Constantly increasing energy demand enforces for searching of new technologies, capable of ensuring cheap and clean electricity and heat. A solution, that seems to have a good chance to meet these expectations, are fuel cells, especially Solid Oxide Fuel Cell (SOFC). As the undeniable advantages of this technology shall be indicated i.e., the high energy production efficiency, the possibility of using of waste heat (due high temperature operation) and no needs for using an external reformer, when the fuel is methane or more complex hydrocarbons. SOFCs seem to be very important element of the dispersed energy system, mainly as cogeneration systems in houses, schools and businesses. In addition, as crucial element, in the development of new energy technologies, shall be recognized high-temperature solid oxide electrolysers (SOEC-Solid Oxide Elecotrolyse Cell) using the reversibility of the processes occurring in the SOFC during supplying the electricity and steam to cell. They provide an efficient method of production high-quality hydrogen, with relatively low energy demand, compared to the currently used polymers cells. Aforementioned reversibility of SOFC (SOEC) work is one of the most promising solutions for the problem of renewable energy sources for storing of excess energy or supplement the deficiency in relation to the current power system needs.

Wide implementation of SOFC and SOEC on the energy market requires the improvement of their ceramic materials constituent: electrolyte, anode and cathode. It is essential to obtain efficient-working cathode material, as the cathodic polarization is limiting the high cell efficiency. Perfect candidates for the cathode materials seem to be compounds based on the copper oxide with simple perovskite structure ($LnCuO_{3-\delta}$) and layered Ruddlesdena-Popper-type ($Ln_2CuO_{4\pm\delta}$), which each exhibit high electron conductivity, the highest among all known oxides. By modification of their chemical composition (substitutions in both cationic sublattices) it is possible to force controlled oxygen nonstoichiometry creation that determines the appearance of the ionic component of the electrical conductivity. Consequently it is possible to obtain compounds having a high mixed ionic-electronic conductivity (MIEC–Mixed Ionic-Electronic Conductors), which plays a crucial role in the effective working of electrode materials in the SOFC (SOEC).

In the cognitive aspect of this project aim is to determine the correlation between chemical composition, crystal structure, physical and chemical properties of new groups of $Ln_{2-x}(Ba,Sr)_xCu_{1-y}Ni_yO_{4\pm\delta}$ and $Ln_{1-x}(Ba,Sr)_xCu_{1-y}Ni_yO_{3-\delta}$ (Ln: La and other selected lanthanides) materials and their effectiveness working in fuel cells. Modification of $Ln_{1-x}(Ba,Sr)_xCu_{1-y}Ni_yO_{3-\delta}$ oxides by substitution of the lanthanide by strontium and/or barium, and copper by nickel, will cause oxygen vacancies disordering at high temperatures, resulting by the appearance of high ionic component, while maintaining the significant electron conduction. The selection of the appropriate range of substitutions in the $Ln_{2-x}(Ba,Sr)_xCu_{1-y}Ni_yO_{4\pm\delta}$ group will allow to obtain nonstoichiometry in oxygen-sublattice ($\delta \neq 0$), and will also determine type of oxygen ions conduction mechanism in the material (vacancy or interstitial mechanism). The development of the synthesis process and its optimization, and then a series studies of the physicochemical properties of analyzed oxides, including among others structural studies, microstructural, thermogravimetric and impedance studies, will allow to determine effect of the copper oxidation state to the aforementioned properties, which seems to be interesting from a scientific point of view.

Moreover, the aim of the project is the construction of a lab-scale SOFC, based on the investigated material, with the best physicochemical properties and commercially used other components of the cell. The electrochemical tests of cell during their work at 600-800 °C will allow to characterize functional properties of the cells, as well as to choose materials with optimum operating parameters. A series of research to be taken, will allow to assess the possibility of using the proposed oxides as an alternative to currently used cathode materials in SOFC and SOEC.