

Multi-Energy Systems: Investigating Hidden Flexibilities Provided by Power-to-X Considering Grid Support Strategies

Department of Electrical Engineering, Mathematics and Computer Science

Dr. Milos Cvetkovic, TU Delft, supervisor

Dr. ir. J. L. Rueda Torres, TU Delft

Dr. L. M. Ramirez Elizando TU Delft

Abstract(25-500 words):

Highly volatile nature of renewable energy sources (RES) has increased the demand for flexibility in electrical power systems. Electrification of the industry with power-to-X (PtX) technologies is one of the most promising ways to increase energy system flexibility since industry accounts for the largest share of the world's total energy demand. However, flexibilities provided by power-to-X models can be concealed in the simulation results due to modelling approximations. Therefore, PtX modelling must be analyzed with respect to the requirements of flexibility analysis. Additionally, the planning and operation of such multi-energy system (MES) needs to be coordinated to use the available resources (RES & PtX) optimally. Thus, a comprehensive energy management approach must be provided for MES.

This study investigates the impact of model fidelity of PtX devices in flexibility analysis. Additionally, impact of hierarchical energy management system to optimally control the flexibility dispatch is investigated. First, a realistic case study is developed for multi-energy system to investigate energy system flexibility. Secondly, power-to-gas and power-to-heat models are developed in OpenModelica, and the effect of operational temperature simplifications of PtX models on flexibility analysis is investigated. Lastly, using co-simulation, PtX models are combined with Pandapower optimal power flow solver for the optimal deployment of flexibility.

The findings of this study have provided a deeper insight into multi-energy system flexibility. The investigation of hidden flexibility has revealed that precision of flexibility analysis is bounded by the efficiency characterization of PtX, and correct efficiency characterization of PtX highly depends on operating temperature conditions. The study also shown that, a comprehensive control approach can be achieved by agent-based hierarchical energy management system and this new understanding may help to improve predictions for the optimum operation point of MES.

Keywords: multi-energy system, energy flexibility, power-to-X, hierarchical control, optimal power flow, co-simulation, electrolyser, heat pump