Abstract for the general public

According to current global trends, hydrogen which is low carbon footprint fuel and can release the RES potential is now becoming the key element of the so-called hydrogen economy. However, in order to decarbonise some of sectors, such as transport or heavy industry, we face major technological difficulties. A solution for this is seen in hydrogen technologies represented by electrochemical cells, which, using electricity from renewable energy sources, can replace common industrial methods of hydrogen production from fossil fuels. Additional possibilities include also production of synthetic fuels (power-to-liquid, power-to-gas) using hydrogen generated in electrochemical cells.

Solid oxide cells (SOC) are advanced electrochemical devices designed to produce electricity from hydrogen and other fuels (SOFC) or produce hydrogen from water vapour using electricity (SOE). In the project, it is planned to delve deeper into the electrolysis mode, specifically in one of its more advanced versions - the simultaneous electrolysis of water vapour and carbon dioxide, the so-called co-electrolysis, at elevated pressure. In this process, both steam and CO_2 are supplied to the cathodic side of SOC. As a result, two electrochemical reactions can take place simultaneously inside the cell: electrolysis of water vapour to hydrogen with oxygen as by-product, and electrochemical reduction of carbon dioxide to carbon monoxide. The possibility of simultaneously carrying out the two electrochemical processes in one device is one of the advantages of solid oxide cells over PEM and alkaline electrolysers. The mixture of hydrogen and carbon monoxide which is produced in co-electrolysis can be used in the production of synthetic fuels in the next step. The scientific challenges become even larger when the process is conducted at elevated pressure in the so-called pressurized co-SOE. The project will attempt to run co-electrolysis in such a way that the specific requirements of reactors and systems for production of synthetic fuels will be met. For this purpose, the project covers extensive experimental research in order to determine the influence of various parameters on the co-electrolysis process, in particular the effect of elevated pressure under different electrical loads which has not yet been thoroughly investigated in the context of the integration of the electrolyser with fuel production reactors. The research will include alternation of operating parameters of the co-electrolyser to fine tune the mixture downstream for the production of liquid fuels such as methanol or ethanol, as well as needs of systems for chemicals or the so-called synthetic natural gas production. The novelty of the project relates to the experimental evaluation of the possibility of generating gas mixtures in co-SOE and fine tuning of the composition by pressurization of the cell, adjusting pressure gradients between the electrodes, modifying operating temperature and gas flow.

Project includes cooperation with one of the leading research teams in the field of hydrogen technologies in the USA – the National Fuel Cell Research Center, University of California, Irvine. This collaboration will aid in creating scientific basis needed to explore undiscovered areas in the field of hydrogen technologies.

During the project it is planned to verify the hypotheses concerning the possibility of adapting fuel mixtures produced during co-electrolysis to the needs of fuel production by variation of thermodynamic conditions and process kinetics. In addition, the results of experimental work will be used to develop and validate a generalized numerical model of pressurized co-electrolysis and to better comprehend the mechanisms of degradation in SOC cells in such operating modes.

Project will result in publications in highly ranked scientific journals such as: International Journal of Hydrogen Energy, Journal of CO_2 Utilization, Applied Energy, Solid State Ionics, Energy, Energy Conversion and Management and others. The project results will be presented at recognized international and national conferences (including WHEC / WHTC, SOFC Symposium, HYPOTHESIS, ICAE, International Symposium on Systems with Fast Ionic Transport, Annual Meetings of ISE, ECOS, Polish Forum Smart Energy, CPOTE).