Case Studies

https://heatpumpingtechnologies.org/annex57/

ANNEX 57

Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks

FlexHeat, EnergyLab Nordhavn, Denmark

Optimized operation of large-scale heat pump with thermal storage including ancillary services

The FlexHeat heat pump system demonstrates how to combine the provision of low temperature heat pump and frequency regulation from large-scale heat pumps.

KEY FACTS

RD&D Status:
Demonstration

Type of heat pump:
Centralized heat pump (HP)

Building description:
4 Cruise-ship terminals and a high bay warehouse

System:
Low temperature district heating

Energy Storage:
100 m^3 stratified hot water storage

Control for the flexible heat pump operation:
Part load control, 7 operation modes enable highly flexible combination of HP and electric heater, and fast adaption of power uptake if required.

General description:
Two-stage ammonia HP, 800 kWth

Source:
Groundwater

Summary of the project:

The establishment and analysis of the FlexHeat heat pump was realized as part of the research and demonstration project “EnergyLab Nordhavn” that studied solutions for integrated energy systems in urban environments in a living lab established in the newly built area Nordhavn in Copenhagen, Denmark.

The FlexHeat heat pump was established in 2018 in the outer Nordhavn area. It is owned and operated by the local utility company HOFOR. The heat pump is an 800 kW two-stage ammonia heat pump that supplies heat to four cruise-ship terminals and a large-scale warehouse via a local district heating grid. The system further includes two electric heaters á 100 kW each and a 100 m^3 hot water storage tank. This set-up allows for a large flexibility regarding the operation schedule of the heat pump. To ensure a high coefficient of performance of the heat pump, the district heating return temperatures were reduced considerably through counselling of the customers.

The system has been designed to allow for flexible operation of the heat pump. This includes optimization of the operation schedule and adaption of the control to allow for fast regulation to potentially supply ancillary services to the power grid.

IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

Delivered by:

Team Denmark

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Flexible operation of FlexHeat system

The FlexHeat system was designed to allow for a high degree of operational flexibility, including the heat pump equipped with variable speed drive, fast-reacting electric boilers and a heat storage tank to allow decoupling the heat production from the heat demand. The aim was to demonstrate the ability to operate 1) according to the heat demand in the grid, 2) minimizing the electricity cost by reacting to the electricity spot market prizes, 3) supplying congestion management services to the distribution system operator, 4) supplying frequency regulation services to the transmission system operator, 5) in combination with other fast regulating assets.

Results:

- Delivery of FCR-N frequency reserve (reaction time 150 s) is economically interesting for the heat pump operator.
- Such short regulation times required to establish a dedicated control that allowed to control the power uptake directly, while ensuring enough superheating in the suction line during fast ramp downs.
- Calculations for the year 2018 showed that the heat production cost could be reduced by 6 % by optimizing the operation schedule (without provision of ancillary services), while the provision of FCR-N frequency regulation would have further reduced the heat generation cost by another 7 %.

FACTS ABOUT THE PROJECT

Place:
Nordhavn, Copenhagen, Denmark

Time Frame:
2015-2019

Project owner/leader:
HOFOR

Project partners:
HOFOR
DTU Mechanical Engineering
(involved in FlexHeat demo site, for all project partners, see https://www.energylabnordhavn.com)

Published articles:

Meesenburg, W., Markussen, W. B., Ommen, T., & Elmegaard, B. (2020). Optimizing control of two-stage ammonia heat pump for fast regulation of power uptake. Applied Energy, 271, 115123. https://doi.org/10.1016/j.apenergy.2020.115126

EnergyLab Nordhavn – Deliverables:

D5.3 – Protocol for intelligent management of heat accumulators
D5.5a - Optimum supply of an island district heating grid by a local heat plant.
D5.5b Manual for optimized operation of an island district heating grid

Further related articles and the deliverables may be found at
http://www.energylabnordhavn.com/publications.html

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