Current and future temperature levels in district heating systems

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Outline

- Three generations of district heating technology
- Benefits with lower network temperatures
- Combined flow and temperature control
- Current temperature levels in Sweden and Denmark
- Typical operation errors giving higher temperature levels
- Current cost gradients for lower temperature levels
- Main conclusions

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Quality	Outdated technology	Low quality for the Soviet DH technology and high to medium quality for other systems	High quality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.

The 4th generation of DHC systems

- What technical solutions to use?
- What market conditions to consider?
- What heat demands to consider?
- What resources to use?
- What network temperatures to use?
- What …….?

Benefits with lower temperatures

- Lower heat losses in heat distribution
- Higher power-to-heat ratios in steam CHP plants
- Flue gas condensation when using biomass and waste with high moisture contents
- Higher utilisation of solar and geothermal heat
- Lower risk for scalding at water leakages
- Higher capacities in heat storages when using somewhat higher storage temperatures
- Use of other pipe materials (plastics etc)

Grid control with a combination of flow and temperatures

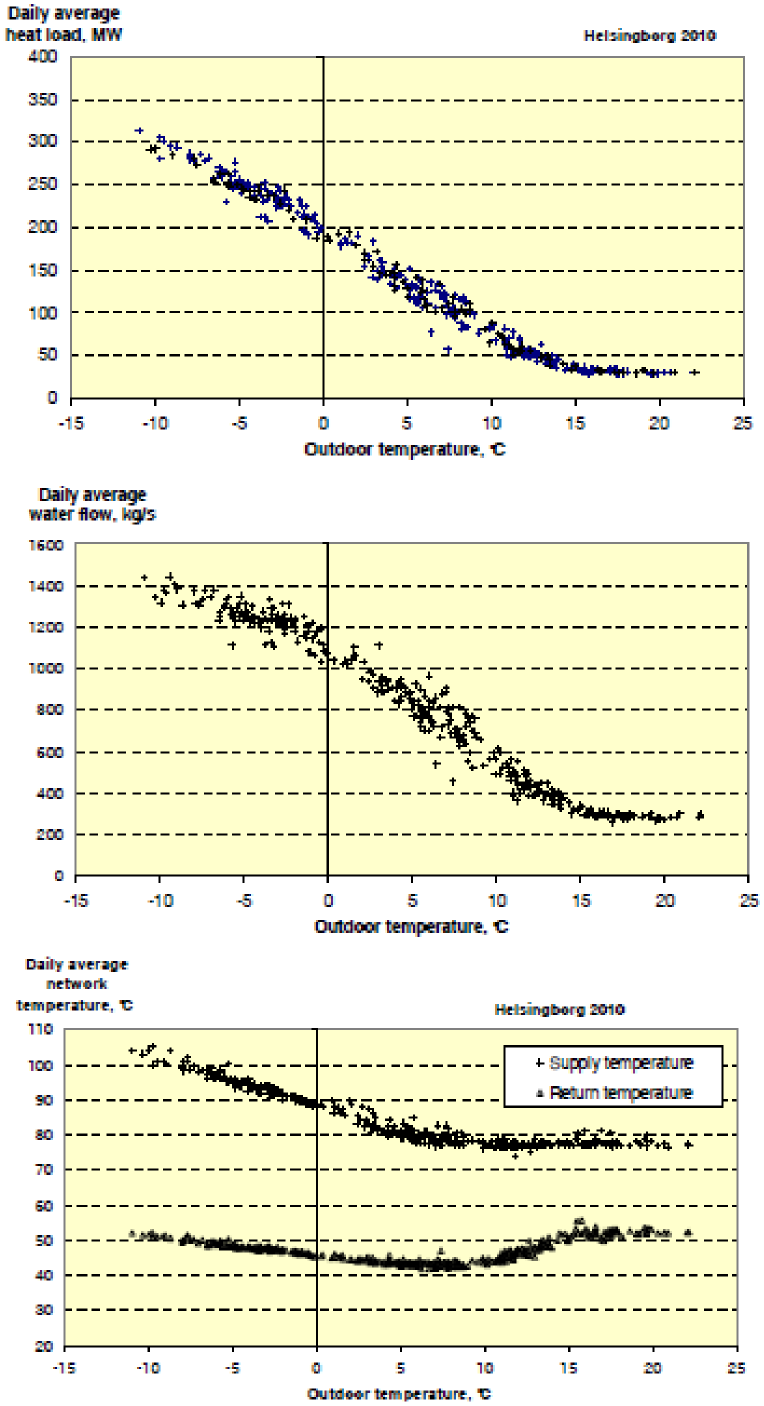
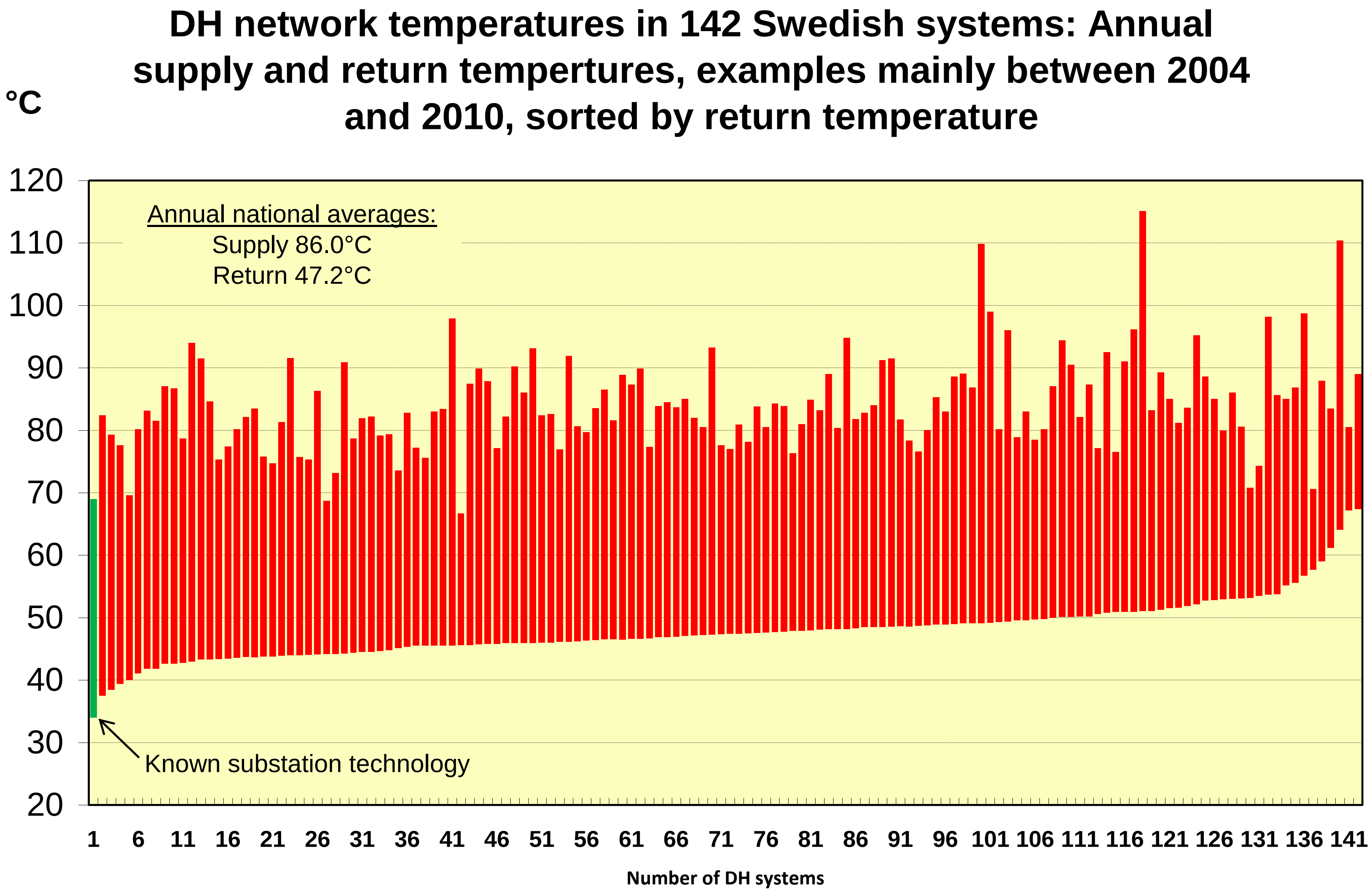


