Fourth Generation of District Heating Technology

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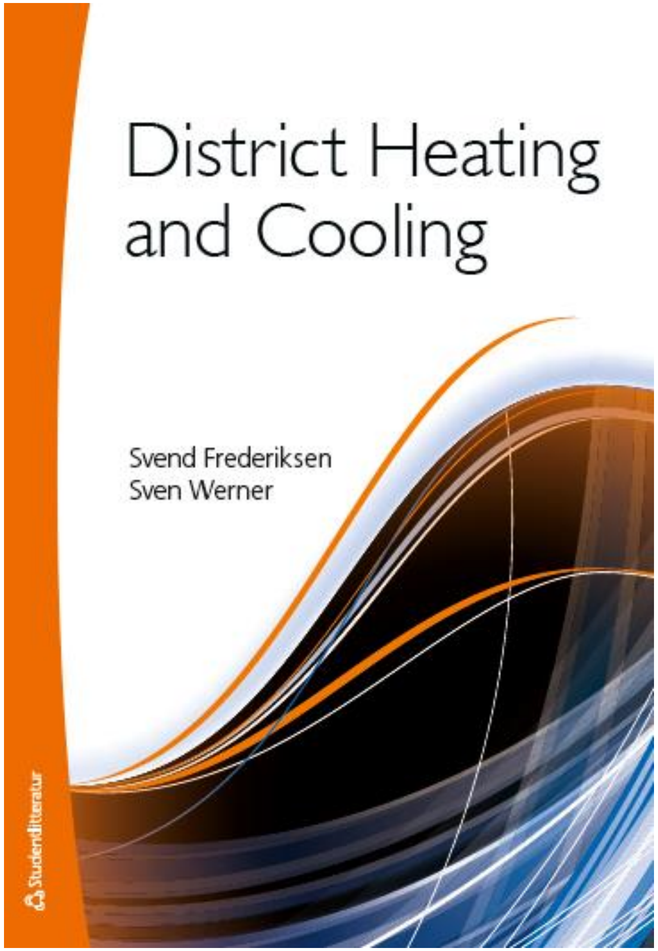
Who is Sven Werner?

- 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”.
- Heads 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).



District heating systems are important in dense cities in the cold climate regions of the world.

How should these systems be further developed in order to stay competitive in the future?

This presentation contains some European ideas about possible answers to this question?

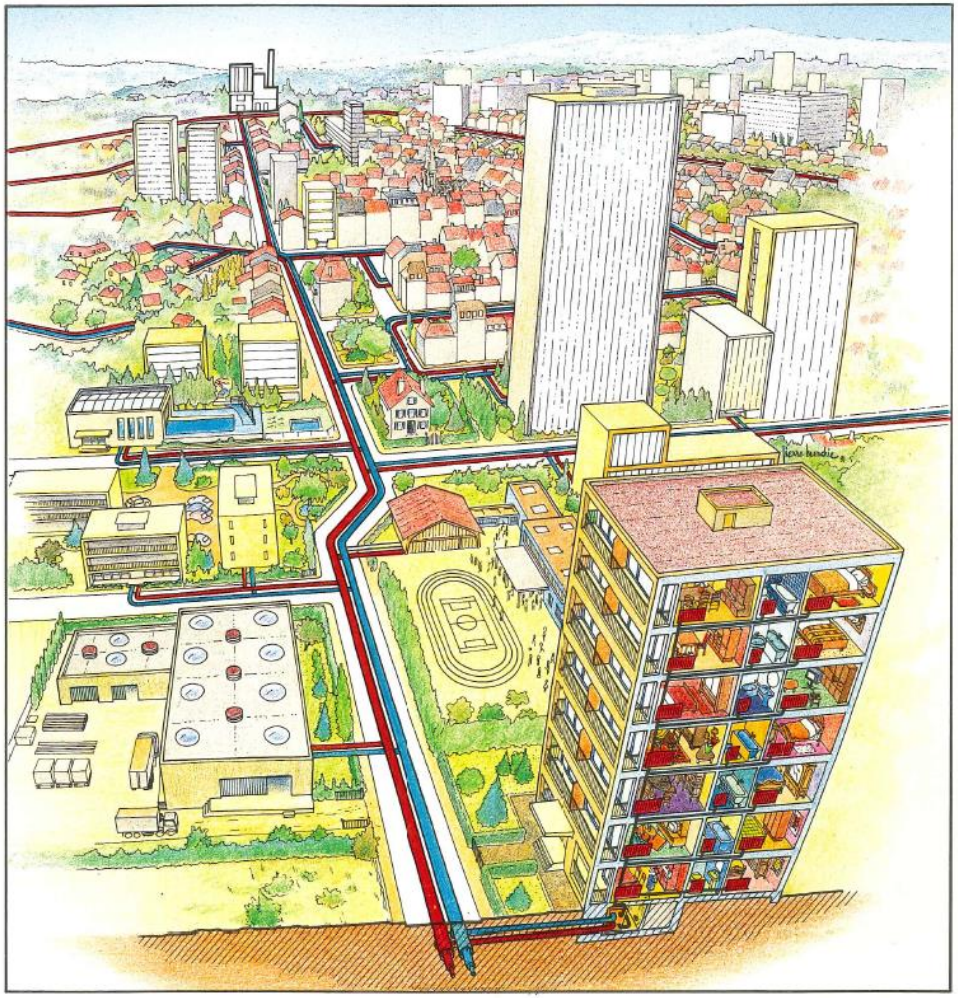


Figure 1.1. Overview drawing showing the basic parts of a district heating system. The picture was originally drawn by Pierre Merchie, France and originates from (AMFE 1991). Reprinted with permission.

The 28 member states of European Union (EU28) having 507 million citizens

Austria
Belgium
Bulgaria
Croatia
Cyprus
Czech Republic
Denmark
Estonia
Finland
France

Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta

Netherlands
Poland
Portugal
Romania
Slovak Republic
Slovenia
Spain
Sweden
United Kingdom

Outline

1. The future challenge with new market conditions for district heating systems
2. The current situation in Europe
3. Linking the future with the past by definition of four generations of district heating technology
4. The future situation: Heat Roadmap Europe
5. Typical features of 4th generation systems
6. Six conclusions

1. The future challenge

Demand side:

- Lower heat demands in buildings because of more energy efficient buildings

Supply side:

- Current direct use of fossil fuels for heating buildings should be replaced in order to reduce carbon dioxide emissions
- Wind and solar power will replace many fossil power plants in the power market, giving less fossil CHP, now dominating heat supply to district heating systems.

Challenge: How will these new heat demands and new heat supplies influence the district heating technology and the competitiveness for district heating in urban areas?

