Carbon dioxide (CO_2) and methane (CH_4) are greenhouse gases (GHGs) with the highest global warming potential, contributing to the Earth's temperature rise by trapping heat in the atmosphere. CO_2 is present in the atmosphere as a result of human activities, mainly from the combustion of fossil fuels, while major sources of CH_4 emissions include livestock farming and energy resource extraction. According to the Green Deal policy, it is essential to reduce GHG emissions into the atmosphere, as well as to utilize and store them. While the best method for disposing of CH_4, as a flammable gas, is its utilization as a valuable energy source, CO_2 must be subjected to permanent or long-term sequestration. One potential method for CO_2 storage is geological sequestration in shale formations that contain large CH_4 deposits. Injecting CO_2 under high pressure into deep shale formations (up to 4000 meters) is expected to stimulate CO_2/CH_4 gas exchange and adsorption processes, causing CO_2 to be trapped in the shale's pore space, while shale gas (mainly composed of CH_4) is displaced and captured (CO_2-ESGR technology).

The unsuccessful attempts to extract shale gas in Poland, carried out in the years 2013-2017, have led to the cessation of further exploration of this energy source. However, in the context of the global energy crisis and considering the technological progress made over the past decade, the topic of returning to shale gas exploitation in Poland is being reconsidered. Therefore, it is crucial that the exploitation of poorly explored shale gas deposits in Poland, as well as the application of new technological solutions such as CO_2-ESGR, must be preceded by detailed laboratory research under *in situ* conditions, along with a series of numerical simulations.

The aim of the project is to conduct laboratory studies of the CO_2-ESGR technology under laboratory-simulated *in situ* stress-pressure-temperature conditions, at depths of up to 4000 meters. At such depths, rock stress is around 100 MPa, shale gas pressure is approximately 10-50 MPa, and the temperature can reach up to 130°C. As part of the project, two unique research stands (IMG-SSR and IMG-GEX) will be constructed to simulate *in situ* conditions and to carry out structural and sorption property studies of shale on one of the devices, as well as seepage and CO_2/CH_4 gas and sorption exchange experiments on the second stand. The results of structural and sorption studies will be compared with data obtained from commercially available devices, on which tests can be conducted on stress-free rock samples, allowing for an assessment of how laboratory-measured parameters differ from those under *in situ* conditions, deep underground. Additionally, permeability studies, in combination with fracture permeability tests of shales under *in situ* conditions, will provide insights into the impact of shale fracturing on the stimulation of gas flow in the pore space.

The most important experiments of the project, CO_2/CH_4 exchange, will involve injecting CO_2 into a shale sample initially saturated with CH_4. This process will trigger CO_2/CH_4 gas exchange in the pore space and CO_2/CH_4 adsorption exchange on the shale pore surface. These experiments will be conducted under laboratory-simulated *in situ* stress-pressure-temperature conditions, marking a pioneering laboratory experiment of this type. Based on the results, the efficiency of the CO_2-ESGR process will be evaluated.

The final stage of the project will be to develop a numerical model based on the results of the analyses and experiments. Numerical simulations will enable the reconstruction of CO_2-ESGR processes under *in situ* conditions at a macro scale. These simulations will enable the evaluation of the applicability of the CO_2-ESGR technology in conditions corresponding to shale gas deposits in Poland.