Interim report – WP10

Reporting months: July 2017 – June 2018

Photo: By & Havn / Ole Malling

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Overall progress of the work towards WP Objectives

WP10.1: The Heat Booster Station (HBS) is operating in Havnehuset, supplying a section of a multifamily building including 22 flats, with domestic hot water and domestic hot water circulation. Based on the first field experience for the HBS, it can be concluded that the HBS unit is successfully installed, commissioned and operating. DHW is produced at 55°C, DHW circulation is heated from 50 °C to 55°C, with a DH supply temperature of approx. 45°C and a DH return temperature of approx. 30°C. The share of electric energy consumption for DHW and DHW circulation is 11-17%, depending on the DHW consumption. The representative electric share is around 11-13 %. The electric load shift potential is limited to approx. 12 kWh/day, whereas the DH load shift potential is approx. 120 kWh/day. On a yearly basis this is the same range as the load shift potential based on the buildings passive thermal capacity relating to the heating system. The DH return temperature could be reduced further, e.g. by compromising the cop of the heat pumps or/and increased heat pump capacity.

WP10.2: Challenges with realizing the load shift schedule principle for 8 flats in Havnekanten has resulted in limited field test results so far. Focus is on solving this and be ready for the coming heating season and apply load shift control.

WP10.3: The supermarket has been confirmed to be a Meny store. The Meny store is expected to open at the end of 2018. Planning of the integration with the district heating grid operated by HOFOR and heat recovery of the supermarket refrigeration system is currently in progress. There has been established cooperation between Danfoss, Meny and Knudsen Køl, who is the refrigeration contractor for the Meny store.

Status and activities in the WP tasks

Task 10.1 (Heat Booster Substation)

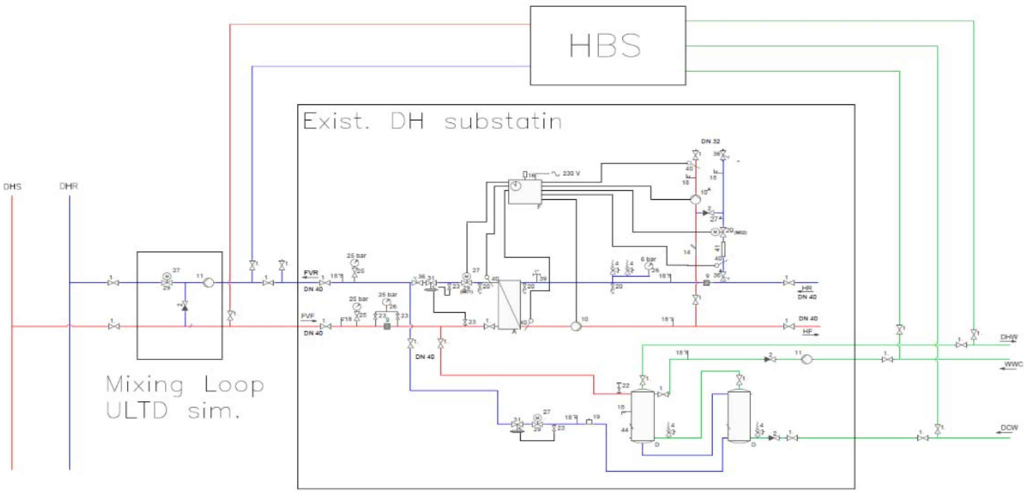
Subtask 10.1.4: Realization, Installation and field installation:

The HBS unit was installed in Havnehuset located at the Nordhavn area of Copenhagen. The heat demand originated from supplying DHW and DHW circulation to 22 flats by 8 risers.10 flats are in a 5-storey setup, and 12 flats are in a 3-storey setup, where the upper flats are in 2-storey.

The HBS consists of 4 parts; the prefabricated station or HBS module (including valves, meters, sensors, controllers, pump, pipes, heat exchanger for DHW and electrical cabinet), a prefabricated large heat pump (main) for the DH tank charging, a prefabricated (small) heat pump for the DHW circulation and two DH storage tanks of each 750 liters volume. The HBS concept can be realized with only one tank, but two were decided due to available space.

The 4 modules are shown on the figure above, where the heat pumps are placed in the front of the left figure.

For the purpose of the field evaluation, the HBS system was installed as add-on to the



existing DHW system of the building. The existing space heating system was operated in the common way, but also supplied by ULTDH. For the sake of obtaining field experience, the ULTDH was established by a mixing loop, see figure above.

HBS data pr. Day	Monday 12.03.2018	Sunday 18.03.2018
Vol DHW [liters]	2.540	2.905
DHW Energy [kWh]	133	152
DHW Circ. Energy [kWh]	78,1	77,5
DH Energy [kWh]	181	204
Main HP Electric cons. [kWh]	9,3	11,7
Circ. HP Electric cons. [kWh]	14,2	14,2
Electric share [%]	11,1	11,3
DH weighted flow temp. [°C]	44,0	44,0
DH weighted return temp. [°C]	30,5	29,1
Energy Bal. (In – Out) [kWh]	-6,5	0,4

