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Integrating decentralized electrically powered thermal supply systems into a smart grid

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Abstract

The goal of the project "Smart Region Pellworm" is the establishment and operation of a smart grid with a hybrid energy storage system on the German island of Pellworm.One part of the project is the integration of power-to-heat appliances into the smart grid for demand side management purposes.Thispaper deals with the prerequisites and lessons learned from the integration of electric night storage heaters into Pellworm's energy management system. Special focus lies on the development of a heat demand prediction model.

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*Keywords:*smart grid, electric storage heaters, heat demand prediction, demand side management, power-to-heat

Nomenclature

DSM	Demand Side Management
EMS	Energy Management System
ESH	Electric storage heater

1. Introduction

The transformation of the German energy supply system from fossil to renewable energy sources is one of the main challenges in today's energy sector. The share of electricity produced from renewable sources will reach up to 45 % by 2025 and up to 80 % by 2050 according to the current German targets [1]. As most renewables are dependent on weather conditions, their availability and power feed-in are subject to large fluctuations. Another threat to the grid stability is the often great spatial spreading of renewable power suppliers and consumers. Therefore, the demand for flexibility options rises with the expansion of renewable energies. Different energy storage technologies are needed as well as Demand Side Management (DSM) options. Furthermore, reliable business models and market designs are required.

The energy supply situation on the German island of Pellworm is comparable to the situation expected in other regions in a few decades. Therefore, the island is selected for a pilot project, conducted by a consortium[2] from industry and research. The goal

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of the project "Smart Region Pellworm" is the establishment and operation of a smart grid with a hybrid energy storage system. During the operation phase of the smart grid, different business models and objective functions are tested. Energy self-sufficiency of the island is not a goal pursued in this project. Instead, an energy system based mainly on renewables with the aid of a hybrid energy storage system is optimized under economic aspects. The connection to the power distribution system via two sea cables is maintained and used. As one part of the project Demand Side Management options like electric storage heaters (ESH) are integrated into the smart grid and used for load shifting.

In this paper, the integration of the electric storage heaters in selected households for Demand Side Management use in a smart grid is described. Emphasis lies on the infrastructural requirements, interfaces to the Energy Management System (EMS) and the developed heat demand prediction model.

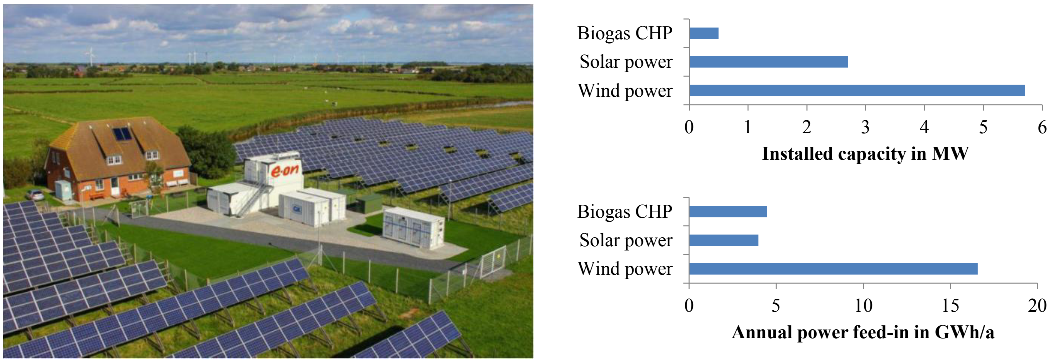

Fig.1. Left: Part of the hybrid power plant and hybrid energy storage system on Pellworm (source: E.ON), right: installed capacity and annual feed in of power plants on Pellworm

2. Power Supply System Pellworm

The islands power supply system is characterized by a power surplus due to large generation capacities from renewable sources, little power consumption and limited transmission capacity in the power distribution grid. The annual feed-in (installed capacity: 5.7 MW wind power, 2.7 MW solar power and 0.5 MW biogas) surpasses the annual power consumption by three times (25 GWh/a vs. 7.7 GWh/a). The power consumption is mainly driven by private households (46 %), local businesses (18 %), electric storage heaters (17 %), and load metered customers (15 %).[3]

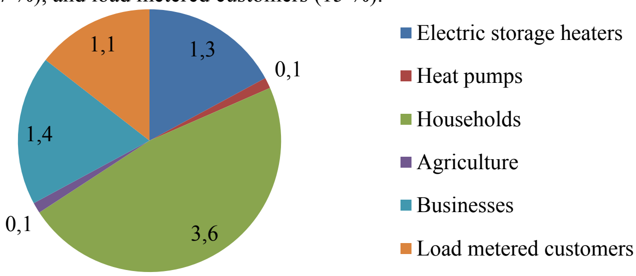

Fig.2. Energy consumption of different consumers in GWh/a on Pellworm in 2011

Within the project, a hybrid power plant with 0.7 MW of solar power and 0.3 MW of wind power is integrated into the newly installed smart grid. Additionally, a lithium ion battery[4] (LIB), a redox flow battery[5] (RFB), 11 decentralized lithium ion batteries[6] on household level and 35 electric storage heaters[7] (ESH) are operated by a central energy management system (EMS),

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Aachen IFHT, Gustav Klein GmbH & Co. KG

[3] in 2011

[4] charge power: 560 kW, discharge power: 1100 kWh, capacity: 560 kWh

[5] power: 200 kW, capacity: 1600 kWh

[6] 6 x type 1: power: 4.5 kW, capacity: 6 kWh, 5 x type 2: power: 10.5 kW, capacity 9 kWh, in total: power: 80 kW, capacity: 80 kWh

[7] nominal electric power: 181 kW