The Future of Thermal Grids

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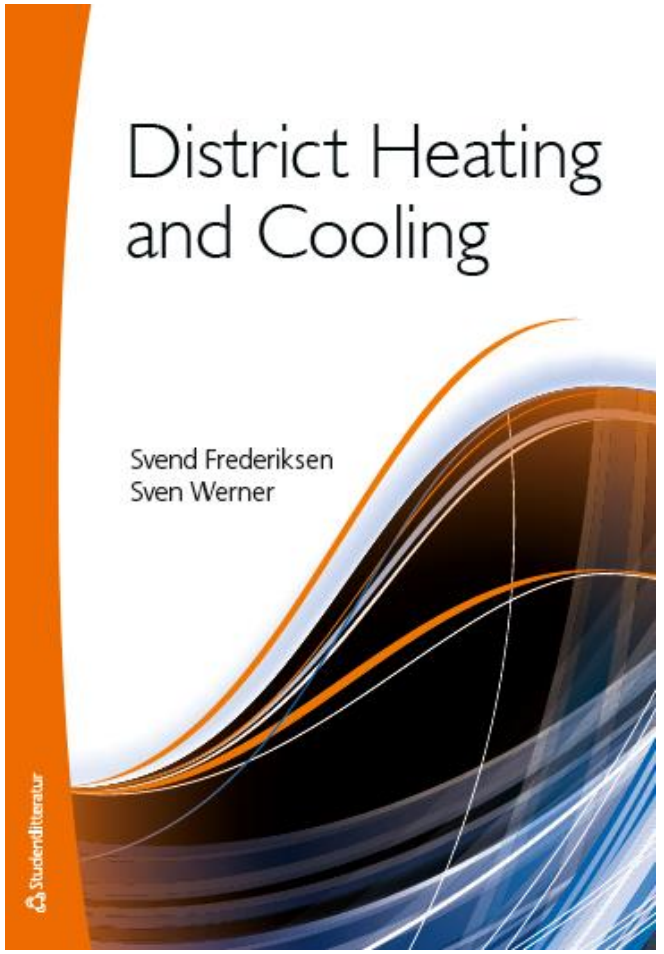
Who is Sven Werner?

- 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”.
- Have coordinated and participated in various research projects concerning the future for district heating in Europe.
- Co-author of textbooks about district heating and cooling in Swedish (1993 and 2014), in English (2013), and in Korean (2018).
- Retired on Dec 31, 2017, but still curious about district heating and cooling.



Outline

- Five basic statements about current and future heat grids
- Heat sources by temperature level
- Economy for lower temperatures in warm district heating networks
- The four generations of district heating
- Examples of current and future temperature levels
- Explanations for high temperature levels
- How to achieve temperature reductions
- Conclusions

Five basic statements about current and future heat grids

1. Current district heating technology was designed for fossil fuels used in CHP plants (our history)
2. Current temperature levels in heat distribution are based on this design tradition
3. Very easy to substitute fossil fuels with biomass or waste at current temperature levels
4. More difficult (and expensive) to substitute with solar collectors, geothermal, heat pumps, and low temperature excess heat
5. We have to redesign our district heating systems to use lower temperatures in order to facilitate the implementation of low temperature heat sources

Future heat sources by temperature level

High temperature heat sources:

- Combustion of fuels, including CHP
- Electric boilers
- Industrial excess heat at high temperatures

Low temperature heat sources:

- Heat pumps
- Solar collectors
- Geothermal heat
- Industrial excess heat at low temperatures
- Heat recovery from cooling devices
- Heat recovery from concentrated electricty use

Economy for lower heat distribution temperatures

- Low temperature heat sources can provide heat at lower costs if heat distribution is performed at lower temperatures
- Reduced heat supply costs provide the future cash flow for the additional costs for obtaining lower heat distribution temperatures

One economy evidence: Denmark 2050

Cost changes for 4GDH vs 3GDH for annual heat demand of 28.2 TWh	million euro/year	euro/MWh
Heat supply costs	- 300-350	- 11-12
Additional costs in buildings	+ 50-100	+ 2-4
Net benefit of 4GDH	- 200-300	- 7-11
Average district heating price in EU during 2013		65

According to: The status of 4th generation district heating - Research and results
https://www.sciencedirect.com/science/article/abs/pii/S0360544218317420

