ENGINEERING
TOMORROW

Energy Efficient Cities

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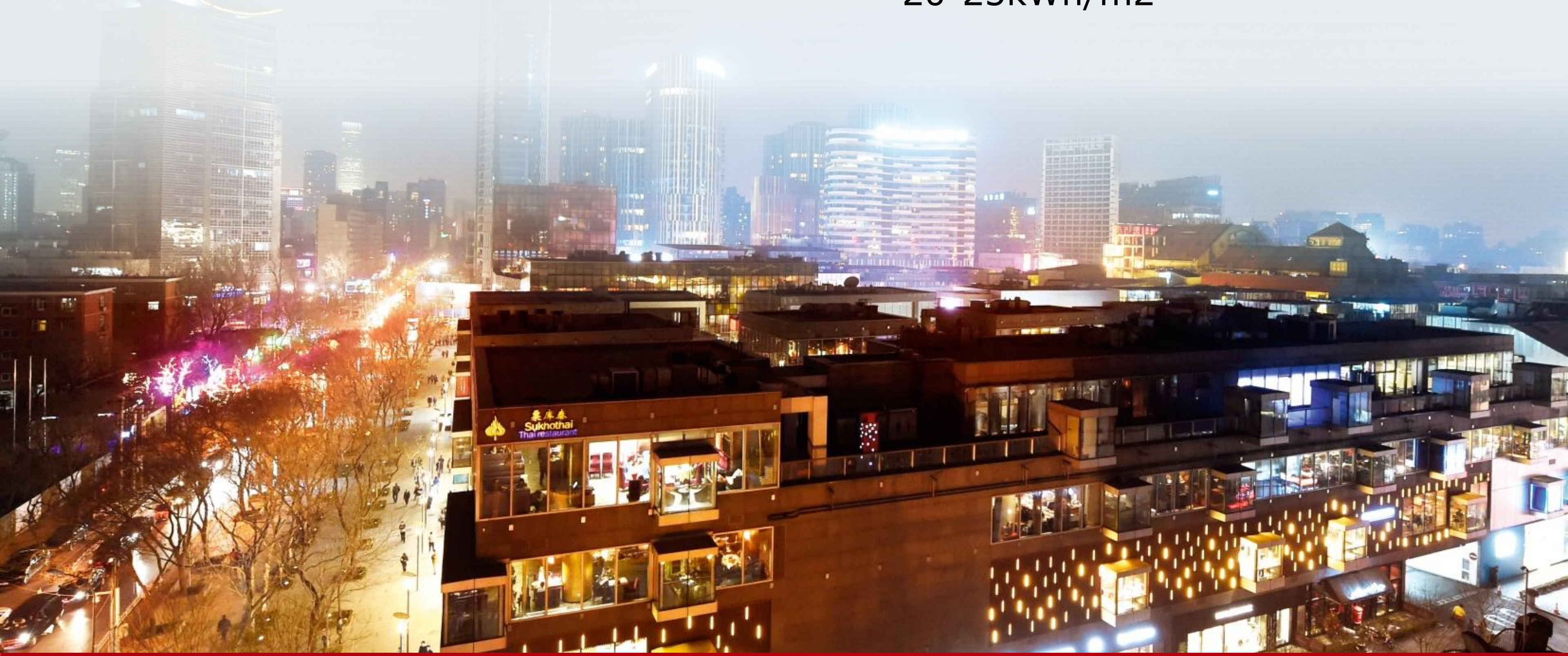
Political targets

Political Targets in Europe by 2020

- 20% reduction of CO2
- 20% share of renewables in energy mix
- 20% increased Energy Efficiency

Political targets in Denmark

- All Buildings fossil free by 2035
- Transport fossil free by 2050
- Building Energy consumption frame: 20-25kWh/m2



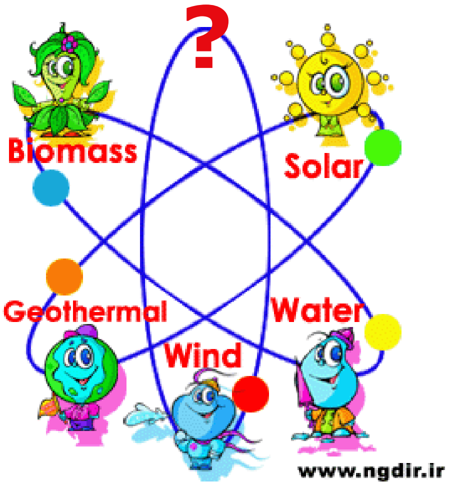
How to achieve the climate and energy targets ?

In reality there are only two ways to achieve the targets

Energy efficiencies – We need to consume less energy!

Renewable energy – The energy consumed needs to be renewable!

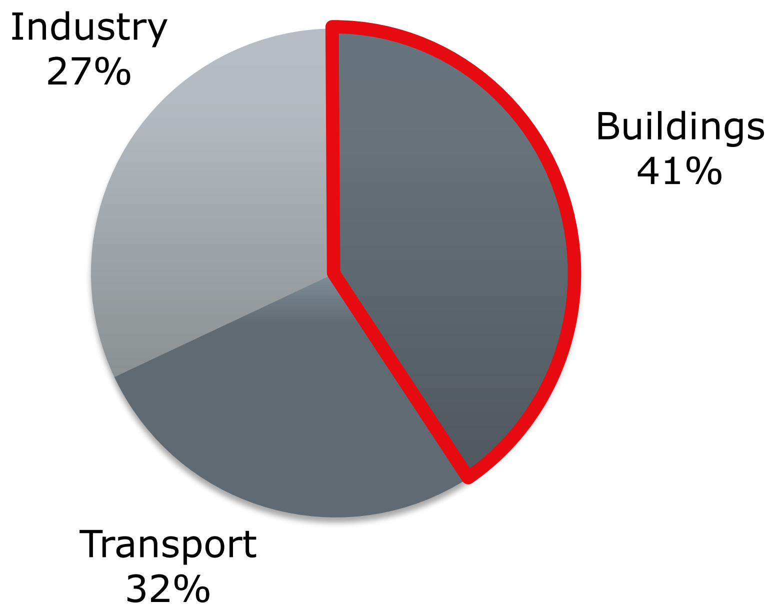
Source: www.climatechangenews.com



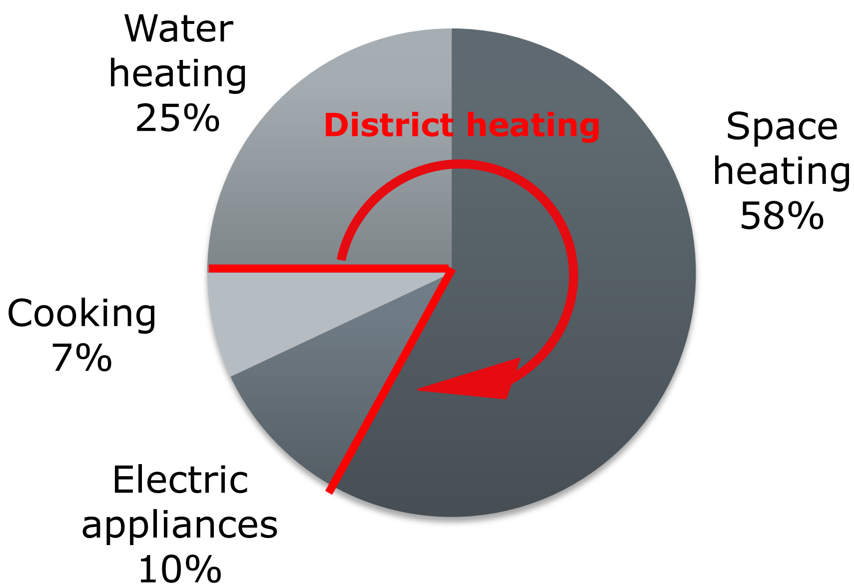
Large potential for energy savings

Buildings account for one-third
of total final energy consumption
in the world …

EU example:

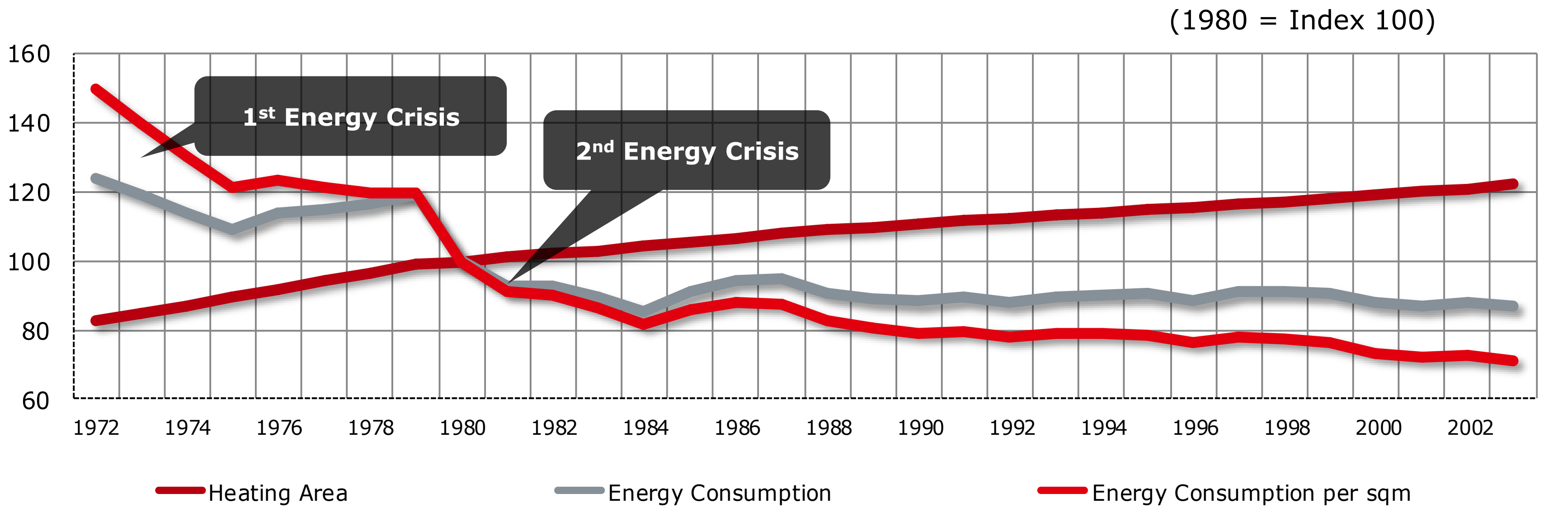


EU building example:



