Enabling low-temperature renewable district energy in cities

Strategic Heating and Cooling Plan for Mongolia

Capacity building seminar

Session 1:

20-05-2022

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AALBORG UNIVERSITY

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Agenda

- Heating roadmaps – Where does DH fit in?
- District Heating (DH) generational transformation
- Low-temperature 4GDH

Heat Roadmaps for transition

- Identification of the technically possible & socio-economically feasible
- Consideration of local nature of heating
- Consideration of the wider energy system
- Alignment to decarbonisation - Paris Agreement and NDC

Everywhere	Urban areas	Rural areas
Energy savings	District energy networks	Mainly heat pumps
Combine savings and supply	High demand density areas	Low demand density areas
~30-50% demand reduction	Supply ~50% of energy demand	Remaining ~50% of the energy demand

(HRE, 2019)

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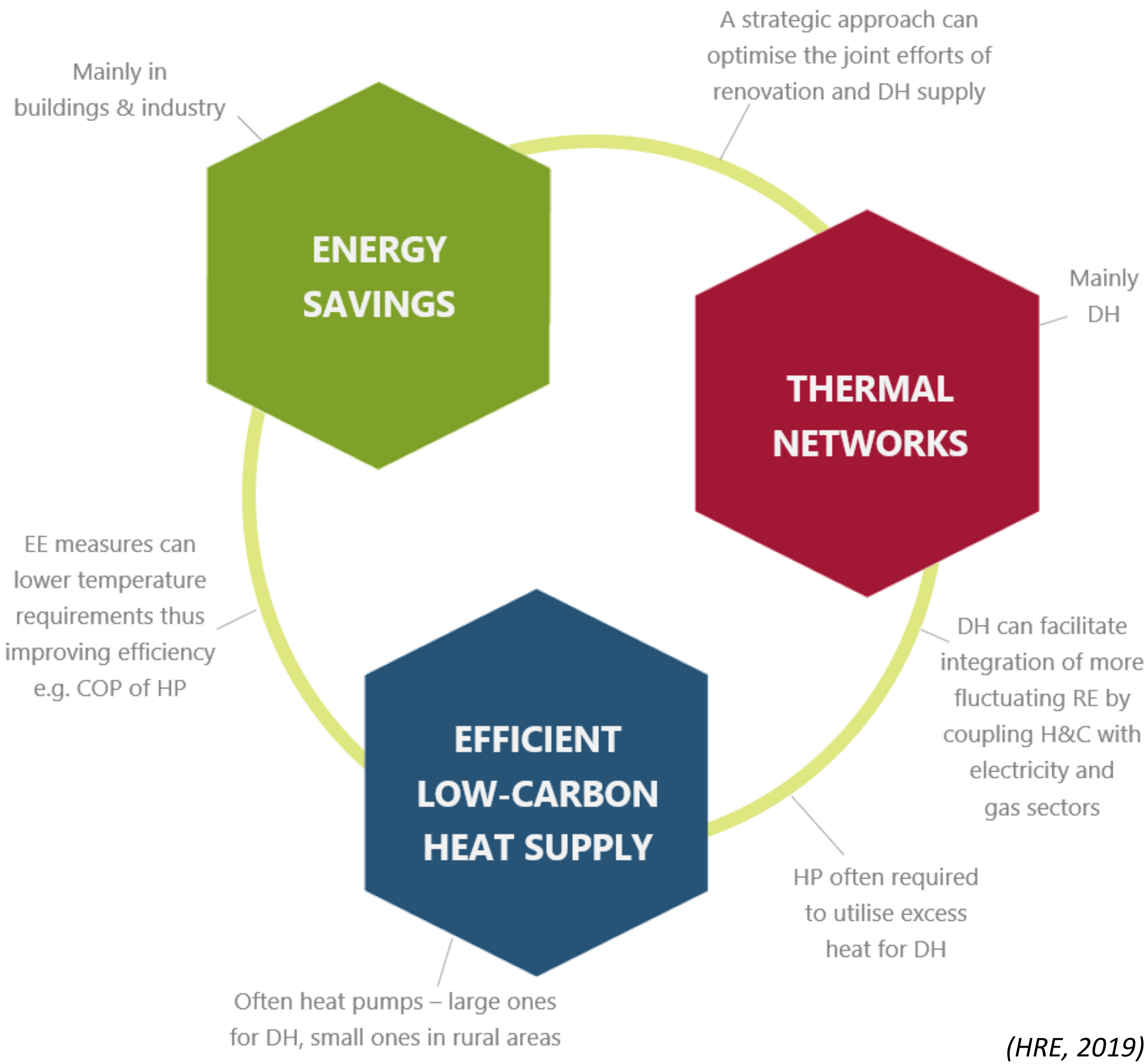
Key elements for transition



