Towards
low temperature systems

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4DH
4th Generation District Heating Technologies and Systems

Technical University of Denmark DTU

Low temperature heat network

- **Low temperature**
- **renewable heat supply to**
- **low energy buildings by**
- **use of warm water network - 4DH**

What was the 1, 2, 3th

First Generation (1880-1930):

Steam as heat carrier. Is today in use in e.g. Manhattan, Paris and partly in Copenhagen.

Second Generation (1930-1970):

Pressurised hot water as heat carrier with temperature above 100 C.

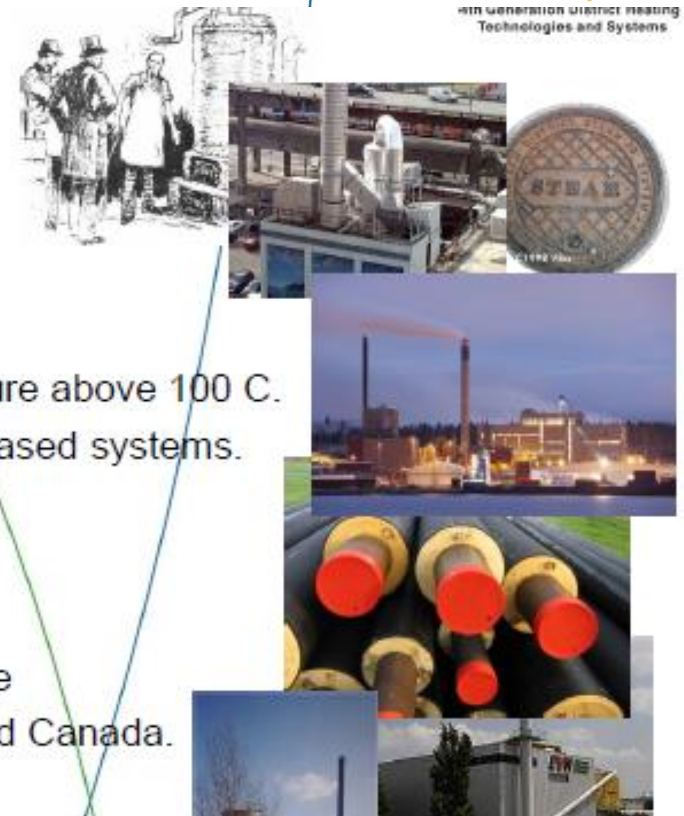
Can be found today in older parts of current water-based systems.

Third Generation (1970-present):

Pressurised water with temperatures below 100 C.

Used in replacements in Central and Eastern Europe

and all extensions in China, Korea, Europe, USA and Canada.



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Review

4th Generation District Heating (4GDH)
Integrating smart thermal grids into future sustainable energy systems

Henrik Lund [a,*], Sven Werner [b], Robin Wiltshire [c], Svend Svendsen [d], Jan Eric Thorsen [e], Frede Hvelplund [a], Brian Vad Mathiesen [f]

Relevant in EU due to:

EU Policy on energy and buildings

EPBD recast:

All new buildings in the EU as from December 2020 (2018 for public buildings) will have to be **nearly zero energy buildings**

the ***nearly zero or very low amount of energy required should to*** a very significant level be covered by energy from **local renewable source**

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Relevant in DK due to:

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Danish Energy Plan *

- **All buildings and electricity fossil free by 2035**
- **Transport and industry fossil free by 2050**

- **Based on:**
- **energy savings and**
- **renewable energy supply**

*
http://www.ens.dk/Documents/Netboghandel%20-%20publikationer/2011/our_future_energy_%20web.pdf

Relevant due to:

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Overall optimization of energy system with Renewable energy for heating buildings

What are the best technologies?