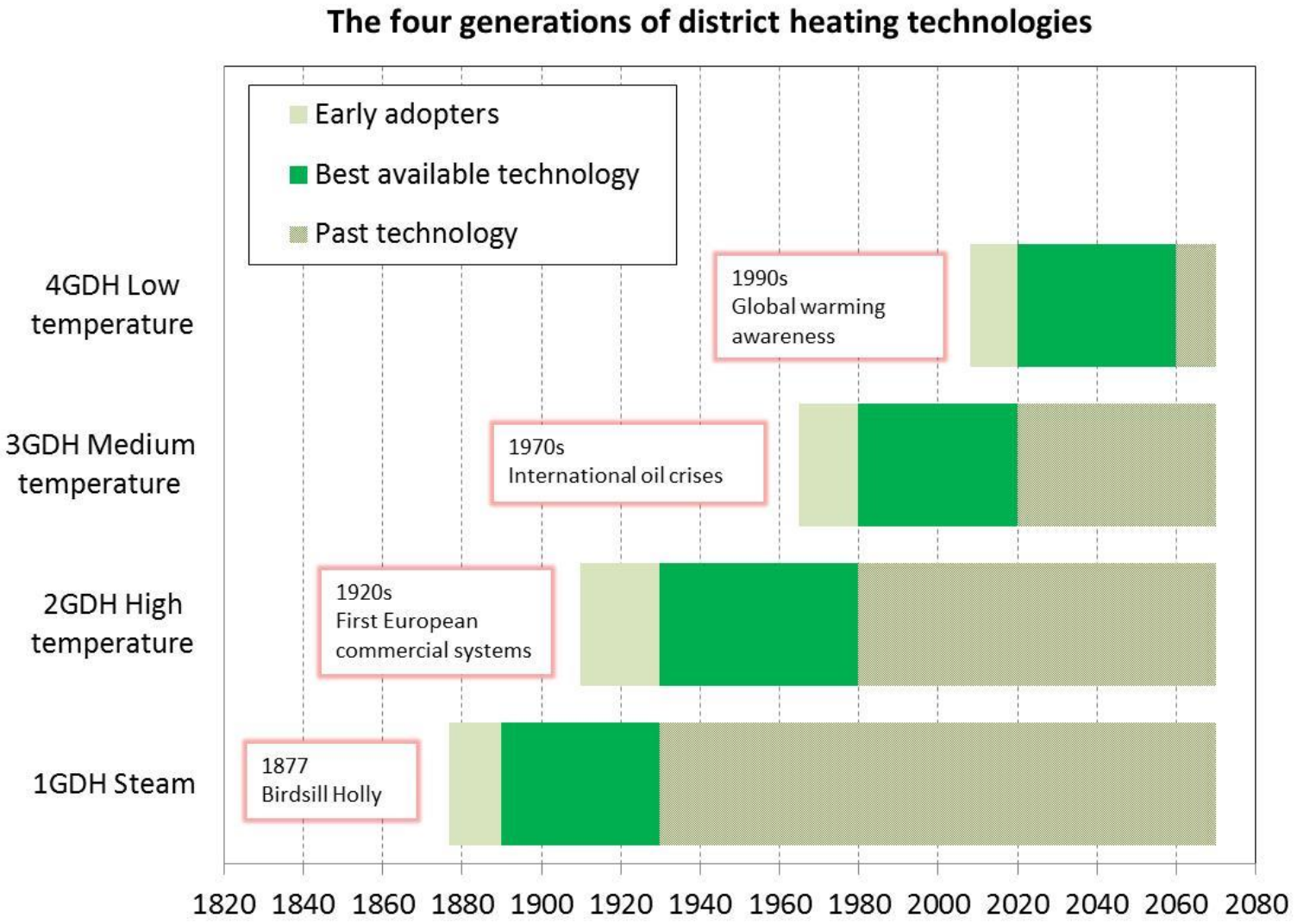


Figure 1. Overview of the four different technology generations of district heating with respect to time periods.

