Deliverable no.: D4.4b
Heat pump installations: air/water or water/water

Photo: By & Havn / Ole Malling

METRO THERM A/S
Kasper Korsholm Østergaard
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Public deliverable ☒
Confidential deliverable ☐

Preface

EnergyLab Nordhavn – New Urban Energy Infrastructures is an exciting project, which will continue until the year of 2019. The project will use Copenhagen's Nordhavn as a full-scale smart city energy lab, which main purpose is to do research and to develop and demonstrate future energy solutions of renewable energy.

The goal is to identify the most cost-effective smart energy system, which can contribute to the major climate challenges the world are facing.

Budget: The project has a total budget of DKK 143 m (€ 19 m), of this DKK84 m (€ 11 m) funded in two rounds by the Danish Energy Technology Development and Demonstration Programme (EUDP).

Forord

EnergyLab Nordhavn er et spændende projekt der løber til og med 2019. Projektet vil foregå i Københavns Nordhavn, og vil fungere som et fuldskala storbylaboratorium, der skal undersøge, udvikle og demonstrerer løsninger for fremtidens energisystem.

Målet er at finde fremtidens mest omkostningseffektive energisystem, der desuden kan bidrage til en løsning på de store klimaudfordringer verden står overfor nu og i fremtiden.

Budget: Projektets totale budget er DKK 143 mio. (EUR 19 mio.), hvoraf DKK 84 mio. (EUR 11 mio.) er blevet finansieret af Energiteknologisk Udviklings- og Demonstrationsprogram, EUDP.

Project Information

Deliverable no.:	**D4.4b**
Deliverable title:	**D4.4b Installation and SAT test report on one booster heat pump installations: air/water or water/water**
WP title:	**WP4 - Smart Network Services**
Task Leader:	**Torben Schifter-Holm, METRO THERM A/S**
WP Leader:	**Magnus Klintström, DTU**
Comment Period:	**[April 2019 to July 2019]**

For further information on this deliverable, please contact:

Kasper Korsholm Østergaard
KKO@metrotherm.dk

For other information regarding EnergyLab Nordhavn, please contact:

EnergyLab Nordhavn Secretariat
Center for Electric Power and Energy, DTU Electrical Engineering
Elektrovej
Building 325
DK-2800 Kgs. Lyngby
Denmark

E-mail eln@dtu.dk
Tlf. +45 45 25 35 54

www.energylabnordhavn.dk

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Executive Summary

As part of the EnergyLab Nordhavn project, By & Havn, METRO THERM A/S and other partners have been looking for relevant installation sites/demonstration hosts for small booster heat pumps, either air/water or water/water. The purpose is to boost domestic hot water to set-point temperature in installations where district heating supply temperature is insufficient for domestic hot water production, i.e., Ultra Low temperature District Heating (ULTDH).

Until now it has not been possible to identify a suitable host for a water/water booster.

While participating in the ELN project, however, METRO THERM has been developing and production maturing a so called micro booster water to water heat pump (MBHP). This product development has its offset in the ELN project and what later became a real product was initially describe and simulated in the DTU master thesis: ”Integration of Micro Booster Heat Pump Units for Domestic Hot Water Preparation in Low-Temperature District Heating Networks”, 2015, by Matteo Caramaschi.

The MBHP has now been launched in most of Europe and the first installations are in operation in Austria.

The heat pump type is also believed to find its way into the Danish District Heating networks, albeit most likely in systems with lower plot ratios than at inner cities.

Version Control

Version	Date	Author	Description of Changes
1.0	2019-04-01	Kasper Korsholm Østergaard	First draft
3.0	2019-06-24	Kasper Korsholm Østergaard	Updated after review
5.0	2019-07-09	Magnus Klintström	Comments checked and removed
6.0	2019-07-30	WPL approved	

Quality Assurance

Author	Reviewer	Approver
Kasper Korsholm Østergaard	Kristian Honoré, HOFOR	WPL group

Status of deliverable		
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Verified	Magnus Klintström, DTU	9-7-2019
Approved	WPL group	30-7-2019

1. Introduction

As part of the EnergyLab Nordhavn project, By & Havn, METRO THERM A/S and other partners have been looking for relevant installation sites/demonstration hosts for small booster heat pumps, either air/water or water/water. The purpose is to boost domestic hot water to set-point temperature in installations where district heating supply temperature is insufficient for domestic hot water production, i.e., Ultra Low temperature District Heating (ULTDH).

