Interim report – WP4

Reporting months: July 2017 – June 2018

Photo: By & Havn / Ole Malling

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Overall progress of the work towards WP Objectives

The recruitment of the residences for the fuel shift installations has been started. Verification of the fuel shift controller and configuration settings is ongoing at DTU Risø SYSLAB. Work on defining and structuring measurement data is started in collaboration with WP2.

Live site for the Quantum Heater installations were located and 9 heaters are installed at E-hub in Nordhavn. The specification and design of Quantum smart controller have now been started and the plan is to demonstrate load scheduling (Electricity price response).

The work to develop a public fuel-shift catalogue is ongoing and is currently a topic of interest for a master thesis student.
As the work focusses on a range of the different types of applications, representative data for use and integration is a key input to differentiate the technologies. However, it is not easy to obtain such data, as the processing of data is not finalized in other work packages.

Status and activities in the WP tasks

Task 4.1 Identification and characterization of smart network services for urban network operation

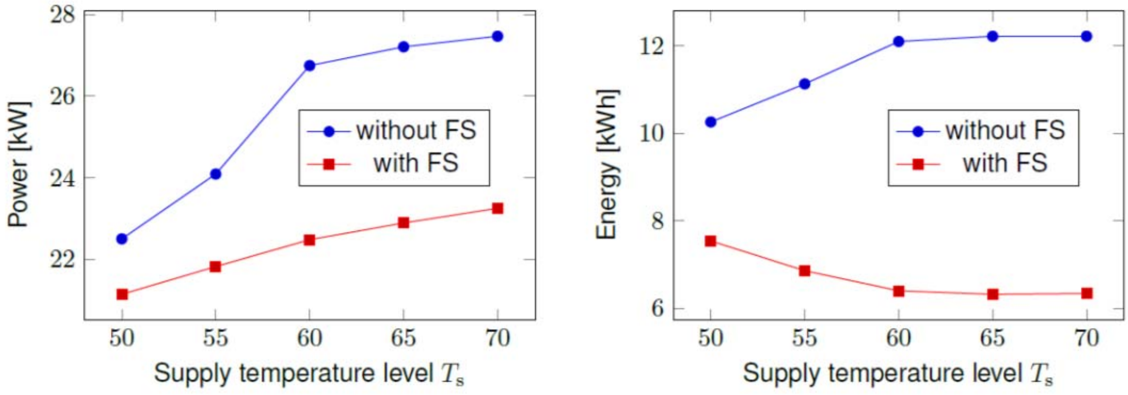
Smart network services (SNS) have been successfully identified and characterized in D4.1, which is already published. Three suggested SNS, i.e., load management, power balancing and frequency support will be implemented and tested by using the experimental setup of WP4.
The task is completed.

Task 4.2 Design of advanced situation-aware control algorithms for using smart energy components to provide smart network services

The conceptual design of situation awareness framework has been implemented in a simulation-based case study. To exemplify the interactions between district heating and power system, dynamic day-ahead pricing scheme was employed. However, we concluded this type of smart interaction is only feasible if we have lower electricity tax than it is right now. Electricity price is much more expensive than district heating price and controller will always choose district heating since it is much cheaper. The result has been presented in a conference paper.

Software based verification was then carried out to verify the conceptual design of situation awareness. The idea was to check if the design of finite-state machine has any flaw that could cause severe impact at the end user side. Simulation in Uppaal (Integrated tool for modelling, validation and verification) validates the design. This simulation result will be summarized in a journal paper.

In addition, a study was carried out to assess the benefit of fuel-shift service. It was found out that, fuel shift could provide substantial benefits (as the figure below) in terms of reducing peak boiler usage, managing network congestion and reducing CO_2 emission level. The result has been published in a journal.



(a) DH base power production

(b) Peak boiler usage

Verification study

The analyzed network consists of 23 single-family houses. The value of power and energy (as shown in the figure above) includes both space heating and domestic hot water heating in the study. Note that the electric heat boosters are only used to heat up the domestic hot water.