Typical supply temperatures for the four different generations

1GDH, steam: 130-220 °C

2GDH, high supply temperatures: 80-150 °C

3GDH, medium supply temperatures: 60-100 °C

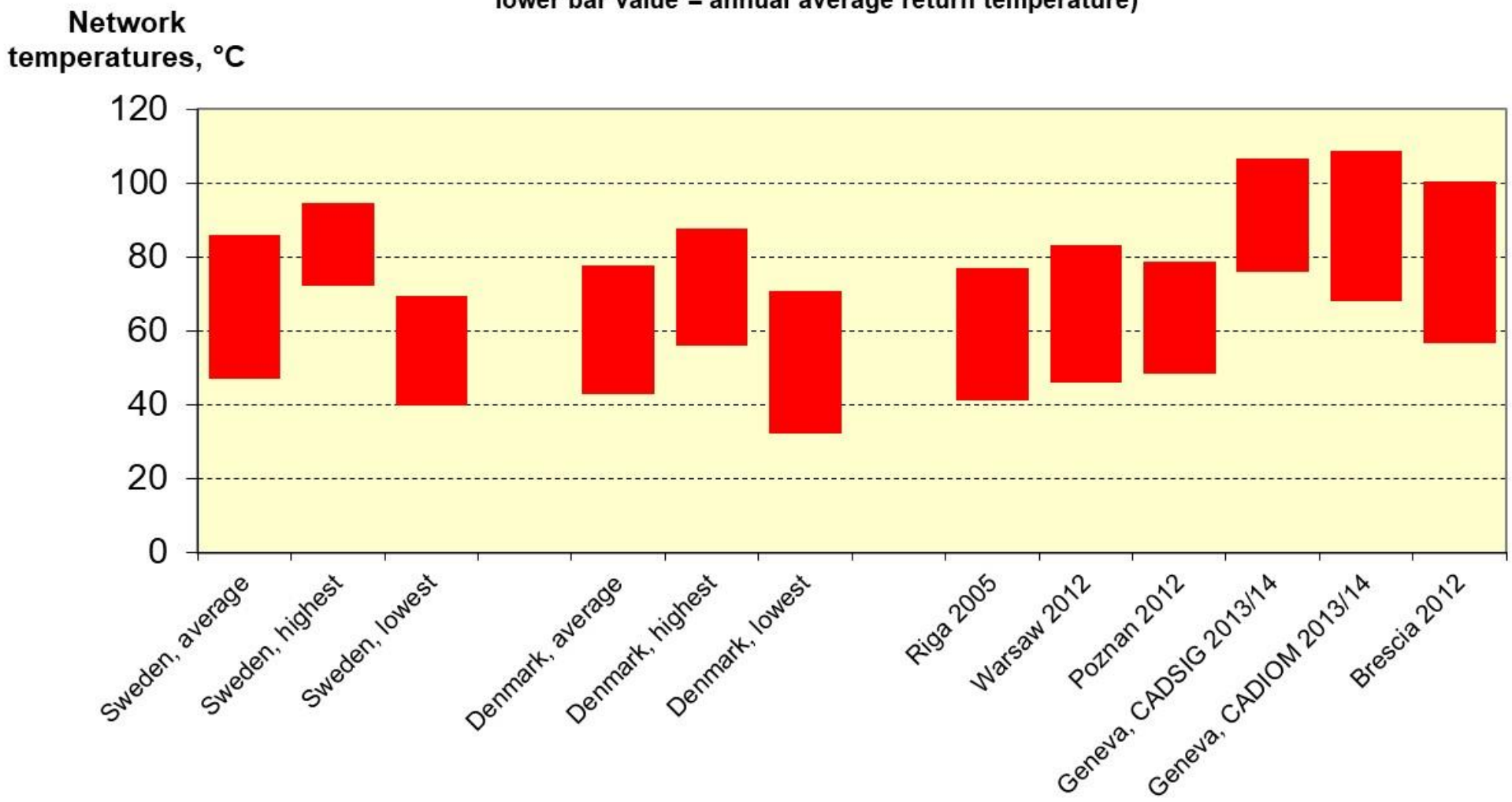
4GDH, low supply temperatures: 10-70 °C, also including cold district heating systems

The five abilities of 4GDH

1. Ability to supply low-temperature district heating for low demands of 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

Comparison of some different temperature levels in current district heating systems