Until now it has not been possible to identify a suitable host for a water/water booster. However, in the ELN showroom a domestic hot water heat pump, operation as an exhaust air heat pumps has been installed. This is handled and describe in deliverable 4.4c.

While participating in the ELN project METRO THERM has been developing and production maturing a so called micro booster water to water heat pump (MBHP). This product development has its offset in the ELN project and what later became a real product was initially describe and simulated in the DTU thesis: ”Integration of Micro Booster Heat Pump Units for Domestic Hot Water Preparation in Low-Temperature District Heating Networks”, 2015, by Matteo Caramaschi.

The thesis work was done in collaboration between DTU MEK and METRO THERM, and Matteo Caramaschi later become a METRO THERM employee.

The MBHP has now been launched in most of Europe and the first installations are in operation in Austria. The product has been launched in Denmark spring 2019 in the METRO THERM and the Vølund brands.

A successful work shop was also held at METRO THERM on Large HPs and Micro booster HPs in District Heating systems in August 2018 debating and comparing the MBHP technology to the use of large heat pumps.

This report gives an overview of the MBHP technology and outlines various installations options.

2. The microbooster hot water heat pump (MBHP)

The MBHP belongs to the latest, high performing generation of DHWHPs produced at METRO THERM. The unit type was introduced autumn 2018, it is manufactured in Helsinge in Denmark, and it is intended for the home marked as well as for export to Europe.

The unit is very versatile by means of a very wide source water temperature operational envelope. It is the best in class and it holds the highest Coefficient of Performance (COP) for this type of heat pumps sold on the marked today partly due to the novel integration of the pre-heating coil into the control and operation of the unit.

2.1 Technical data

P: Pump control, no pre-heating coil
V: Valve control, no pre-heating coil
PS: Pump control, incl. pre-heating coil
VS: Valve control, incl. pre-heating coil

Technical data	Unit	P	V	PS	VS
Nominal volume, storage tank	l	190		180	
Diameter	mm	ø603			
Height	mm	1570			
Weight	kg	98		104	
Water connections	"	¾ - BSPT (ISO 7-1)			
Heat source connections	mm	22 – Compression fittings			
Maximum allowed water pressure	MPa	1,0			
Maximum allowed heat source pressure	kPa	0,3	1,0	0,3	1,0
Refrigerant	-	R134a			
Electrical connection	V/Hz	230/50 (L1, N, G)			
Fuse size	A	10(13)			
Max. size supplementary electrical heater	W	1500			
Max. water temperature in the tank (heat pump alone)	°C	65			
Source water temperature range	°C	5[1]- 60[2]			
Min. required source water flow	l/h	100			
Performance – W25/10-53.5 (L tapping)[3]					
Unit COP (Heat pump alone)	-	5.2[4]			
Heat-up time	hh:mm	04:30			
Average heating capacity	W	2100			
Performance - W40/10-53.5 with optional coil (L tapping)[3]					
Unit COP (Including pre-heating)	-	8.5[4]			
Heat-up time	hh:mm	03:50			
Average heating capacity	W	2500			

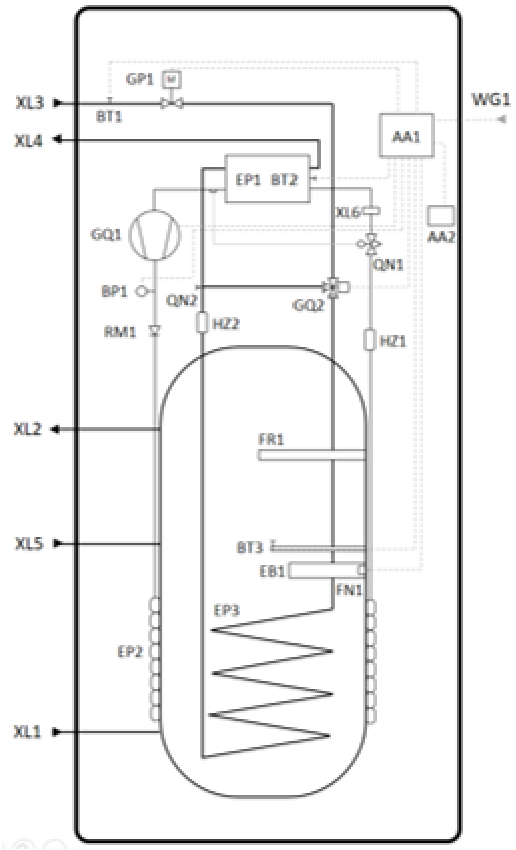
[1] Brine. If uninhibited water, the minimum source temperature can be 10 °C.
[2] Only for units with coil. For units without coil, 55 °C applies.
[3] Test methodologies of EN16147, modified heat source temperatures.
[4] Results to be subjected to 3rd party verification.

