

The use of renewable energy sources (RES) is a predominant trend in research on new technologies for the production of final forms of energy. Despite many advantages, these sources are often characterized by unstable and discontinuous operation, and their production mismatches the instantaneous demand of the power system. It is therefore necessary to develop a technology for electricity storage. Without high-efficiency, reliable and relatively inexpensive energy storage solutions, the power sector, especially in Poland, will face significant problems in the near future. One way of storing energy is producing hydrogen in the electrolysis process, with the use of excess electricity produced in RES. This is the so-called *Power to Fuel* (PtF) technology. Hydrogen can be further processed to produce liquid methanol. For this purpose, it is necessary to supply the process with carbon dioxide, which may come, for example, from absorption installation of CO₂ separation from the flue gases produced in fossil-fuel-fired power plant. The primary advantage of storing methanol in relation to hydrogen is its ease of storage, further use e.g., in fuel cells, engines and gas turbines.

The primary objective of the project will be to analyze the innovative concept of a system using methanol produced in the process of hydrogen synthesis (from the electrolysis process fed with redundant electricity generated in renewable sources, e.g. wind turbines or photovoltaic cells) with carbon dioxide (from the absorption installation of CO₂ separation from flue gases produced by coal-fired or natural gas-fired power plants). This system can act as an energy store (in the form of hydrogen and/or methanol) and as electricity (and heat) generator. An important innovation element of the proposed solution is the transport of hydrogen through natural gas pipelines and its separation by membranes and the use of methanol in the fuel cell. An innovative solution also proposed in the project is thermal integration of the methanol reactor with an absorption CO₂ capture installation in order to reduce its energy consumption and/or with the ORC (*Organic Rankine Cycle*) module to produce additional electricity. The analyzes and accompanying system optimizations will be carried out both, taking into account thermodynamic (efficiency) and economic (effectiveness) criteria. In addition, experimental research (on a test stand) on the electricity production in the methanol fuel cell will be carried out. Methanol can be treated as a fuel, but it is also one of the most important raw materials in the chemical industry.

Utilization of energy storage and renewable energy sources will increase the reliability of energy supply, which will consequently result in lower emissions (including dust, sulfur and nitrogen oxides and carbon dioxide), improvement of the quality of the generation system and increase the energy security and health of the population. Power to Fuel technology is indicated as one of the storage methods that has a great application potential, especially where the dominant renewable energy sources are sources with discontinuous operation characteristics (e.g., wind turbines or photovoltaic cells), and thus also in Poland.