- **RE-based District heating in cities**
- **RE-based Heat pumps outside cities**

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Relevant due to:

Optimization of fossil free energy system

What is the best combination of

- **Energy savings in buildings**
- **Efficiency in distribution of heat**
- **Renewable energy (waste, bio, solar, geo)**

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Strategic Research Centre for 4th Generation District Heating Systems 2012 - 2017

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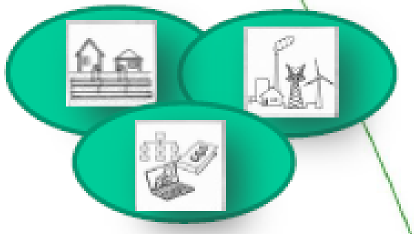
4th Generation District Heating Technologies and Systems

The **Aim** is to assist in the development of 4th Generation District Heating Technologies and Systems (4GDH).



Objectives:

- Scientific platform for research activities
- Societal understanding of the role of District Heating
- Further additional national and international projects

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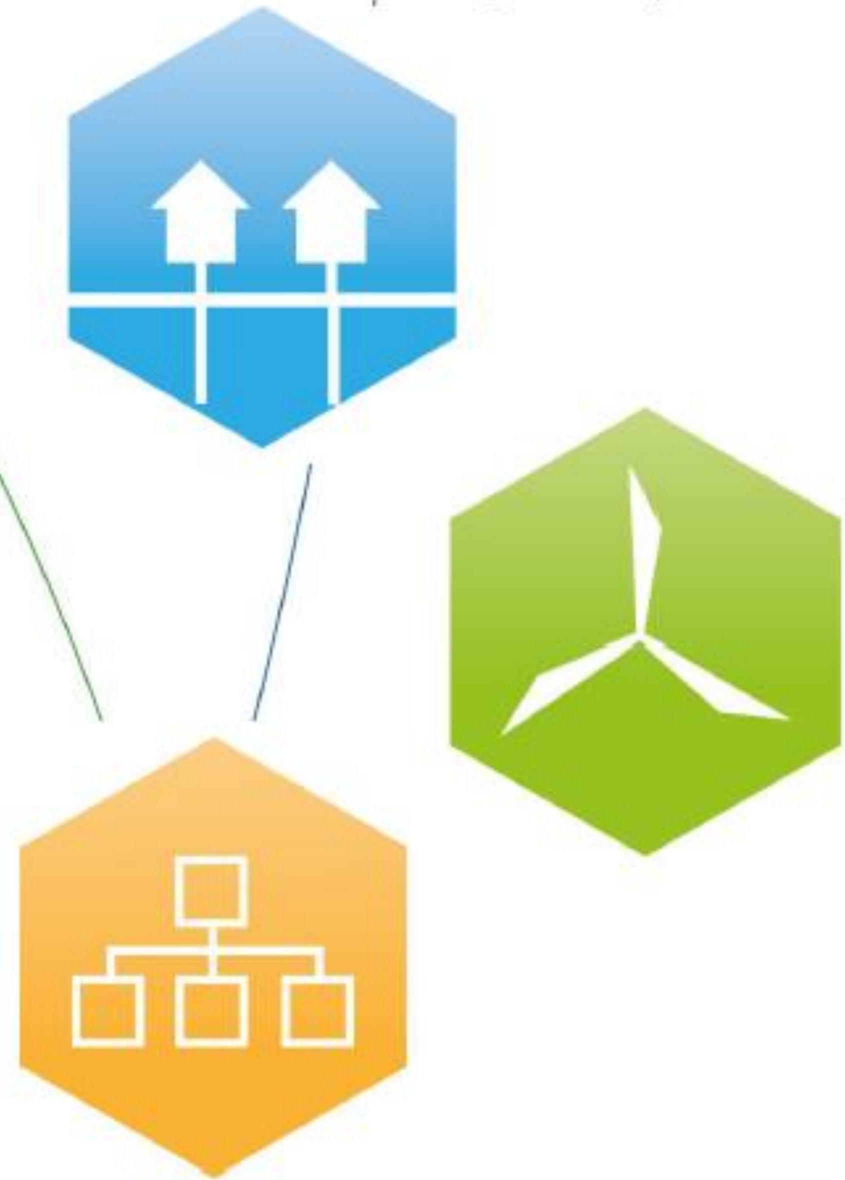
Three pillars

