Towards a sustainable "Energiewende" - Power-to-X technologies as a matchmaker

Ouda M. Salem , Max J. Hadrich. Achim Schaadt and Christopher Hebling
Hydrogen Technologies Division,
Fraunhofer Institute for Solar Energy Systems ISE, Germany

Within the global challenge of establishing a sustainable society, the desired properties of the energy system have recently been discussed. With high penetration of renewable energy capacities to achieve the national and international CO_2 reduction targets, sector coupling is a crucial measure for a reliable and sustainable energy system. Chemical energy storage based on electricity conversion *via* water electrolysis to H_2 and O_2 followed by conversion of H_2 to different energy carriers of interest is a promising option for long term and seasonal storage capacities. Together with the benefits of different sector coupling and storage in unlimited capacities, chemical energy storage creates opportunities for increased flexibility and optimization of the power generation system.

The transport sector consumes 30% of the primary energy and contributes to 20% of the net CO_2 emissions. Therefore, in order to reduce emissions for both urban health concerns and a climate change context, there is a need to bring alternative fuels to the market, particularly for the mobility sector. With the demand for individual mobility still growing, renewable fuels allow to tackle pollution issues thanks to their superior combustion properties, thus making complex and expensive exhaust gas treatment obsolete.

At Fraunhofer ISE, technology paths to use carbon dioxide for chemical conversion of hydrogen to sustainable fuels, chemicals and materials have been investigated and put into practice for about a decade. CO_2 is to be separated from the air, from seawater, from biogenic sources (biogas) or from existing industrial processes (i.e. soda ash, cement, steel, ammonia industries). Hydrogen is to be produced from renewable sources (electrolysis, microbial electrolysis, photocatalysis, etc.). Then, easily storable liquid fuels such as methanol can be synthesized in a heterogeneous catalysis process. In contrast to the established methanol production from synthesis gas, which is currently obtained almost exclusively from fossil sources, the presented process is sustainable. We have been cooperating with partners from industry and research in the field of technological development of efficient, scalable and selective PtX processes. Candidates such as methanol, dimethyl ether (DME), Oxymethylene dimethyl ethers (OME) and ammonia are in our research focus (Fig 1).

In this presentation, an overview of our Power-to-Liquid activities will be presented and the levers to enhance the progress of these promising technologies will be discussed. Moreover, highlights from our dynamic methanol synthesis based on conventional or renewable feedstocks will be introduced. Complementary, insights from the techno-economic evaluation of "green" methanol synthesis will be allow to discuss the financial and political requirements for a successful "Energiewende". Additionally, a case study for the OME synthesis, based on the novel concept developed at Fraunhofer ISE, will be presented. The results to be presented illustrate the imperative impact of the renewable energy resource availability in different locations worldwide. Last but not least, Power-to-ammonia technology potentials will be highlighted.

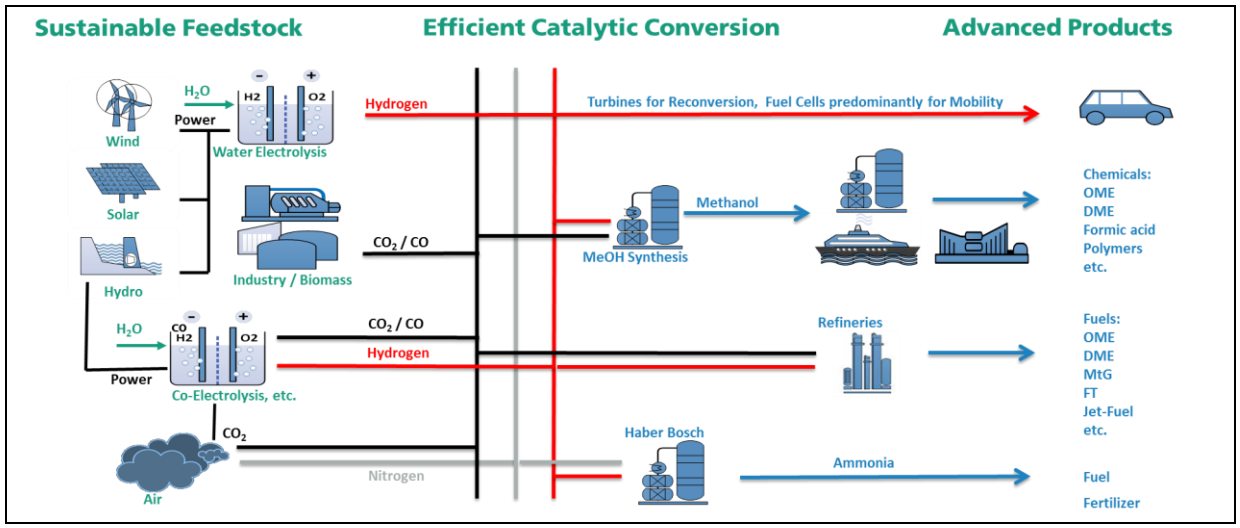

Fig 1: Power-to-X process chains