Abstract
The efficient usage of energy at all stages along the energy supply chain and the utilization of renewable energies are very important elements of a sustainable energy supply system. Especially at the conversion from thermal to electrical power a large amount of unused energy (“waste heat”) remains. This energy, because of its relatively low temperature and low energy density can generally not be used for the generation of electrical power by the conventional thermodynamic cycles (Clausius Rankine, ORC, Kalina).

Direct thermal to electrical energy conversion, without the intermediate step of kinetic energy that is with no moving parts therefore gives an alternative of high potential. The improvements in material sciences and the progress of nanotechnology bring thermoelectric materials and therefore thermoelectric converters to renewed significance. The efficiency of thermoelectric converters in general depends on material parameters summarized in the figure of merit ZT. Furthermore design aspects, especially the leg length, and heat transfer conditions have a significant influence on power output and efficiency. The main goal of the project “The thermoelectric power plant”, a cooperation of EMPA Dübendorf and ETH Zurich, Power systems and High voltage laboratories, is to show the feasibility of a thermoelectric power generation unit. Therefore theoretical calculations and selected experiments have been carried out. The goal of this work was the development of tools for the evaluation of thermoelectric power generation units and devices.

The modelling has been done on two size levels. On the large scale level a high number of thermoelectric modules have been integrated in a heat transfer unit, respectively a cross-flow heat exchanger. On the lower size level the modules were modelled in 3D including all non-linearities and irreversibilities and simulated with the method of the finite elements (FE). For the validation of the FE simulation prototypes of thermoelectric oxide modules (TOM) were created at EMPA Dübendorf, the power output characteristics measured and compared with the results of the simulation.

The conformity of the results was quite satisfactory and could be repeatedly reproduced. The simulation gives new access to the interior of thermoelectric modules, which will be very important for future development steps. Different optimization strategies can be operated with little expenditure of time.