4DH
4th Generation District Heating Technologies and Systems

Supply:
Low temperature District heating

Production:
Renewable Systems Integration

Organisation:
Planning and Implementation



AALBORG UNIVERSITY

13 PhD projects

Strategic Research Centre for 4th Generation District Heating Technologies and Systems

PhD 1.1. Heating of existing buildings by low-temperature district heating
PhD 1.2. Supply of domestic hot water at comfort temperatures without Legionella
PhD 1.3. Conversion of existing district heating grids to low-temperature operation and extension to new areas of buildings
PhD 1.4 Minimising losses in the DH distribution grid

Ph.D. 2.1: Energy Scenarios for Denmark
Ph.D. 2.2 Thermal storage in district heating systems
Ph.D. 2.3 Distributed CHP-plants optimized across more electricity markets
Ph.D. 2.4 Low-temperature energy sources for district heating
Ph.D. 2.5 The role of district heating in the Chinese energy system

PhD 3.1: Strategic energy planning in a municipal and legal perspective
PhD 3.2: Price regulation, tariff models and ownership as elements of strategic energy pl
PhD 3.3: Geographical representations of heat demand, efficiency and supply
PhD 3.4: Geographical representations of renewable energy systems

Concept of low temperature heat network

Low temperature DH: Supply/return: 50C / 20C

Heat supply: No fossil fuels & no biomass fuels

Low temperature district heating necessary because:

- **more renewable heat produced at 50C than at 80C**
- **acceptable heat loss from network (20%) for low-energy buildings**

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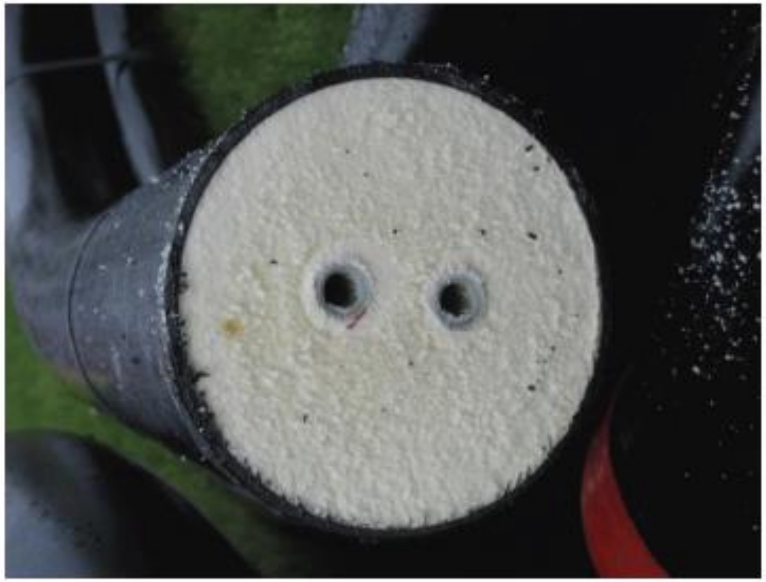
Heat network
Reduce heat loss by

- **Lower temperatures**:
- Supply at end user 50C
- Return at end user 20C

- **Lower heat loss coefficient** :
- Twinpipes with small diameter pipes (14mm) in service pipes



Figur 12 Tværsnit af det fremstillede prototyperør 14/14/110 mm

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Heat network
Heat loss calculation

