FlexHeat – Intelligent and Fast-regulating Control

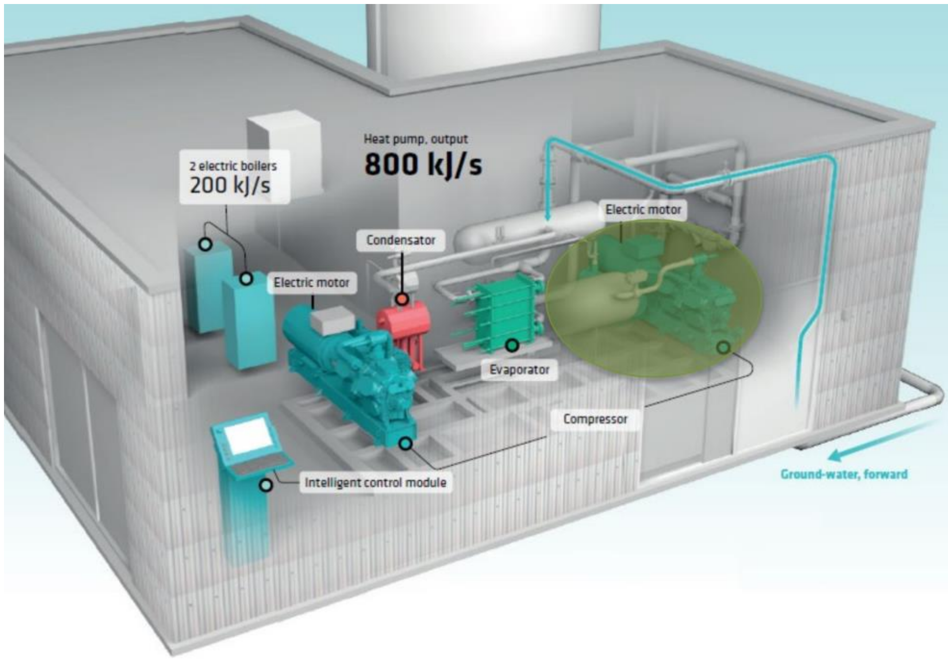

Figure 1: 3D drawing of the energy system with the most important [HOFOR, communication department, 2021]

Summary of project

A flexible energy system consisting of an 800 kJ/s ammonia-based ground-water heat pump with reciprocating compressors, 200 kJ/s electric boiler and a thermal storage tank of 100 m^3. This system delivers heat to 4 customers in an island district heating grid, which were supplied by oil-fired boilers previously.

This system is optimized by a linear-optimization model supported by a dynamic model of the heat system to schedule optimal planning production with a real-time communication setup to control the heat pump accordingly, see figure 2. The linear-optimization model includes heat forecast with inputs from weather data, complex stratified storage tank modelling, and start-up costs for the heat pump, and an electricity price forecast is supplied to find the minimum costs for the system.

On top of this, the heat pump has been modified to provide fast regulation services to the grid – here, the optimization module can additionally plan for the heat pump to deliver this service, and, still under construction, a setup is implemented to read the grid frequency and stabilize this accordingly by changing the set-points of the heat-pump.

The preliminary results indicate that operating costs can be reduced by 7 % by introducing intelligent operation with the linear optimization model, and an additional 6 % costs reduction can be achieved by delivering grid services.

Learnings and results

The most important finding here is that ammonia-based heat pumps can regulate fast enough to deliver the FCR-N service (frequency stabilization service).

It was found that this would compromise the COP due to pre-heating of the suction line and compressor blocks as well as the increased overheating from the evaporator, and that a control scheme where you would only do this if you were asked to deliver a grid service would be optimal – hence, the overall COP of the facility is not compromised, unless you choose to do so, and here you could be making money delivering a grid service.

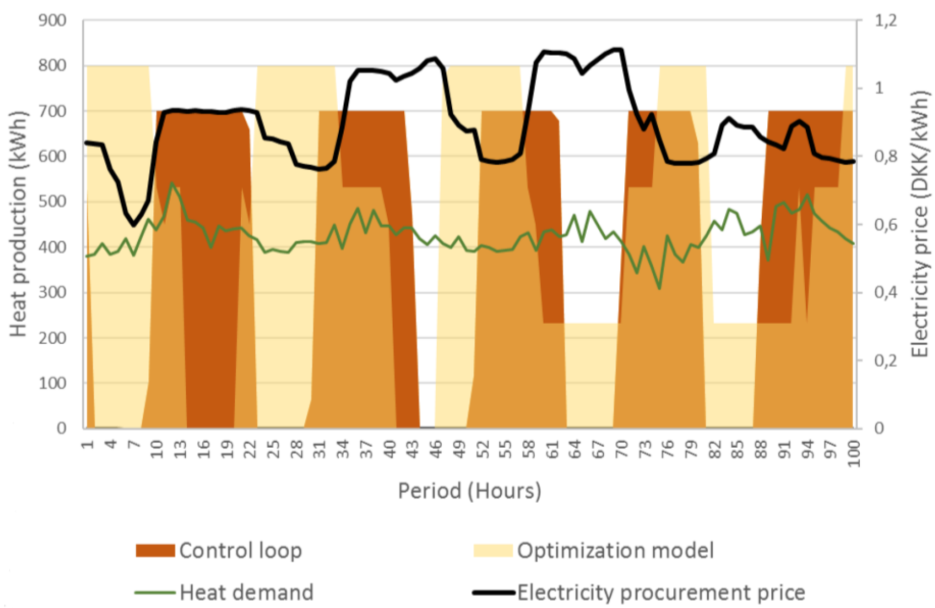

Figure 2: Flexible heat production during winter [HOFOR, 2021]

These results give an idea of asking manufacturers for a fast-regulation option in the design and control of the heat pump, the next time HOFOR build a heat pump. HOFOR have seen the feasibility of doing so, and more compressor types and refrigerants should be tested – so it is ensured, that heat pumps can help out the electricity grid now and in the future, to the benefit of the electricity system and the district heating customers.

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FACTS ABOUT THE PROJECT

IoT Catagory: Grid services.

Goal: Reduced heat production costs for the system and ensure that heat pumps can help stabilize the current and future electricity system.

Beneficiary: User, TSO and the heat pump manufacturer.

Data required: Weather forecasts, electricity price forecasts, heat pump operation data, grid frequency measurements.

Analysis method Control engineering.

Modelling requirements: Primary model is a linear-optimization model, which has been backed up by a dynamic model to support the constraints implemented.

Quality-of-Service: Real-time control signals and 24-hour optimization schedules.

Project participants: HOFOR, DTU MEK, Johnson Controls (Factory and Enterprise), COWI

Time schedule: 2018-2020

Technology availability: TRL 7.

Link to webpage:

http://www.energylabnordhavn.com/deliverables.html (see deliverable 5.5a)