Efficiency of district heating and buildings in Denmark
- Energy demand is decoupled from the growth

Denmark 2003 building energy consumption per sqm decreased by 29% compared with year 1980, and 53% compared with year 1972

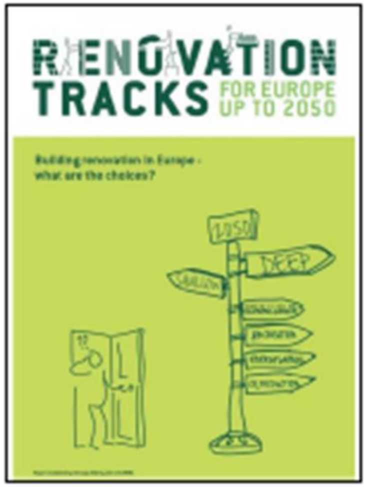


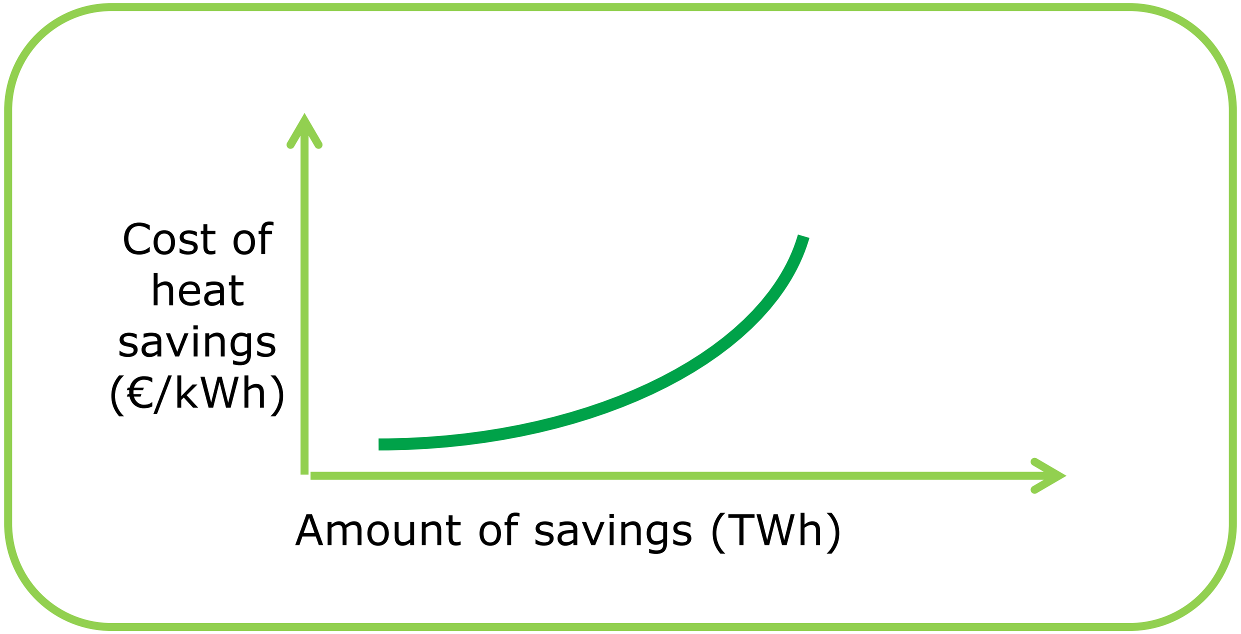
Source : Danish Energy Agency

Danfoss contributed to three of the four improvement areas

- ✓ Improve the efficiency of central heating systems
- ✓ Metering and Charging
- ✓ Frequency converters control
- ○ Improve insulation of doors and windows, roof, wall

In typical buildings large energy savings can be achieved fast with limited investment





Source: Aalborg University, David Connolly

Fundamentals

- **Key principles for optimized space heating/cooling system performance:**

Ensure that

1. the desired **temperature level is automatically kept** in the room, office etc.

2. the **energy** the heat/cool emitter needs for providing the desired temperature **is delivered in the right amount, at the right time**

- These are the **necessary conditions** for providing desired temperature levels with as little energy input to the heat/cool generator as possible – independent of the heat/cool supply, such as boiler, heat pump, district heating ...

Status of fundamentals in the EU

Do Europe's buildings meet the necessary conditions?

1. temperature level is automatically kept: NO

- Example: In EU **residential buildings** about 500 million radiators are equipped with manual, non-automatic controls

- This leads to overheating and unnecessary energy consumption because the heat output is not adjusted automatically to varying (solar radiation, outside temperature, solar radiation, occupancy, cooking ...) heat demand

- Improvement potential: replacement of manual by automatic control reduces energy consumption by approx. 15%-46%, depending on e.g. system characteristics - **but independent of heat supply**

- Overall EU annual energy saving potential according to ecofys: 170 TWh

Status of fundamentals in the EU

Do Europe's buildings meet the necessary conditions?

2. Energy is delivered in the right amount, at the right time: NO

- We estimate that around 80%-90% of Europe's multifamily and non-residential buildings have no automatic adjustment of heat/cool supply to heat/cool emitters – i.e. no **automatic balancing**
- Energy consumption improvement potential per building, in addition to automatic temperature control: between 10%-25%
- Furthermore: lack of comfort due to overheating in some parts of the building, and insufficient heat/cool in other parts of the building, and due to noise

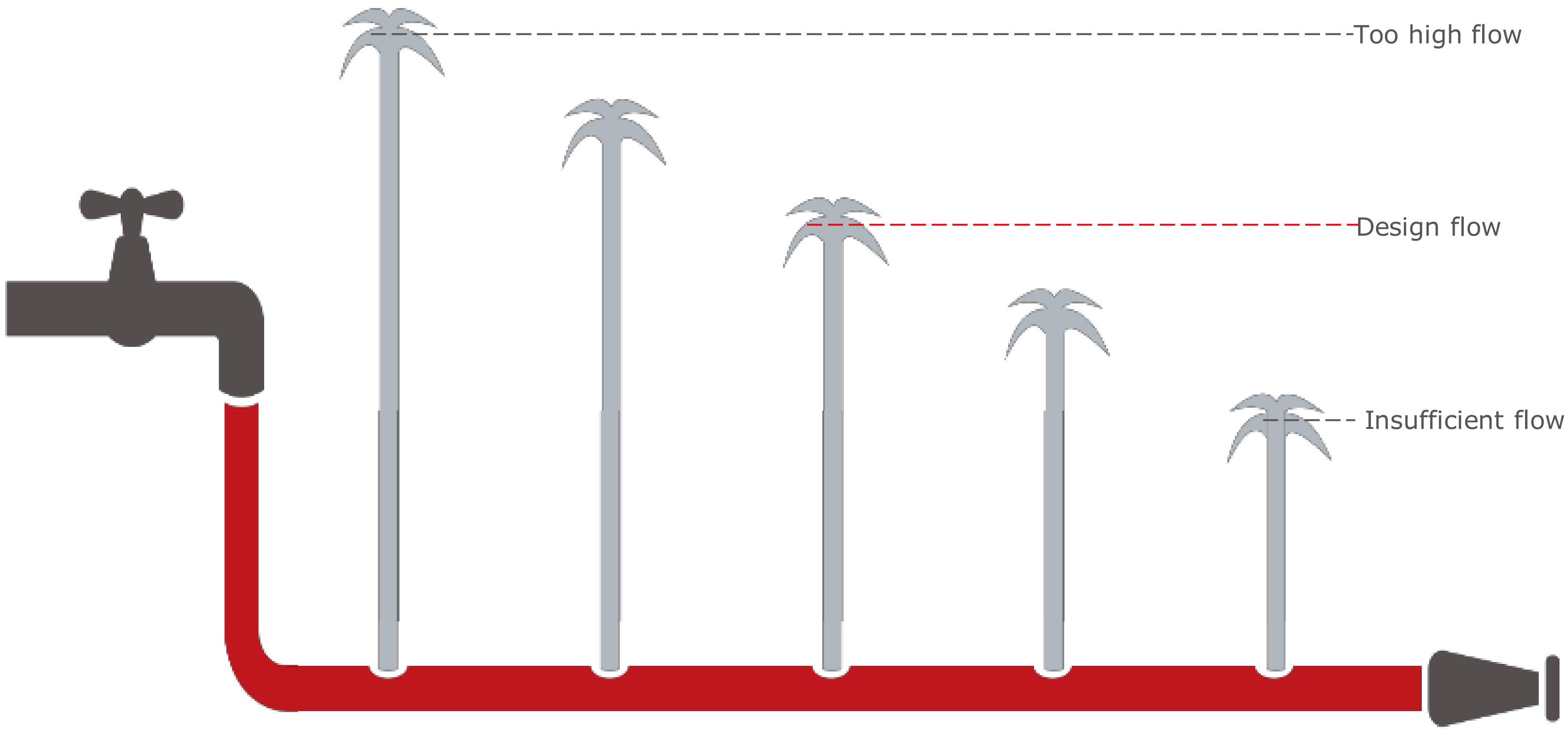
Automatic balancing in 30s

- Space heating and cooling demand is mainly dependent on the outside air temperature, which can vary significantly during the day
- A system is balanced if we have right flow rates and differential pressure in the system, during full load and partial load conditions to keep constant indoor air temperature.
  - Why automatic? *Only automatic balancing fulfills this role also at partial load condition.*
- **Example:** Thermostatic radiator valve: ensures the appropriate hot water flow into the radiator at all load conditions

A glimpse inside the block ...

