Demand Response on domestic thermostatically controlled loads - DTU Orbit (11/11/2019)

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Electricity has become an inevitable part of human life in present day world. In the past two centuries, the electric power system has undergone a lot of changes. Due to the awareness about the adverse impact of the fossil fuels, the power industry is adopting green and sustainable energy sources. For a safe and reliable operation of electric power systems, the balance between electricity generation and consumption has to be maintained. The conventional fossil fuel based power generation achieves this balance by adjusting the generation to follow the consumption. In the electric power system with renewable energy sources, the production cannot be adjusted to match the demand due to the fluctuating nature of the renewable energy sources. Therefore, the demand has to be adjusted to match the power production. The concept of adjusting the demand to match the production is called demand response. In general, the electricity consumers are classified as industrial, commercial and domestic. In this dissertation, only the thermostatically controlled loads (TCLs) in the domestic segment are considered for the demand response study. The study is funded by Danish Council for Strategic Research (DCSR) and supported by the project “Inducing consumer adoption of automated reaction technology for dynamic power pricing tariffs” (INCAP). As project INCAP provides access to domestic refrigerators, the TCLs considered for the demand response study are domestic refrigerators. In this study an experimental facility is developed to measure parameters from the refrigerators, in order to control them. The experimental facility is also used to communicate pseudo electricity prices to the consumers and has options to unsubscribe the control from the user end, as a part of the INCAP project requirement. A temperature prediction strategy is developed to predict the refrigerator temperature and to estimate the flexibility available for demand response activation. A field experiment with refrigerators is conducted to study secondary frequency control using demand response activation on TCLs. The response time and the ramp rate characteristics of a real population of domestic refrigerators, as well as their ability to provide frequency control, are analysed. The response characteristics are compared with conventional power plant specifications, indicated in the Danish grid code. The changes in the TCLs flexibility, with respect to different power reduction levels, are analysed. Finally, the impact of demand response activation on the TCLs aggregated power is studied in terms of error in power limit, ramping rates and peak overshoot in different control scenarios. Lastly, the advantage and disadvantage of the different control scenarios are analysed.

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