2.2 Main features

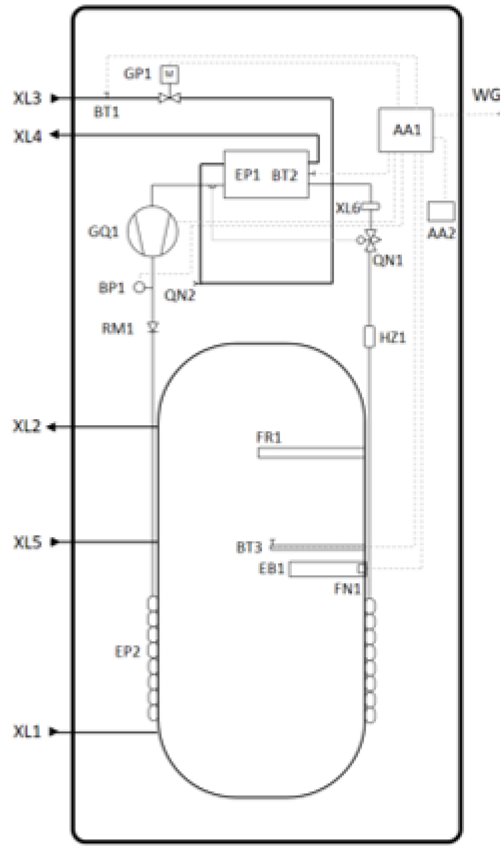
- Floor standing unit with rear or front pipe connections
- Enamelled steel tank
- Easy transport and installation
- Hot water tank charging strategies:
  - Direct pre-heating via internal heating coil and/or
  - Via heat pump circuit
- Flexible operation with a wide range of heat source e.g. district heating, space heating return, ground or air source heat pump
- Source water flow control by either circulation pump or control valve
- Legionella control via heat pump alone up to 65°C
- Electrical back-up heater
- Low sound emissions
- User friendly LCD display
- Modes of operation: AUTO, ECO, BOOST, BACKUP, HOLIDAY mode
- Functionalities: Photovoltaic, Smart Grid Ready, Low Tariff
- Outstanding COP

2.3 Layout

With optional direct pre-heating



Without direct pre-heating

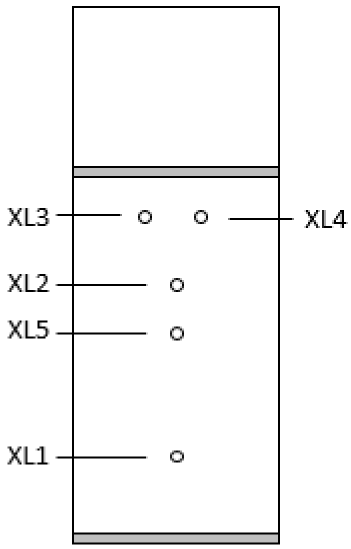


Refrigerant circuit
GQ1: Rotary compressor
GQ2: Three-way valve*
GP1: Control valve with motorised actuator or variable speed pump
RM1: Check valve 3/8"
EP1: Flat-plate evaporator
EP2: Condenser
HZ1: Filter drier
QN1: Thermostatic expansion valve
XL6: Service valve
1: Suction line 3/8"
2: Discharge line 5/16", 3/8"
3: Liquid line 5/16", ¼"
4: Liquid line 3/8", ¼"

Sensors
BT1: Source inlet temperature
BT2: Source outlet temperature
BT3: Tank water temperature
BP1: High pressure switch

Water circuit
XL1: Water inlet ¾" or 22 mm
XL2: Water outlet ¾" or 22 mm
XL3: Source inlet 22 mm
XL4: Source outlet 22 mm
XL5: Water recirculation ¾" or 22 mm
EP3: Coil*
FR1: Anode
FN1: Thermal protection
QN2: Air vent
HZ2: Filter/Strainer*
EB1: Electric element

