4th Generation District Heating

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What are the district heating generations?

1G
- STEAM
- Steam system, steam pipes in concrete ducts
- Temperature level: < 200 °C

2G
- IN SITU
- Pressurized hot-water system
- Heavy equipment
- Large "build on site" stations
- Efficiency: > 100 °C

3G
- PREFABRICATED
- Pre-insulated pipes
- Industrialized compact substations (also with insulation)
- Metering and monitoring
- Efficiency: < 100 °C

4G
- 4th GENERATION
- Low energy demands
- Smart energy (optimum interaction of energy sources, distribution, and consumption)
- 2-way DH
- Efficiency: 50-60 °C (120 °C)

Heat sources:
- Biomass conversion
- 2-way District Heating
- Chp biomass
- Centralized district cooling plant
- Centrally heat pump
- District Heating
- Geo thermal
- PV/Wave
- Wind supplier electricity
- Industry supplies
- Large scale solar
- Seasonal heat storage
- Chp waste incineration

Principles:
- Temperature level
- Efficiency

Same service but lower temperature and higher efficiency
4GDH benefits towards the heat source
- Possibilities of renewable and surplus heat utilization

- Solar heat and power
- Geothermal
- Surplus wind power
- Waste incineration
- Industry
- Supermarkets
- Consumers

Large heat storage

CHP
Other benefits of 4GDH systems to the energy infrastructure

• Increased CHP efficiency
  – Lower supply temperatures increase power generation efficiency
  – Lower return temperatures increase flue gas condensation

• Reduced distribution losses
  – Heat losses are linear dependent on the temperature
  • The lower the network temperatures are the less heat loss is experienced

• Better match of supplied energy quality and demanded energy quality
What impact has the 4GDH concept on currently applied technologies?

- **Distribution network**
  - Pipe dimensions optimized in relation to heat loss as well as pumping power consumption
  - The low supply temperature opens up for increased application of flexible pre-insulated plastic pipes
  - Fast installation
  - Cost efficient

- **Space heating**
  - Heat emitters:
    - *Radiators*: need to be dimensioned for 55°C supply, 25°C return for 20°C indoor air temperature (55/25/20°C)
    - *Floor heating*: No impact as floor heating is generally designed for 45/25/20°C
  - Control equipment:
    - High focus on smart controllers
What impact has the 4GDH on currently applied technologies?

• **Domestic hot water (DHW) preparation**
  – Due to the low supply temperature instantaneous DHW preparation using **high efficiency heat exchangers** and **high quality controls** are required to ensure good cooling of the supply and stable temperatures.
  – DHW piping volume should be less than 3 liters to minimize legionella issues.
Domestic hot water idling functions

- With the elimination of domestic hot water circulation a new (old) issue emerged:
  - People are in general impatient

- To limit the waiting time for domestic hot water some aspects need to be considered:
  - a) Minimize the pipe distances and dimensions from the DHW unit to the taps and
  - b) To keep the supply pipe and/or the domestic hot water heat exchanger warm during non-tapping periods by using by-passes, on the primary side.
Why does 4GDH fit with future low energy buildings?

• **Low energy buildings:**
  – To maximize energy efficiency low energy buildings are generally designed with low temperature heating installation
    • Floor heating
    • Low temperature radiators
  – Domestic **Hot Water** installation is designed to minimize energy consumption
    • Instantaneous DHW preparation
    • Minimum DHW pipe distances
    • No DHW circulation

• Those points fit exactly with 4GDH!
4GDH and multifamily buildings?

- **Flat stations**
  - Suitable for low-temperature DH
  - Flat station in each flat
  - Overall DHW system volume <3 L
  - Individual control over space heating
  - Simple energy metering
    - 😊 One heat meter for all heat consumption
  - No DHW circulation
    - 😊 Reduced heat loss
  - No vertical risers in flats
    - 😊 Reduced noise
    - 😊 Reduced heat loss
Experience I – Danish single-family houses from 1970
- Simulation results

• The simulations showed:
  – Even for non-renovated buildings 50°C supply temperature is sufficiently high for 79% of the year
  – With moderate renovations, new windows, low-temperature supply can be used for 93% of the time

• This implies that already today low-temperature district heating could be achieved with a temperature boosting during the coldest periods

![Duration of T_supply over certain temperature graph]

Experience II – Low energy houses (2011)  
- Lystrup, Denmark

• Project supported by the Danish government

• 40 low-energy single-family houses

• New DH design: Higher DH water speed, higher pressure drop

• Only 14% heat loss from DHN vs. 41% for traditional designed 80/40°C

• Additional pumping energy is only 4% of primary energy saved from heat loss

• Good cost-efficiency

• No complaints

• Instantaneous substation lowering of developed low-temp. substations

\[ \Delta p_{\text{max}} = 8 \text{ kPa/m} \]

\[ w_{\text{max}} = 2 \text{ m/s} \]

\[ \phi d_{\text{min}} = 14 \text{ mm} \]
Low-temperature experience III
- Sønderby, Denmark

Low-temperature DH for existing buildings
- Project supported by the Danish government
- 75 single-family buildings from 1997
- Floor heating

Realization
- New low-temperature DH in-house substation
- New DH network
- Heat loss reduced from 40% -> 14%
  - 80% of heat demand supplied from main **DH return line**
  - Average $T_{sup} = 55\degree C$
  - No complaints
Experience IV - Heat pump supplied by Ultra-LTDH (2014)  
- Copenhagen, Denmark

- DH supply temperature is 40°C
  - Space heating part is not “boosted” => floor heating

- DH supply flow part for DHW is split up in two parts:
  - Heat source (evaporator) / Heat sink (condenser) → supply for DHW preparation
  - Constant heat source, high and stable COP (4.5)
Experience V – Electrical heater to boost the DHW (2016) - Copenhagen, Denmark

• DH designed for 40/25°C
  • Electric heater added at the outlet of DHW
    – DHW instantaneously heated to 37°C by DH
    – Electrical heater boosts the temperature up to 60°C by electric heater
  • Expected heat loss reduction is:
    - 17% compared to 50/25°C
    - 40-55% compared to 80/40°C
• Prototypes installed in 5 houses
  – First results are promising
Experience VI - Surplus heat from supermarket cooling system  
- SuperBrugsen in Høruphav, Denmark

Supermarket
- Area: 1000 m², built in 2010
- Cooling Capacity: 160 kW
  - Waste heat: 60-100°C

- Partnership model:
  - SuperBrugsen – earns money on the waste heat and increases its green profile
  - Danfoss – DH application and technology provider
  - DH utility – more “green energy”
Thank you for your attention

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