Fourth Generation of District Heating Technology

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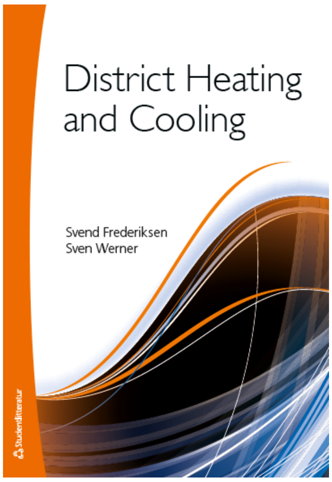
Who is Sven Werner?

- Professor in energy technology at Halmstad University since 2007.
- Been active with district heating research since 1978. PhD in 1984 with ”The heat loads in district heating systems”.
- Coordinate and participate in various projects concerning the future for district heating in Europe.
- Co-author of textbooks about district heating and cooling in 1993 and 2014 (Swedish versions) and 2013 (English version).
- Will retire on Dec 31, 2017.



Outline

1. Conclusions from Heat Roadmap Europe
2. Definition of Fourth Generation of District Heating (4GDH)
3. Early 4GDH simulations
4. Conclusions
5. Our HRE and 4GDH projects

1. Heat Roadmap Europe

Have district heating systems a future in Europe?

Heat Roadmap Europe projects

- 1st Heat Roadmap Europe pre-study 2012 about the future conditions for district heating in a business-as-usual scenario. Benefit of lower costs with **14 billion EUR** in 2050.
- 2nd Heat Roadmap Europe pre-study 2013 about the future conditions for district heating in a strong energy efficiency scenario. Benefit of lower costs with **100 billion EUR** in 2050.
- Stratego – HRE3, European IEE project between 2014 and 2016 with several partners. Detailed studies of five European countries.
- Heat Roadmap Europe 4, European H2020 project between 2016 and 2018 with several partners. Detailed studies of further ten European countries.
- Outputs and corresponding maps are available at www.heatroadmap.eu

The European heat density map

482 D. Connolly et al. / Energy Policy 65 (2014) 475–489

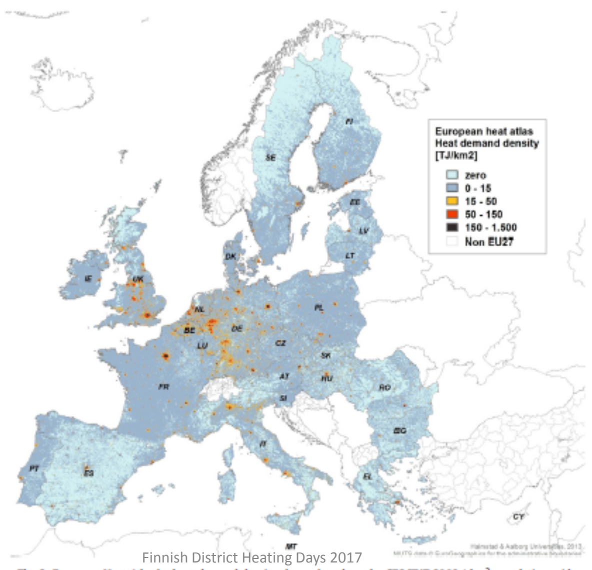


Fig. 6. European Heat Atlas by heat demand density classes based on the GEOSTAT 2006 1 km² population grid.

Heat synergy regions

676 U. Persson et al. / Energy Policy 74 (2014) 663–681

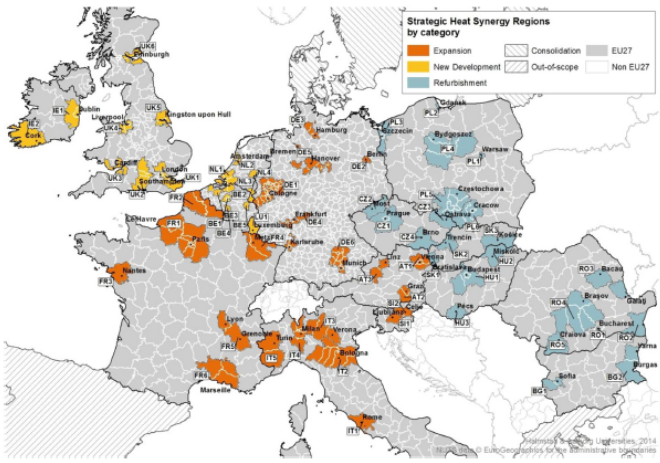


Fig. 9. 63 Strategic heat synergy regions in 16 selected EU27 Member States, by categories Expansion, New Development, and Refurbishment.

