Indirect control of flexible demand for power system applications. - DTU Orbit (02/02/2019)

Indirect control of flexible demand for power system applications.
This thesis addresses the topic of control of flexible demand to provide support to the operation of the electric power system. We focus on the indirect control approach, a framework that enables demand response by means of a consumption incentive signal. Initially, the concept of flexibility is defined and a classification of flexible electric loads is presented. In order to evaluate the potential of flexible demand, the storage capacity associated with the operation of a number domestic electric loads is quantified by means of simulations. Subsequently, the topic of indirect control of flexible demand is addressed. We investigate the subject considering both how to achieve a shift in the consumption of the single DSRs, and how to generate the indirect control signal for a population of DSRs in order to support the operation of the grid. In the former case, we develop algorithms that achieve a shift in the consumption according to an indirect control signal. We present from simple control algorithms with a few requirements up to model predictive control strategies. The performance of the indirect control algorithms are compared by means of hardware-in-the-loop simulations using Power Flexhouse, a facility of DTU Elektro for testing demand side management strategies, as experimental site. In the latter case, we develop four applications where flexible demand is required to support power system operations. The applications are: integration of the operation of flexible demand and conventional generating units by means of unit commitment, mitigation of congestions in radial distribution networks, photo-voltaic self consumption and consumption peak shaving by means of a distributed optimization strategy. Finally, motivated by the perspective of the interplay between flexible demand and storage in the operation of the future power system, we develop a model predictive control strategy for a smart building with the objective of supplying space heating and providing regulating power to the grid according to a dynamic electricity price. We named this application energy replacement to indicate that the predictive control is able to switch among several energy sources to supply space heating according to the electricity cost. In the process of developing this work, we propose novel validated mathematical models for a domestic refrigeration unit and a fuel cell. Models are realized applying a state-of-the-art grey-box methodology, using measurements from the following experimental devices: the freezer of Power Flexhouse and the 15 kW PEM fuel cell of the EPFL Distributed Electrical Systems Laboratory (EPFLDESL).

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy
Contributors: Sossan, F., Bindner, H. W., Nørgård, P. B.
Number of pages: 220
Publication date: 2014

Publication information
Publisher: Technical University of Denmark, Department of Electrical Engineering
Original language: English
Electronic versions:
sossan_thesis.pdf
Research output: Research › Ph.D. thesis – Annual report year: 2014