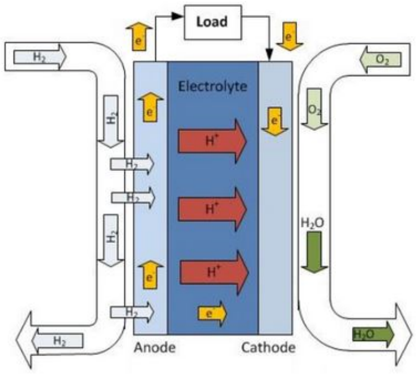


$H^+$SOFC—working principles

**Research project objectives/Research hypothesis** The aim of the project is to develop an reduced order model of proton conducting solid oxide fuel cell ($H^+$SOFC).

The model will take into account several factors neglected/not existed in the models currently used. This model will be based on the general dependencies of thermodynamics, chemistry and electrical engineering, almost without using empirical equations which based solely on experimental data.

**Expected impact of the research project on the development of science, civilization and society** Fuel cells, in particular high temperature (SOFC and MCFC) are considered as the most promising sources of electricity in the future, due to their potentially very high coefficients in power generation not limited by Carnot cycle.

In order to determine the potential of using high temperature fuel cells and their competitiveness in relation to current sources of electricity, a proper mathematical model is needed that allows to simulate and optimize the series of processes both for fuel cell itself as well as other system's equipment.

Currently used models (see full description) are mainly based on equations which approximate the fuel cell voltage–current density curve ($E = f(i)$), whereas the curve is obtained during experimental testing of the cell. This means very close relationships between the models and used experimental data for tuning the model parameters, this results in difficulties in identifying the cell performance under conditions significantly different from the conditions prevailing during the experiments. Attempts to select the fuel cell design parameters and optimize of working parameters are very difficult in this case, if not impossible.

A few years ago, there were reported a new way for describing of fuel cell processes. This method is called "reduced order model", and competitives the classical method—based on the balance of losses (so called loss estimated). The novel method for cell modeling has been applied to many types of fuel cells (solid oxide fuel cells, which conducts ions $O^=$), molten carbonates fuel cells and other. The novel method bases on the other method for describing the cell operations, thus the new coefficients appear, which has not been defined by previous research as well as their values and dependencies are not defined. In fact, authors of the proposal did attempt to preliminary study and build a simplified model of a proton conducting SOFC in article "The reduced order model of a proton-conducting Solid Oxide Fuel Cell" Journal of Power Technologies 95, 2014. Development of these variables and definition of new models to explain and the selected phenomena and their verification on the basis of experimental data are going to have a significant impact for development of a scientific discipline.

**Research project methodology** The methodology, which will be applied for project realization consist of theoretical research, numerical simulations. In addition, the experimental research is supposed to be done. The experiments are going to be provided at properly modified existing laboratory stand. The project provides for the following tasks:

- Prediction and analyzing of the main parameters of the new model of $H^+$SOFC, significant from the view of model parameters relevant to the design point conditions as well as the off-design operation
- Derivation of the relevant relationships of the Reduced Order model of $H^+$SOFC;
- The inter-relatedness of thermodynamics, chemistry, physics and electrical engineering parameters of the model;
- Implementation of the model into numeric environment;
- Comparison and analysis of results obtained by using the model against the experimental data; examination of the model behavior for conditions other than empirical—analysis of the impact of various parameters on the fuel cell performance.

The project will require the organization of the team having the experience and achievements both in terms of studies and research on high temperature fuel cells as well as modeling and simulation of power engineering processes. Such possibilities fully exist in the Institute Heat Engineering, Warsaw University of Technology.