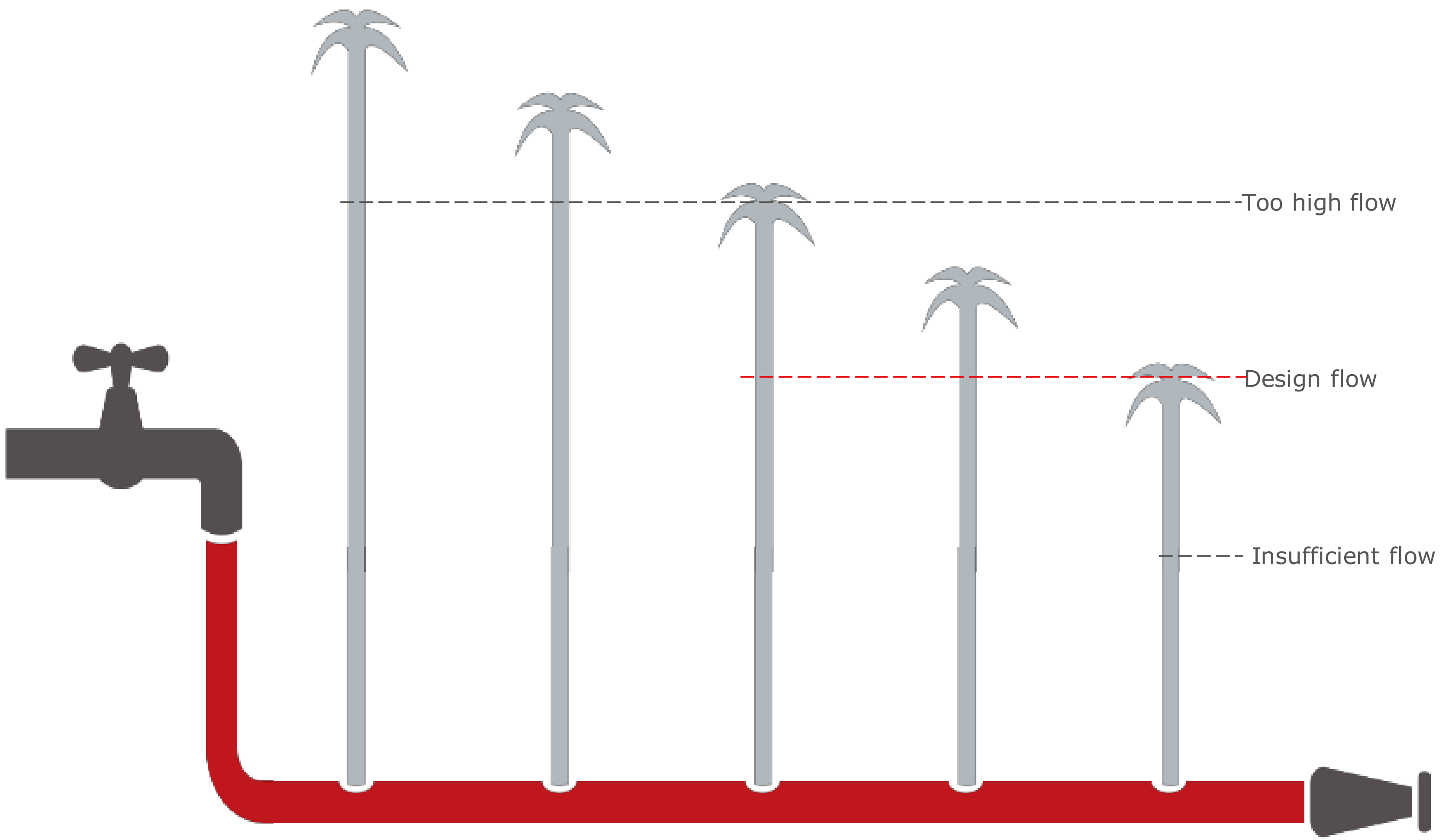
Without automatic balancing

- Too high and too low pressure at many/most rooms in the building



Without automatic balancing

- If solved with more flow to the system the general situation will be oversupply



Hydraulic balancing
- Building installation

- It is necessary to balance the whole system, including the building installation

Step 1

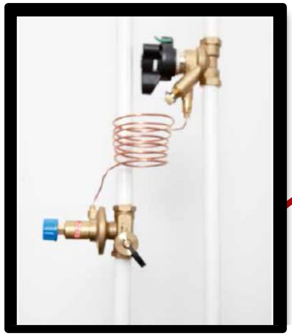
Pre-setting radiator valve
Adjustable k_v value

