Gas concept is considered as a promising solution for this problem. In this case, excess electricity is used to produce an energy carrier (e.g. hydrogen or methane) which can be easily stored and utilized later. Hydrogen is of particular interest because of its high end use efficiency in fuel cells, and – in addition – hydrogen from alternative resources is CO_2 neutral. Due to the fact of a regional mismatch of production and consumption of electricity highly efficient and flexible hydrogen transport systems are of utmost importance. In case of the existance of an extraction technique of hydrogen from a mixture of natural gas and hydrogen the existing natural gas pipeline infrastructure can be a favorable option.

Objectives

The research group “Separations Engineering and Simulation” at TU Wien aimed for the development of technology components which allow recovery of hydrogen transported through natural gas grids to be recovered in highly pure form and on-site compression to provide fuel-cell ready hydrogen for local supply. Important goals were to develop an energy-efficient and robust technology which can be applied to a wide range of H_2 concentrations and natural gas pipeline pressure levels.

Solution

Legally, the addition of H_2 to natural gas as an extra fuel is already permitted now – country dependent at levels of 2 percent up to 10 percent. This level might increase in the future if the demand for decentral hydrogen supply will rise.

HylyPure® provides a membrane gas separation in the first stage for the separation of H_2 from the natural gas grid which acts as pre-concentrator for the gas mixture and drastically reduces the volume flow rate. This separation stage does not require additional energy because of the high system pressure in natural gas pipeline of up to 70 bar. Starting from e.g. 4% H_2 in the natural gas, the H_2 concentration can be increased to up to 50% H_2 in the first stage.

In the second stage, hydrogen will be further enriched and simultaneously compressed applying a newly developed electrochemical membrane stage. Water vapor content in this process stage needs precise control by a newly developed water management. The compressed product – pure hydrogen – is dried and further purified to eliminate trace components according to process needs, it is now ready to supply H_2 fuel stations or for direct use in fuel cells. The residual gas mixture is re-compressed and fed back into the natural gas pipeline system. If the electrical energy for the compression is provided from renewable resources, the separation may be considered is CO_2 neutral..

Results

HylyPure® allows a safe H_2 transport and a fuel cell grade recovery, as extensive model calculations for various application scenarios have shown. Based on the design tool developed at TU Wien, the plant can be customized to the process requirements of the specific local application.

The developments at TU Wien show that the specific electric energy consumption including separation and compression can be reduced to 0,5 – 0,8 kWh/m³ STP hydrogen. This corresponds to 10% and up to 15% of the hydrogen energy content. In addition, the hydrogen transport over typical distances between a few kilometers and up to a few hundred kilometers requires up to 1% of the hydrogen energy content.

In addition, the investment of one mechanical compressor stage can be saved compared to conventional separation technologies such as the previously developed HylyPure® process where pressure swing adsorption is applied in the second stage.

Highest ecological and economical efficiencies can be achieved with HylyPure® while at the same time local regulations regarding the injection of hydrogen into the natural gas grid can be met.

Advantages

The new HylyPure® technology using electrochemical hydrogen compression is very compact in design. It requires only one mechanical component for the re-compression of the residual methane from the second separation stage. This results in higher availability and longer service intervals.

The process is highly modular and can be easily scaled from 1 m³/h up to several 100 m³/h. As such, HylyPure® NEW is perfectly suitable for the future supply of hydrogen fuel stations and – in combination with Power-to-Gas concepts – for H_2 transport in natural gas grids.

The specific energy demand for on-site separation and compression of hydrogen by HylyPure® is between 10% and 20% of conventional water electrolyzer technologies for H_2 production. Thus HylyPure@ NEW could become a major contribution to decentralized energy supply, future hydrogen based mobility concepts, and the supply of H_2 as an important resource for the chemical industry of the future.

HylyPure® NEW and know-how from TU Wien will facilitate and contribute to the energy system, the chemical industry and future mobility systems through:

- Energy efficient transport of hydrogen using well established natural gas grids
- Separation and compression by optimal combination of hydrogen recovery, minimized energy consumption and investment costs
- Highest hydrogen quality of the H_2 recovered from the natural gas grid – 99,97% H_2 quality according to ISO 14678-2:2012
- CO_2 neutral H_2 separation
- Simple, safe, economical and flexible supply of decentralized hydrogen fuel stations
- Efficient hydrogen supply for the chemical industries of the future which does not rely on fossil hydrogen supply any more

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