(HRE, 2019)

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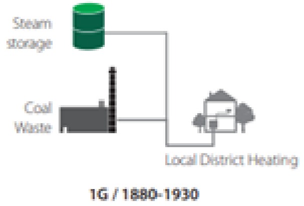
Steam systems
DH 1st generation

- Steam as heat carrier
- High temperature (up to 300 °C)
- Predominantly in systems before 1930
- High heat losses
- Can be used for industrial processes



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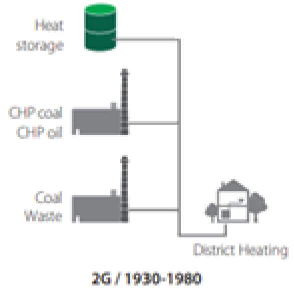
High temperature water systems DH 2nd generation

- Pressurized hot water as heat carrier
- Pressurized high temperature water (>100 ^{o}C)
- 1930-1980
- Still remains in parts of the current water based systems



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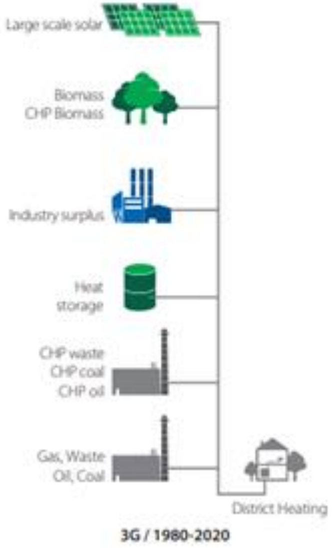
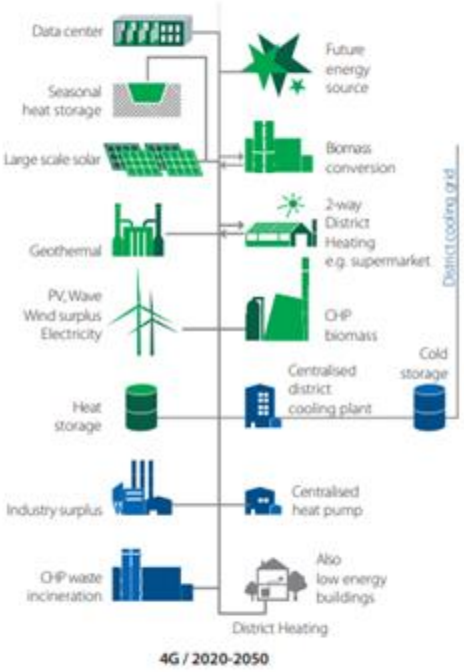
Medium temperature water systems DH 3rd generation

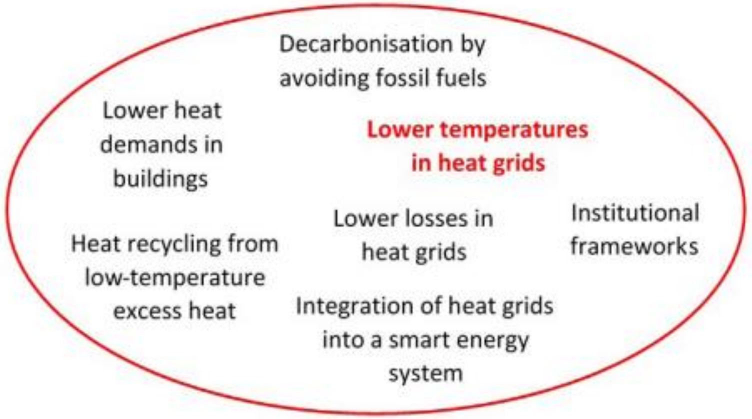
- Pressurized water as heat carrier
- Between 70-95 °C (below 100 °C)
- 1980-2020
- Current system in most Scandinavian systems



Low temperature systems DH 4th generation

- After 2020
- Heat distribution to existing, renovated, and new buildings
- Recycles heat from low-temperature waste heat sources and integrates RE heat sources
- Low-temperature (< 70^{o}C) – unleashed potential