Figure 10-26. Corresponding daily average values for heat loads, mass flows, and the network temperatures at the heat supply units in 2010 for the Helsingborg district heating system.

Current temperature levels

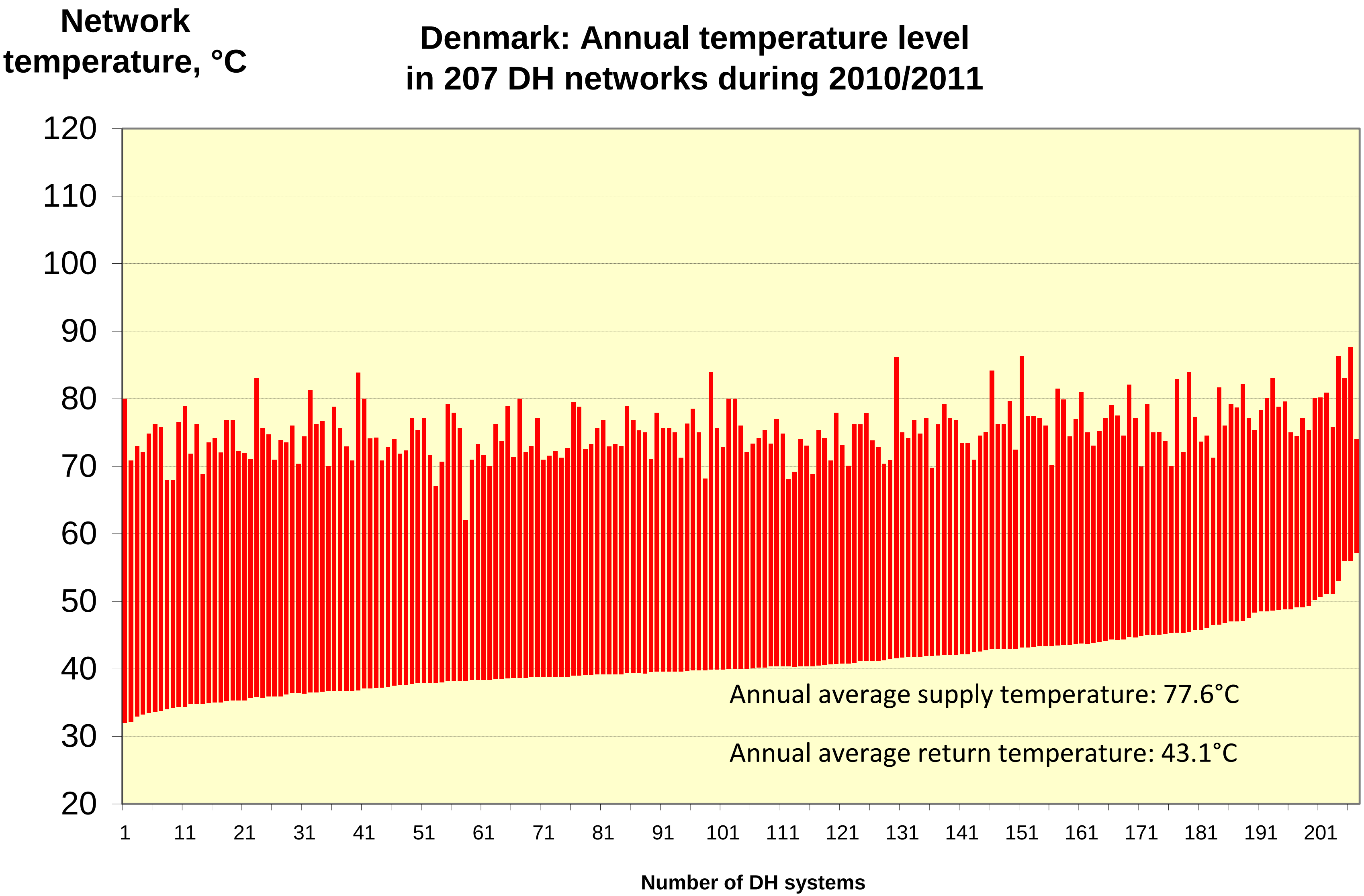
- Sweden: Temperature levels in Sweden gathered by FVB Sweden (Stefan Petersson), a consulting company.
- Denmark: The annual 2010/11 statistics from Dansk Fjernvarme.
- The tradition from using high distribution temperatures comes from the use of fossil fuels with high heat values, having no problems of generating high temperatures