Regarding academic publication so far, 2 conference papers and 1 journal paper have been published and 1 journal paper submitted.

Task 4.3 Design development and testing of low-cost controllers for distributed energy resources

We have now been able to locate a live site for the Glen Dimplex Quantum heaters and have installed 9 heaters at the E-hub EnergyLab Nordhavn premises in Nordhavn. The heaters are installed in the three conference rooms and in the showroom. As there is no disparity between private or public test situations, we will be able to gather live data and not only data and demonstrations from the test lab as previously planned.

Installed Quantum heater in the showroom in Nordhavn

Another Quantum heater has been installed at the DTU Lyngby campus and will be used during the development of the controller software.

There have been some difficulties to start communication between the control system and the Quantum devices.

The test of communication was divided into two parts:

1) Test whether laptop could retrieve the data from the heater.
2) Test whether a configuration frame from laptop could be received and accepted by the heater.

So far, only part 1) was finished and verified and part 2) is still ongoing. The script for communication needs further development from the developers at Glen Dimplex. These issues are about to be solved and work is ongoing in adapting software to perform tests.

Because of the previous reduced scope (see 2017 Interim report) and due to the delays and time shortages, it has been decided to reduce the scope to only include and demonstrate Load Scheduling.

Task 4.4 Design, development and testing of low-cost controllers for fuel-shift technologies and/or low temperature district heating

The installation of all 24 fuel-shift ready Metro Therm district heat units with combo water heaters is done in Nordhavn Casa and Tetris.

In Kielsgade 11 one installation is equipped with DTU ELN controller, and is up and running.

A model is agreed for ensuring that the residents in Casa and Tetris, who participate in the experiment with fuel-shift and cold district heating, will not have to pay for the electricity used for heating of domestic hot water during the trial period.

A series of tests have been carried out at DTU Powerlab DK, at Risø on the Metro Therm district heat unit System 5, with 110L combo water heater and DTU ELN controller.

To ensure that the system runs without operating problems and complies with the water standard DS439 tapping requirements for shower, the system has been tested under normal district heating temperature > 60°C, cold district heating at 45°C and fuel-shift.

Test setup at PowerlabDK PowerFlexHouse Risø

Testing is still being carried out to determine the optimal sensor position, for the minimum amount of electricity used, during cold district heating operation.

A domestic hot water heat pump, METROAIR AQUA 201, will be installed in the showroom. It is connected to the supply of hot water to the toilets and kitchen and to the ventilation of the showroom.

The METROAIR AQUA 201 will be included in and provide the project with measurement results.

An information meeting with residents at Frikvarteret has been held, where we informed the residents about the project and explained what we want to install.
The responses from and after the meeting were positive and we expect to start installations during or end of the summer period.

Task 4.5 Demonstration, evaluation and comparison of control solutions for using smart energy components to provide smart network services

This task has not yet been started, but the organization has been identified and is now awaiting the rollout of equipment in EnergyLab Nordhavn to be completed.

Task 4.6 Development of public fuel-shift catalogue

The work on development of a catalogue was delayed by approx. 7 months due to a shift of effort and contributions by key personnel in the group. The work is thus ongoing and monthly meetings are held to ensure the progress of the task. To add to this, the development of the fuel shift catalogue is currently a topic of interest for a master thesis student.

As the work focusses on a range of the different types of applications, representative data for use and integration is a key input to differentiate the technologies. However, it is not easy to obtain such data, as the processing of data is not finalized in other work packages. Calculations of initial cases were performed, which indicate that the real benefit of the technical solutions should be evaluated on socioeconomic terms, rather than private economic, as the current taxes and tariffs do not support the use of such technologies. For this reason, the group is also participating in the task on energy prices and tariffs in WP8.

Following the ongoing work,
- Remaining relevant technologies to be considered in the catalogue should be modelled.
- Few relevant cost scenarios should be established in T8.4.
- Calculation of key performance indicators based on the models.
- Description of the method and of all considered technologies.

