Hydrogen oxycombustion for zero-emission and high-efficiency electric power generation

Hydrogen is considered as one of the main components of the future world's low-carbon economy. Many national and international initiatives and policies are dedicated to development of hydrogen production, delivery, storage and conversion technologies. Several roadmaps have been created defining the mid- and long-term hydrogen introduction plans as well as its role in economic sectors in the European Union, United States, and Japan. This initiatives are driven by the depletion of cheap fossil fuels, as well as environmental pollution, energy security and future economic competitiveness. The foreseen role of H_2 in the future economy is versatile, however the main final utilization places are in industry, energy and transportation sectors. Many of the hydrogen utilization technologies considered today are not mature and many new are emerging. Therefore substantial further research is required to develop efficient and environmentally friendly technologies.

Solar, wind and ocean renewable power generation is intermittent, and mismatch of electricity production from these sources and the electricity demand exists. Storage of the renewable energy is therefore required. One of the possibilities is to use water electrolysis, in which H_2 and O_2 are produced. Should the electricity demand increase, the energy stored in hydrogen can be utilized for electricity production. For that purpose fuel cells or turbine cycles are most frequently considered.

In this project the concept of using advanced steam turbine cycles for power generation is considered. Such cycles were already investigated computationally, and the studies indicated that efficiency of electricity production in these cycles can be very high. The common feature of the cycles is that the steam is generated in combustion chambers, where H_2 and O_2 are introduced. As a result, electricity is produced, with the only residual product being water, thus the cycles can be called zero-emission. Since pure oxygen is used as an oxidizer, the process is called oxycombustion.

In the project oxycombustion of hydrogen will be studied experimentally and by numerical modelling. The purpose of the research is to understand the underlying phenomena responsible for stable and complete combustion of the hydrogen. The results of the project will be the determined conditions at which stable and complete combustion of hydrogen is possible. Furthermore, reliable computational tools for prediction of the combustion process will be developed. The gathered knowledge will be instrumental in development of future hydrogen fueled zero-emission and highly efficient steam cycles. The project will therefore contribute to the solution of the intermittency of renewable energy sources and transition to low-carbon economy.