Heat Roadmap Europe - main conclusion

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

Professor Henrik Lund, Aalborg University

(head of the Danish 4DH research centre)

2. Definition of Fourth Generation of District Heating (4GDH)

What district heating technology should be used in the future?

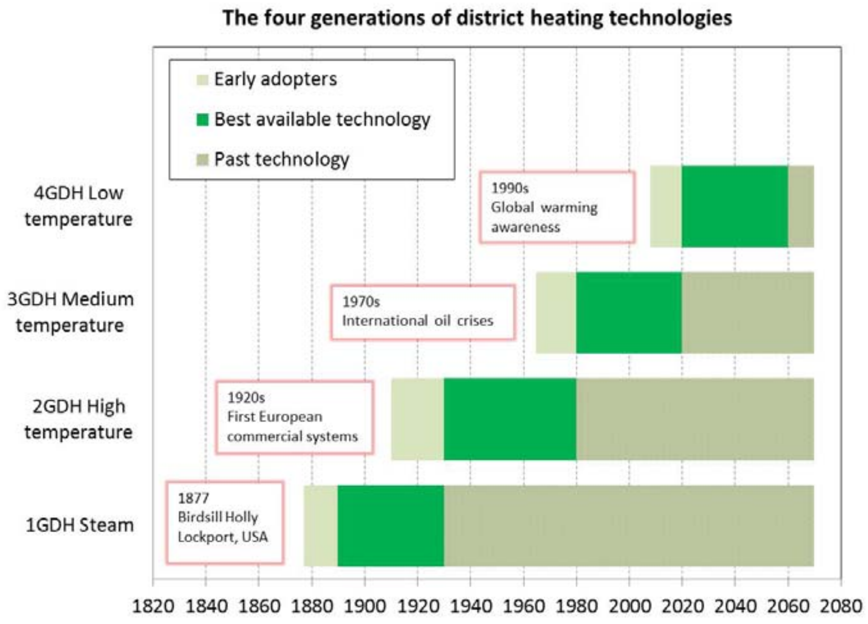
3GDH and 4GDH conditions

Current 3GDH technology was developed in the 1970s and 1980s, when

- Buildings had **high heat demands**
- Heat supply was based on **fossil fuels**

Future 4GDH technology should consider

- Buildings will have **lower heat demands**
- Heat supply will be based on **renewable, recycled, and stored heat**



4GDH, definition paper

Energy 68 (2014) 1–11

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Review

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

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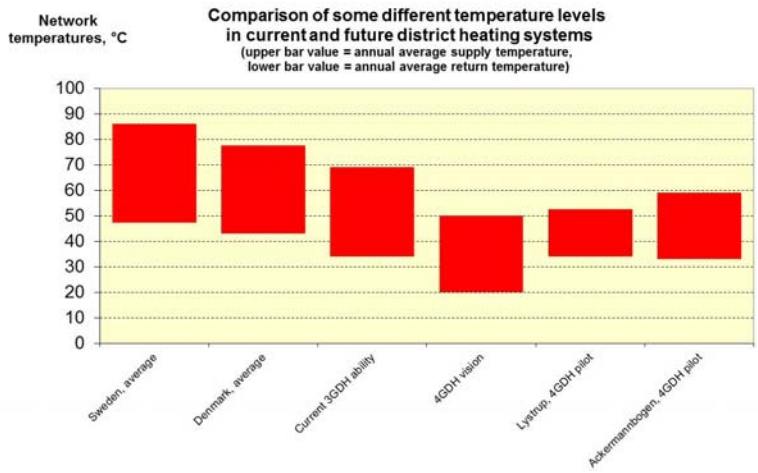
The five abilities of 4GDH

1. Ability to supply low-temperature district heating for space heating and hot water
2. Ability to distribute heat in networks with low grid losses
3. Ability to utilise renewable heat and recycled heat from low temperature sources
4. Ability to be an integrated part of smart energy systems
5. Ability to ensure suitable planning, cost and motivation structures