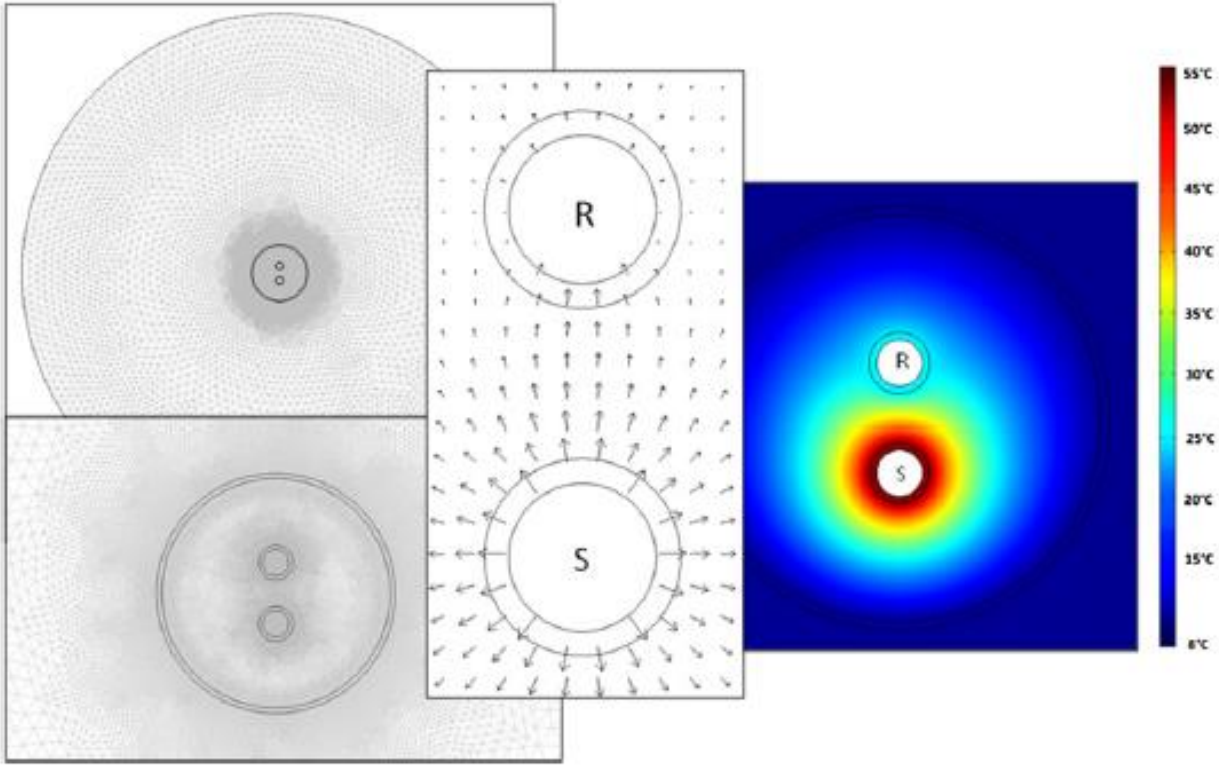
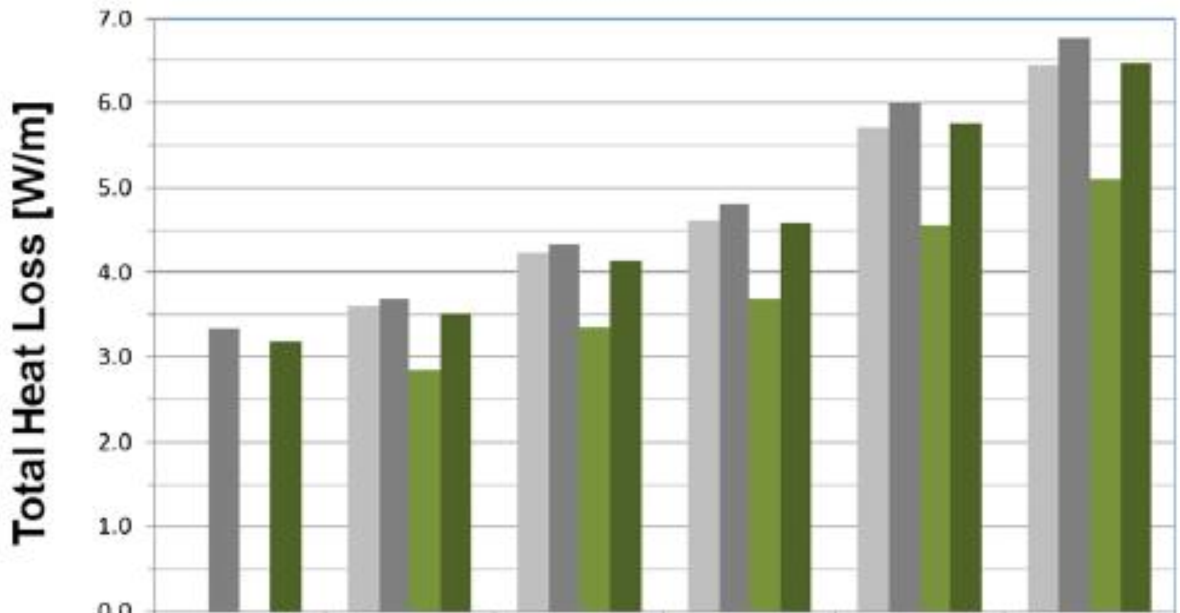


