The Energy Union strategy adopted by the European Commission has the ambition to achieve a fundamental transformation of European energy system by moving to smarter, more flexible, integrated and secure ways of delivering energy to consumers. It requires significant changes of the existing energy and fuels sector. First of all a significant emphasis is put on renewable energy sources (RES) and smart and diversified energy systems, as well as on circular economy concept. Recently, the so-called hydrogen economy has become particularly important in global and national energy policies. It is already widely recognized that hydrogen is an essential and necessary component of decarbonized energy systems and will be key to achieving the 2050 climate goals, i.e. limiting the global temperature rise to 2°C or below. Replacing fossil fuels with hydrogen allows for almost complete elimination of emission of harmful substances to the atmosphere, including carbon dioxide. However, for wide application of hydrogen, integrated actions are required on the production, transport, storage and usage side of this energy carrier.

The proposed project concerns evaluation of the potential of using biomass for the production of valuable products – biofuels and fertilizers, by involving anaerobic digestion or gasification processes, combined with hydrogen production in high temperature electrolysis process. Such type of electrolysis is at relatively early stage of development. In this project it is integrated with other processes (to provide heat) to allow its wider use. Also, the effective use of oxygen, being an important byproduct of the electrolysis, will be analyzed. This may be crucial for further development of hydrogen-based generation technology as it will improve the effectiveness and profitability of such systems. An innovative concept of using oxygen for improving the quality of composting will be experimentally verified. The entire system for biofuels production will be modelled and optimized in terms of its thermodynamic, environmental and economic performance. Position of such systems in future national economy will be check by the prospective methods modelling.

The proposed project merges the current trends and needs in the development of energy systems as it combines hydrogen production in the high temperature electrolysis process, the use of renewable energy sources, carbon dioxide utilization and energy storage in the form of liquid and gaseous fuels. Moreover, the proposed innovative solution fits into the concept of hydrogen economy, as production of green hydrogen is a key process here, and circular economy, as it may use waste forms of feedstock (manure, food residues, agricultural wastes) to produce valuable products, such as fuels, heat or fertilizers. It also allows for the useful management of oxygen produced in the electrolysis process and for negative emission of carbon dioxide, as CO_2 is captured from carbon neutral sources..

The proposed in this project solutions allows for:

1) Useful management of oxygen, being a valuable byproduct of the electrolysis process, e.g., in the oxy-gasification or oxy-combustion processes and digestate management;
2) use of biomass, including low quality biomass (manure, food residues, sewage sludge, etc.) that would otherwise be wasted contributing to greenhouse gases emission;
3) use of high temperature electrolysis (thus, increasing the efficiency and resilience of the systems), and effective integration of individual processes and heat cascading to generate required heat;
4) effective production of fertilizers based on the residues of fermentation processes and oxygen utilization, thus fitting to circular energy concept;
5) obtaining high quality energy carriers (e.g. liquid fuels in Fischer-Tropsch process and/or biomethane in methanation process) that can be used for energy generation and storage, transport and industry;
6) production of useful products in the carbon negative technologies.