Description for the general public

The pursuit of more sustainable and environmental friendly generation in energy sector is enforced by the climate changes, that are the effect of human activates (mainly GHG emissions from different industry sectors). There are different pathways, depending on the countries energy and climate policies, but some points are raised in all of them, viz. renewable energy sources, energy effectiveness and decarbonisation. The proposed project is coherent with all three points, as it emphasize the use of renewable energy sources (by means of biomass and geothermal energy), increase of energy utilization efficiency (by means of cogeneration of heat and electricity) and the decarbonisation (by means of CO_2 capture, utilization and storage) of the energy sector. In Poland all three mentioned points are addressed in *Polish Energy Policy up to 2030* and *Responsible Development Strategy* which both documents presents the pathways for the development of national energy sector.

The objective of the proposed project is to developed an optimal structure of the biomass-fired combined heat and power plant with CO_2 capture integrated with CO_2 enhanced geothermal systems by means of process mathematical modelling and advanced exergo-ecological and techno-economic analysis. The proposed concept of an integrated energy systems aims to prove the economic and environmental benefits resulting from the synergy of cogeneration of heat and electricity, renewable energy sources usage (biomass and geothermal) and CO_2 capture, utilization and storage technology. As the result practical guidelines concerning structure and design of the analysed systems (with empathise on Polish conditions) will be provided, together with the results of energy, environment and economic analysis. This makes the proposed project within the scope of applied research where the results can be put in use by potential investors in industry.

Throughout the project process mathematical modelling, as well as system approach to the exergetic, environmental and economic analysis will be used. It is worth mentioning that project presents the interdisciplinary studies, as both thermal power engineering and geological studies will be combined. First of all the mathematical models of biomass-fired combined heat and power (BCHP) plants with CO_2 capture will be developed. Further on the supercritical CO_2 (sCO_2) geothermal plant will be modelled. In addition, different configuration of the BCHP plant will be considered, as well as CO_2 capture plant and geothermal plant. In parallel the mathematical models of suitable for CO2 enhanced geological structure will be developed, which will take into account the sedimentary rock formations. Then the numerical simulation of the geothermal reservoir with CO2 as working fluid will be perform. Further on both models will be combined into simulator, which will allow to perform an comprehensive energy analysis of an integrated BCHP plant. It will include the crucial factors like long-term operation, decrease of available heat flow rate from the geothermal deposits and CO2 storage capacity. The results of those analysis, together with the developed simulator will be then use as an input to the advanced exergo-environmental analysis to show the sources of thermodynamic imperfections (by means of exergy losses) as well as evaluate the whole life cycle environmental impact. In the final part the techno-economic analysis will be done, which will provide the answer of the overall technology readiness level together with the economic profitability.

The proposed aim and scope of the project allows to perform an comprehensive assessment of the proposed concept, which will not only lead to the practical application of the proposed scientific methodology, but also is directed towards new knowledge in the field of sustainable energy systems. This could lead to the increase in awareness of the benefits resulting from the synergy of the RES, cogeneration and CCUS, which could further have an positive effect on the sustainability of energy sector, and therefore on the society. The proposed within the project methodology and results might help to widespread the knowledge concerning the integration of bio-CCS technologies with the utilization of captured CO_2 in enhanced geothermal systems. Advanced exergo-environmental analysis, based on the input-output mathematical models will also allow to present the usefulness and practical application of those methods, as well as benefits for their implementation together with the techno-economic analysis.