Step 2

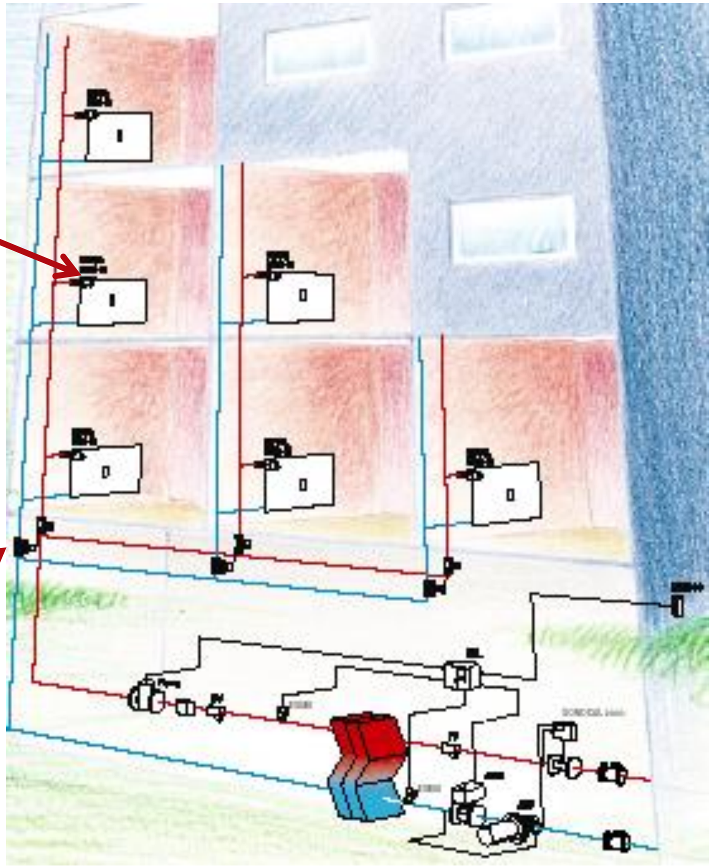
Thermostatic actuator

Optimum solution

TRV integrated with pre-setting function

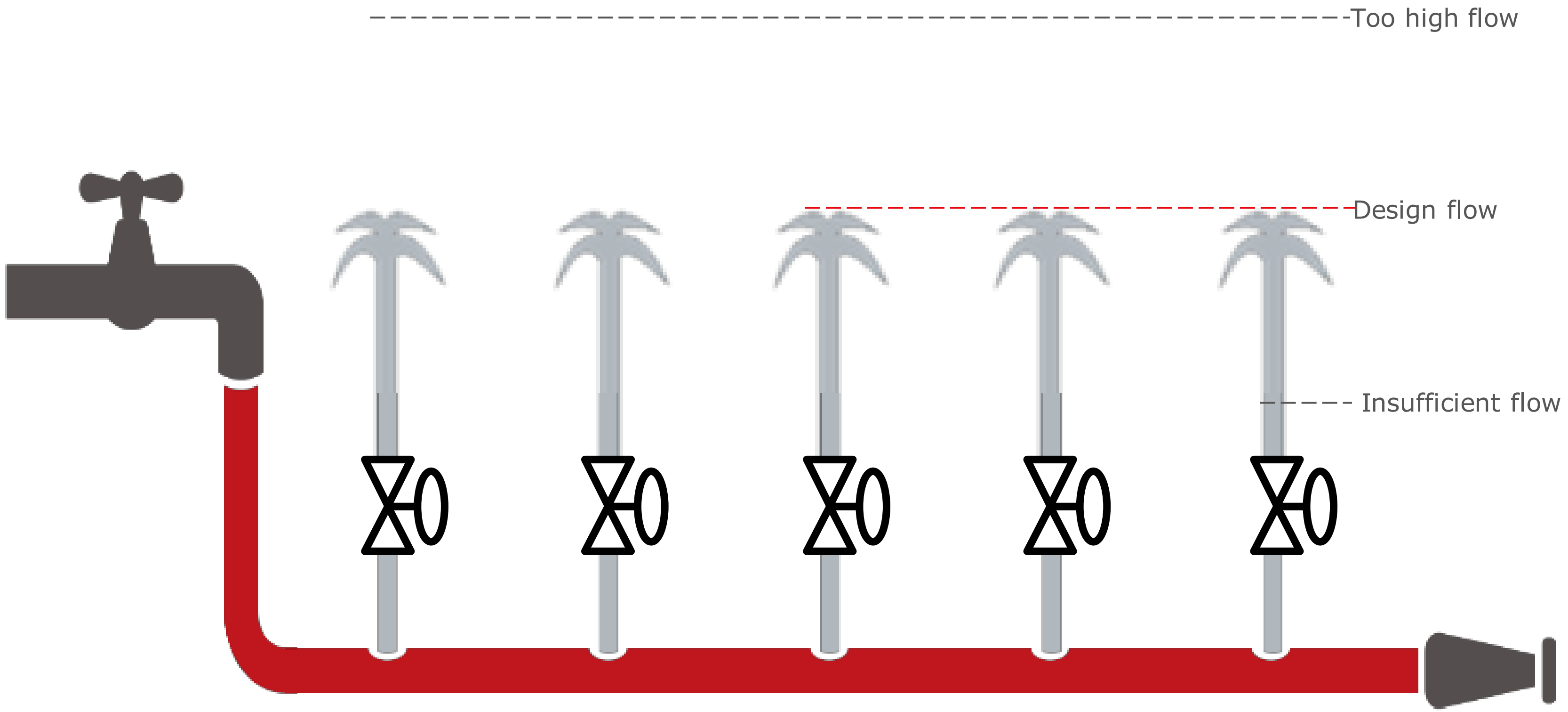


DP controller for balancing between risers



With automatic balancing

- Flow is adjusted to the actual demand



Housing association in Sweden

- Residential building with 25 apartments and a total floor area of 1.876 m^2
- New thermostatic valves and an automatic balancing solution increases comfort and reduces energy consumption by more than 20%
- Energy savings up to 129 MWh per year

Increased comfort

- Optimized comfort by control of heating with new radiator thermostats
- Residential building in Holland with 144 apartments
- 6 radiator thermostats per apartment
- Energy savings up to 228 MWh per year

Energy-efficient solutions
- short payback time

- Well-proven solutions already exist. Why wait?

Energy renovation	Estimated savings	Repayment period	Estimated investments (DKK)
Replacing manual valves with thermostats	20 – 25%	2 – 3 years	500 DKK per radiator*
Balancing valves	5 – 15%	2 – 3 years	200 DKK per radiator**
Replacing the oil or gas boilers with heat pump (air-water heat pump)	50 – 75%	10 – 15 years	100 – 130.000 DKK*
Replacing an older oil boiler with modern condensing boiler	20 - 30%	5 - 7 years	50.000 DKK ***
New low energy windows	20 – 25%	20 – 25 years	150.000 DKK****
Insulation of exterior walls and roof	10 – 20%	15 – 25 years	150 – 200.000 DKK****

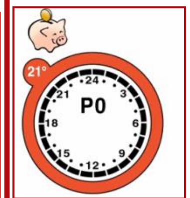
* *Calculations are based on an average Danish household of approx. 130 m^2 equivalent to the average of the approx. 1.6 million households that the Danish District Heating companies supplies*

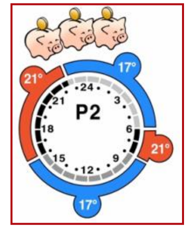
** *Based on buildings with several apartments – investment will vary with the number of apartments*

*** *Based on data from the Danish Oil Industry Association (EOF)*

**** *Figures from the Danish portal Bolius – knowledge center for homeowners*

Buildings - Thermostatic Valves

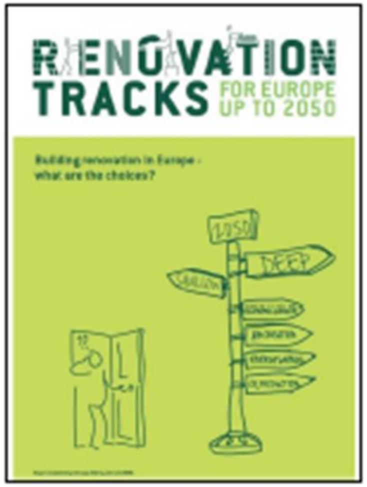



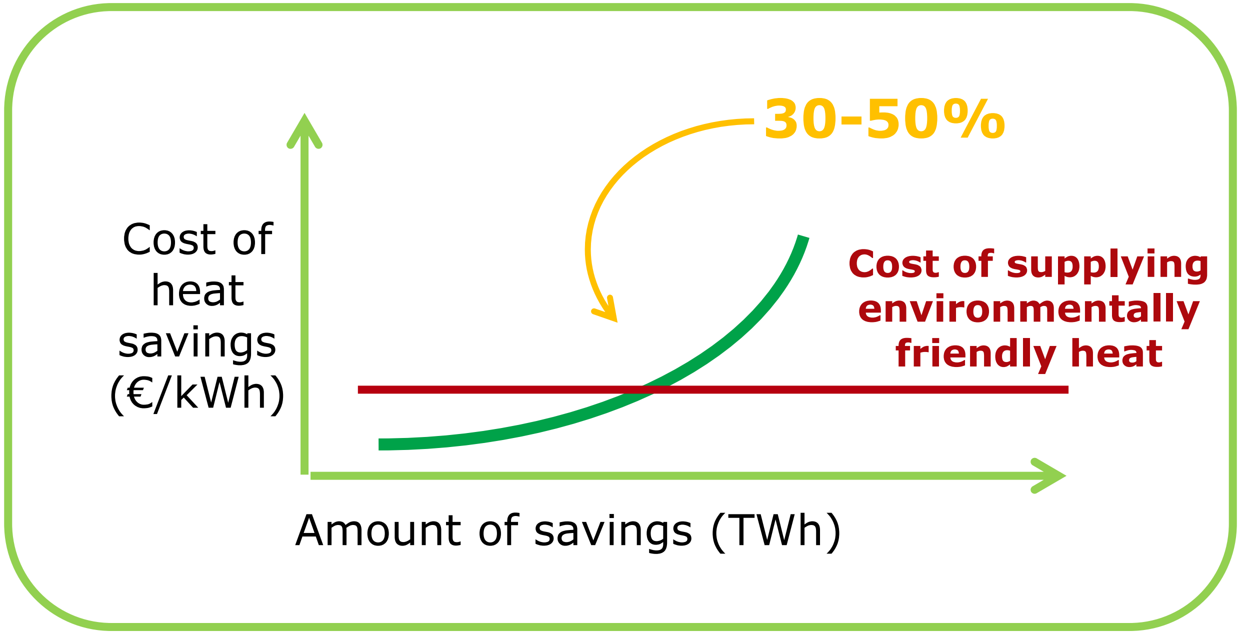

To \ From	Manual valve	Old thermostat (>15 years)	New RA 2000 thermostat	Electronic thermostat (no setback)	Electronic thermostat (P1)	Electronic thermostat (P2)	Electronic thermostat (P2 + holidays)
Manual valve	0%						
Old thermostat (>15 years)	31%	0%					
New RA 2000 thermostat	36%	8%	0%				
Electronic thermostat (no setback)	39%	13%	5%	0%			
Electronic thermostat (P1)	42%	17%	10%	5%	0%		
Electronic thermostat (P2)	46%	22%	15%	10%	5%	0%	
Electronic thermostat (P2 + holidays)	46%	23%	16%	11%	7%	1%	0%

…additional functionalities coming…

P1 = Set pack period 17°C, all days 22:30 - 06:00
P2 = P1 plus set back period 17°C all working days 08:00 - 16:00
P2 + holidays = P2 plus 1 week holidays in October and February

Energy efficiency is required on both the demand and supply side of the heat sector