2. The current situation: Basic heat flows

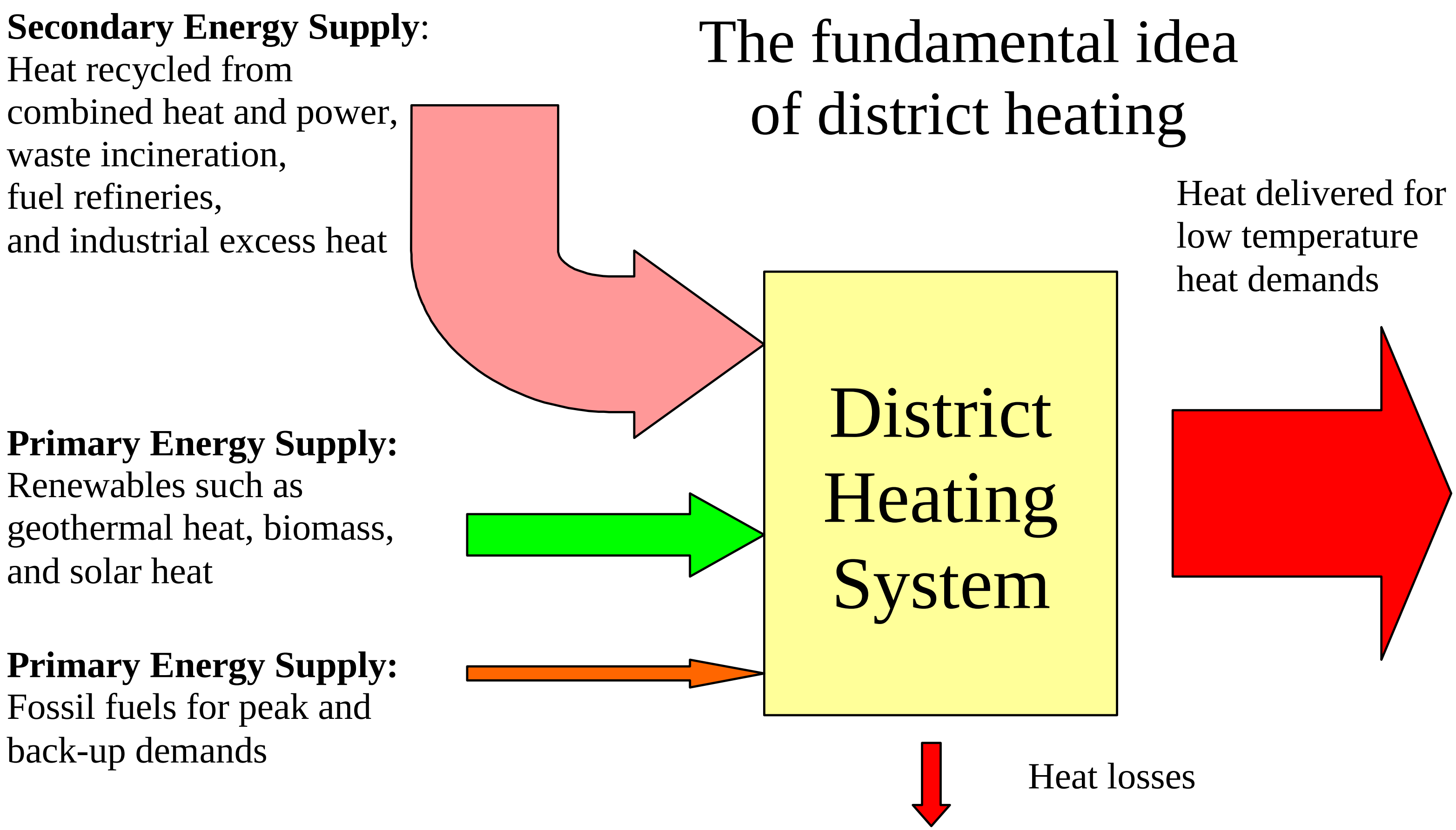
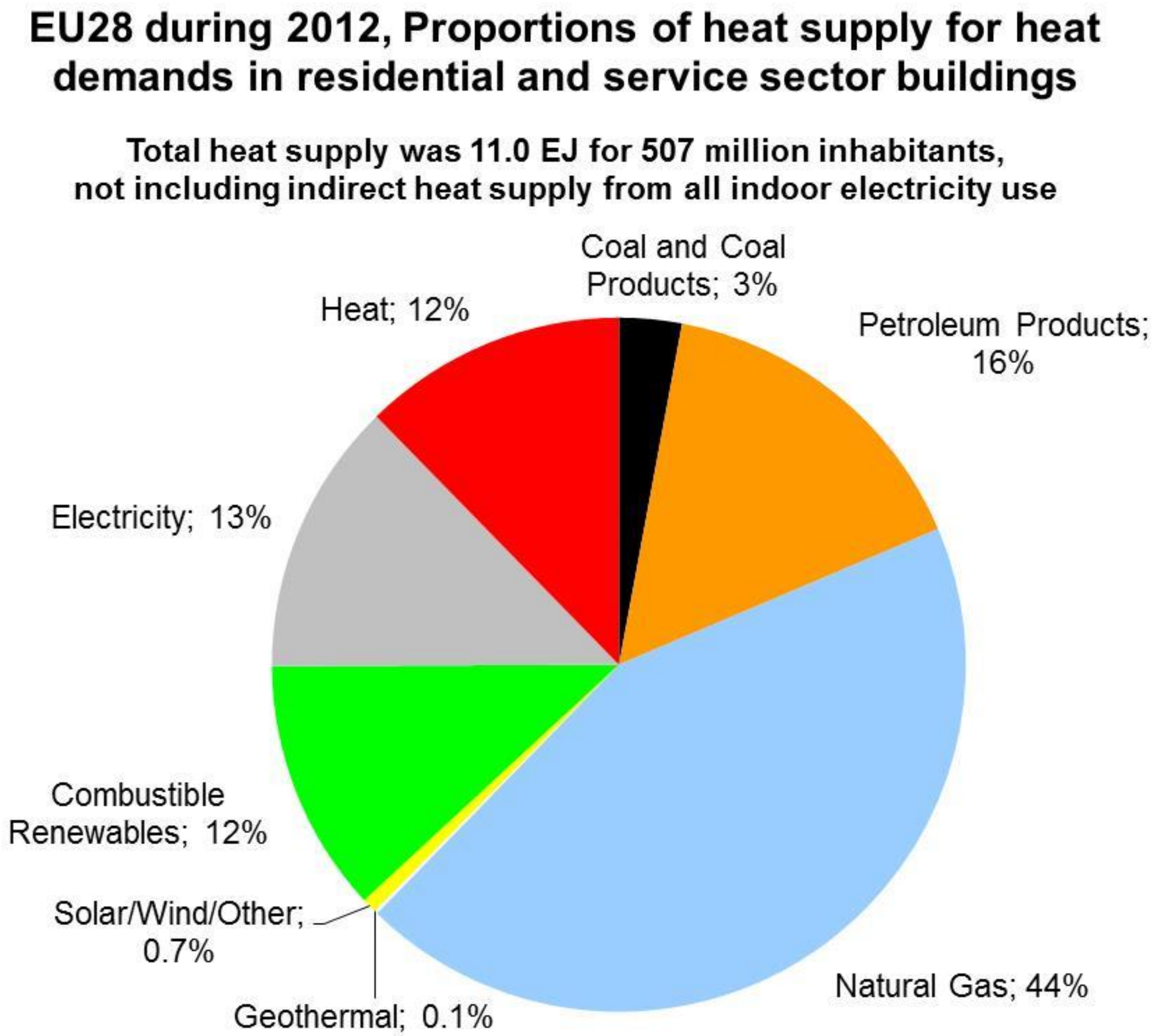


Figure 2-1. The basic energy flows in a district heating system designed according to the fundamental idea.

