District Heating 4.0
The new generation of district heating systems

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Outline

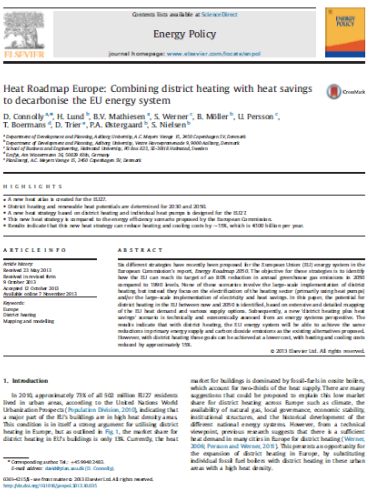
- Background: Questions in the air
- The three generations of district heating
- The Danish 4DH project
- Heat supply options
- Other choices
- Heat distribution temperatures
- Conclusions

Questions in the air

- What heat demands to consider?
- What market conditions to consider?
- What heat resources to use?
- What technical solutions to use?
- Can we have viable district heating systems in the future?

Results from Heat Roadmap Europe

- First pre-study 2012: District heating is competitive in business-as-usual scenario.
- Second pre-study 2013: District heating has higher competitiveness in energy efficiency scenario



Energy Policy

Heat Roadmap Europe: Combining district heating with heat savings to decarbonise the EU energy system

Major conclusion from
Heat Roadmap Europe

District heating is here to stay, but district heating has to change

Professor Henrik Lund, Aalborg University
(project coordinator in the Danish 4DH-project)

3 generations of DH in use

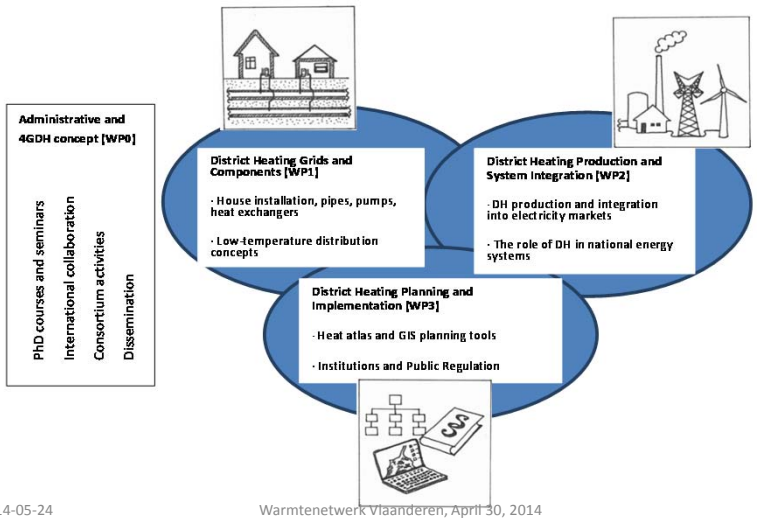
	1st generation	*2nd generation*	*3rd generation*
Period of best available technology	1880-1930	1930-1980	1980-
Heat carrier	Steam	Pressurised hot water, mostly over 100ºC	Pressurised hot water, often below 100ºC
Labels	STEAM	A. SOVIET DH TECHNOLOGY B. MARKET-BASED DH SYSTEMS	SCANDINAVIAN DH TECHNOLOGY
Typical components	• Steam pipes in concrete ducts • Often no condensate return • Steam traps • Compensators	• Pipes in concrete ducts • Large shell- and tube heat exchangers • Extensive substations • Heavy, material intensive components	• Prefabricated, preinsulated pipes directly buried into the ground. • Compact substations using brazed plate heat exchangers • Material lean components
Quality	Outdated technology	Low quality for the Soviet DH technology and high to medium quality for other systems	High quality
Current use	New York and Paris. Replacement in Hamburg and Munich	Older parts of all early district heating systems	All replacements in CEE and former USSR countries and all extensions and new systems in China, Korea, Europe, USA and Canada.

