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Smart Energy Operating System

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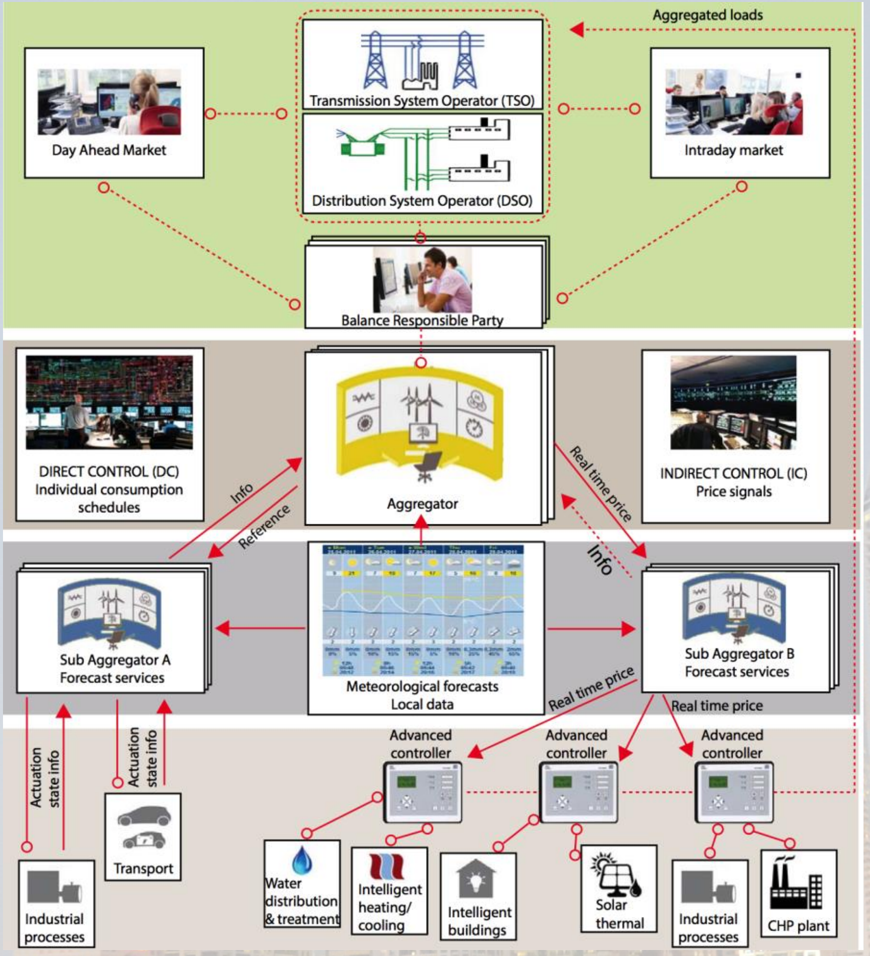
INTRODUCTION

The energy production of renewable energy sources is uncertain and fluctuating, given a strong dependence on weather conditions. For this reason the power system needs to be reactive in order to guarantee stability and system security. A solution that has been discussed is the introduction of Demand Response (DR) mechanisms. The main idea is to move from supply that follows demand towards demand that follows supply. A power system that implements DR mechanisms can take advantage of the consumers' flexibility by shifting or changing their consumption.



The overall framework for the Smart-Energy Operating-System is shown in the figure. To operate the power system in such a way, a new actor has been introduced, the Aggregator as illustrated in the figure. The Aggregator coordinates and operates the production and consumption of its distributed energy resources (DERs) either directly or indirectly eg. by broadcasting a real time price. The Aggregator is responsible for representing its DERs towards the system operators, providing different services such as voltage control, load balancing and reserves.

SOLUTION APPROACH

The Aggregator is assumed to be a player operating at the system operator (TSO or DSO) level, which represents aggregated DERs in the entire transmission area at the balancing market. The Aggregator operates through a balance responsible party (BRP). The objective is to use the flexibility provided by the Aggregators' portfolio to support the transmission system operator needs, and integrate a large share of renewable energy. The reason for its existence is that usually most DERs cannot shift enough energy load to bid into the electricity market. The Aggregator thus operates between the grid operators and the DERs. The level II Aggregator in Figure 1, estimates the potential DERs flexibility and offers it directly in the real-time market or to the transmission system operator's regulating power market. The presented control framework can be used to robustly handle heterogeneous grids with different renewable energy sources, and adapted for both DC and IC schemes.

Level II
The Aggregator estimates its available flexibility and submits bids to the regulating power market directly or through the Balance Responsible Party (BRP). After the clearing of the spot market, the Direct control Aggregator (DC) will dispatch individual consumption schedules, while the Indirect control Aggregator (IC) will broadcast price signals.

Level III
For the DC part an important role of the Sub-Aggregator is to estimate the states of the DERs and compare the states with contractual values. In the case of IC the role of the Sub-Aggregator is to determine and communicate a signal in real-time to which the DERs respond by adjusting their operation according to the Aggregators needs. Another role of the Sub-Aggregators is to provide reliable probabilistic forecasts for loads, prices and weather conditions depending on the control strategy implemented.

KEY FINDINGS

With our approach the Aggregator can be seen as a coordinating unit between its different subsystems. The presented Aggregator is able to handle energy fluctuations and uncertainty coming from stochastic renewable generation sources (e.g. wind and solar). A robust implementation has been modelled that includes scenarios, and results show a better use of the electricity generated by renewable energy sources.

[J. Parvizi, J. B. Jørgensen and H. Madsen: Robust Model Predictive Control with Scenarios for Aggregators in Grids with High Penetration of Renewable Energy Sources. Presented at IEEE-SmartGridComm conference i Aalborg, 31st of October 2018]

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Acknowledgments: Innovation Fund Denmark. Grant 1305-00027B