District Heating Substation with Electrical Booster Supplied by 40°C Warm District Heating Water

EUDP project - District Heating unit with Electrical Booster for Ultra-Low-Temperature District Heating

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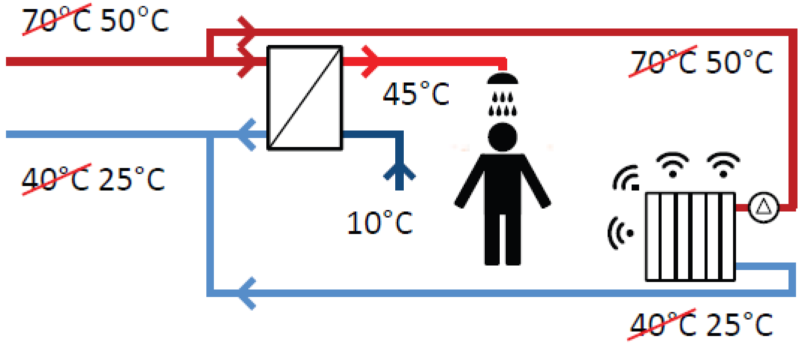
Why reducing the DH supply temperature?

- Improve energy efficiency and better use of renewables
  - Big scale heat pumps -> increase of COP
  - Solar-thermal plants
- Enable use of low-grade waste heat
- Reduce heat loss from DH network
  - Importance increased with reduced demand of buildings



Low-temperature district heating principle

- Temperature levels:

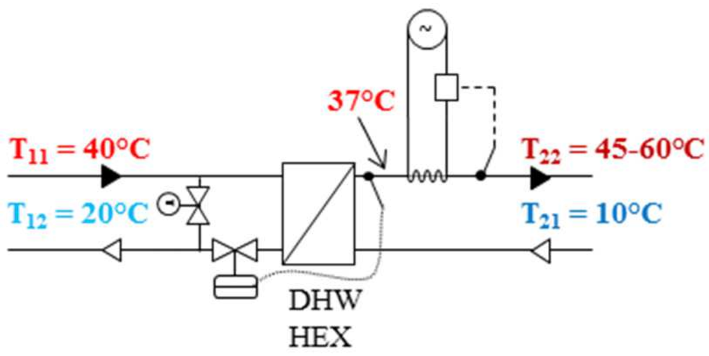
DH supply temperatures		DH network heat loss [%]	Need of on-site heat source
>60°C	Traditional DH	100%	NO
50°C	Low-temperature DH	81%	NO
40°C	Ultra-low-temperature DH	56%	YES

Development ⇨ of new unit

International Conference on Smart Energy Systems and 4th Generation District Heating, Copenhagen, 25-26 August 2015

Substation with electrical booster

- DH substation + instantaneous electrical heater (on DHW side)
  - DH designed inlet temperature: 40°C
  - DHW temperature: (37°C) -> 45- 60°C
  - Substation bypass: 40°C
  - DHW output: 24 kW
  - Max. el. power: 11 kW -> 35 A main fuse



Scheme of electrical booster

- Theoretical share of electricity on
  - DHW : *(10°)* ⇨ 37°C ⇨ 45°C = 23%

    (10°) ⇨ 37°C ⇨ 55°C = 40%

  - Total heat demand:

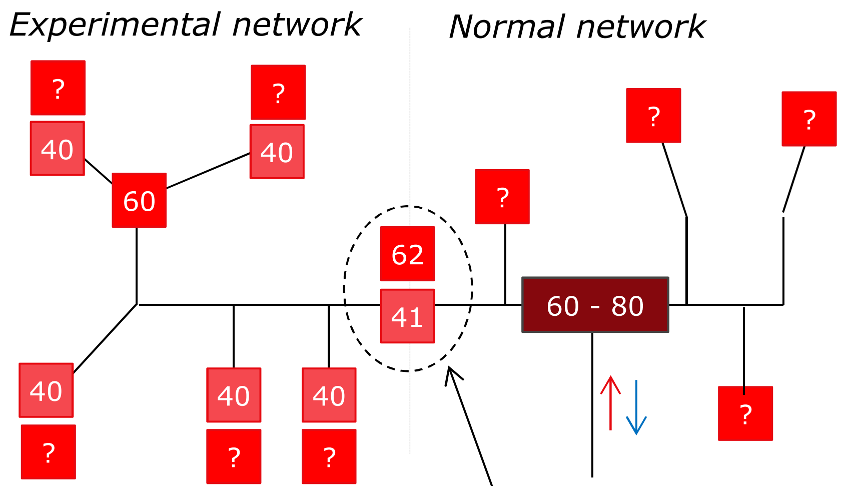
Building area: 120 m²	Construction year	Space heating demand [MWh/y]	DHW demand* [MWh/y]	Theoretical share of el. on total heating energy [%] DHW 45°C	Theoretical share of el. on total heating energy [%] DHW 55°C
Low-energy house	2010	6,3	1,8	5,1	8,9
Existing building - newer	1997	16,4	1,8	2,3	4
Existing building - old	1970	20	1,8	1,9	3,3

