DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Intelligent Energy Management System for Virtual Power Plants

Location: Pontoppidanstræde 101, Room 23

Time: Monday 29 June 2015 at 13.00

PhD defendant: Philipp Braun

Supervisor: Professor Remus Teodorescu

Moderator: Associate Professor Tamas Kerekes

Opponents: Professor Josep Guerrero, Dept. of Energy Technology, Aalborg University (Chairman)
Associate Professor Moisès Graells, Departament d'Enginyeria Química, UPC, EUETIB, Barcelona, Spain
Professor Eleonora Riva Sanseverino, University of Palermo, Italy

All are welcome. The defence will be in English.

After the public defence there will be an informal reception at Pontoppidanstræde 101 room 25/27.

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Abstract:

Wind power is the fastest growing renewable energy source with the highest share of power production in the Danish power system. Increasing wind power production also causes new challenges for the power system.

One possibility to enable higher shares of wind power in the system is to build virtual power plants (VPPs). In this work, VPPs refer to wind power plants (WPPs) connected to an electrical battery energy storage system (BESS) which is in close proximity to the WPP, and both plants are able to participate in the Danish power market (ancillary service markets and day-ahead market). BESSs demonstrated to be suitable storage technologies that have been integrated in power systems worldwide in recent years. Such storage systems are underlying a fast development track and have improved over the past decades considerably. This makes an increase in the number of VPPs more likely in future.

Potential investors in VPPs face several questions before and after an investment decision for a specific BESS is made. This work addresses the following questions:

1. Is a VPP a profitable investment and if so, which technology or combination of different technologies of BESSs and which size should be purchased?
2. Once the BESS is purchased and grid connected: When should the VPP submit bids to which power market and in what quantity?
3. Once the awards on the power market are announced and the latest wind power production forecast is available: How should the VPP be operated in order to face minimum penalty payments for imbalances due to, e.g. changes in wind power production?

This thesis proposes a deterministic mixed-integer-linear-programming (MILP) formulation to address the above stated optimization problems. One generic (MILP) problem is formulated that can be used to address each of the above stated questions depending on the input parameters provided to the model. The model focuses on the BESS including capacity fade which is a battery specific property. It determines the performance, live-time, and - most important - the annualized costs of the BESS. Modeling capacity fade opens up the possibility to take into account BESS's annualized costs based on a function of its state-of-health (SoH).

The proposed MILP formulation is verified based on three case studies following the problem formulation. There is one case study for each question described above.