# Climate and environmental protection, modern energy

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Power generation sector is the crucial industry shaping the socio-economic system. Protection of the environment and mitigating the climate change are priorities for moving towards sustainable growth. In this respect, Silesian University of Technology (SUT) is active in a number of research fields. Generally, one can distinguish three categories of research:

1. sustainable energy growth,
2. the circular economy,
3. air quality assessment and protection.

Energy sector is a dominant factor influencing the global climate changes with significant impact on pollution of air, water, and soil. The implementation of the sustainable growth strategy should, therefore, put special stress on the transformation of the traditional energy generation sector. The challenge is not only on the side of substitution of the traditional, based on combustion of fossil fuels systems, by renewables and increase the efficiency of a single process, but the integration of all components into an efficient, targeted towards zero emission, system. The scientists from Silesian University of Technology have extensive experience in the field of improvement efficiency of the processes and reducing the emission of harmful compounds from the combustion of fossil fuels. Thanks to the extensive research carried out as part of one of the largest applied research projects, a number of pilot installations were created, that's allows to study the possibility of emission reduction of harmful compounds to atmosphere.

Parallel to transformation of energetic sector, the concept of the circular economy is introduced, as for instance the application of geopolymers can be implemented. The SUT, already has enormous contribute to various aspects of the transformation of the energy system. The thrust of the research in the coming decades will encompass the following areas: development of novel technologies that allows to increase share of renewable energy in the market, application of new materials in photovoltaic cells (organic, perovskite, silicon-based) and optimization of wind turbines of new generation. With constant growth of the renewable energy share in power generation sector the difficulty is in the random availability of the electric power produced from wind and sun comes into play. The beneficial solution that can solve this problem is development of the energy accumulation technologies. Special stress will be put on the accumulation of energy via hydrogen generation in the context of

power2gas and power2chemical technologies, with parallel utilization of CO2 generated by traditional sources. Implementation of this research will require an in-depth investigation and optimization of the electrolysis process. Implementation of this research will require an in-depth investigation and optimization of the electrolysis process. SUT researchers have also deep knowledge and experience in the field of development new technologies concerning enhancement of efficiency of coal-fired boilers, control the composition of the flue gases (easier capturing and storage of CO2), and reduction of harmful species emission.

SUT staff has developed an original concept of thermoecology (thermodynamic-ecology cost) which gives an insight into the impact of a given process on the depletion of natural resources, using life cycle coupled with exergy analysis. This approach is unique not only on a national but also on a global scale, confirmed by numerous publications, e.g. on nuclear energy and systems for the integration of non-renewable and renewable technologies. This approach sheds new light on the optimization of industrial processes in terms of the limited access to natural resources. Moreover, the research on heavy metals removal (eg. mercury) via chemical and biological processes, will be continued, similarly to the waste utilization technologies.

To the environmental mainstream of research, important in the context of smog problems in most Polish cities, especially at the southern part of Poland, i.e. Silesian District, belongs also the question of reduction of air pollution. The assessment of the impact of atmospheric and internal air pollution on the health of the general population belongs to the discipline of environmental management. The past climate and environmental changes have been recorded in various natural archives: ice cores, tree rings, sea and land sediments. Climate reconstructions form the basis for verification of climate models and forecasting. One of the most powerful tools utilized are isotope methods, whose development and application is for a long time a trademark of SUT. In addition to these basic areas of applications for dating and environmental change studies, the industry driven research is conducted on verification of biocomponent concentration in various substances. Another research area where SUT achievement is focused on is the works on limiting the negative impact of synthetic refrigerants whose presence in the atmosphere contributes to global warming and depletion of the ozone layer. These tests are mainly aimed at the use of natural working fluids such as $CO_2$, e.g. in ejector cooling systems, and the construction of mathematical models that describe the phenomena occurring in refrigeration systems.

It should be stressed that SUT staff has already significant achievements in all these research areas, thus valuable results can be expected in the very near future. Another important feature of the carried out research is the parallel experimental and advanced computational techniques used. Developed mathematical models are very often used by researchers from around the world, as evidenced by the many cited scientific papers published in the top 10% journals in engineering, chemical engineering, computer science, mechanics, and thermodynamics.

It should be also pointed out that the Faculty of Energy and Environmental Engineering at which part of the research is conducted in mentioned fields has in the Polish ranking system the highest possible category A+.

Researchers from SUT, coordinate or participate in research projects granted by European Union, i.e. Horizon 2020, projects focused on Polish-Norwegian cooperation, as well as from domestic funds.

Along with the mentioned personal potential, within rapidly growing labs network. The list is too long to be included here. Limiting the range solely to photovoltaics, SUT exploits the nationwide largest photovoltaic farm used also for research novel photovoltaic materials lab and an autonomous Photovoltaic Lab. The University has its own, distributed computer cluster, and has applied for a 440 million pln supercomputer of highest computing power nationwide. It is expected to be installed in 2021. The biological portion of the research aimed primarily on waste utilization is supported by equipment commissioned within a large 80 million project (Biofarma) within which one-third of the budget has been used for the bioenvironmental equipment.

The SUT staff through intensive contacts and joint research projects has developed a wide network of contacts including six universities from the top 20 institutions in the Shanghai list namely University of California, University of Cambridge, Massachusetts Institute of Technology, University of Oxford, Swiss Federal Institute of Technology Zurich (ETH), University College London and US National Lab Lawrence Livermore Laboratory.

The structure of the investigations conducted in SUT is a balanced mixture of fundamental and applied research. The University maintains close contacts with international and national corporations like ABB Corporate Research Center, General Electric, SGL Carbon, Tauron SA, Arcelor Mittal, Sumitomo FW, PKN ORLEN and numerous small and medium enterprises.