Sweden



DH network temperatures in 142 Swedish systems: Annual supply and return tempertures, examples mainly between 2004 and 2010, sorted by return temperature
°C
120
110
100
90
80
70
60
50
40
30
20
Annual national averages:
Supply 86.0°C
Return 47.2°C
Known substation technology
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
126
131
136
141
Number of DH systems

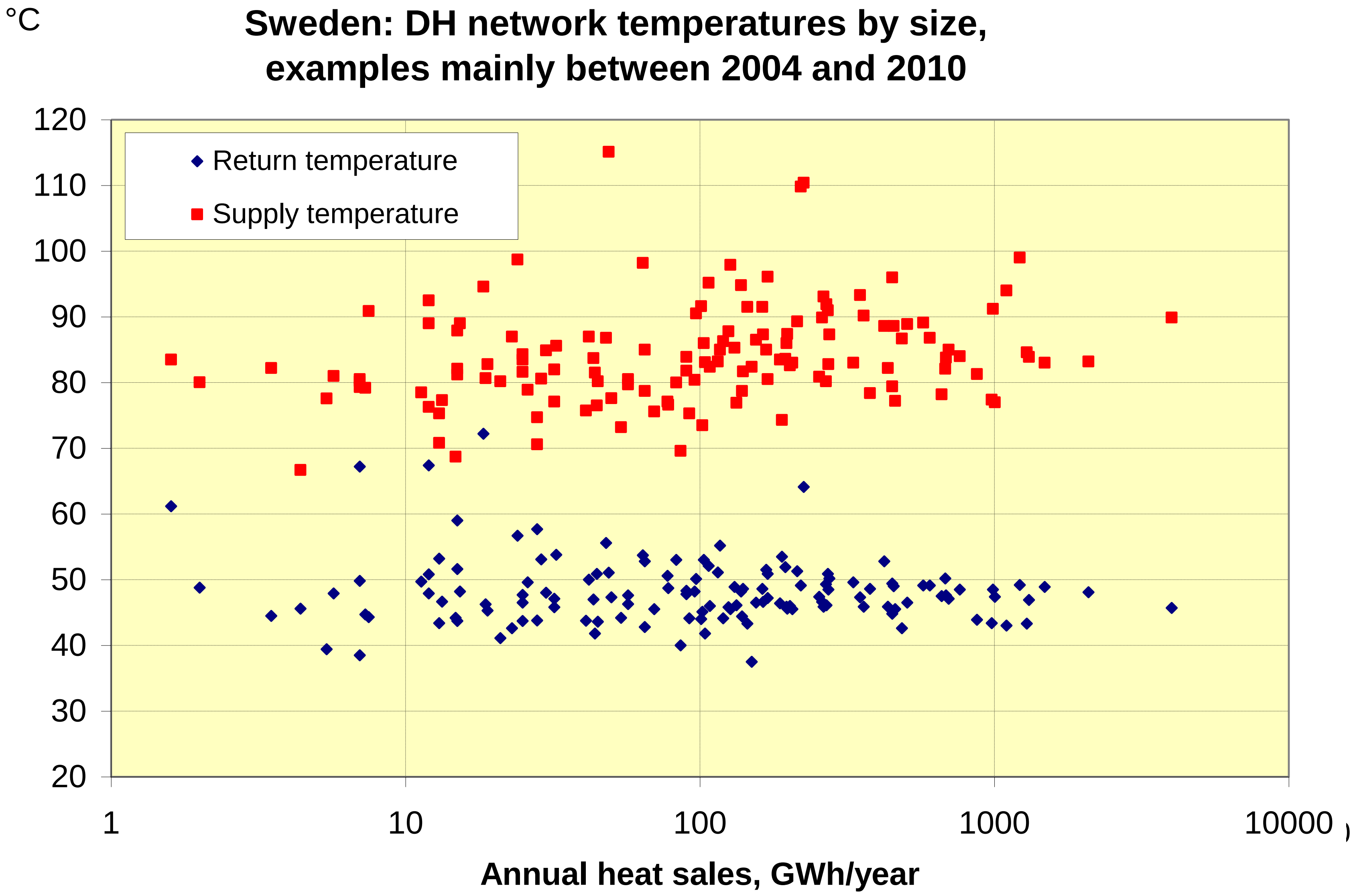
Denmark



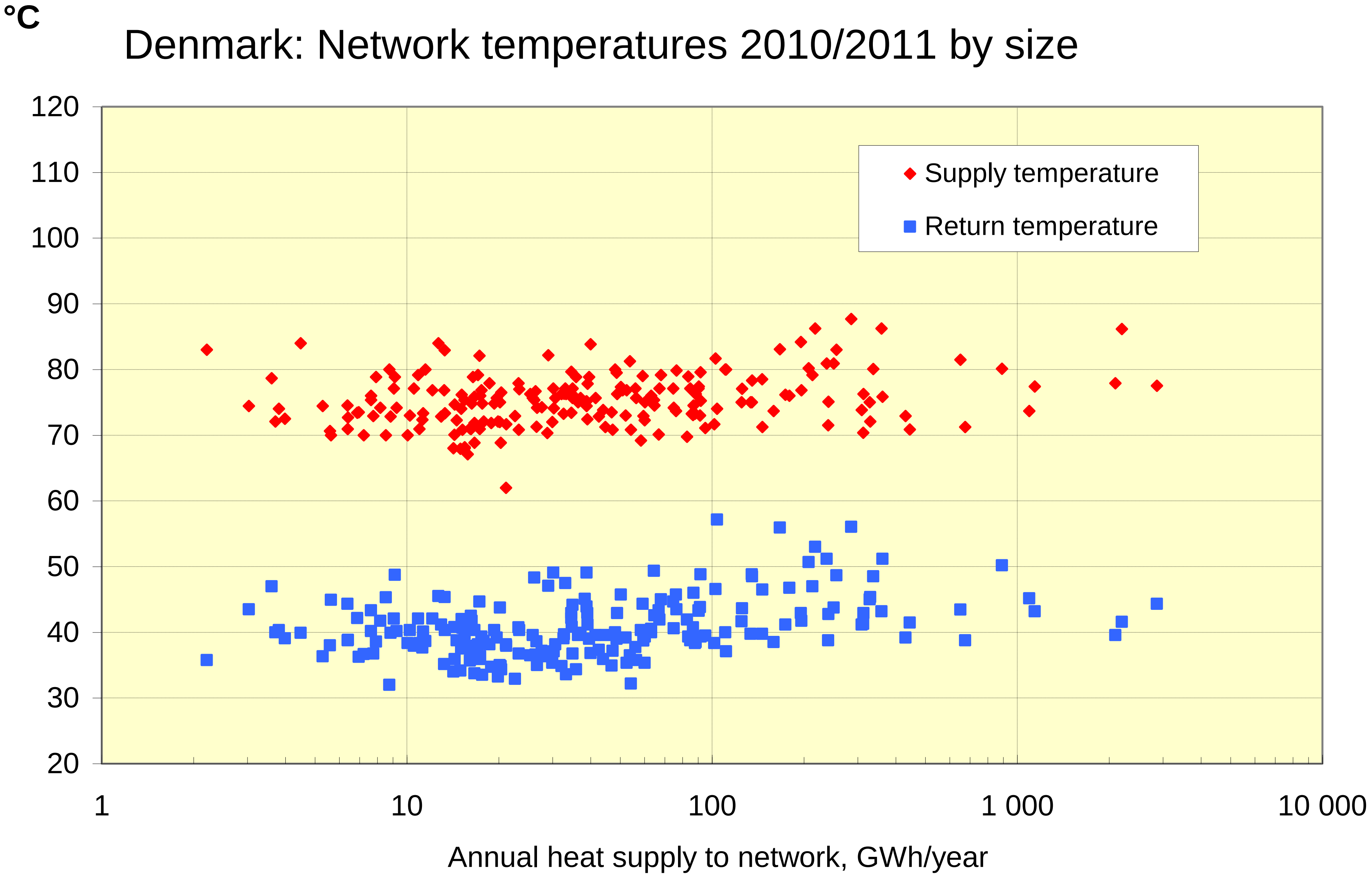
Annual average supply temperature: 77.6°C