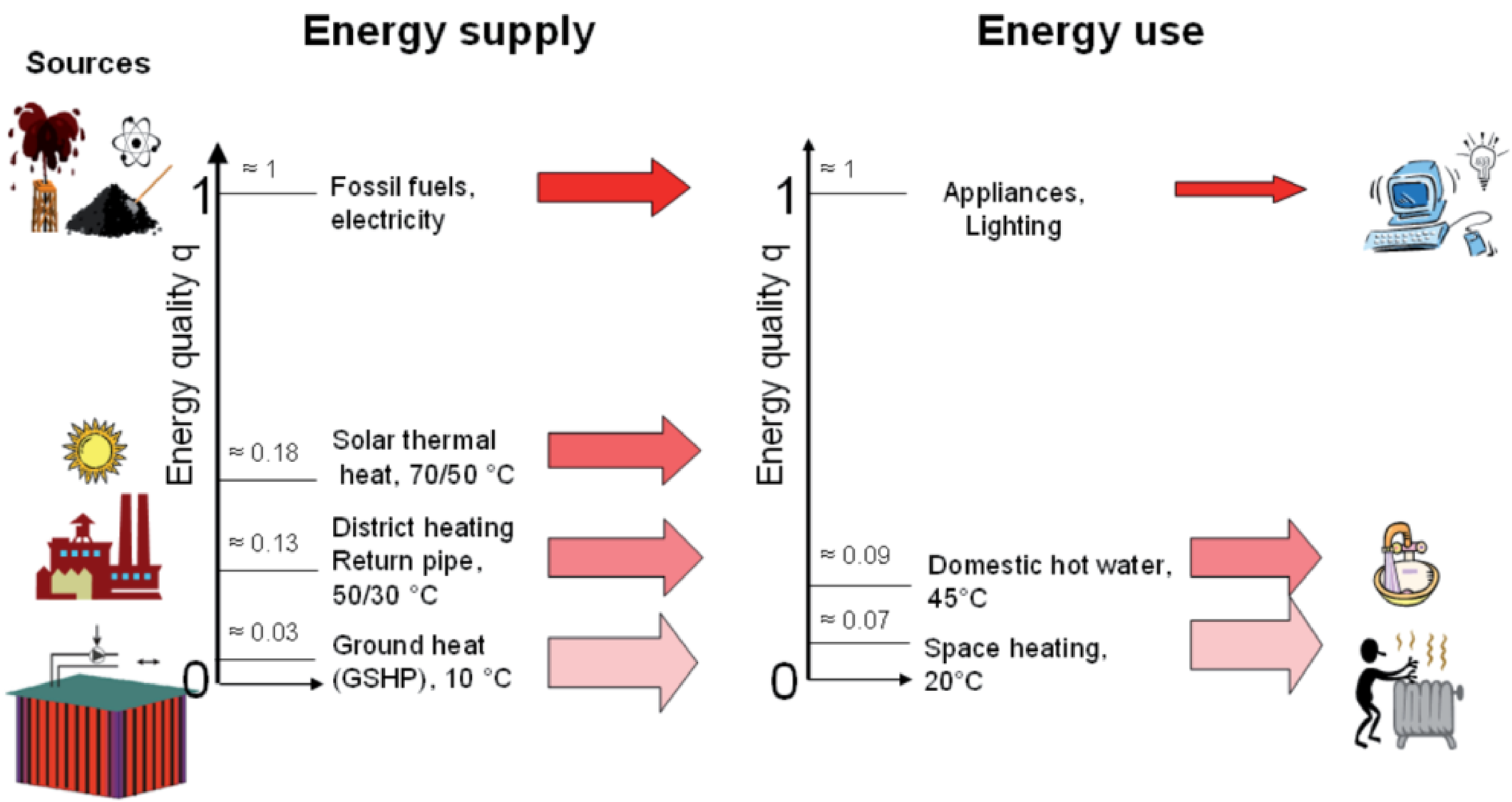




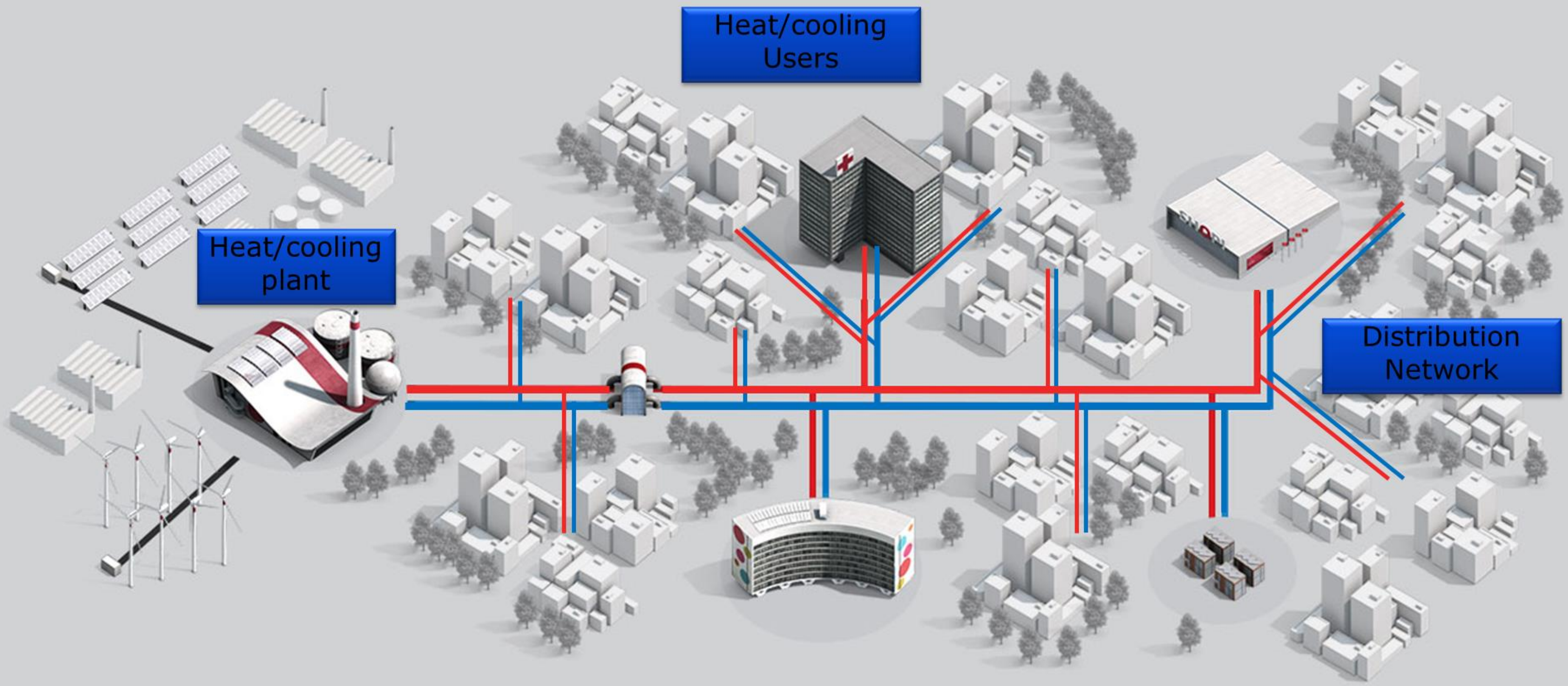
Source: Aalborg University, David Connolly

Optimum energy usage

- The optimum energy use can be found by exergy optimization
  ➔ Matching energy quality supplied to the energy quality demanded



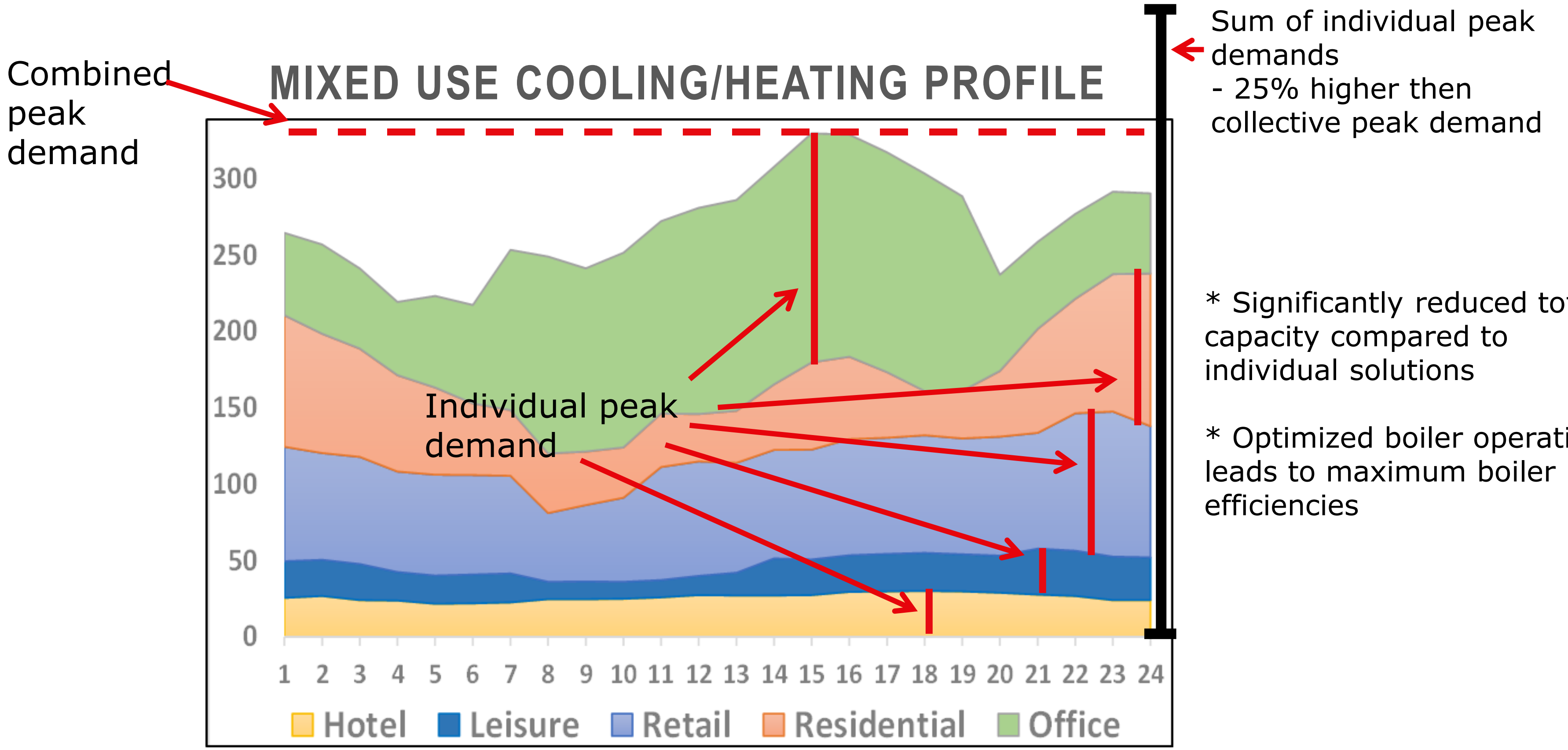
What is district energy



Source: Danfoss A/S

Space heating/cooling
- Simultaneity results in lower total generating capacities

- Different consumers have their peak demand at different times. District energy systems can take advantage of this fact.