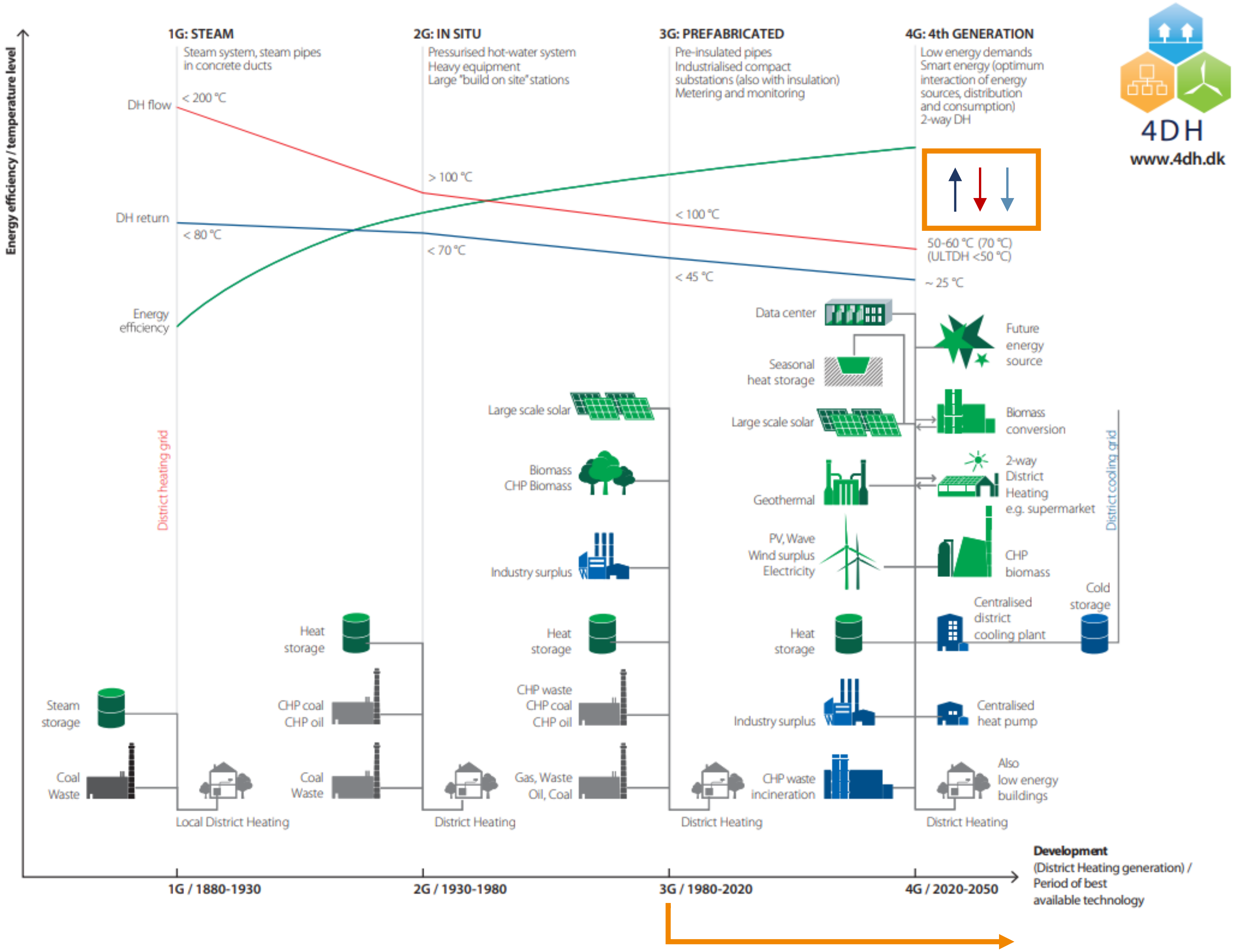




(IEA, 2021)

District Heating (DH) generational transformations

- Technology transition
- Heating sources throughout
- Temperature and efficiency



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Energy
Volume 164, 1 December 2018, Pages 147-159

Review

The status of 4th generation district heating: Research and results

Henrik Lund [a], Poul Alberg Østergaard [a], Miguel Chang [a], Sven Werner [b], Svend Svendsen [c], Peter Sorknæs [a], Jan Eric Thorsen [d], Frede Hvelplund [a], Bent Ole Gram Mortensen [e], Brian Vad Mathiesen [f], Carsten Bojesen [g], Neven Duic [h], Xiliang Zhang [i], Bernd Möller [a, j]

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3GDH vs. 4GDH

Parameter	**3GDH**	**4GDH**
Yearly average supply/return temperatures at DH plant	80 °C/45 °C	55 °C/25 °C
	ΔT = 35 K	ΔT = 30 K
DH Grid losses	28%	19%
DH heat pump COP (resource temp. 5 °C; yearly average)	2.9	3.9
DH heat pump COP (resource temp. 35 °C; yearly average)	4.2	7.1
Waste heat sources for direct DH application	0.83 TWh +2.28 TWh from district cooling	2.4 TWh +2.28 TWh from district cooling
Waste heat sources for indirect DH application through heat pumps	1.67 TWh	2 TWh
	Added 0.4 TWh to electricity demand	Added 0.28 TWh to electricity demand
CHP (Combined cycle)	$\eta_e = 52\%$ & $\eta_t = 39\%$	$\eta_e = 52\%$ & $\eta_t = 44\%$
DH Biomass boilers with condensation	95%	105%
Thermal storage	3.17 M€/GWh	3.70 M€/GWh
Solar thermal	544 €/MWh	382 €/MWh