** Measured in the project*

Demonstration area and conditions

- City of Odder
- Five buildings from 1997
- Mainly floor heating + few radiators

- DH network and testing conditions



One of the buildings

Mixing shunt

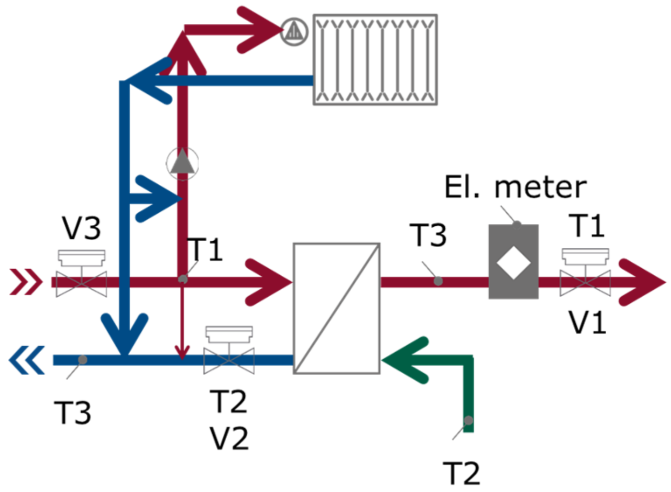
Supply temperature

62 *El. heater OFF + street bypass 60°C*

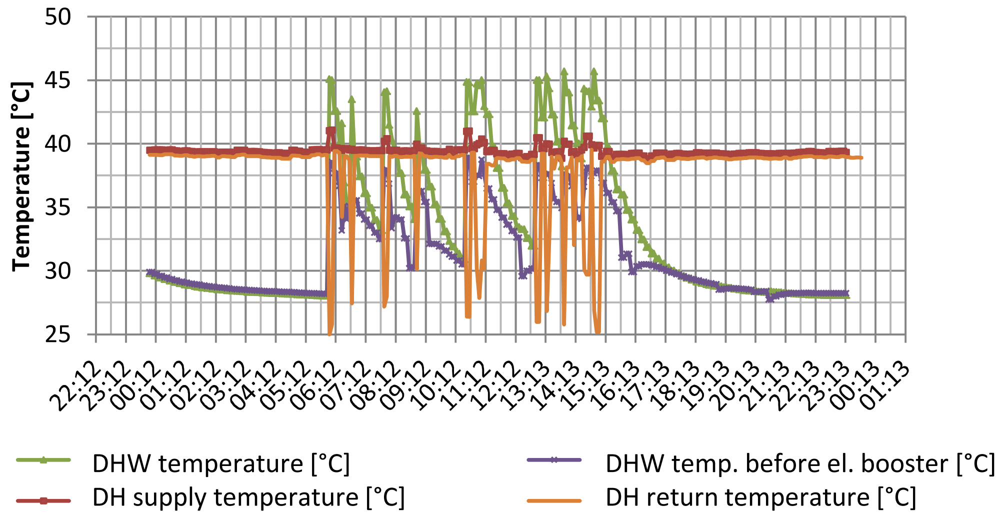
41 *El. heater ON + house bypass 40°C*

Performance – user perspective

Measuring setup



Performance of electric booster



El. share on DHW part-> 23% 30%

Building area: 120 m²	Construc tion year	SH demand [MWh/y]	DHW demand [MWh/y]	Share of el. on total heating energy [%] DHW 45°C	
				Theoretical (23%)	Measured (30%)
Low-energy house	2010	6,3	1,8	5,1%	6,7%
Existing building	1997	16,4	1,8	2,3%	3%
Existing building	1970	20	1,8	1,9%	2,5%

Economy

Reduced heat price can come from:

