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Published in:
Book of Abstracts, Sustain 2017

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Li, R., Wang, J., Zong, Y., Foteinaki, K., & Rode, C. (2017). Enhancing demand side flexibility in Nordhavn buildings for integrated multi-energy systems. In *Book of Abstracts, Sustain 2017* [L-9] Technical University of Denmark.

Enhancing demand side flexibility in Nordhavn buildings for integrated multi-energy systems

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EnergyLab Nordhavn is a large-scale research and demonstration project based in the Nordhavn neighborhood of Copenhagen, one of the largest urban development districts in Europe (EnergyLab Nordhavn, 2015). The district functions as a living laboratory for testing smart energy technologies, business models, and operational solutions at every level – component, building, and grid. Buildings are crucial elements in smart energy solutions due to their function of coupling different energy sectors on the demand side and their considerable potential for offering flexible energy consumptions as energy system services. Energy flexibility in buildings can be distinguished in two forms: thermal flexibility and electrical flexibility.

Thermal flexibility of buildings were investigated to explore the potential services could be provided to district heating grids. Field measurements were conducted aiming to find a solution to eliminate the use of peak load boilers in the heat production. The results indicated that residential buildings had large thermal flexibility potential as the supply water temperature could be reduced significantly; however, office buildings had greater potential for heat conservation due to its greater heat demand (Sandersen, 2017). Modeling and simulation studies were carried out to investigate the thermal flexibility of various building designs. The thermal flexibility was strongly influenced by thermal insulation of building envelope, outdoor conditions and occupant behavior. Building thermal mass was found to be influential only if the thermal resistance of the envelope was sufficient (Sarran, 2016). Floor heating system was found to be the most flexible system in comparison with radiator heating and air heating (Zilio, 2016).

To achieve 100% renewable energy generation by 2050 in Denmark, electrical flexibility is required in order to ensure a reliable and balanced power system operation during variation of renewable energy generation (Ma, 2013). Besides the smart grid-oriented demand response program running with appliances in residential buildings, the electrical flexibility through buildings can be realized by utilization of electrically driven heating units, e.g. heat pumps and electric boosters. The demand side flexibility provided by cross-energy sectors can contribute to higher renewable energy penetration (Yi, 2016 & 2017). The simulation results of an economic model predictive control-based energy management system for the heating system in the apartments of the Nordhavn area show that the flexible consumption and integrated multi-energy systems must be developed with correlative dependence and interplay to meet the challenge of integrated fluctuating renewables.

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