Research project objectives/Research hypothesis The aim of the proposed project is a mathematical model development of molten carbonate fuel cells to examinate the dynamics of such fuel cells and systems based on them.

The project realization brings mathematical model of molten carbonate fuel cell for examination and simulation of dynamics behaviours of such fuel cells and power systems with fuel cells. On the basis of proposed model, the behaviour of fuel cell at transient conditions will be scrutinize i.e. fuel cell stack start up, stop, emergency situations etc. Hence, the project realization will reveal fuel cell dynamic characteristics, which enable selection of proper control system. In other words, the project is going to define the allowable response time for selected parameters to maintain the longlasting operation of such devices.

Research project methodology The project provides for the following tasks:

1. Gathering data on materials for fuel cell construction - heat conductivity, heat capacity, ion and electric resistance.
2. Definition of the most popular stack constructions - nominal fluid velocity, temperature and pressure distribution, the accumulation volume, heat insulations etc.
3. Definition of dynamic characteristics of devices, which cooperates with fuel fuel cell - turbines, compressors, pumps, heat exchangers
4. Comparison and analysis of time constants for process, which occurs inside fuel cells - selection of process, which have a significant impact on modeling of energy systems - the preliminary model simplification
5. Comparisaon and analysis of time constant of fuel cell with other auxilary devices - definition of dynamic class of model — fast changeable / medium changeable / low changeable —- second model simplification
6. Development of molten carbonate fuel cell dynamic model —- definition of equations, coefficients — model validation based on available data
7. Examination of molten fuel cell dynamics based on proposed model—definition of allowable time constants for selected parameters, fuel cell behaviour at emergency situation etc.

Expected impact of the research project on the development of science, civilization and society The increasing fuel prices with electricity increase will result in necessity for implementation more efficient systems for electricity generation. Fuel cells convert chemical energy into electricity by electrochemical processes, hence they are not limited by efficiency of heat engine. In addition, high temperature fuel cell are considered as heat source for traditional energy system (i.e. in specific range), thus it is a potential for highly efficient (over 70%) hybrid systems, which operates at relatively moderate temperatures and pressure. In order to define the potential applications and provide corresponding simulations and optimazation, the construction of mathematical model is crucial.

The available in literature dynamic models of particular sub-componets in power unit are mainly 0D, which depite the steady operation, takes into account the adequate dynamic characteristics (heat and mass accumulation, inertia of rotating components etc). Development of corresponding MCFC model which could be integrated with existing models have a crucial importance for selection of optimal control system and definition the operating data for both fuel cell and auxilary devices.