2. The current situation in Europe



2. Current situation:

District Heating Systems in Europe

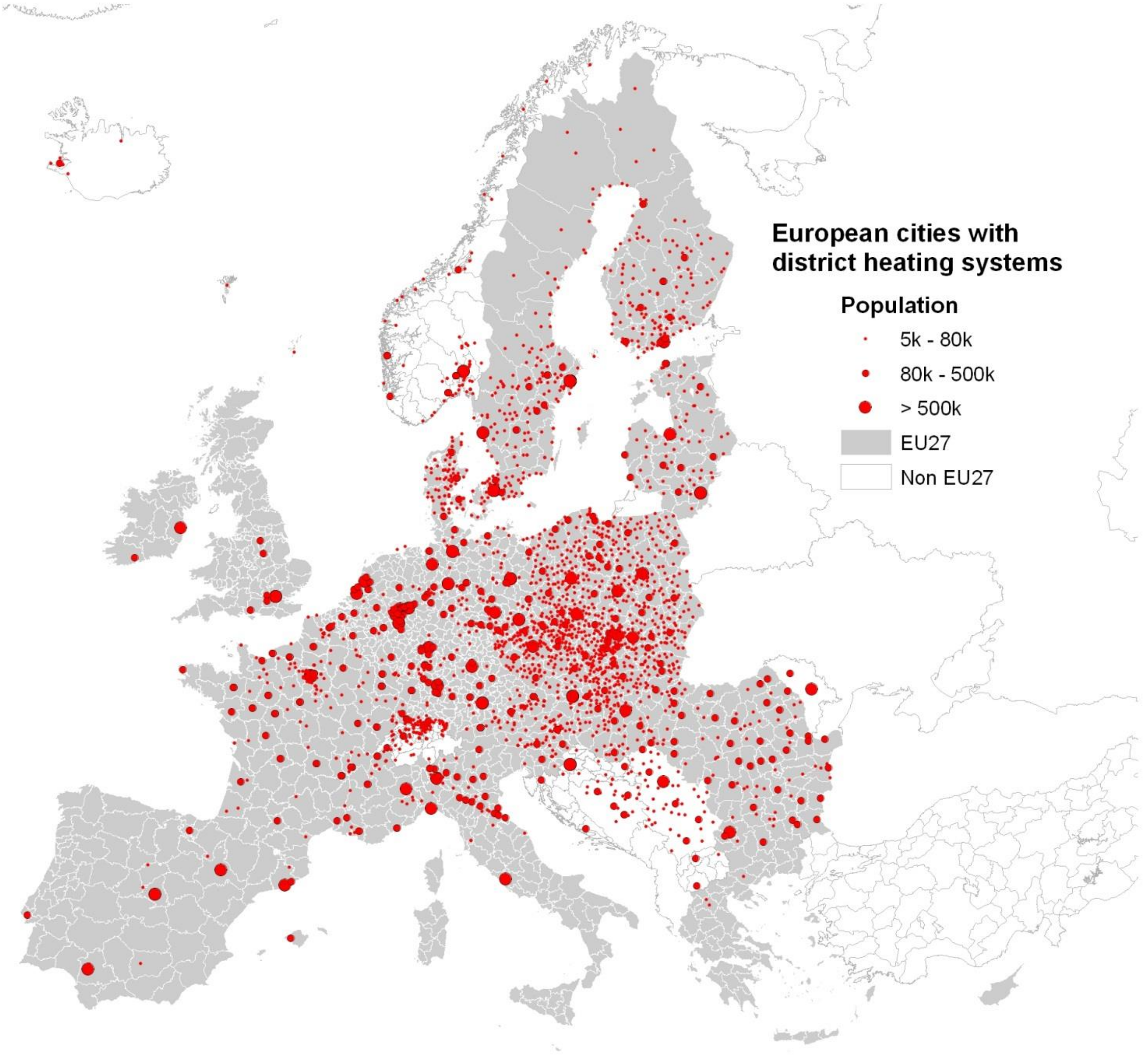
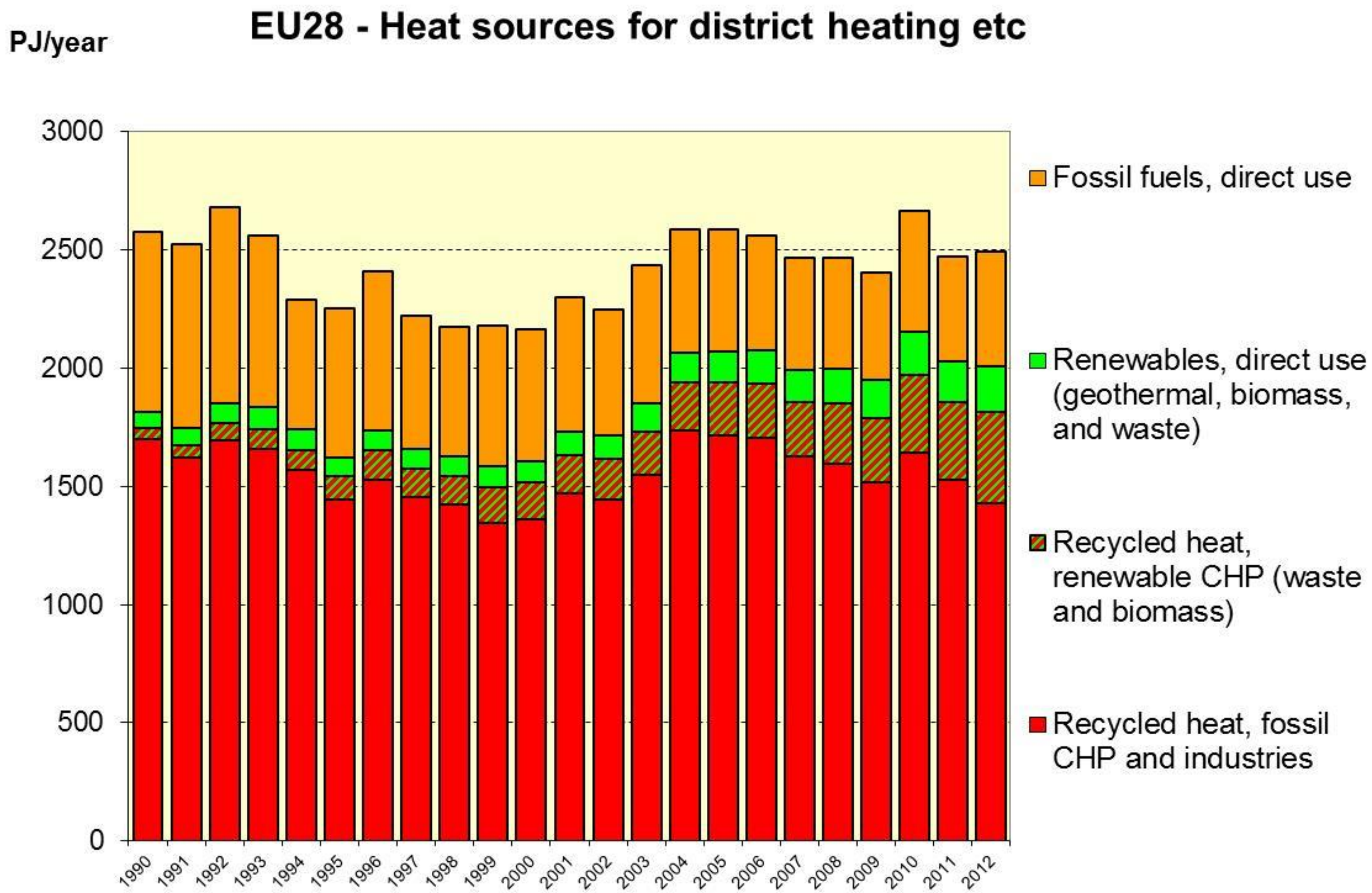