What is 4DH and who is involved?

- Research Centre financed by The Danish Council for Strategic Research, industry and partners.
- Many partners involved: Universities, industry, consultancies, and large district heating companies
- 2012-2017, with a total budget of 10 M€. Currently, the largest district heating academic project in Europe.

4DH: Research areas

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



13 PhD projects in 4DH

- *1.1. Heating of existing buildings by low-temperature district heating*
- *1.2. Supply of domestic hot water at comfort temperatures without Legionella, Xiaochen Yang, DTU*
- *1.3. Conversion of existing district heating grids to low-temperature operation and extension to new areas of buildings, Soma Mohammadi, AAU*
- *1.4 Minimising losses in the DH distribution grid*
- *2.1: Energy Scenarios for Denmark, Rasmus Lund, AAU*
- *2.2 Thermal storage in district heating systems, Sean Bryant, AAU*
- *2.3 Distributed CHP-plants optimized across more electricity markets, Peter Sorknæs, AAU*
- *2.4 Low-temperature energy sources for district heating, Urban Persson, Halmstad University*
- *2.5 The role of district heating in the Chinese energy system, Weiming Xiong, Tsinghua University*
- *3.1: Strategic energy planning in a municipal and legal perspective, Michael Herborn, SDU*
- *3.2: Price regulation, tariff models and ownership as elements of strategic energy planning, Søren Djørup, AAU*
- *3.3: Geographical representations of heat demand, efficiency and supply*
- *3.4: Geographical representations of renewable energy systems, Stefan Petrovic, DTU*

The 4GDH context

The 4GDH definition paper was published last month

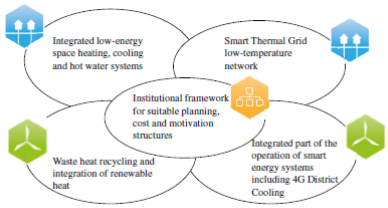


Fig. 1. Illustration of the concept of 4th Generation District Heating including smart thermal grids.

Energy

Review

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

Henrik Lund, Sven Werner, Robin Wiltshire, Svend Svendsen, Jan Eric Thorsen, Frede Hvelplund, Brian Vad Mathiesen

ABSTRACT

1. Introduction

Heat supply conditions

- Less thermal power in the future European power system. More solar and wind power. Giving less CHP in the future.
- Demand for balancing fluctuating solar and wind power. Can be managed by large electric boilers and heat pumps in district heating systems.
- Lower temperature levels will give better conditions for geothermal heat, industrial excess heat, solar heat, CHP from waste incineration and biomass, flue gas condensation and higher capacity in atmospheric heat storages. Also opportunities for heat recovery from computer centres, chillers etc.

Other choices

- Customer interface: Flats or buildings?
- Shortcuts between supply and return pipes as today or three pipe system?
- The Legionella issue at lower network temperatures?
- Hot water circulation or three DH pipe systems inside buildings?
- Regulatory framework in the future?

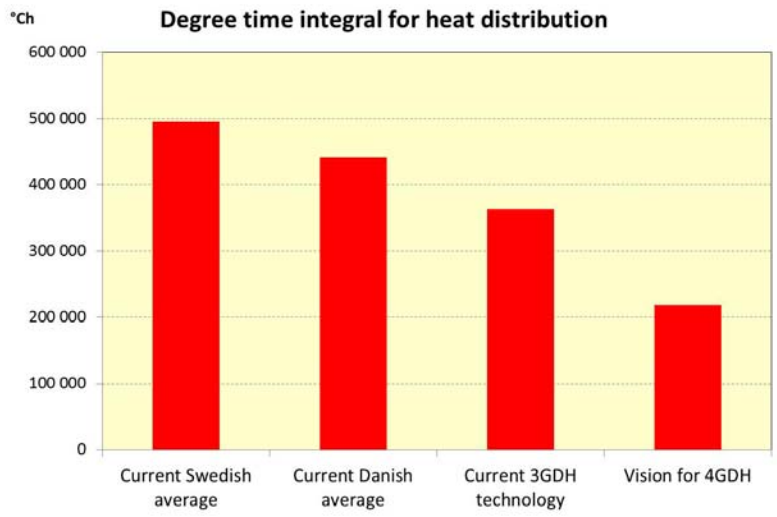
Heat distribution temperatures

Lower supply and return temperatures will give:

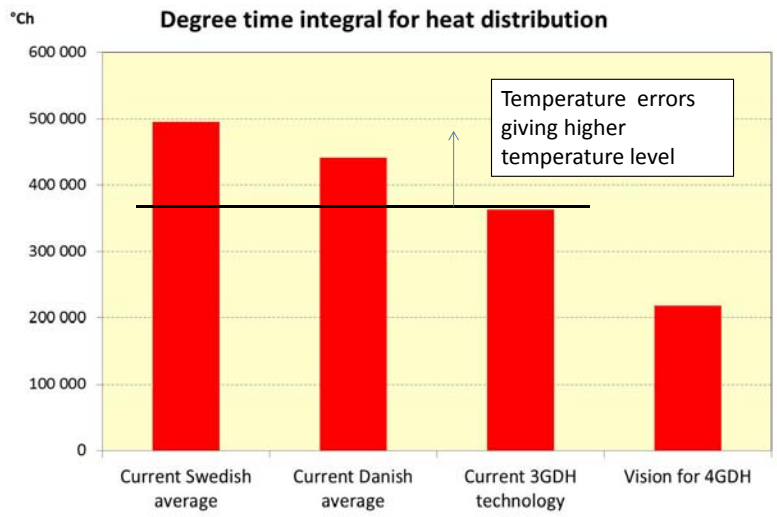
- More supply options
- Lower risks for scalding
- Lower distribution losses
- Possibility to use other pipe materials than steel

However, lower network temperatures will require lower temperature in customer heating systems, but will be easier to obtain at low heat demands.

Current vs future temperature levels



Current vs future temperature levels



Evaluation of early 4GDH systems

- IEA-DHC-project between 2011 and 2014 about new systems close to the future 4GDH technology
- Selection criteria: Low heat densities, low heat demands or low network temperatures.
- Seven examples from Turkey, Denmark, Sweden, Germany, Canada, and United Kingdom.

Evaluation: Temperature levels in early 4GDH systems

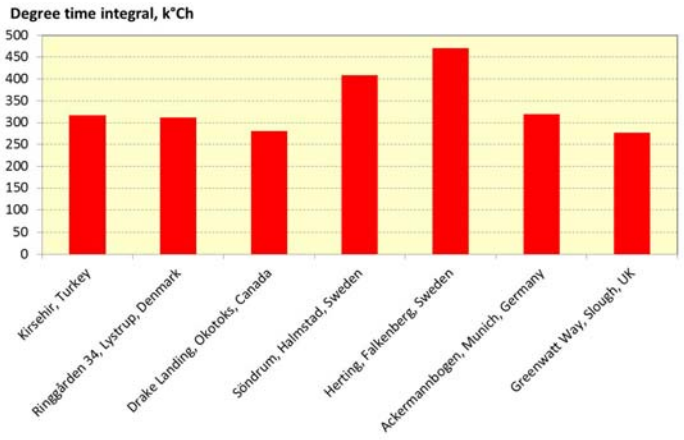


Figure 9.2. Degree time integral as temperature level indicator. This parameter is the main driver behind the distribution heat loss.