- Low-grade heat (40°C):
  - Sea water heat pump (sea water cooled from 4°C - 2°C):
    - COP ≈ 2.9 for 80/40°C
    - COP ≈ 4.2 for 50/30°C => reducing the el input 31 %
    - COP ≈ 5.2 for 40/25° => reducing the el input 43 %
  - Use of low-grade waste heat in price level 100 - 332 DKK/MWh
- Return temperature reduction: Biomass CHP reduction 40 → 25°C brings 6% lower heat production price
- DH network heat loss reduction

Heat loss "60°C" vs "40°C" (summer conditions)				
DH network supply temperature [°C]	heat loss [MWh/d]	Average supply	Average return	Return temp during idling [°C]
62°C	0,056	61,1	57,5	58
41°C	0,033	42,0	35,5	37
Heat loss reduction [%]	41%			

Example – existing building (1997)

Annual cost [DKK/house/y]				
	benchmark = today 100% DH	**variant A** (DH price 70%)	**variant B** (DH price 70% & 50% fuses)	**variant C** (DH price 70% & el. price 70% & 50% fuses)
Reduced heat loss from DH network	0	-452	-452	-452
Energy bill for DH part	9328	6336	6336	6336
Energy bill for electricity part	0	1156	1156	809
Electric booster unit	0	250	250	250
Installation	0	100	100	100
Fuses - improvement	0	500	250	250
Total	9328	7889	7639	7293
Simple payback time [y]	0,0	11,8	7,1	5,9
Expected lifetime [y]	*20*	*Electrical booster unit [DKK]*	*5000*	
DH original price [DKK/MWh]	*512,5*	*Installation [DKK]*	*2000*	
El. original price [DKK/kWh]	*2,14*	*Add 10 A to fuses [DKK]*	*10000*	

- Electrical booster enables lower price for district heating through higher heat source efficiencies and reduced heat loss from DH network

Next steps

- Continue with testing and improvements
  - Better el. heater
- More economical analyzes
- Make it as a product
- Find out how long we can run with 40°C supply temperature

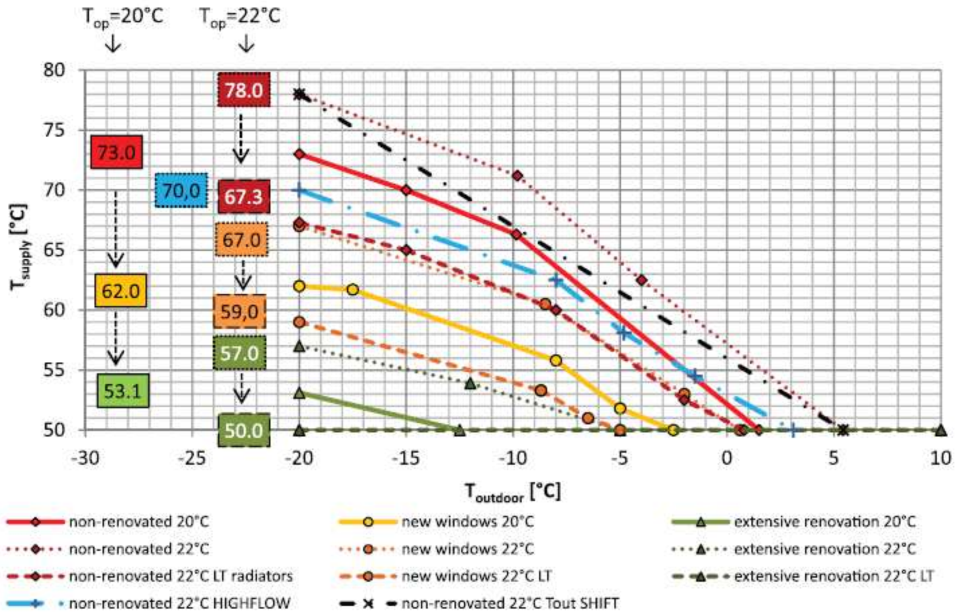


Fig. 3. Supply temperature curves for all the investigated cases.

Source: Renewable-based low-temperature district heating for existing buildings in various stages of refurbishment, Brand M, Svendsen S. in Energy 2013, vol. 62, p. 311-319.

Conclusions

- It works, keep high DHW comfort
- Electricity share 2-7% from annual heating energy
- Reasonable payback time also in not "optimal case"
- DHW not as "the requirement" for minimal DH supply temperature
- 40°C supply temperature:
    - Reduced DH heat loss by 50% compared to 80/40/8°C
    - Improves energy efficiency of heat sources
    - Enables low-grade heat sources
- It might be "NEED" for the future DH systems
- Possible to use in both, low-energy but also existing buildings

Thank you

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