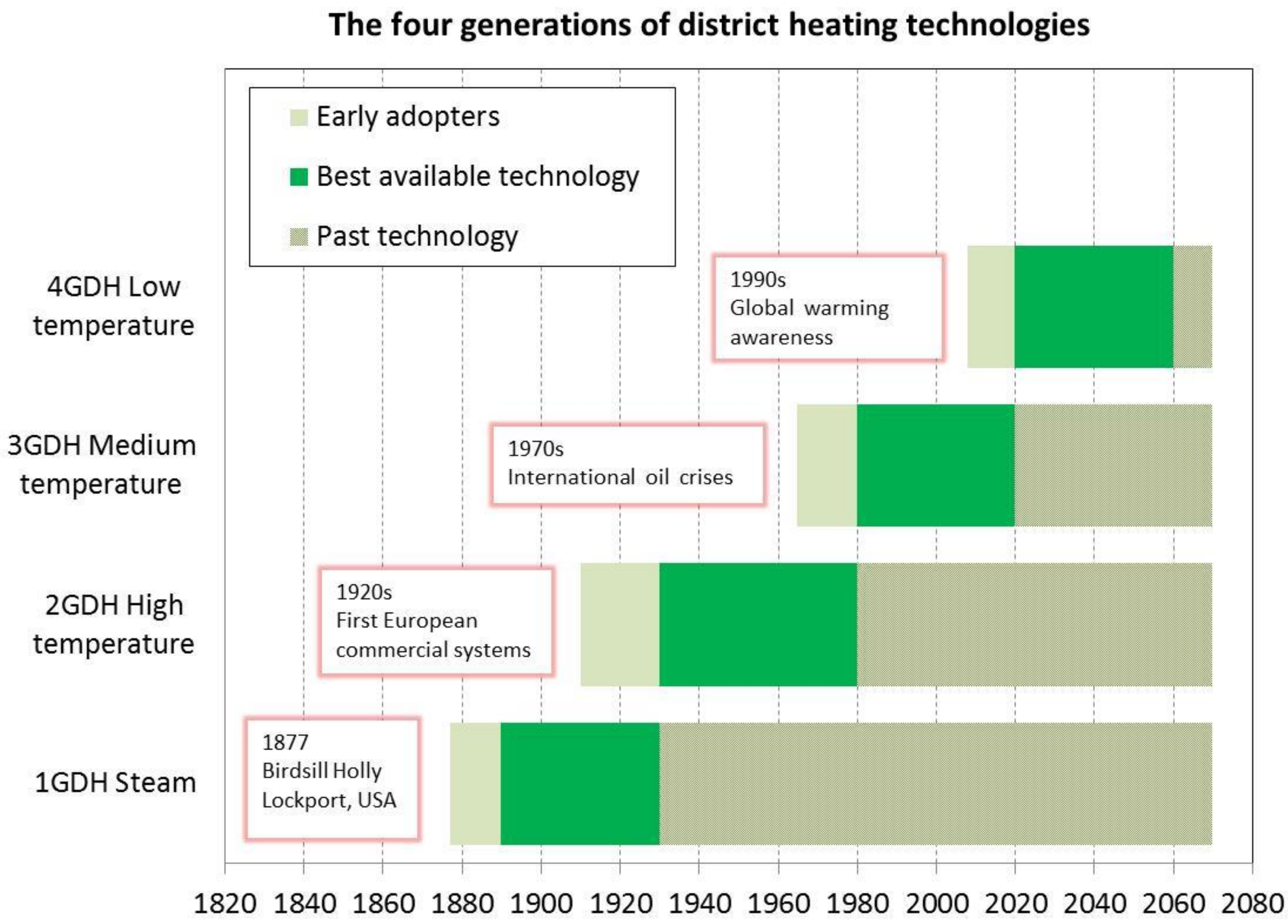
Figure 12-2. Map showing district heating systems in Europe in 2011. Systems have been identified in 2779 cities and towns having more than 5000 inhabitants. Further 1395 district heating systems have been found in smaller towns and villages, mostly in Denmark, Sweden, Switzerland, Austria, the Czech Republic, and the Slovak Republic. According to national statistics, further about 1500 systems are in operation. Source: The European DHC database at Halmstad University (Urban Persson).

2. Current situation: Heat supply



Average annual growth rates within district heating systems (between 2002-2012): Biofuels 9 %, Waste 6 %, Geothermal 15 %, and Solar 28 %.

3. Linking the future with the past



3. Linking the future with the past

Market demand:

- **What is the future market for district heating in Europe?**

Technology enhancements (since 1GDH, 2GDH, and 3GDH were designed based on the availability of fossil fuels):

- **What will be the typical features of 4GDH, dominated by renewables and heat recycling?**

4. The Heat Roadmap Europe Initiative

- **What is the future market for district heating in Europe**?
- Heat Roadmap Europe, prestudy 1 (2012) concerning business-as-usual scenario with current heat demands
- Heat Roadmap Europe, prestudy 2 (2013) concerning a high energy efficiency scenario

4. The Heat Roadmap Europe Initiative

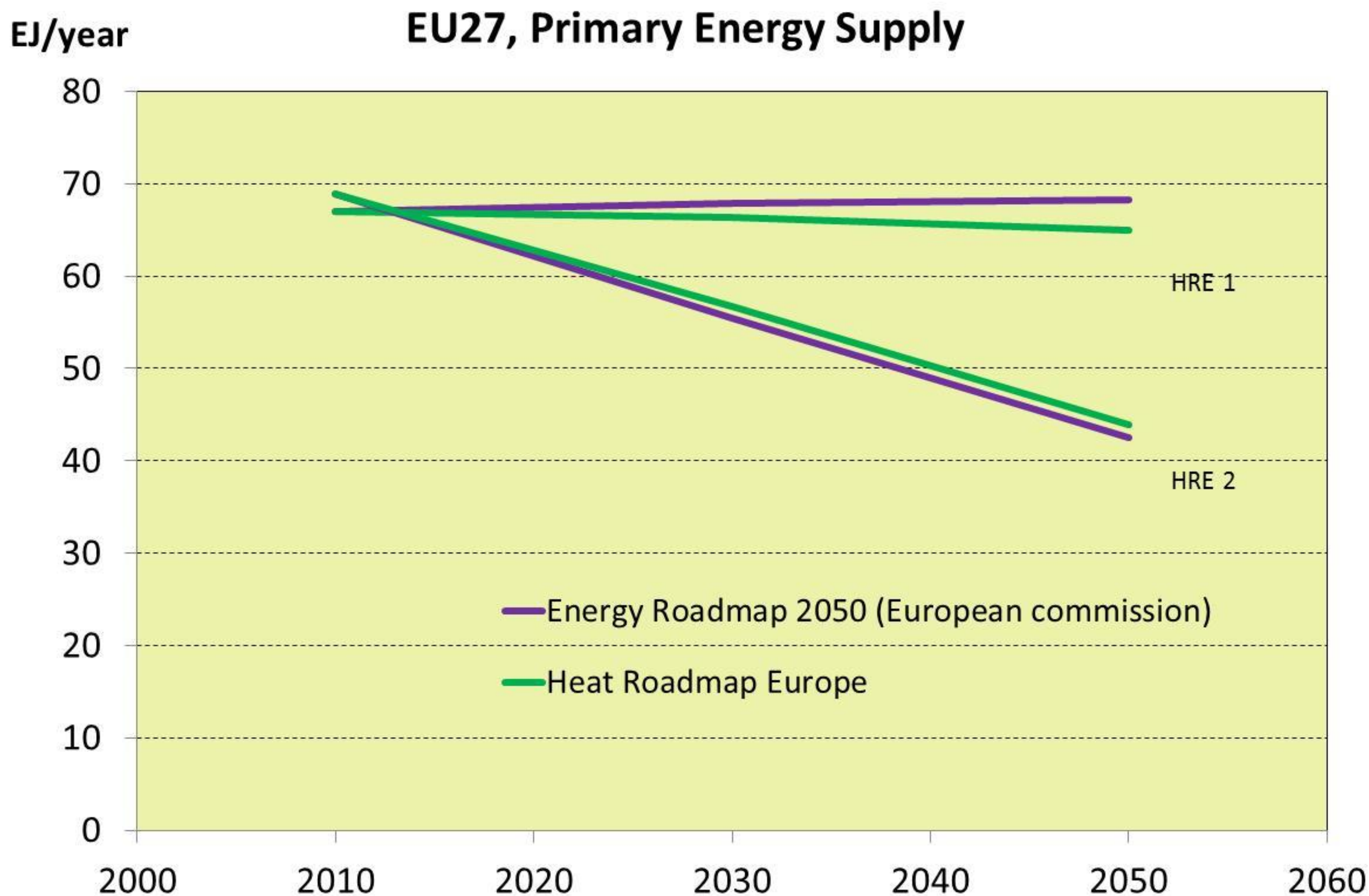
- The **heating and cooling sector has largely been overlooked** in all scenarios exploring the energy future towards 2050.