The table above includes the essential performance of the HBS for two days. The main performance data relates to the share of electricity consumption, which was approx. 11% of the used electric and DH energy, the DH inlet temperature of 44°C and DH return temperature of approx. 30°C. To understand the low electric share, it should be noted that e.g. out of 133kWh for DHW, the 49 kWh were boosted via the main heat pump condenser and the remaining 84kWh were directly from the DH supply. This also explains why the main heat pump's electricity consumption is lower than the circulation heat pump, even though the DHW energy consumption is higher than the DHW circulation heat loss. The electric share depends on the use of DHW, in case of no DHW use at all, and still considering the tank to be charged, the electric share would be approx. 30%. In case the DH tank is not charged the electric share would correspond to the COP of the circulation heat pump, approximately 20%. In case of a low DHW consumption, e.g. one measured day of 1.318 liters of DHW, the electric share was 15,7%. The energy balance on the daily basis indicates that the delivery of energy to DHW for the week-day is slightly out of balance, dut to shift between DHW load and charging of the tank.

Based on the field experience so far, the capacity during charging of the tank is 3,0 kW electric and 30 kW thermal from DH net. Based on 4 hrs. charging time pr. day, the load shift potential becomes:

Electric load shift potential:	12 kWh/day
DH load shift potential:	120 kWh/day

Comparing this to the heat demand pr. day of the building, which is in the design peak load range of 50 kW, and considering shifting this 5 hrs, the load shift potential for heating becomes 250 kWh/day, and this for peak load. On a yearly basis the average load shift potential is less than half, meaning that for a new building of this type, the load shift potential of DHW is in the same range as for the heating system. No load shift potential is present for the circulation heat pump, since its running continuously.

Heat pump for domestic hot water circulation: Conceptual work was changed a couple of times during the last period. Now the concept if finally in place. The heat pump system is specified and ordered. The test site is agreed, and it is located at Strandboulevarden close to the Nordhavn area.

Task 10.2 (Smart Control of building heating service)

Energy meters currently collect data from four apartments, which represent two sets of identical apartments. The average ambient temperature was 0ºC during the month of March 2018. In this time, the heating demand was fairly constant in each apartment, and the overall average was 6 W/m2. We expect to be able to shift all of this heating for a period of more than 3 hours per day without disturbing the occupants' thermal comfort. We have data agreements with 8 apartments, so these apartments could provide a load shift of 15.7 kWh/day during the coldest months of winter. The total floor area of the building is 8671 m2, so the load shift potential for the entire building is 156 kWh/day.

Task 10.3 Utilisation of spare heat pump capacity

Subtask 10.3.2 Control Concept Development:

A system efficiency measurement algorithm (COP=coefficient of performance) is under development and is expected to be integrated into the Meny supermarket control system by end 2018. This is the first step towards optimization the energy efficiency by enabling measurement of the actual system efficiency.
Further activities are ongoing together to develop control strategies for ensuring energy optimal cooling and heat production in the supermarket control system. These are still at an early stage and is not expected to be rolled out before second half of 2019.

Deliverable status

D #	**Deliverable title**	**Planned completion month**	**Status** **1** = on schedule **2** = completed **3** = delayed
D10.1b	Heat Booster substation realisation for field test and installation in buildings	Feb. 2018	**2 – by April 2018**

Dissemination

The WP10 was presented at the Nordic Energy Experience 2018, hosted at the E.HUB.

Thorsen JE, Ommen T., FIELD EXPIERIENCE WITH ULTDH BOOSTER SUBSTATION FOR MULTIFAMILY BUILDING, for the International Symposium on District Heating and Cooling, DHC2018, September, Hamburg.

Zühlsdorf B, Meesenburg W, Ommen TS, Thorsen JE, Markussen WB, Elmegaard B. Improving the performance of booster heat pumps using zeotropic mixtures. Energy 2018;154. doi:10.1016/j.energy.2018.04.137.

Nielsen, Emil Munch, Master Thesis, “Experimental assessment of the dynamic behavior of a booster heat pump”, DTU-Department of Mechanical Engineering, May 2018

Next steps

WP10.1: Focus on demonstrating load shift based on energy system data for the HBS demonstration. Manufacture, test and install the circulation HP at Strandboulevarden.

WP10.2: Focus on getting more Danfoss Link systems in apartments connected to the Danfoss Cloud (more data). Test and ensure stability of the Cloud scheduling feature. Support data extraction to DTU from Danfoss Cloud.

WP10.3: Get HRU installed and test system efficiency measurement algorithm.

Quality Assurance

Status of deliverable		
Action	By	Date
Sent for review	Jan Eric Thorsen	15.06.2018
Reviewed	Brian Elmegaard – DTU-MEK	21.06.2018
Approved	WPL group	06.07.2018

Author	Reviewer	Approver
Jan Eric Thorsen	Brian Elmegaard	Christoffer Greisen

The project “EnergyLab Nordhavn – new urban energy infrastructures” will develop and demonstrate future energy solutions. The project utilizes Copenhagen’s Nordhavn as a full-scale smart city energy lab and demonstrates how electricity and heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimized energy system. The project participants are: DTU, City of Copenhagen, CPH City & Port Development, HOFOR, Radius, ABB, Balslev, Danfoss, CleanCharge, METRO THERM, Glen Dimplex and the PowerLab facilities. The project is supported by EUDP (Energy Technology Development and Demonstration Programme), grant 64015-0055 and runs from 2015-2019.