3. Early 4GDH simulations

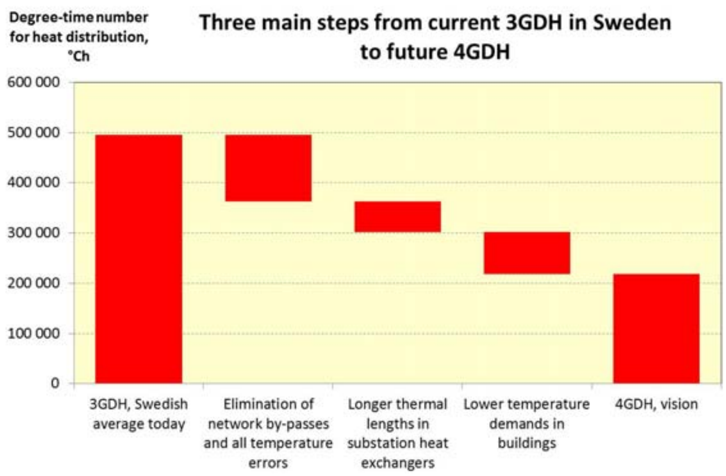
How to obtain really low return temperatures?

Temperature levels in district heating networks



Typical annual average supply and return temperatures in heat distribution networks for both current and various 4GDH systems.

Temperature levels in district heating systems

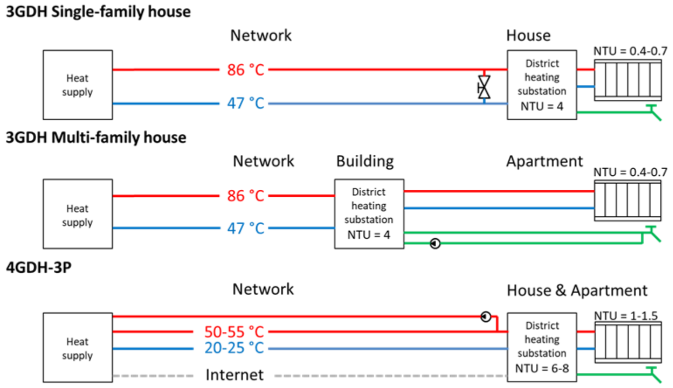


Estimation of the three main steps for obtaining lower temperature levels in Sweden.

Our 4GDH-3P proposal for new residential buildings

1. Additional **third pipe** for taking care of the recirculation flow, when no heat demands appear
2. **Apartment substations** in multi-family buildings
3. Heat exchangers with **longer thermal lengths** in substations and customer heating systems

3GDH and 4GDH residential solutions



Overview of the two current 3GDH applications and the proposed 4GDH-3P system design for residential buildings concerning customer interfaces, number of pipes, and typical thermal lengths (NTU = number of transfer units) used in substations and radiators. Red lines denote supply temperatures, blue lines denote return temperatures, and green lines denote domestic hot water temperatures.

4GDH-3P benefits

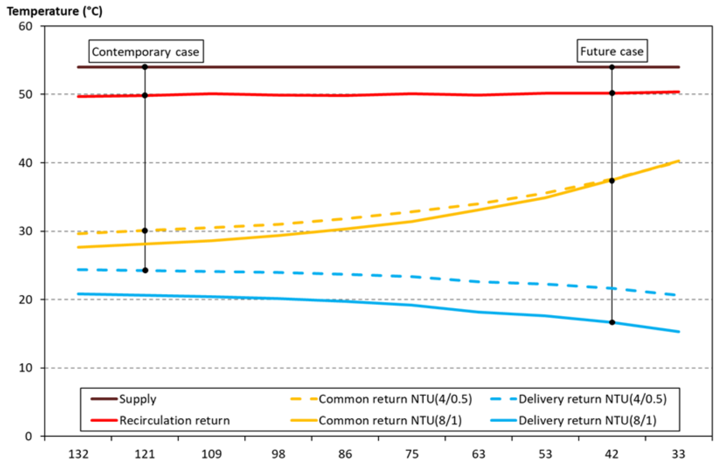
1. Recirculation flows will not pollute cold return flows with warm supply water
2. Longer thermal lengths will decrease supply temperatures
3. Lower temperature levels in distribution networks, providing lower heat losses and better operation conditions for all heat supply plants **(the main economic driver)**
4. Elimination of all domestic hot water circulation pipes in connected buildings
5. Elimination of Legionella risks
6. Easier for building owners to reach NZE-thresholds, since heat losses from domestic hot water circulation are excluded
7. No large radiator system with bad allocation of radiator flows
8. Final customers can chose own indoor temperatures
9. Possible with heat meters for each final customer (according to the Energy Efficiency Directive)
10. Better industrial conditions for manufacturing of substations (longer series)
11. Better conditions for finding temperature errors in customer heating systems

and some more benefits.