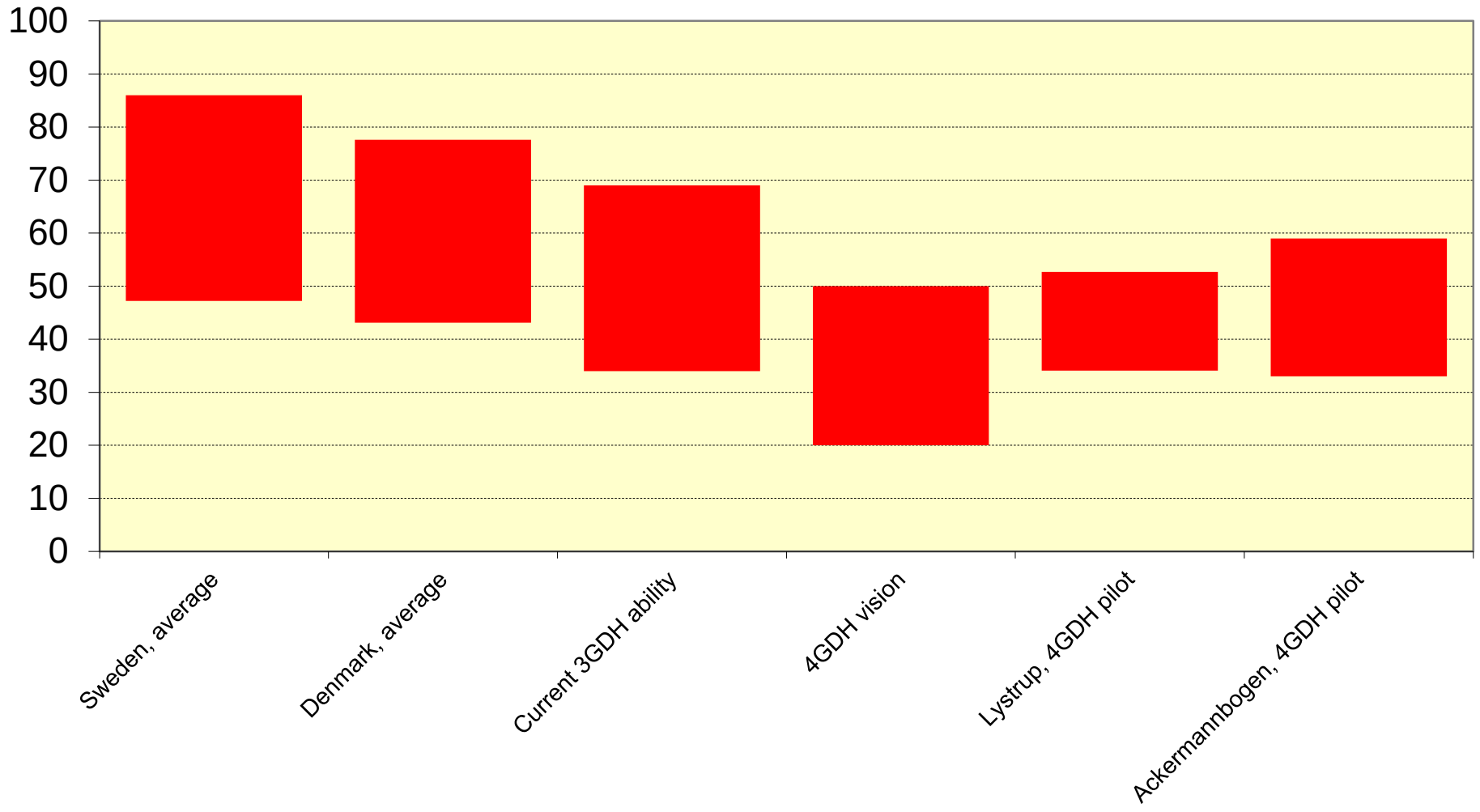
(upper bar value = annual average supply temperature, lower bar value = annual average return temperature)

