DESIGNING BUSINESS MODELS FOR DIFFERENT MARKET PARTICIPANTS IN A HYBRID RETAIL ENERGY MARKET

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Overview

The increasing global energy demand and the further development of European energy markets will raise new challenges and business opportunities for different market participants in the energy supply chain across the different energy domains electricity, heat and gas. In general, the different energy services (e.g. heating, cooling, lighting, transportation, etc.) demanded by customers can be met by different energy domains. Thus, electricity, heat and gas supply companies are competing for customers' energy services (technically speaking: load profiles) depending on their system boundaries in the energy supply chain. If there are certain coupling technologies (e.g. Combined Heat and Power (CHP), Power2Gas, etc.) available alongside the energy supply chain, the different distribution grids can be interpreted as one multi-domain energy network.

The work presented in this paper is part of the European FP7 project "OPtimising Hybrid Energy grids for smart citieS (OrPHEuS)". This project targets the development of a hybrid energy network control system to achieve better efficiency and smarter operation enabling a cooperative coexistence of the different energy domains. For the economic validation of different control strategies a formal framework is set up describing the objectives, practices and interdependencies of the various market players, namely generators, distribution system operators (DSO), supply companies and consumers. The data used for this validation is obtained from the OrPHEuS project demonstration sites in the city of Skellefteå, Sweden, and in the city of Ulm, Germany.

In detail, the analytical contribution of this paper is the development of mutually consistent business models for each market participant from a hybrid energy networks' point-of-view considering the existing market rules but also anticipating possible future structural changes in the energy market design.

Methods

The models are formulated as linear programs (LP) and mixed integer programs (MIP). They are implemented in MATLAB using the Gurobi Optimizer. Some interesting aspects of the objectives of the various market participants are indicated in the following:

i. To describe the consumers' objectives, several LPs are presented. Starting from a cost function for standard customers (without self-generation) several models are developed by gradually adding new terms and constraints according to additionally installed technologies (e.g. PV systems, heat pumps, batteries and heat storages, etc.) in order to describe the characteristics of "prosumers" (with self-generation).
ii. For the description of supply companies (retailers) basically four cases are considered which differ in the following criteria:
    - An energy supply company can either just purchase energy from the wholesale market or in addition also operate own generation plants.[1]
    - A supply company can operate on one or more energy domains. A CHP owner, e.g., could bid in the electricity wholesale market and at the same time feed into the district heating network.
iii. The model describing the DSOs' objectives focusses on the asset management of the existing grid and possible further network extension. It is formulated as a MIP and aims to find the optimal time for reinvesting in existing and/or new assets from an economic point of view subject to the constraints set in a grid regulation process.[2]

The data used for simulating the various objective functions of the different market participants is obtained from the OrPHEuS project demonstration sites.

[1] Note that this does not apply to pure district heating utilities.
[2] Energy networks have to be regulated due to their natural monopoly character.

Results

At present, model development is close to finalisation. The control strategies to be validated are still being designed. The results of the simulation are expected to show quantitatively, depending on the respective question, the following:

i. A ranking of the cost effectiveness of several additional technologies or technology portfolios (with or without self-generation) to meet different energy services demanded by consumers.
ii. The value of own generation plants for supply companies compared to pure energy purchases/trading in terms of energy procurement costs and risk and, furthermore, the value of multi-domain operation in terms of cost efficiency.
iii. The impact of various regulatory mechanisms on the optimal asset management strategies of DSOs in terms of timing and amount of investments.

Conclusions

The results of the analyses presented in this paper shall improve the understanding to implement sustainable business models for several of the market participants in a hybrid network environment. Depending on the system boundaries and constraints for each of the market participants the business models are expected to indicate different rankings of beneficiaries among the market participants for different use cases.

References

[1] H. Auer and D. Schwabeneder, “Report on a multi-dimensional framework for smart hybrid energy network analyses”, Working Document for the deliverable D2.2 of the European FP7 Project “OrPHEuS”