4GDH-3P simulations

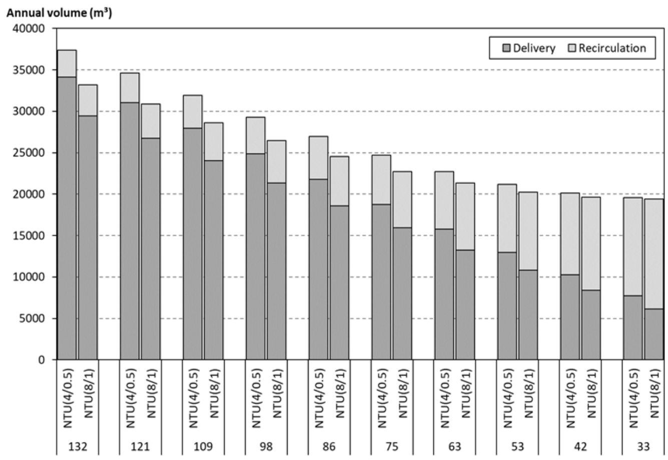
- In order to understand the merits of the 4GDH-3P proposal, a simulation model has been developed.
- Inputs to the model are annual specific heat demands in connected buildings and thermal lengths for heat exchangers and radiators.
- The model has been applied for one local heat distribution area with 49 single-family houses and network trench length of 1100 m.

4GDH-3P simulations



Annual simulation results with regard to case area temperature levels at the starting point to the distribution area. Horizontal axis displays variation of heat power signatures, expressed as corresponding specific heat demands in kWh/m^2, year. Common returns constitute mixing of delivery and recirculation flows as in the 3GDH technology.

4GDH-3P simulations



Annual simulation results with regard to case area water flow volumes at the starting point to the distribution area. The flow volumes are divided into delivery and recirculation flow volumes. Horizontal axis displays variation of heat power signatures, expressed as corresponding specific heat demands kWh/m2, year, and variation in thermal lengths corresponding to the chosen long and short alternatives.

4. Conclusions

1. District heating systems can have a bright future in Europe
2. However, the current district technology should be refined in order to meet future market conditions
3. Computer simulations verify expected future network temperatures of about 50-20 °C
4. Many pilot and demonstration projects are required for final verification of the new 4GDH technology

5. Our HRE and 4GDH projects

Heat Roadmap Europe

1. Heat Roadmap Europe 1, pre-study with Euroheat & Power, 2012
2. Heat Roadmap Europe 2, pre-study with Euroheat & Power, 2013
3. Stratego (Heat Roadmap Europe 3), IEE project, 2014-2016
4. Heat Roadmap Europe 4, Horizon 2020 project, 2016-2018

Fourth Generation of District Heating Technology

1. 4DH Research centre in Ålborg, Danish Innovation Fund etc, 2012-2017
2. Towards 4GDH, IEA-DHC Annex X, 2012-2014
3. Transformation Roadmap for 4GDH, IEA-DHC Annex XI, 2014-2017
4. Implementation of 4GDH, IEA-DHC Annex TS2, 2016-2017
5. Fjärrvärmens framtida roll i Europa (The Future Role of District Heating in Europe), Fjärrsyn 2014-2017
6. Framtida fjärrvärmeteknik (Future District Heating Technology), Fjärrsyn 2016-2017

All these financial supports have been appreciated!

The End

Thank you for your attention!

Heat Roadmap Europe at:

http://heatroadmap.eu/

The 4DH research centre:

http://www.4dh.dk/

The 4GDH definition paper by Henrik Lund et al:

http://www.sciencedirect.com/science/article/pii/S0360544214002369

Recent review of DHC in the world:

http://www.sciencedirect.com/science/article/pii/S036054421730614X

Recent review of DHC in Sweden:

http://www.sciencedirect.com/science/article/pii/S0360544217304140