Research project objectives/ Research hypothesis Research project objective is a determination of the structures and parameters of power cycles based on supercritical CO_2 as a working medium. The main idea of the proposal is using a fluid with low temperature of critical point for electricity generation and compare those cycles against steam turbine cycles. Additionally, it possible to equip the system with CO_2 storage tank, which helps in efficiency control of system power by changing amount of CO_2 in the system—giving highest possible efficiency of power generation during part load conditions.

Additional task of the project is a verification of common opinion that supercritcal CO_2 cycles are characterized by significant higher efficiency that a Rankine cycle for the same operational parameters, and investigation of using such the systems in CO_2 separation unit installed in coal fueled steam turbine cycles to create a binary system for improving total efficiency.

Research project methodology Based on the literature survey, the models of the supercirical CO_2 system will be created. The system will be optimized for the highest possible efficiency as an objective function and then compared against the Rankine based cycles. It is predicted that authors' own conception of the systems will be obtained by choosing the system configuration for differ objective function than power efficiency, e.g., boundary power, installation costs, amount of "utilized" CO_2, etc.

The project will be implemented based on a few complementary tasks in developing the supercritical CO_2 based cycles:

1. Variant analysis of the systems based on supercritical CO_2 as the working fluid
2. Determination of the variant for future detailed investigations
3. Developing of models and testing the models (choosing a model of the working medium; model of CO_2 expander (turbine); model of CO_2 pump; model of CO_2 compressor; model of heat exchanger; model of storage tank of CO_2)
4. Simulation and selection of the most rational system parameters for chosen cycles
5. Integration of the system with CO_2 separation units (MEA/membranes/MCFC)
6. Analysis of the obtained results and judging the perspectives of the utilization of such the systems

The project will be implemented based on mathematical modeling and numerical simulation. For this purpose, both commercial programs (HYSYS, AspenPlus, GateCycle) to which the proposal authors have access and ability to use as well as their own codes created for the project will be used.

The project will require the organization of a team having the experience and achievements both in terms of study and research of advanced cycles and energy systems, including those with atypical features, as well as modeling and simulation of circuits and systems with their components. Such opportunities exist at the Institute of Heat Engineering.

Expected impact of the research project on the development of science, civilization and society The ever increasing electricity demand necessitates a search for new, cheaper methods of power generation. It aims to reduce both operating costs and investment power. It is widely believed that the power of steam virtually exhausted the possibilities for improvement. Among other concepts, high hopes lay in cycles which used in working fluid other than steam (e.g., CO_2) and adjusts for this factor the most favorable thermodynamic cycle. CO_2 would be widely available if CCS/CCU units will be installed as a common part of the power plants. The system integration of those two technologies will define new horizons in both power system efficiency increase as well as carbon dioxide utilization.

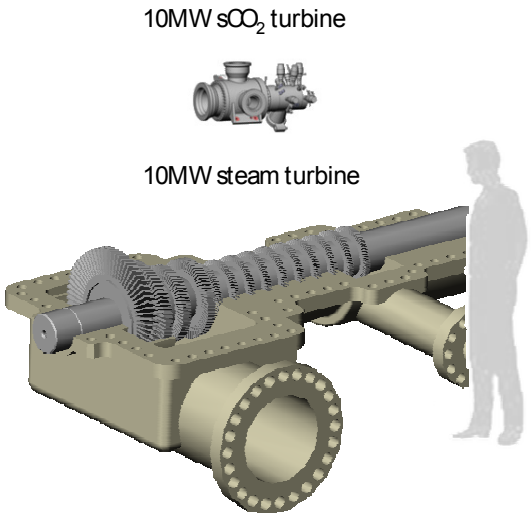

Figure 1: Comparison of turbines with a power of 10 MW working on CO_2 and steam [1]

The presented state of the art shows that supercritical CO_2-based cycles experiencing a renaissance. Since the first work of the 70s of the last century has passed nearly 40 years, and in the last three years there has been a real rash of articles on this topic. However, this research is mainly theoretical and targeted either nuclear reactors or into concentric solar panels. Research is also being conducted in the United States on the basis of one of the government programs. One of the most interesting may be the inclusion of circuits based on supercritical CO_2 CCS in coal-fired power, which gives the project the appropriate cognitive significance.

References

[1] M. Persichilli, A. Kacludis, E. Zdankiewicz, T. Held, Supercritical CO_2 power cycle developments and commercialization: Why sCO_2 can displace steam ste.