Fig. 5. Mesh model of a pre-insulated twin pipe buried in the ground (left). Heat flux between the media pipes (middle) and temperature field in Aluflex twin pipe 16–16/110 (right); temperature supply/return/ground: 55/25/8 °C.

Heat loss of 3-6 W/m



	DN 14	DN 16	DN 20	DN 26	DN 32	DN 40
Standard		3.61	4.24	4.62	5.71	6.45
FEM Standard	3.339	3.679	4.329	4.8	6.015	6.758
Advanced		2.86	3.36	3.69	4.55	5.1
FEM Advanced	3.187	3.513	4.135	4.587	5.753	6.466

Fig. 9. Comparison of 4 different approaches for steady-state heat loss calculation. Aluflex twin pipe series 2, supply/return/ground temperatures: 55/25/8 °C.

Optimization of network

Requirements:

- Minimize heat loss
- Supply of DHW at 40C within 10 sec at tap
- Return in DH at 20C

Possible solutions:

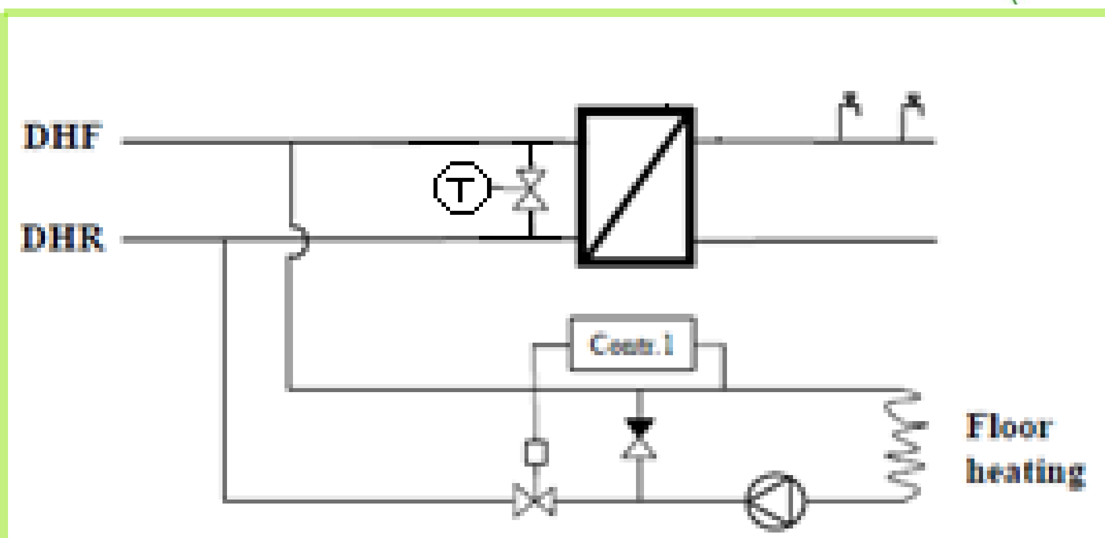
- Minimize pipe diameter
- DH supply circulation in loop
- No bypass from supply to return