Annual average return temperature: 43.1°C

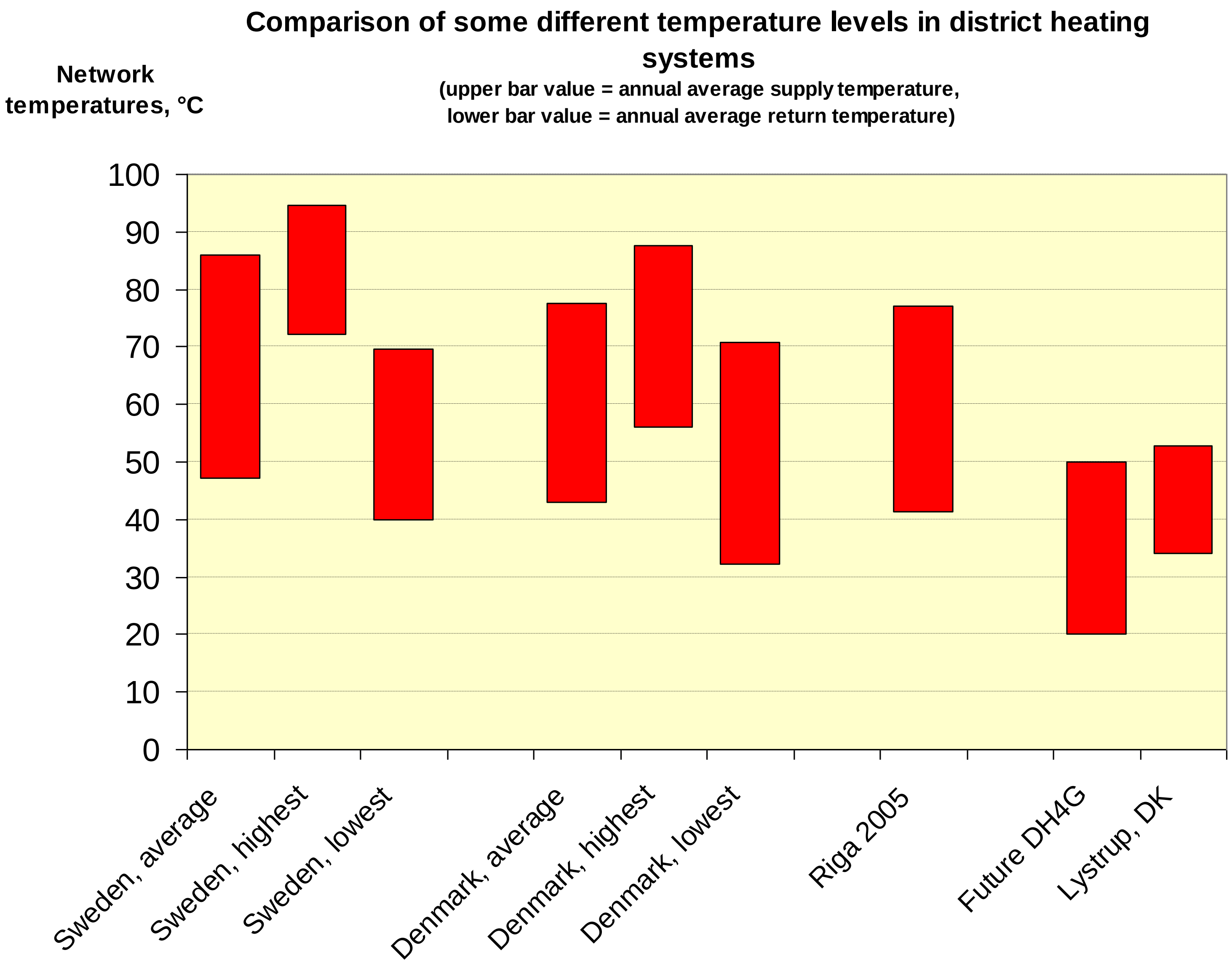
Sweden, by size



Denmark. by size



Comparison, supply and return

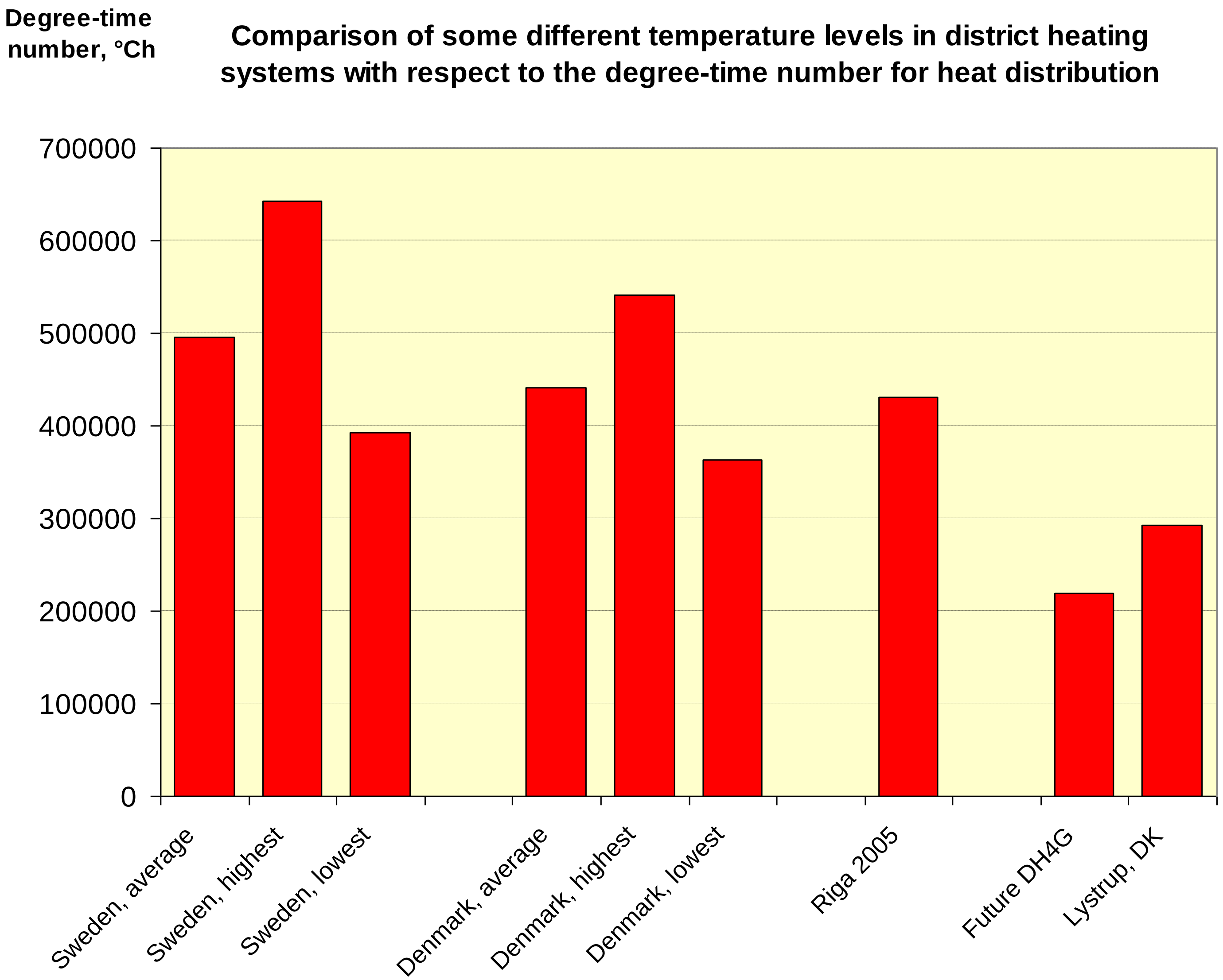


Degree time number for heat distribution

The degree time number for heat distribution is a measure of the temperature level for estimating the distribution heat losses.

This number is the time integral of the temperature difference between the average network temperature and the outdoor temperature.

Comparison, degree-time number



Conclusions from current situation

- No common standard for temperatures used in heat distribution (in contrast to electricity networks)
- Somewhat lower distribution temperatures in Denmark compared to Sweden
- Temperature level has a low correlation to system size.
- Degree time number can be cut to about half in the future by using low temperature distribution.

Typical operation errors giving higher temperature levels in Sweden

The deviation between actual and theoretical return temperatures are caused by:

- Shortcut flows between supply and return pipes in the network (can be 10% of full flow)
- Low supply temperatures at peripheral substations due to high heat losses
- Errors in customer heating systems
- Errors in customer substations