Controller
AA1: Main printed circuit board
AA2: Display circuit board



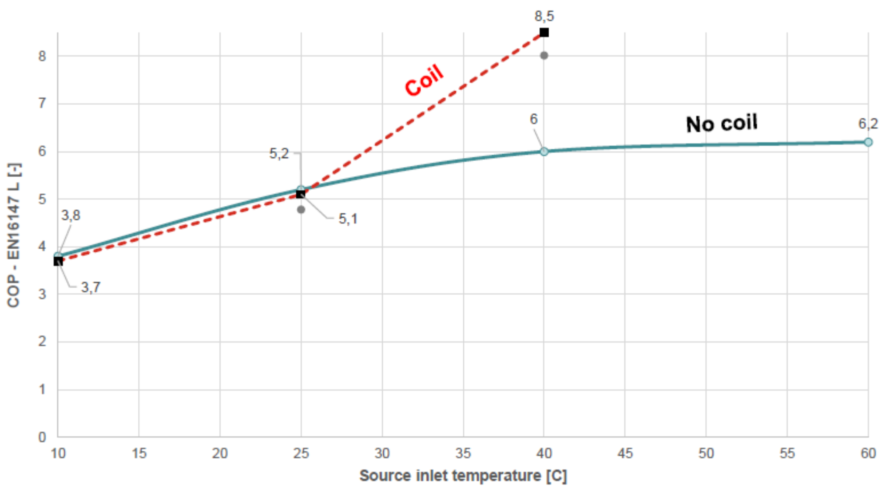
*Optional component, available only for units with pre-heating coil
Nomenclature according to IEC 81346.

2.4 Working principle

The heat pump water heater is composed of a water tank, a refrigerant circuit, a cabinet and a display connected to a control board. The main scope of the appliance is to heat water stored in a tank by use of some sort of low temperature water supply. The source water could be ultra-low temperature district heating, low temperature water from a centralised heat pump in a micro grid, excess process heat, etc.

The unit is programmed to start heating the water inside the tank when its temperature falls below a predetermined level. The unit stops when the water temperature reaches a set point that can be regulated by the user. In general, the appliance is designed to produce enough hot water to cover the need of a household of 4 persons.

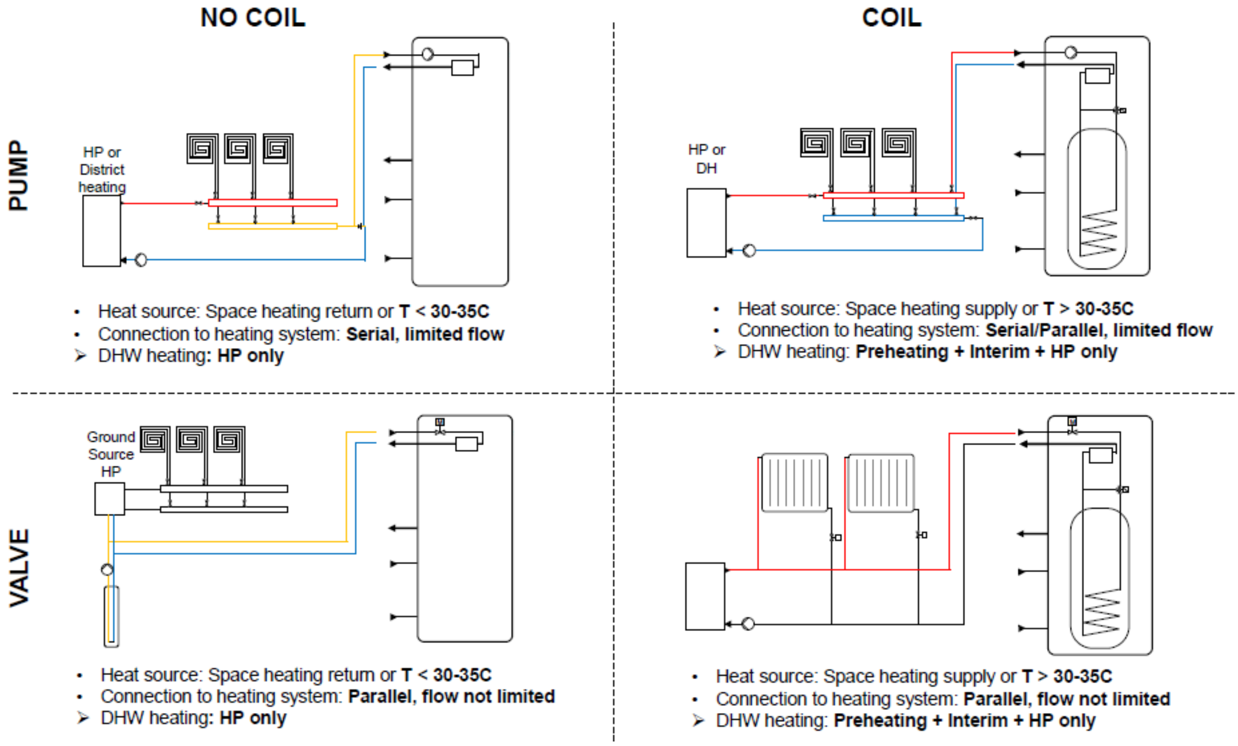
Very high COPs can be obtained, especially with a unit with a preheating coil where only minimal electrical power is used to drive the compressor to lift the water temperature the final interval to set-point.