Deliverable status

D4	Deliverable title	Planned completion month	Status **1** = on schedule **2** = completed **3** = delayed
D4.1	Report/paper on Identification and characterization of smart network services for urban network operation	Oct. 2016	**2**
D4.2	Situation-aware control algorithms for using smart energy components to provide smart network services with software-based verification report	Dec. 2018	**1**
D4.3a	Installation and SAT test report on Glen Dimplex storage space heating technology	Dec. 2017	**3**
D4.3b	Low-cost controllers specification, design and test report	Jan. 2018	**3**
D4.3c	Validation document on field-data collection from storage heaters	Feb. 2018	**3**
D4.4a1	Installation and SAT test report on 11 installations of district heating units with hot water tank (small tanks)	Nov. 2017	**3**
D4.4a2	Installation and SAT test report on 11 installations of district heating units with hot water tank (big tanks)	Jan. 2018	**3**
D4.4b	Installation and SAT test report on one booster heat pump installations: air/water or water/water	Nov. 2017	**3**
D4.4c	Installation and SAT test report on two domestic hot water heat pumps with integrated water tank	Sep. 2015	**3**
D4.4d	Low-cost controllers specification, design and test report	July 2017	**2**
D4.4e	Validation document on field-data collection from DHW appliances	Dec. 2018	**1**
D4.5a	Validation document on field-data collection from demonstration	Sep. 2018	**1**
D4.5b	Report on demonstration, evaluation and comparison of enabling smart network services through autonomous control solutions and coordinated control solutions	Sep. 2018	**1**
D4.6	Public fuel-shift catalogue and their role in the smart energy system	Oct. 2018	**1**

All activities in 4.3 were delayed due to needed re-scoping and as we first late 2017 were able to locate a site, (E-hub) for the installations of the Quantum heater.

D4.3a Delivery report created. Planned ready June 2018
D4.3b Design of low cost controller started.

D4.4a1 and D4.4a2. The reports will first be created after the installations of the fuel shift controllers in Nordhavn. Planned Aug / Sept.

D4.4b Heat booster will be installed in E-hub during/after summer 2018.

D4.4c No locations found for the domestic heat pump installations.

Dissemination

Published

Cai Hanmin, You S, Wang J, Bindner HW, Klyapovskiy S. Technical assessment of electric heat boosters in low-temperature district heating based on combined heat and power analysis. Energy. 2018 May 1;150:938-49.

Cai Hanmin, You S, Bindner HW, Klyapovskiy S, Yang X, Li R. Optimal scheduling for electric heat booster under day-ahead electricity and heat pricing. InUniversities Power Engineering Conference (UPEC), 2017 52nd International 2017 Aug 28 (pp. 1-4). IEEE.

Cai Hanmin, You S, Bindner HW, Klyapovskiy S. Load Situation Awareness Design for Integration in Multi-Energy System. InEnergy Internet (ICEI), IEEE International Conference on 2017 Apr 17 (pp. 42-47). IEEE.

Submitted

Cai Hanmin, You S, Ziras C, Li R, Honore K, Bindner HW. Demand side management in urban district heating networks, ***submitted to Applied Energy***

Next steps

- Structuring (metadata) of data in collaboration with WP2.
- Collaboration with T8.4 about establishing of smart control logic functions and cost scenarios.
- Calibration of 160 l water tank for fuel shift (Casa).
- Install ELN fuel shift solution in Tetris and Casa buildings.
- Develop Quantum smart controller.
- Planning and carrying out of tests and measurements in Tetris and Casa buildings for fuel shift.
- Planning and carrying out of tests and measurements in E-hub for load scheduling of Quantum heater.

- Publication of due deliverable reports.
- Consider relevant technologies to be modelled and included in the fuel shift catalogue.

Quality Assurance

Status of deliverable		
Action	By	Date
Sent for review	Magnus Klintström	2018-06-13
Reviewed	Jan Eric Thorsen	2018-06-14
Approved	WPL	02-07-2018

Author	Reviewer	Approver
Magnus Klintström	Jan Eric Thorsen	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 64014-0555 and runs from 2015-2019.