- **Heat Roadmap Europe** focused on the future European heat and cooling market and its importance in terms of emission reductions, cost savings, job creation, investments, and **a smarter energy system.**

4. The Heat Roadmap Europe Initiative

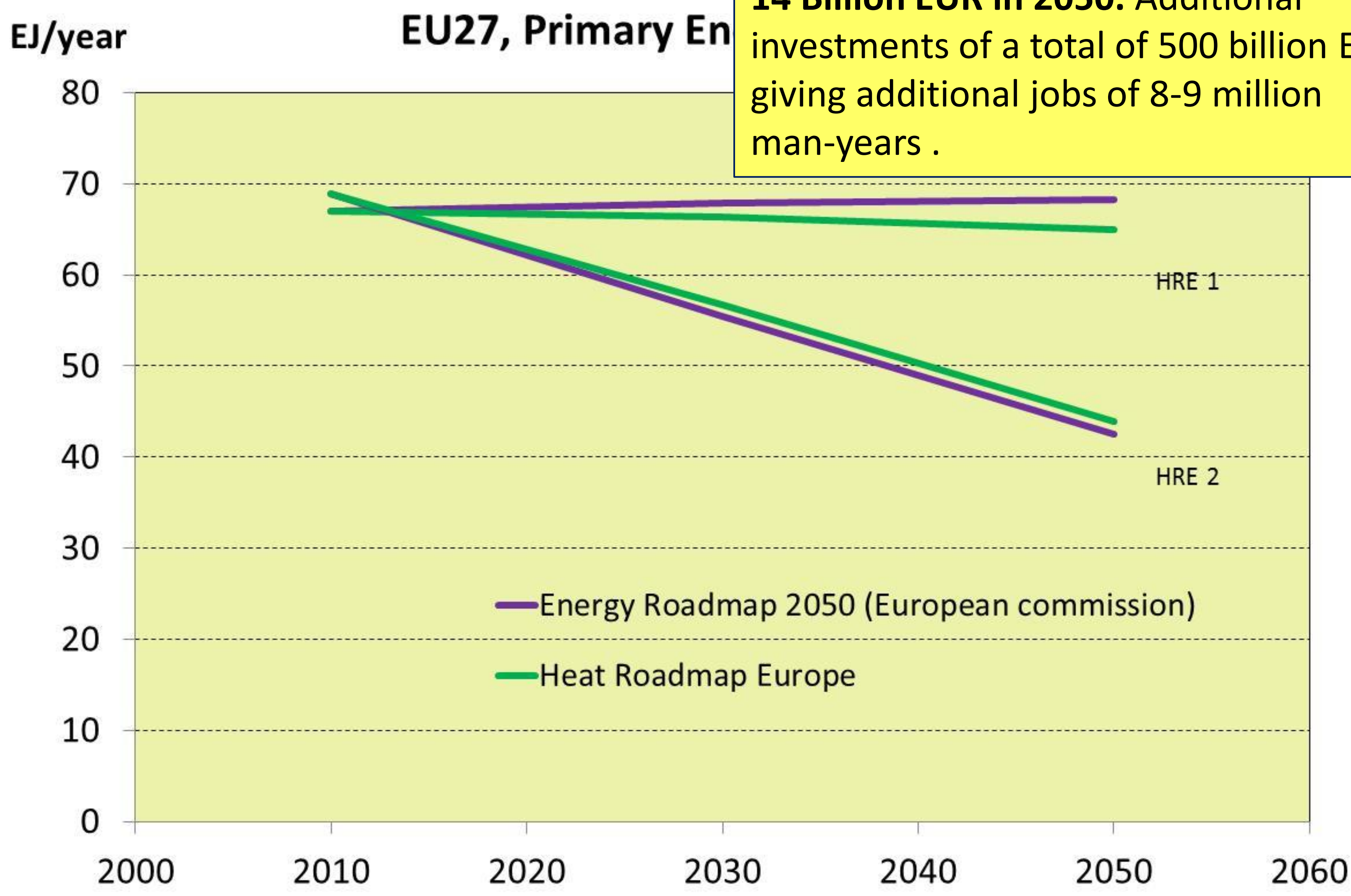
- All results are benchmarked against the EC communication called **Energy Roadmap 2050** (Dec 2011), which did not see a bright future for district heating with a market share of **10%** in 2050.
- **Heat Roadmap Europe** presumes a market share of **50%** for district heating in 2050 for heating the EU27 buildings.
- The current market share is **12%.**

4. Heat Roadmap Europe - Results



4. Heat Roadmap

HRE 1 results: Reduced fuel costs of 30 Billion EUR with 50% district heating in 2050. Total heating costs are reduced by **14 Billion EUR in 2050.** Additional investments of a total of 500 billion EUR giving additional jobs of 8-9 million man-years .