For further information, please see:
https://www.metrotherm.dk/produkter/varmepumper/brugsvandsvarmepumper/metro-microbooster

2.5 Possible applications

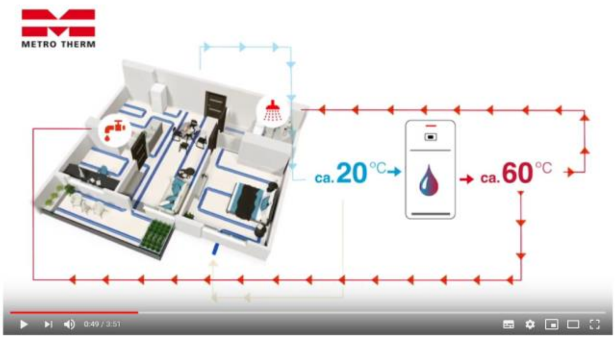
The figure below is generic at is intended for inspiration.



3. Installation in Austria

The first larger scale commercial use of the MBHP is at two housing developments in Austria. A version of the MBHP (pump, no pre-heat) is installed in each flat utilizing return flow from the floor heating. A larger centralised ground source heat pump is supplying space heat to each flat.

In summer, the central ground source heat pump can be switched off and the MBHPs are gaining source water energy by cooling the floor heating water, thereby providing cooling to the dwelling. Alternatively by passive heat exchange to the ground source brine circuit.



For more information about the installations please see:
https://youtu.be/0NmssKuXBF4

4. Perspectives of micro booster technology in Denmark

A work shop was also held at METRO THERM on Large HPs and Micro booster HPs in District Heating systems in August 2018 debating and comparing the MBHP technology to the use of large heat pumps. It was generally accepted that among the ULTDH solutions, micro-booster HPs (apartment units) were best for low space heat demand densities, while the building units (booster HP and air-source HP) are more feasible for larger space heat demand densities. At least for efficient district heating networks with high plot ratios and low network losses.

The MBHP is having most effect at lower plot ratio networks (suburban areas and towns) where the overall heat loss is larger than in dense urban areas. In suburban areas and towns the effect of lowering the network temperatures by use of MBHP technology is significant due the large savings on heat loss. In these areas, dwellings are also often bigger and it is therefore easier to accommodate MBHPs in each dwelling.

The MBHP has been launched in Denmark in the spring 2019 in two brands, i.e., METRO THERM and Vølund. The unit has gained interest from a number of district heating operations, either as means of lowering temperatures in new extension of existing networks or alternatively as means of solving on-going challenges with too low flow temperatures for sufficient domestic hot water production for customers in the far end of the network.

Besides classic district heating networks the MHPS is also believed to play a future role in micro networks where, e.g., a common heat pumps is supplying a number of dwellings with space heat at ultra-low temperatures and the MBHPs are generating DHW in each dwelling. The prospects are many.

5. Conclusion

A micro booster heat pumps has been successfully developed by METRO THERM. The development has its offset in a master thesis work performed early in the EnergyLab Nordhavn screening period.

Although it has not been possible to find suitable hosts for the MBHP in the ELN project the unit has now been commercialised and is sold in a number of countries in Europe. It is also believed that the MBHP will gain volume in the Danish heating system in the future.

Given the late stage of the ELN project there is no intentions to continue searching for a suitable demonstration host in the project.

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