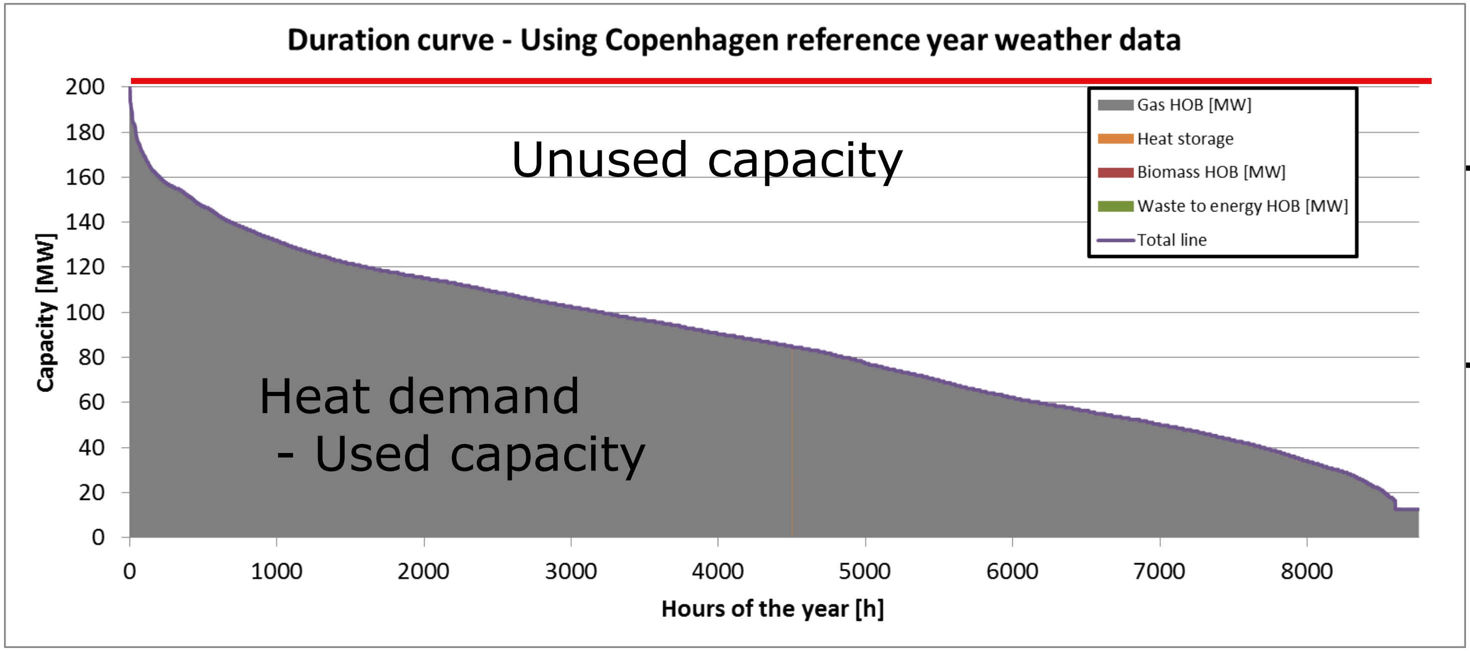


* Significantly reduced total capacity compared to individual solutions

* Optimized boiler operations leads to maximum boiler efficiencies

Environmental and cost efficient sizing of heat sources
- Danish example

- If we look on the heat load curves of cities we typically have something like the following:

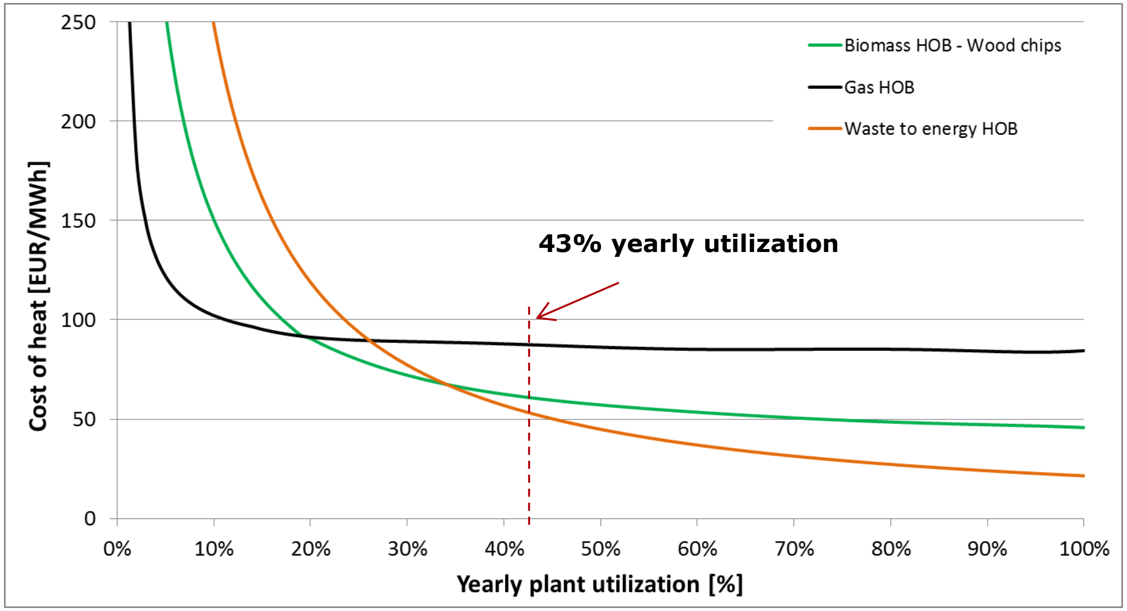


One **200 MW** plant would have approximately **43% yearly utilization**

- How to choose the right heat source or mix of heat sources for the given heat demand profile?

Cost of heat from different sources

- Example of available heat sources:
  - Waste incineration HOB – Sizes 15-60 MW (60% minimum load)
  - Biomass HOB – Sizes 1-100 MW (25% minimum load)
  - Natural gas HOB



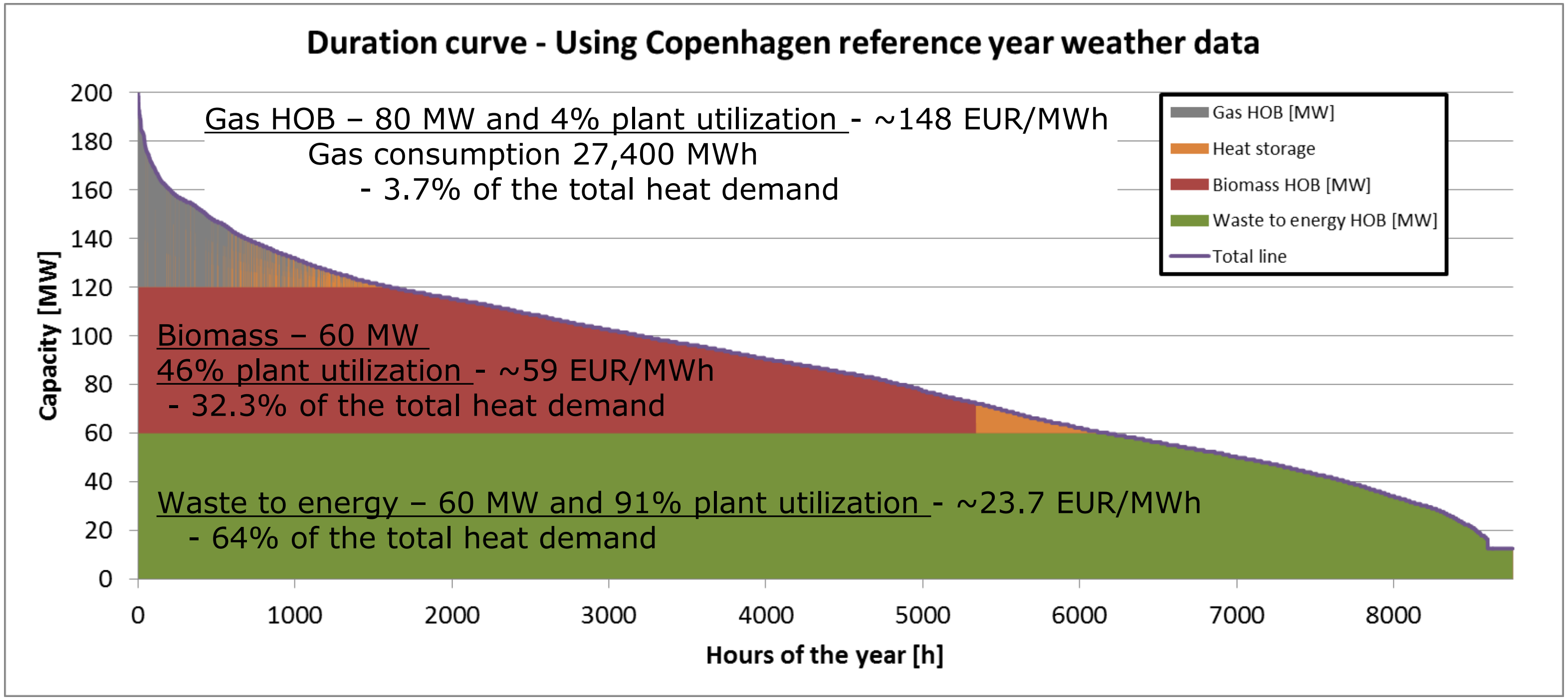
Cost of one heat source approach:

- Gas HOB: 87 EUR/MWh
- Biomass HOB: 61 EUR/MWh
- W2E: 53 EUR/MWh

- In this case it is clear that the base load provider should be the waste to energy plant

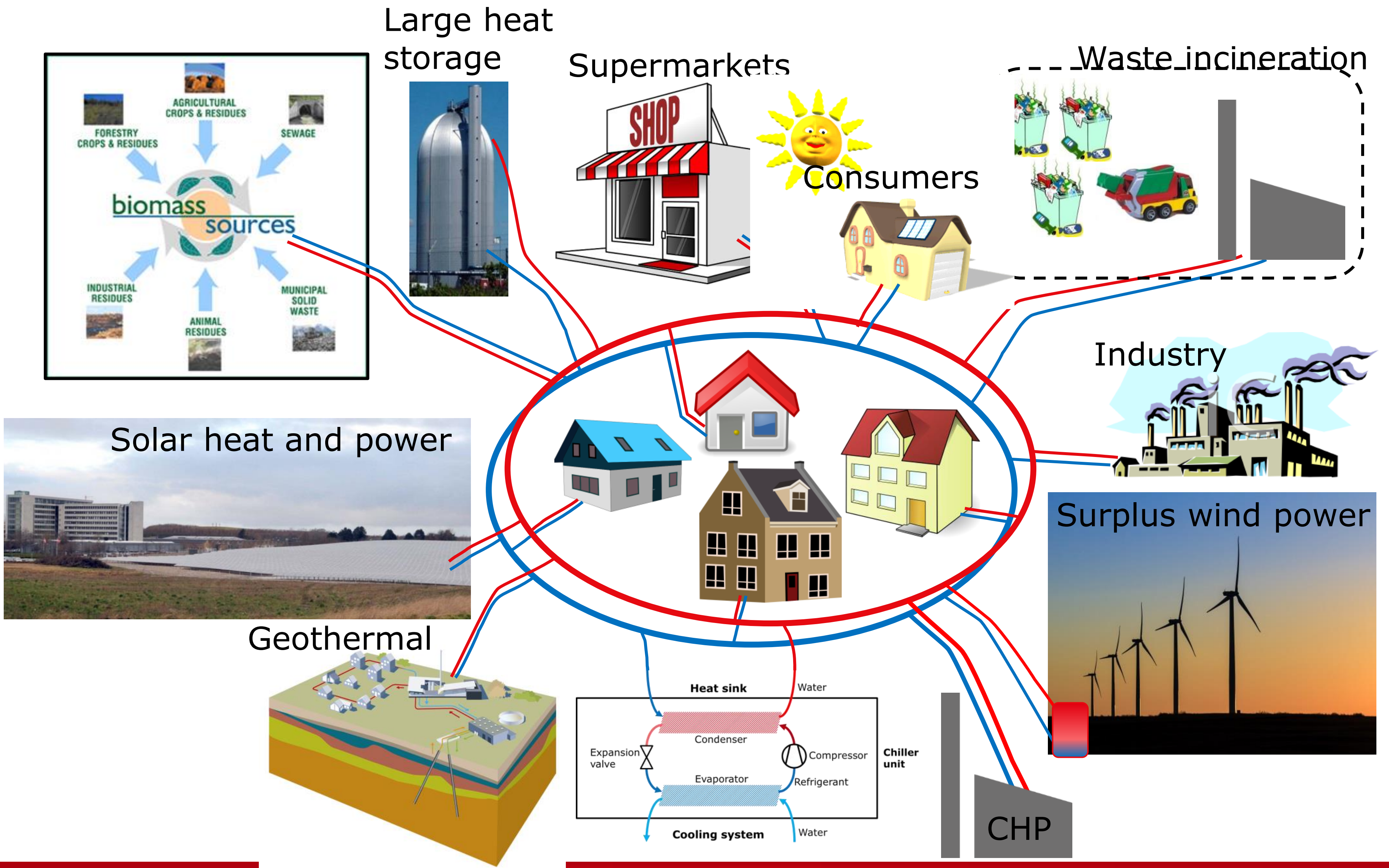
Pooled heat sources
- Economic and emission optimum

- Given underlying assumptions the optimum plant combination in respect to heat cost and environmental emissions would become



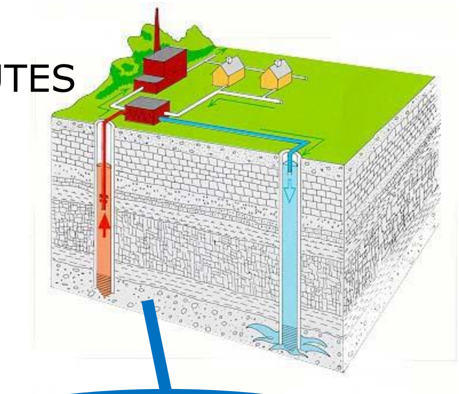
- Average heat cost: 39.7 EUR/MWh

District heating
- Possibilities of renewable and surplus heat utilization



District cooling

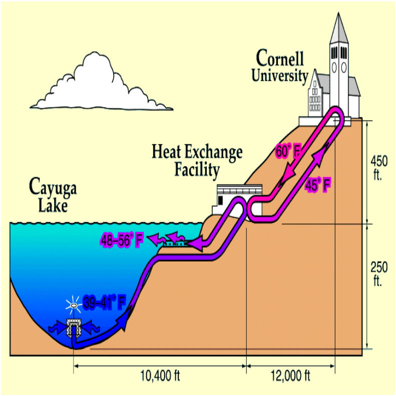
UTES



Electric chillers

Free cooling

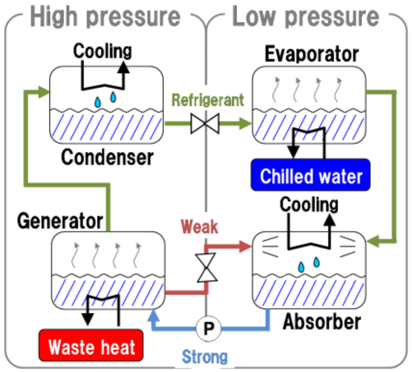
Ocean, lake or river



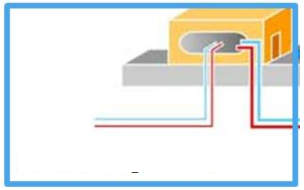
District cooling distribution grid

Air cooling

Absorption chillers



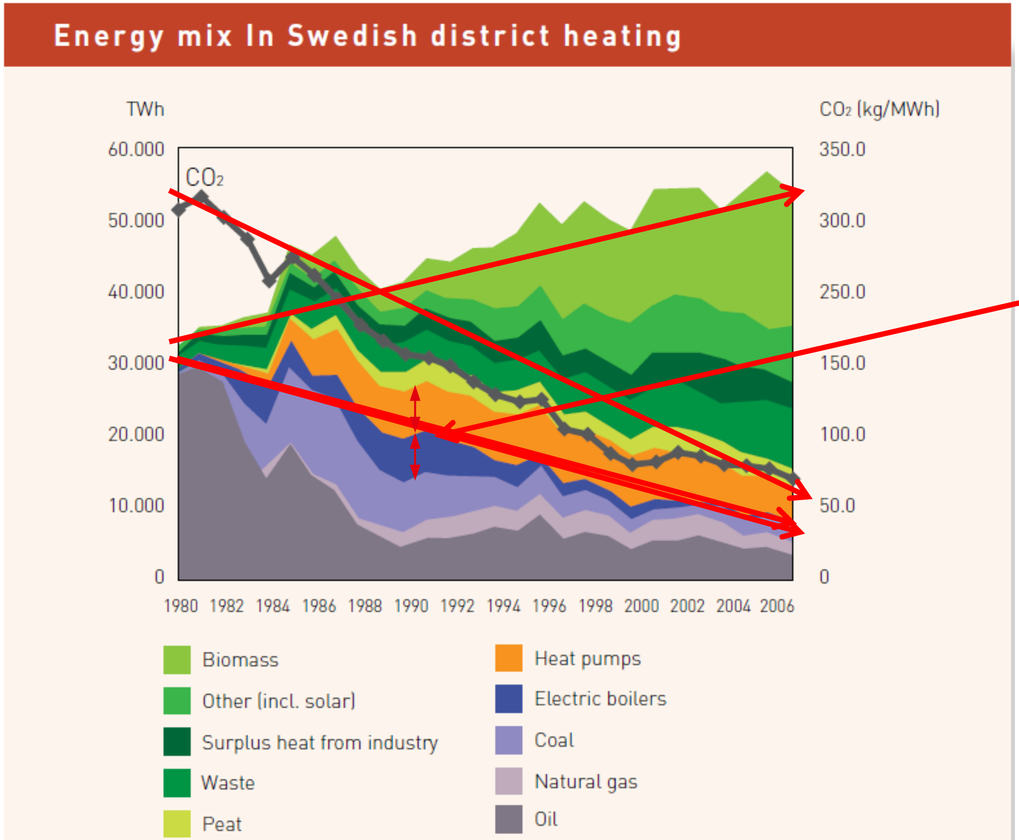
Thermal storage tanks
- Ice
- Chilled water