Summary of operation errors giving high return temperatures

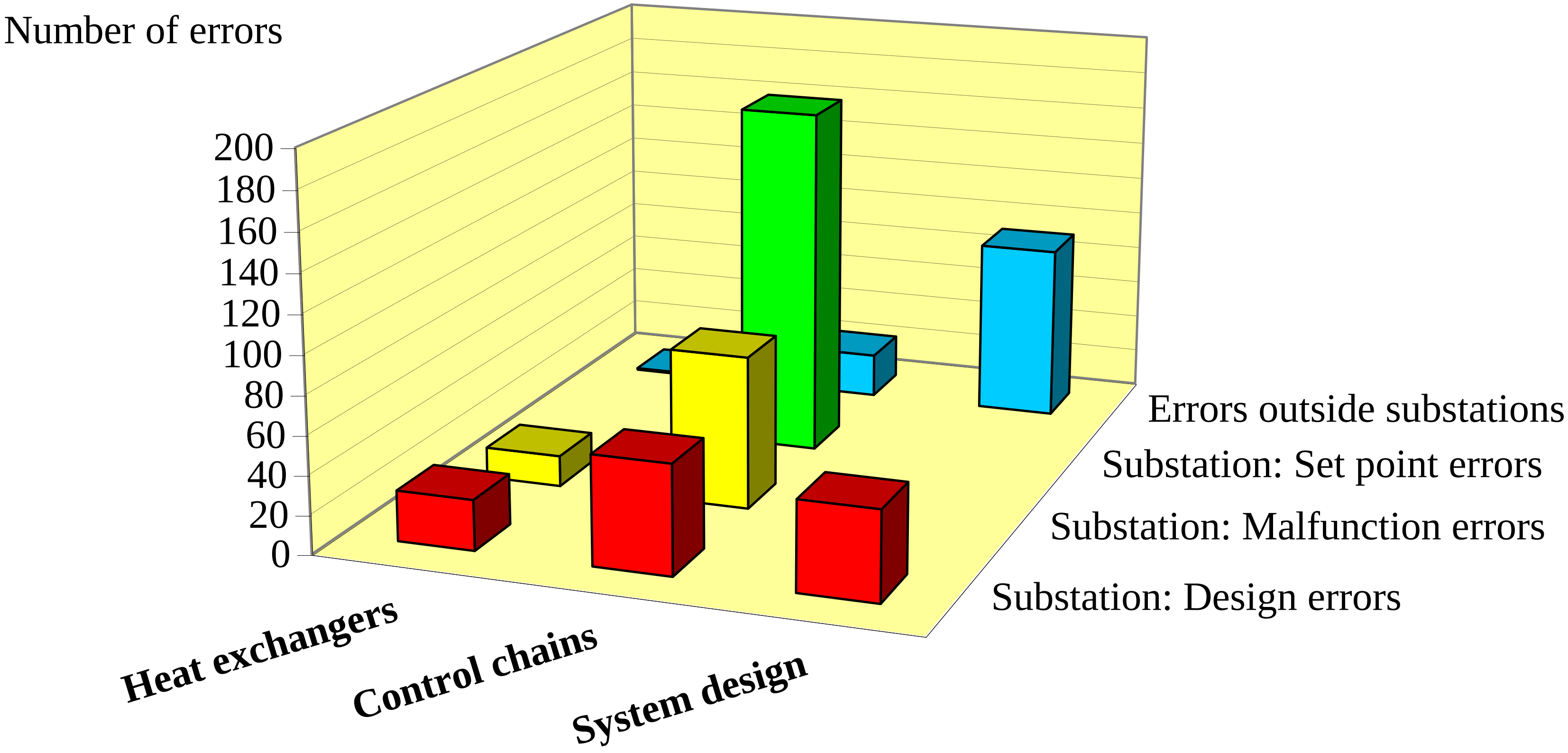


Figure 10-21. Overview of 520 cooling errors in 246 substations found from several Swedish inventories during 1992-2002 in substations having low annual average temperature differences. Source: FVB Sweden. Reprinted with permission.

Temperature levels, high return temperatures

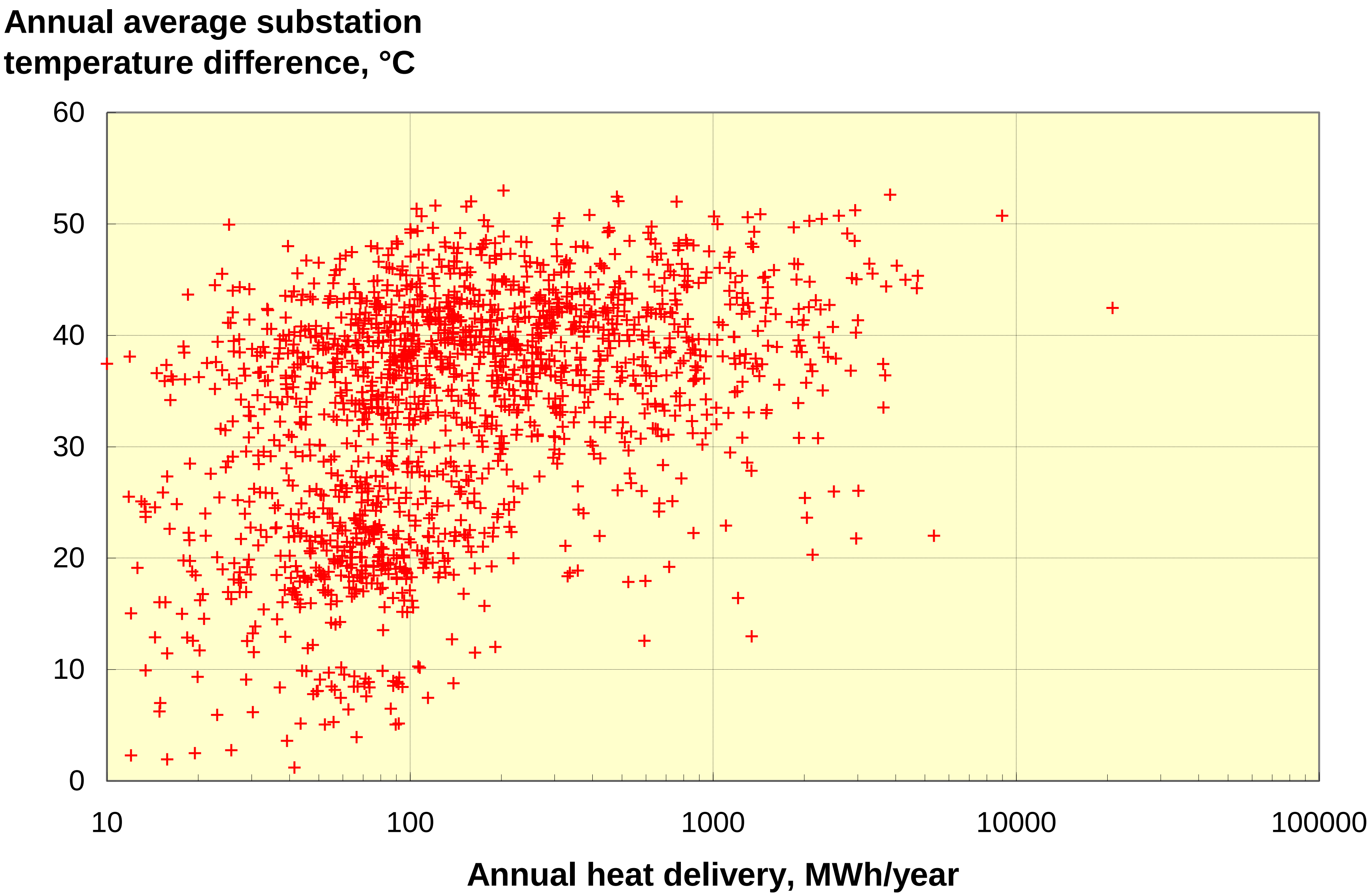


Figure 10-22. The effective annual average temperature difference between the supply and return temperatures for each substation in a district heating system during 1999. Source: Cilla Dahlberg Larsson, FVB Sweden. Reprinted with permission.