Substations
Heat exchanger for DHW

High efficiency –

Supply temp. district heating: 50 C

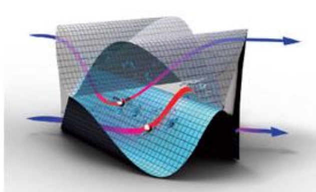
DHW : 45 C

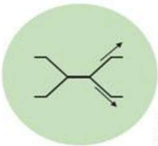


Substations
Heat exchanger for DHW

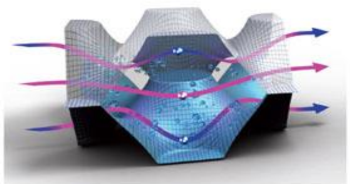
- **Micro Plate Heat Exchanger from Danfoss (right)**
- **Heat exchanger for DHW:**
- **13L/min 32kW 10C/45C - 50C/19C**
- **Temperature differences of 5 C**
  - – **www.mphe.danfoss.com**

Brazed plate heat exchangers only have a narrow brazing surface where the two 'peaks' of the plates touch.





Micro Plate Heat Exchangers have a broad, flat brazing surface which adds stability to the construction.

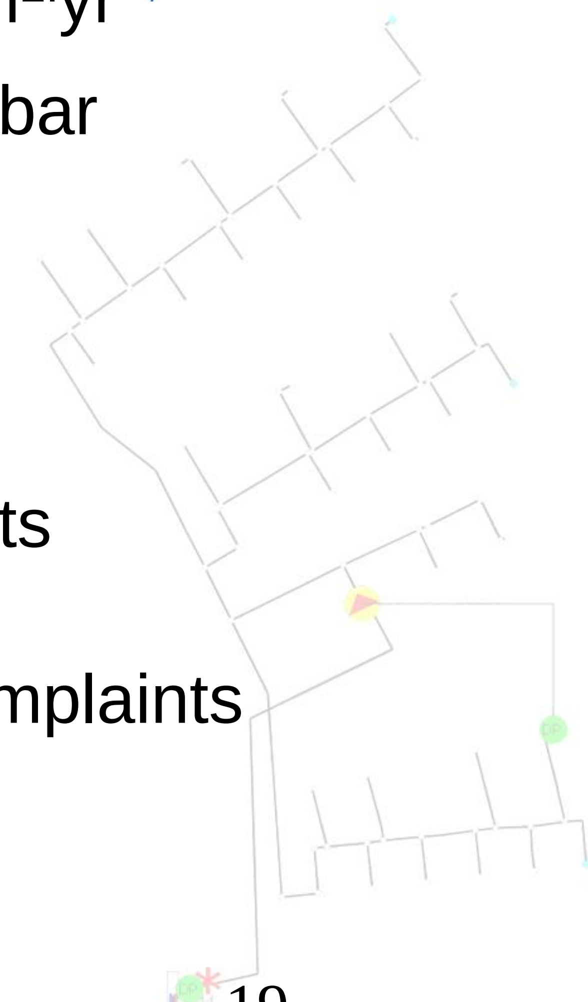


Demonstration projects

- ***2001-2004**:* EFP-2001: District heating supply to low-energy areas
- ***2006-2009**:* EFP-2007: Development and demonstration of low-energy district heating for low energy buildings
- ***2008-2011**:* EUDP 2008-II: CO_2 reductions in low-energy buildings and communities by implementation of low-temperature district heating systems. Demonstration cases in EnergyFlexHouse and Boligforeningen Ringgården
- ***2011-2014** (expected completion):* EUDP 2010-II: Full-scale demonstration of the future low-temperature district heating in existing settlements. The project is ongoing.
- ***2011 – 2014** (expected completion):* EUDP – Heat Pumps in District Heating (HPinDH)