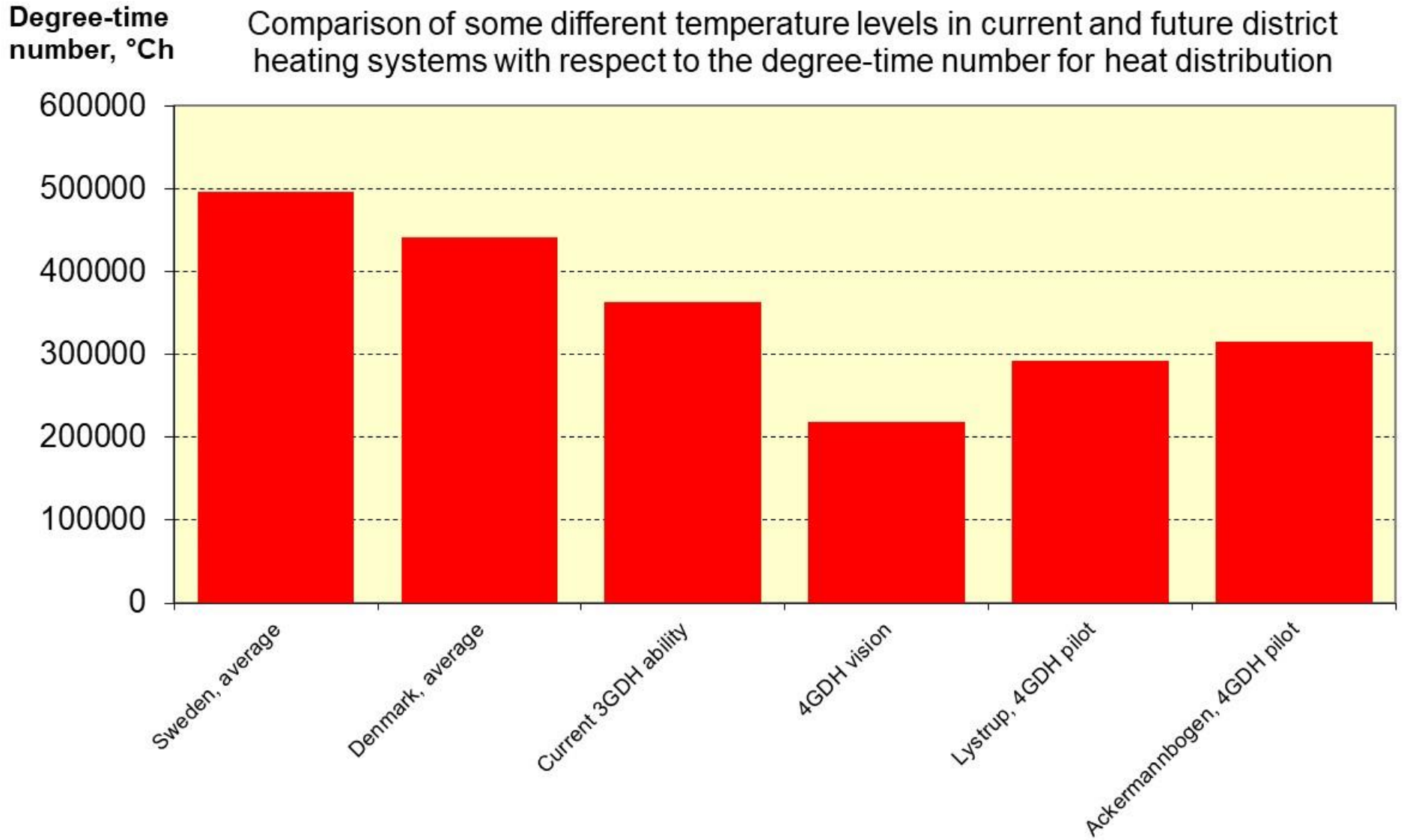


Network temperatures, °C

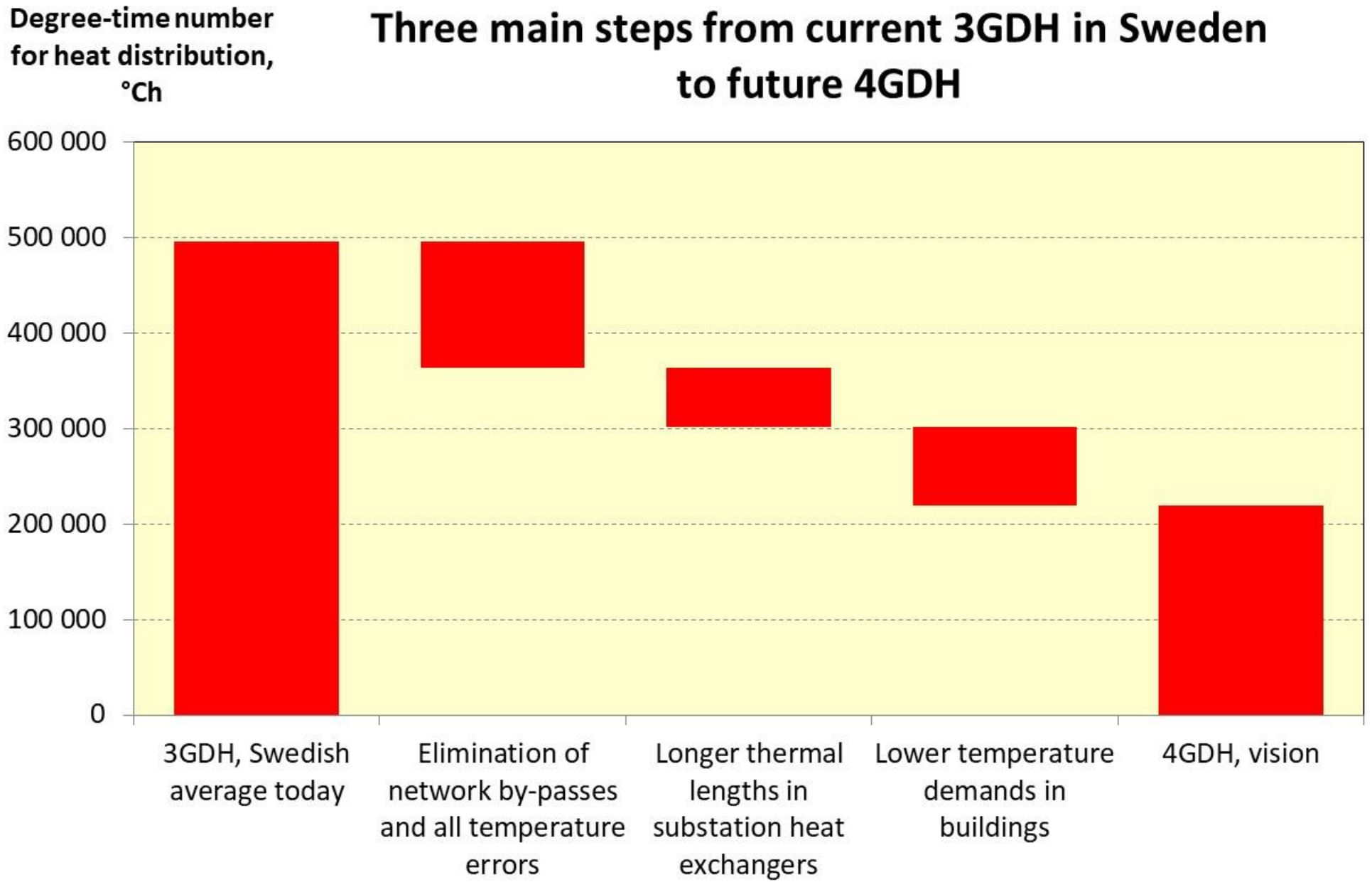
Comparison of some different temperature levels in current and future district heating systems

(upper bar value = annual average supply temperature, lower bar value = annual average return temperature)




Degree-time number, °Ch
Comparison of some different temperature levels in current and future district heating systems with respect to the degree-time number for heat distribution
600000
500000
400000
300000
200000
100000
0
Sweden, average
Denmark, average
Current 3GDH ability
4GDH vision
Lystrup, 4GDH pilot
Ackermannbogen, 4GDH pilot