Typical design errors

- Heat exhangers in parallel flow instead of counterflow
- Wrong heat exchanger chosen (too short NTU)
- Use of non-recommended control configurations (as two control systems working with the same set value)
- Too large valves
- Wrong valve motors chosen
- Use of non-recommeded substation configurations

Typical malfunction errors

- Fouling in heat exchangers (but not as frequent as heat engineers suspect)
- Leaking valves
- Defective control units
- Defective valve motors
- Defective temperature sensors

Typical set point errors

- High set point value chosen for the radiator system, often later mixed to a lower temperature. Sometimes the set value is higher than the supply temperature from the district heating network! Should not be possible.
- High set point value for hot water preparation, also often later mixed to a lower temperature (legionella issue).

Typical errors outside substations

- No thermostatic valves in radiator system (no heat demand control)
- No hot water circulation system and temperature sensor far from the heat exchanger (control of standstill flow)
- Three-way diverting valves in radiator system (from the former use of oil burners)
- Low supply temperature in the district heating network (due to high heat losses)

Current cost reduction gradients for lower temperatures

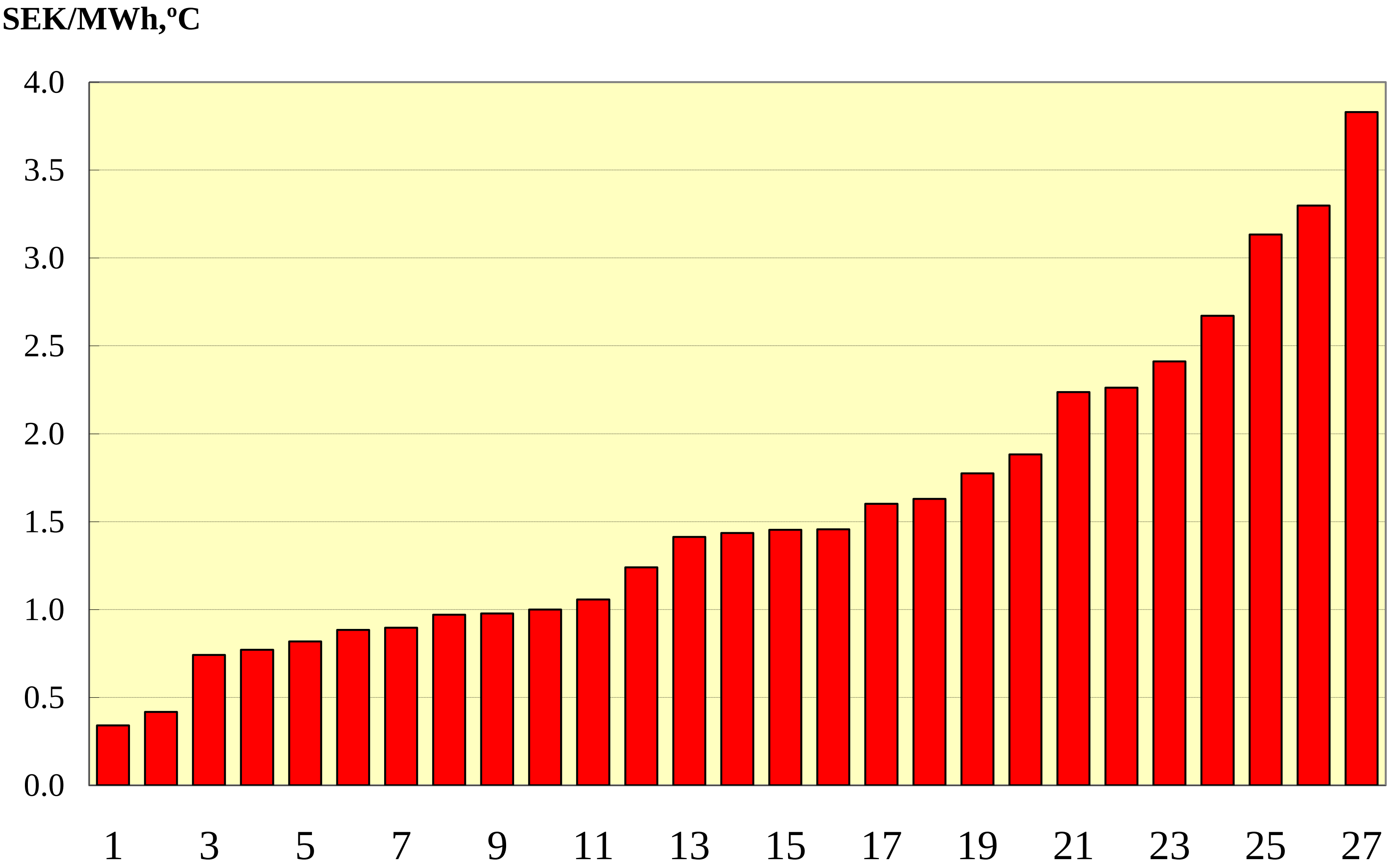


Figure 10-23. The cost reduction gradient for lower return temperatures estimated for 27 Swedish district heating systems 1996-2010 related to the heat delivered to customers. Source: Stefan Petersson, FVB Sweden. Reprinted with permission.

Main conclusions

4th generation systems need

- Design of equipment for a low temperature level in customer buildings, substations, and networks. Including intelligent control systems reducing the risk for operation errors.
- An elaborated strategy for continous quick identification of operation errors giving high return temperatures and higher temperature levels