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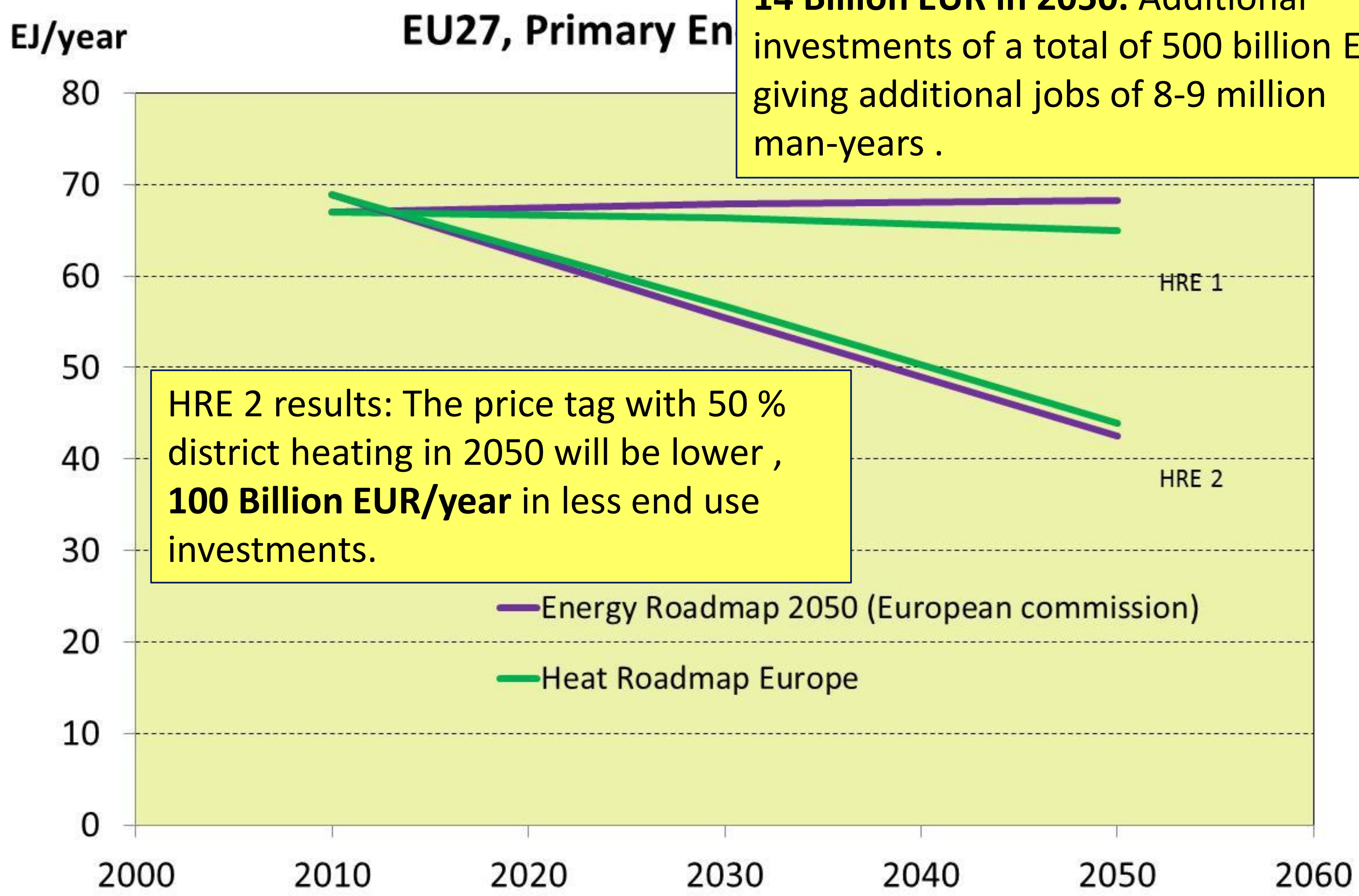


HRE 2 results: The price tag with 50 % district heating in 2050 will be lower , **100 Billion EUR/year** in less end use investments.

4. The Heat Roadmap Europe Initiative

A. **Forecast: District heating will be suitable in dense urban areas, while local heat pumps and biomass boilers will be suitable in other areas.**
B. **News:** First ever estimation of the district heating benefits in the future European energy system.
C. **Less costly:** We can avoid the most expensive end use energy efficiency measures in buildings by using district heating as an energy efficiency tool.
D. **Paradox:** District heating will have a higher competitiveness in a future more energy efficient Europe.

4. The Heat Roadmap Europe Initiative

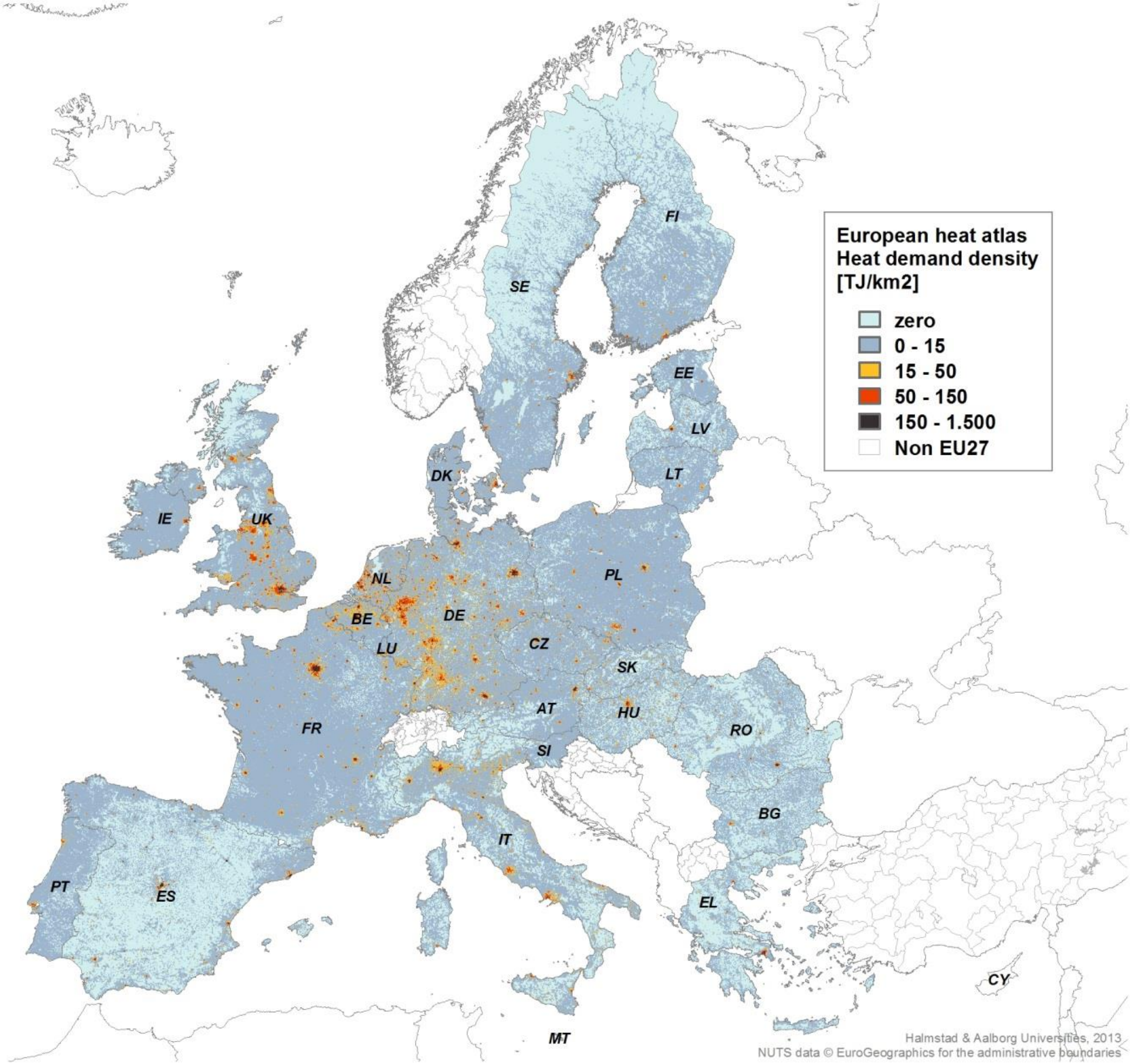
We sliced EU into about 1300 pieces (NUTS3 regions), and estimated what was possible in each region.