Other cooling sources

How district heating and green energy

- District energy is a proven concept to decarbonize the energy consumption

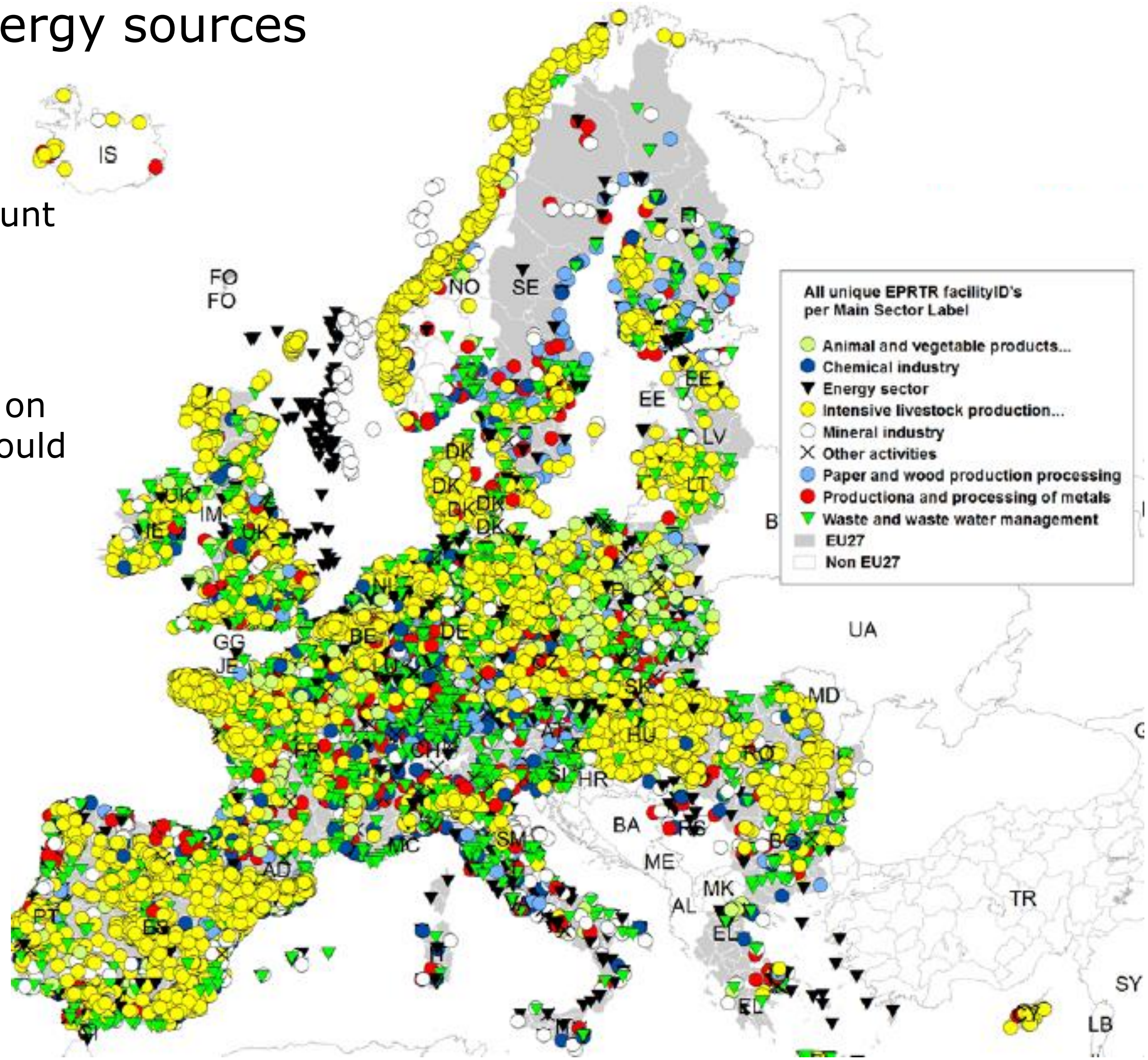


Source: Swedish District Heating Association

- The share of fossil fuels has been reduced from 90% to ~15%
- Heat pumps have phased out electrical boilers
- Green and renewable energy has grown from 10% to 85% since 1980
- CO2 emissions have been decreased by 80%!

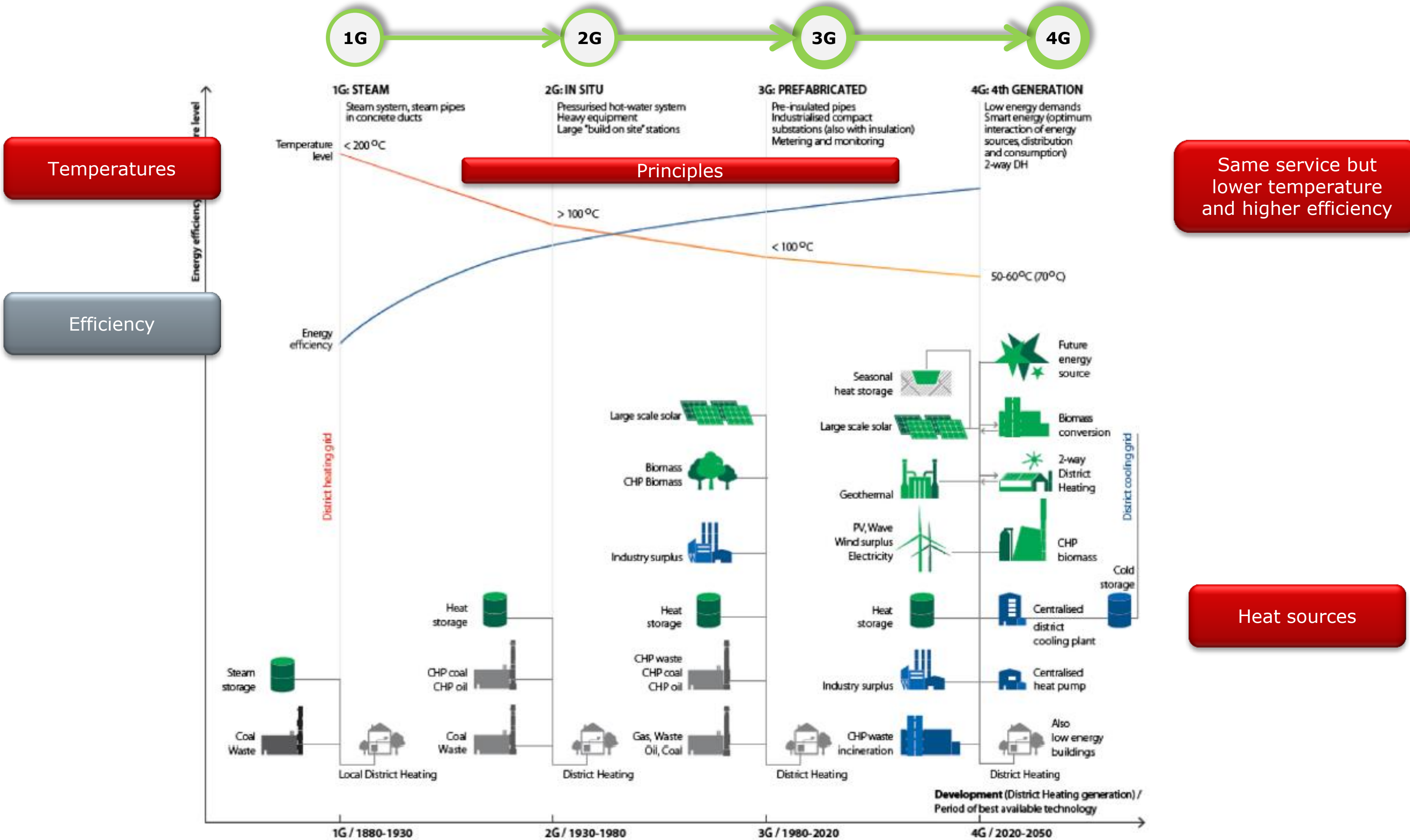
Low temperature energy sources

- There is an enormous amount of low temperature excess heat available in Europe
- By applying a holistic view on the energy system these could be exploited



source: Urban Persson, www.4dh.dk

District heating generations
- Mega trends



Thank you for your attention

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