Three main steps from current 3GDH in Sweden to future 4GDH



Summary of operation errors giving high return temperatures

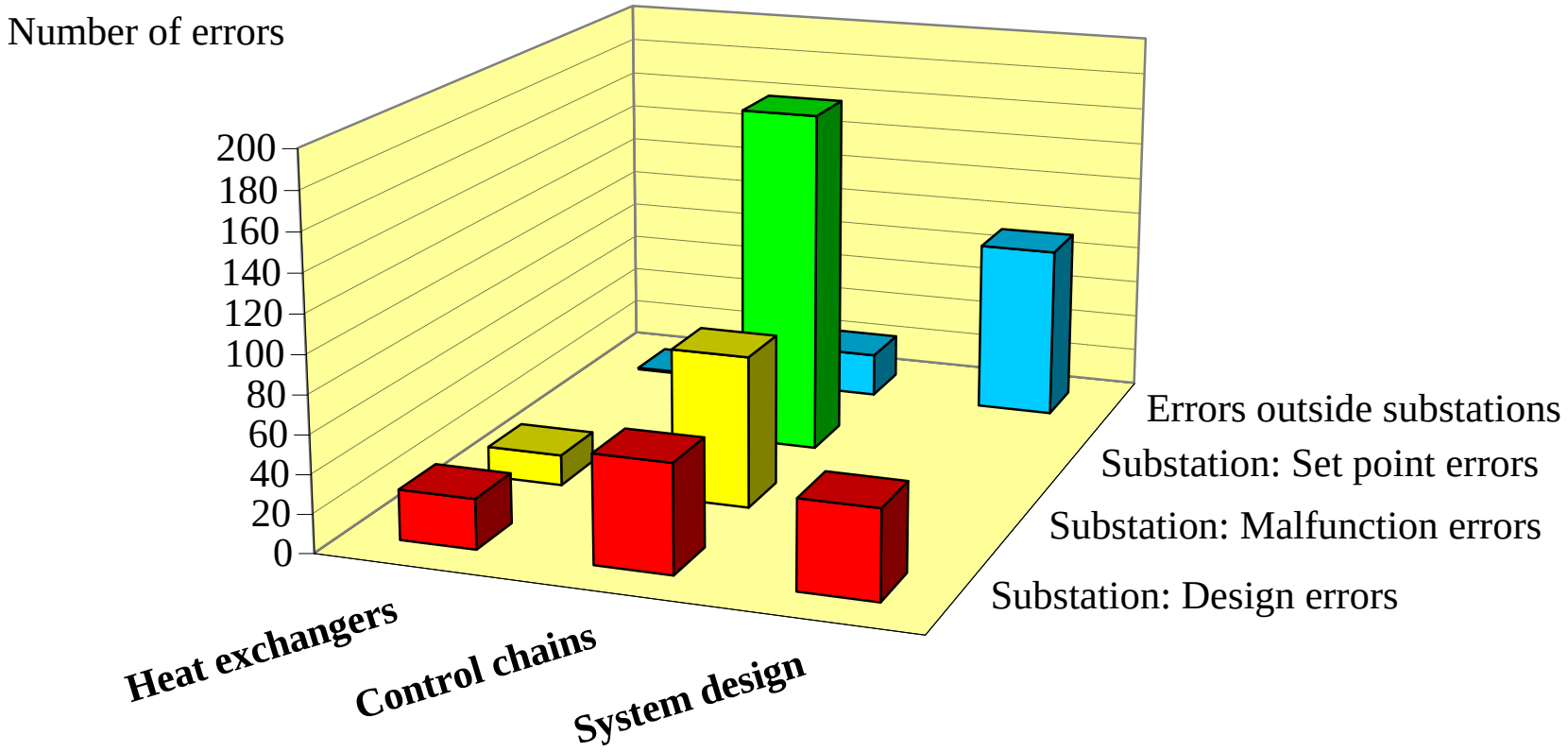


Figure 10-21. Overview of 520 cooling errors in 246 substations found from several Swedish inventories during 1992-2002 in substations having low annual average temperature differences. Source: FVB Sweden. Reprinted with permission.

Condensed Transformation Roadmap

1. **Eliminate temperature errors** in existing distribution networks and substations in order to make existing systems more efficient. This will reduce existing temperature levels.
2. **Avoid these temperature errors** in new networks and in new substations.
3. Use **heat exchangers with longer thermal lengths** in substations for indirect connection of customer heating systems and closed hot water preparation. This will reduce the temperature differences between the warmer distribution waters and the colder fluids to be heated.

Condensed Transformation Roadmap, continued

4. **Reduce existing customer temperature demands** by elimination of local temperature errors, reduction of heat demands by means of energy efficiency measures, and by installation of larger heating surfaces in radiator and ventilation systems.
5. New low temperature networks in conjunction with existing systems can be **connected by concurrent operation** of these parts as secondary networks.
6. The long-term vision is to deliver heat to substations with a **supply temperature of 50°C, while obtaining a return temperature of 20°C** in warm district heating systems.

Conclusions

- With new non-combustible heat sources in the future, lower temperature levels in heat distribution networks are more optimal
- Temperature levels in heat distribution networks are created in substations and in customer heating systems
- New guidelines for substations are required for getting lower temperature levels in future heat distribution networks

The End

Thank you for your attention!

The 4GDH definition paper by Henrik Lund et al:
http://www.sciencedirect.com/science/article/pii/S0360544214002369
The status of 4th generation district heating: Research and results:
https://www.sciencedirect.com/science/article/abs/pii/S0360544218317420
The 4DH research centre:
http://www.4dh.dk/
Recent review of DHC in the world (open access):
http://www.sciencedirect.com/science/article/pii/S036054421730614X
Recent review of DHC in Sweden (open access):
http://www.sciencedirect.com/science/article/pii/S0360544217304140
Novel low temperature heat distribution technology (open access):
https://www.sciencedirect.com/science/article/pii/S0360544217322004