6. Utvärdering: Temperaturnivåer i distributionsnäten

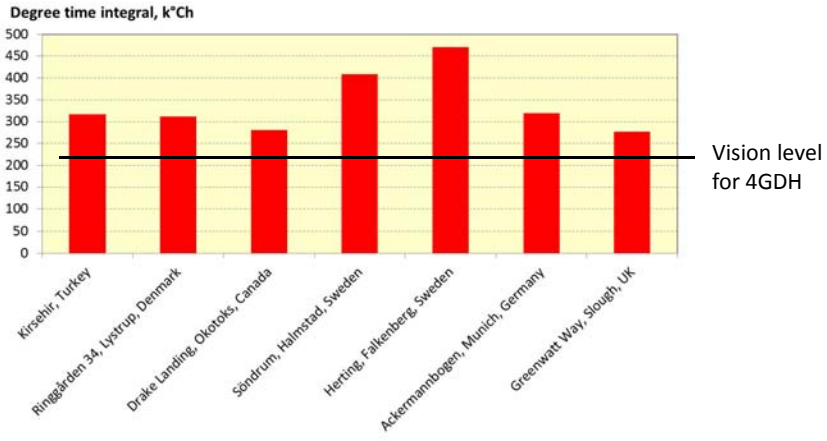


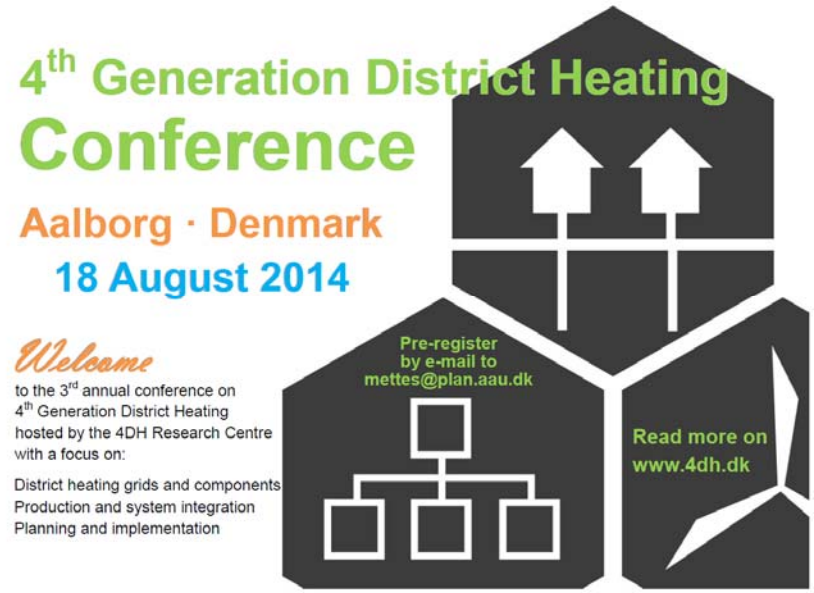
Figure 9.2. Degree time integral as temperature level indicator. This parameter is the main driver behind the distribution heat loss.

Higher temperature levels from temperature errors

- Another of our research projects have shown the importance of continuous commissioning in order to identify temperature errors in substations and customer heating systems
- Currently, temperature errors are accepted since higher temperatures can be supplied
- In future 4GDH systems, temperature errors must be identified and eliminated in order to maintain the low temperature level.

Conclusions

1. We have many ideas about 4GDH, but not verified yet.
2. Work in progress within the 4DH-project and more projects are planned (Horizon 2020 applications).
3. Heat Roadmap Europe: District heating can deliver major benefits and is competitive in a future Europe.
4. Evaluations of early 4GDH cases show some margins for improvements.
5. Continuous commissioning can be a future tool for identifying temperature errors in substations.



The End

Questions?

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www.4dh.dk (4DH-project)
http://www.4dh.dk/hre (Heat Roadmap Europe)
http://www.sciencedirect.com/science/article/pii/S0301421513010574 (HRE)
http://www.sciencedirect.com/science/article/pii/S0360544214002369 (4GDH)