Demonstration in new LE-buildings - Lystrup [1,2]

- Research projects (2007, 2008, 2010)
- 40 low energy row-houses 37 kWh/m^2·yr
- DH design parameters: 50/25°C, 10 bar
- District heating network
  - AluFlex Twin pipes (insulation series 2)
  - reduced pipe sizes -> higher pressure drop
  - annual distribution heat loss approx. 20%
- Development of substations concepts
  - no problem with Legionella and comfort
- System runs already 2 years , no complaints



Demonstration
In new LE-buildings- Lystrup

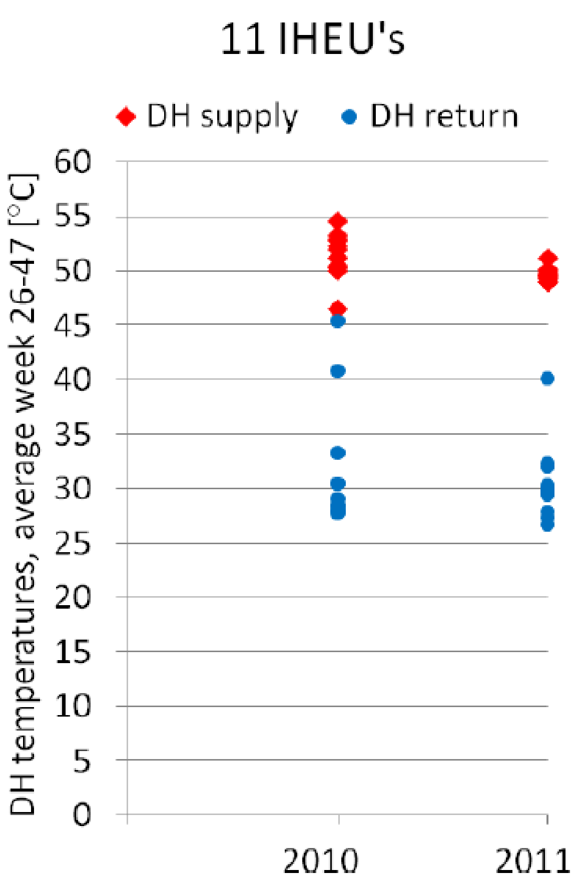


Figure 9: Supply and return temperatures for 11 IHEU's average of week 26-47, 2010/2011.

Table 5: Investment costs

	Costs (2010)		
Item	**[€/m]**	**[€/unit]**	**Total [€]**
Pipes*	120		65,000
Pipe fittings*	32		17,000
Pipe laying**	131		100,500
DHSU substation*		3,700	41,000
IHEU substation*		2,600	78,000
Substation installation**		1,000	41,000
Pump + frequency controller*		2,400+2,000	4,400
Total Cost			**346,900**
Cost per house			**8,460**

Demonstration In existing buildings

- How much we can reduce the supply temperature?
- Which renovation measures (if any) should be performed?

- Simulation of typical single-family house from 70s
  - radiators originally designed 70/40/20
  - influence of windows renovation

Case	windows properties	Energy demand for SH [MWh/year]	Peak power for SH [kW]	Supply temperature needed in radiators for:		
				Tout=-21°C	Tout=0°C HIGH	Tout=0°C LOW
no renovation	U-value: 2,5 W/m^{2}K g-value: 0,43	10 .49	5,8	65/43/20	60/29/20	50/34/20
new glazing	U- value: 1,4 W/m^{2}K g- value: 0,43	8.3	5,0	65/35/20	60/26/20	50/29/20
new windows	U- value: 0,9 W/m2K g- value: 0,35	7.55	4,5	65/32/20	52/25/20	50/26/20

Demonstration

In existing buildings

75 houses i DK gets low tempe-rature DH to reduce loss from grid

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Implementation plans - conclusions

Detailed investigations needed

- Based on new 4GDH technologies
- Based on an optimised energy system
  - Fossil free
  - No imported biomass for fuels

Optimal solutions

Political implementation needed