Other energy modellers just cut EU into 27 pieces (the national energy balances)

Figure 11: The NUTS3 regions of Europe, of which 1289 are located within the EU27 European territory and 14 are located overseas. (from the second pre-study)

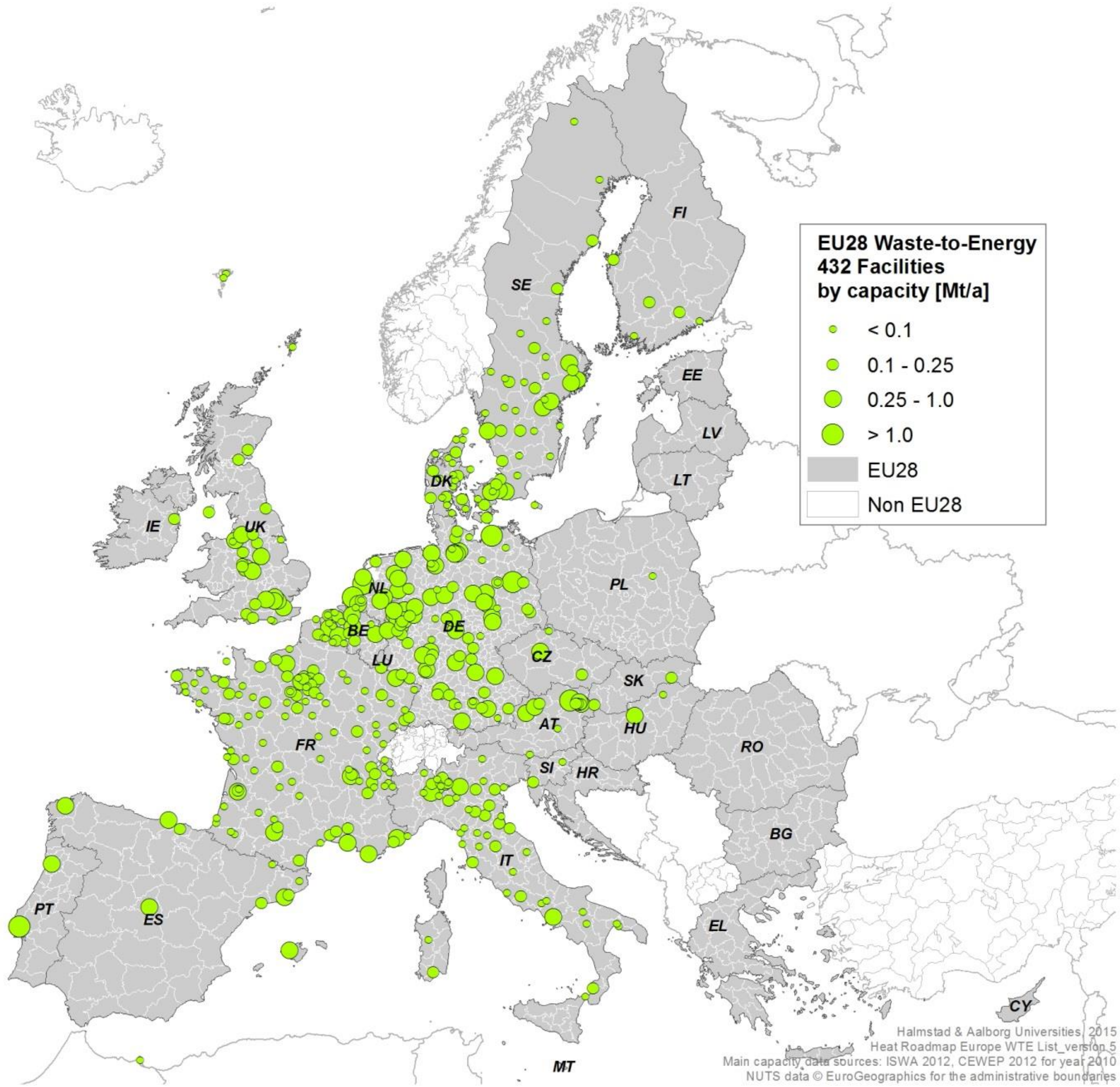
4. The Heat Roadmap Europe Initiative

The high resolution heat density map from the second pre-study



4. The Heat Roadmap Europe Initiative

All waste incineration plants within EU with respect to size and location as example of available large central heat sources.



4. 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)

5. Typical features of 4GDH

- **What will be the typical features of 4GDH, dominated by renewables and heat recovery?**

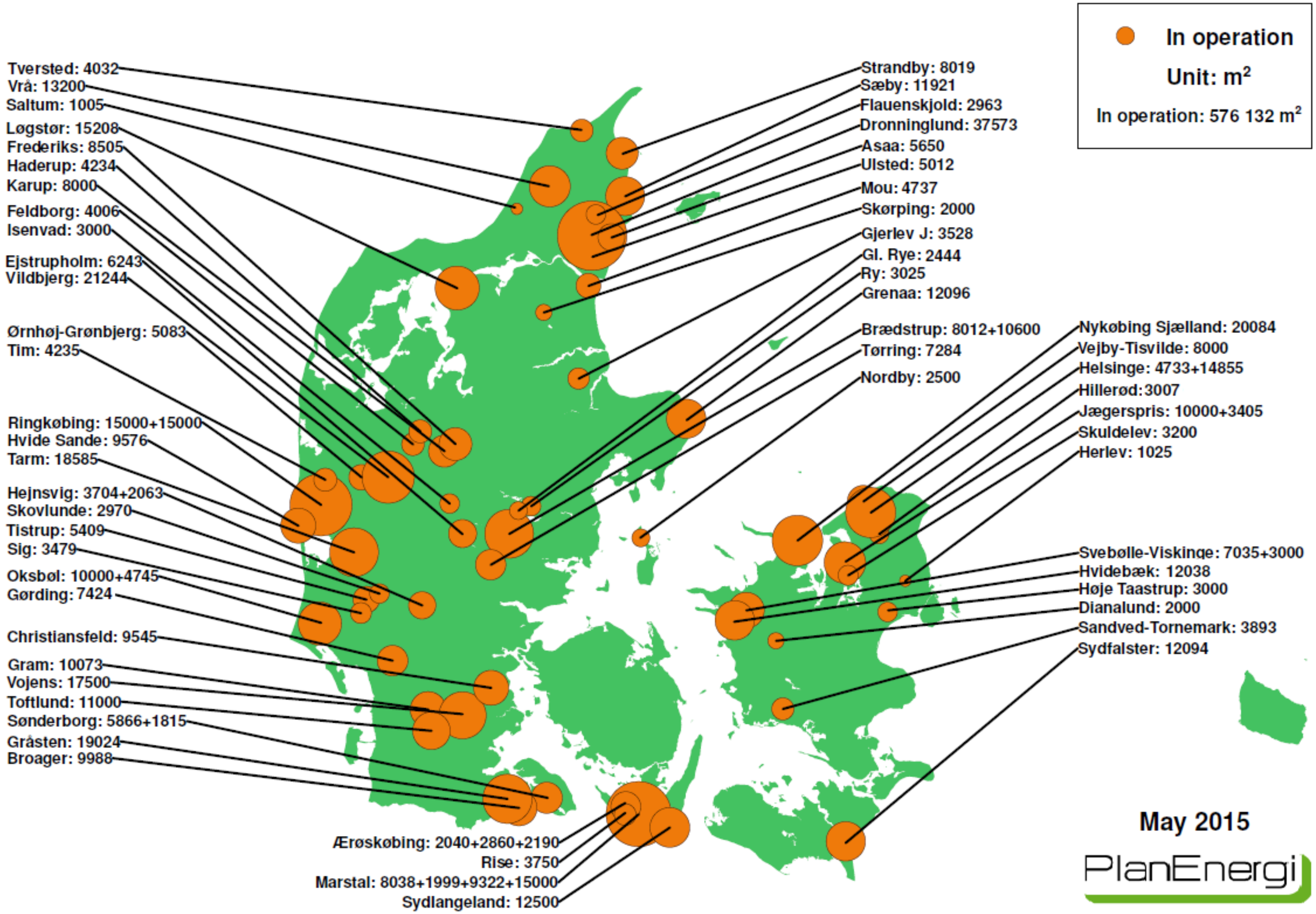
5. Typical features of 4GDH

Supply side:

- Biomass and waste in steam CHP plants with flue gas condensation, but fierce future competition from other uses of biomass and waste for petrochemical feedstock
- Heat recycled from biomass and waste refineries
- Heat recycled from energy intensive industrial processes
- Heat recycled from electricity intensive users, such as large data centres
- Natural geothermal resources
- Thermal solar collectors
- Use of excess electricity in large heat pumps and electric boilers from fluctuating solar and wind power
- Heat storages for both daily and seasonal purposes

All these supply technologies becomes more efficient and competitive if the supply temperatures in district heating networks becomes lower.

