The tasks undertaken in the project concern the possibility of the combustion process thermal energy recovery. Flowing out of a thermal engine, the exhaust gas usually carries large amounts of heat which in many cases is lost to the environment. Utilizing even a small part of this waste energy will make it possible to improve the conversion process efficiency and, consequently, produce savings in fuel consumption and reduce environmental pollution. One example of processes generating great amounts of waste heat is energy conversion in the internal combustion engine. Considering the process low efficiency and the vast popularity of the internal combustion engine applications, the device is a perfect object of analyses investigating the possibility of waste energy recovery. With the number of cars operated worldwide exceeding 1.1 billion, and a huge number of other vehicles and machines, we are aware of the scale of the problem. Moreover, as internal combustion engines are usually small-capacity units, no energy recovery systems are generally applied in them. The research will be conducted using thermoelectric modules as the device enabling direct conversion of heat into electricity. Thermoelectric cells operate on the principle of the Seebeck phenomenon, which consists in generating an electromotive force in a system of semiconductors if their junctions are characterized by different temperatures. The electricity generated in this way will constitute an additional usable effect of the combustion process. The works will have an experimental and numerical nature.

The experimental part will be realized by constructing a testing stand intended for the assessment of the process of hot exhaust gas heat absorption. The stand will be composed of a hot gas generator and an energy recovery chamber, where heat exchangers will be placed to capture the energy to be used further on in the recovery system. Thermoelectric modules are selected as the device converting waste heat into a usable effect – electricity – because they have a number of favourable characteristics, e.g. simple and compact design, no moving parts, small size, low failure rate, ease of service and noiseless operation. Special care should be taken to ensure an intensive heat transfer on both surfaces of the thermoelectric module as the temperature difference between the “cold” and the “hot” end is an essential factor affecting the device operation.

In parallel, the thermal and flow processes occurring in the testing installation will be simulated numerically. In the early stage of the research, the thermal and flow calculations will be used to design the structure of the testing stand heat exchangers. After the stand is constructed and fully metered, numerical simulations will be validated experimentally.

It is then planned to investigate the impact of wave phenomena and the gas supply periodicity on the heat transfer in the exhaust gas duct and, as a consequence, on the electric power generated by the cell. Moreover, an assessment will be made of the functionality of introducing an acoustic wave to the system as the heat transfer intensification factor.

Testing on a real engine exhaust gas system will be performed in parallel to identify instances of the exhaust gas flow unsteadiness and determine the unsteadiness character. The testing results will become boundary conditions for quantitative modelling of the phenomena taking place in the recovery system. Investigations are also planned of the gas composition impact on the heat transfer.

The outcome of the research will widen the knowledge of the phenomena occurring close to elements of the exhaust gas thermal energy recovery and enable better understanding of how this recovery is affected by the flow unsteadiness. The analysis will also make it possible to answer the question whether, considering the present state of the art in the technology of thermoelectric cells, using them in energy recovery systems finds justification.