5. Solar district heating in Denmark



5. Solar district heating in Denmark

Two examples with solar district heating combined with biomass boilers and large pit heat storages.

Marstal, Denmark

Vojens, Denmark

5. Typical features of 4GDH

Demand side:

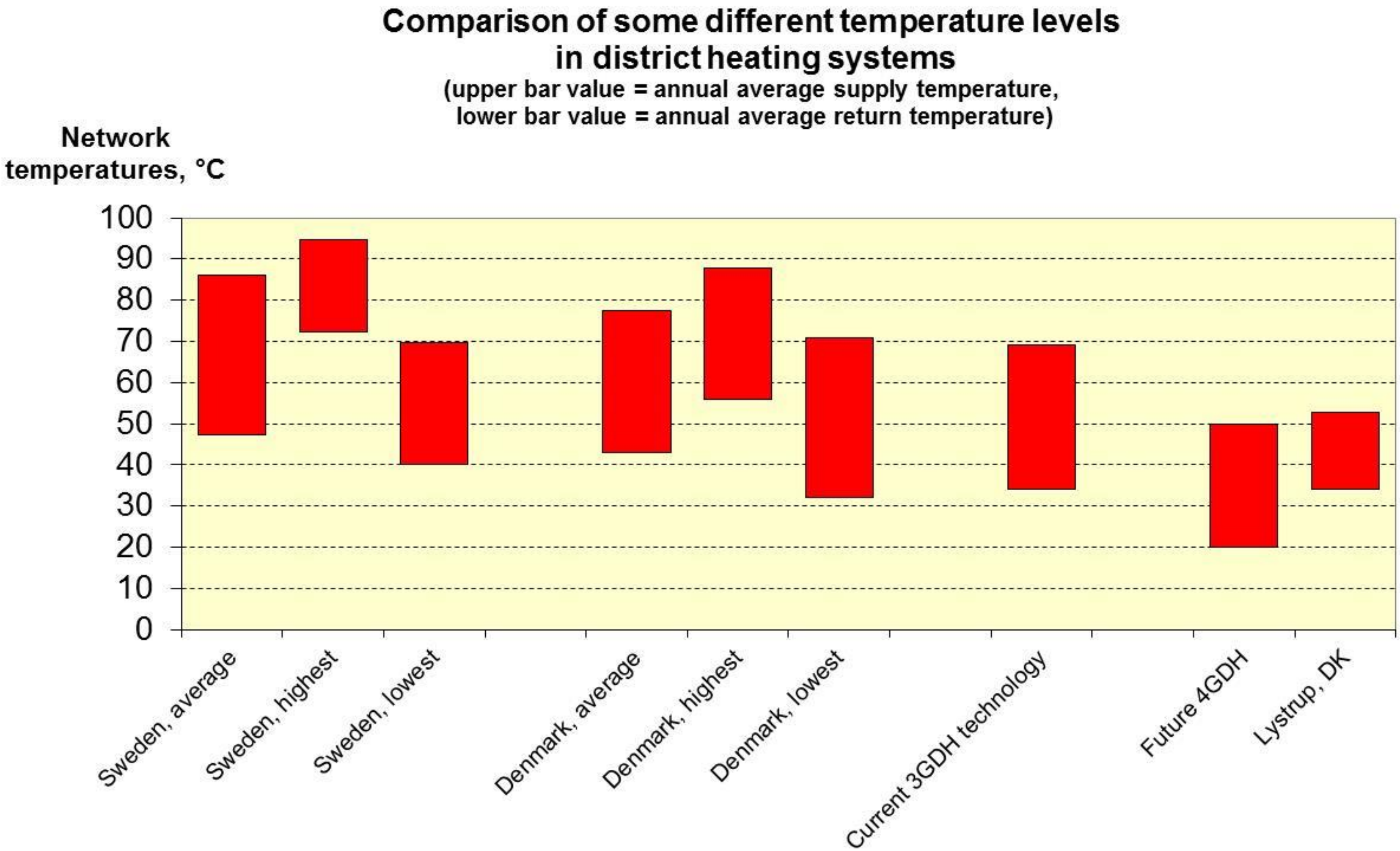
- Lower heat demands in new buildings make it possible to use lower temperatures in the their internal heat supply
- Lower heat demands in refurbished buildings make it possible to use lower temperatures in existing radiator systems.

Hence, buildings will require lower supply temperatures in the future.

5. Typical features of 4GDH

- Previous two features give both driving forces and possibilities for lower temperatures in district heating networks.
- Hereby, the network temperatures becomes a very important performance indicator for 4th generation systems.
- **How could lower network temperatures be reached?**

5. Typical feature: Network temperatures



5. Typical feature: Network temperatures

Two main strategies in order to get lower district heating network temperatures:

1. Elimination of all current temperature faults in distribution networks, substations, and customer heating systems (about half of the required change from 3GDH to 4GDH)
2. Reduced heat demands in both new and existing buildings or more radiator surfaces (about the other half of the required change)

5. Typical feature: Network temperatures

Hence,

- The HVAC, heat pump, and district heating communities should cooperate in order to get low temperature space heating systems in the future.
- This should be the main global strategy in order to increase the profitability of renewables and heat recovery in both heat pumps and district heating systems.

6. Six conclusions

1. District heating systems will be more competitive in the future energy efficient Europe than in the current European energy system.
2. Future 4GDH systems based on renewables and heat recovery will be more competitive when using lower network temperatures, since previous three generations were designed for fossil fuels.
3. Expected strong involvement from the HVAC community in order to provide low temperature demands for both district heating systems and local heat pumps.

6. Six conclusions

4. No 'one size fits all' available. We have **three** basic possibilities in order to replace the current use of fossil fuels: **energy efficiency measures, renewables, and heat recoveries.**

5. The future size of district heating systems will depend on sizes of heat sources: Big central heat sources will create large systems, while small decentral heat sources will create small systems.

6. **Use energy at least twice! Say yes to heat recovery when possible. Do not say no to a possibility to substitute fossil fuels. Do not rule out future enhanced district heating by referring to old fossil-based district heating.**

Acknowledgement

- This presentation is based on research performed within the Danish **4DH research centre** with basic funding from the **Innovation Fund Denmark**.
- My participation in this research programme is co-financed by **Fjärrsyn**, the Swedish research programme for district heating and cooling, provided by the Swedish Energy Agency and the Swedish District Heating Association.

The End

Thank you for your attention!

More info about Heat Roadmap Europe at:

http://heatroadmap.eu/

More info about 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