(Lund, H., et al., 2018)

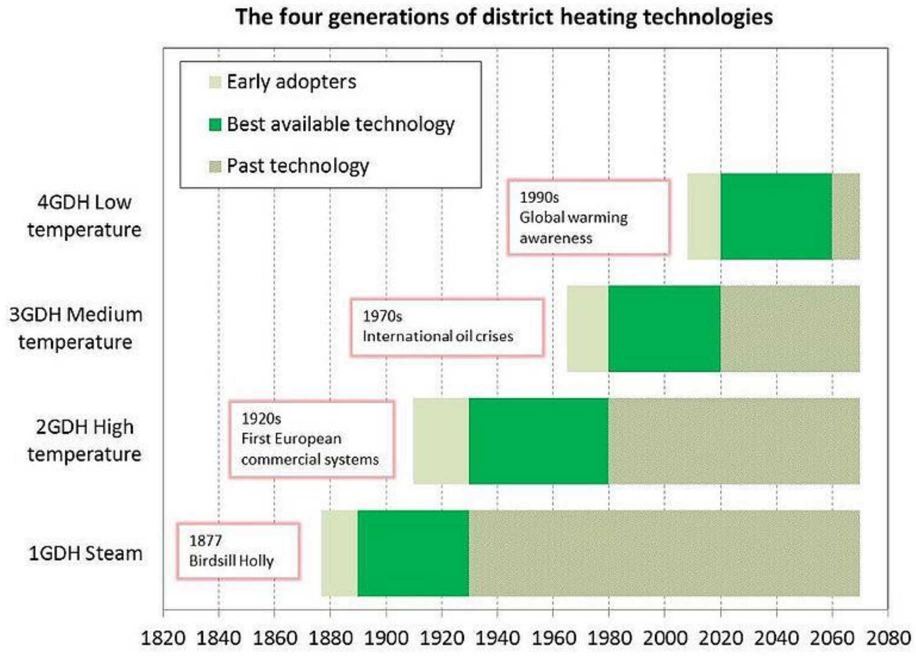
1. < grid loses
2. > COP
3. Integration of waste heat with and without heat boosting
4. Increased efficiency in production of heat from other technologies. E.g. CPHP, boilers.

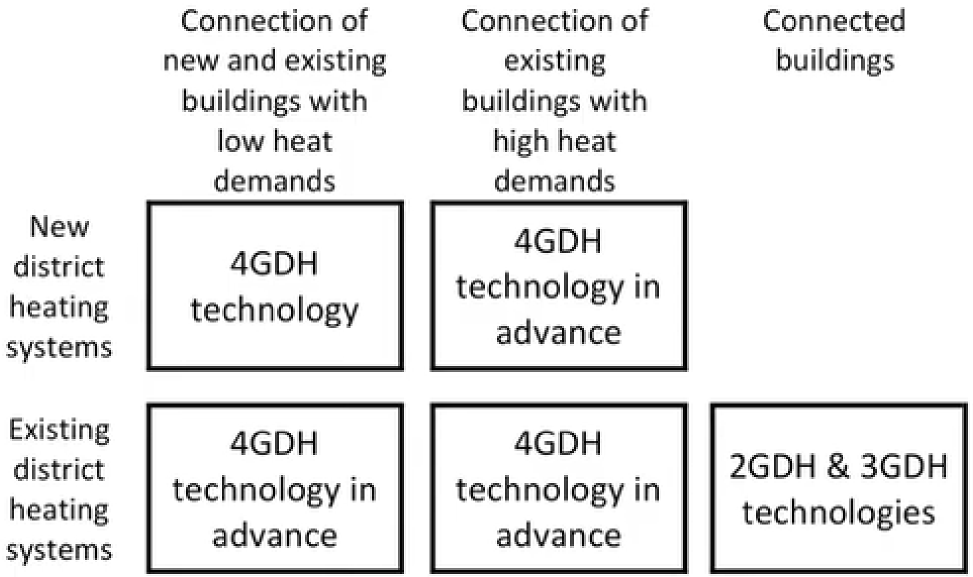
Shifting pathways towards 4GDH

International Energy Agency Technology Collaboration on
District Heating and Cooling including Combined Heat and Power

Annex XI final summary report

Transformation Roadmap from High to Low Temperature District Heating Systems





(IEA, 2017)

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Enabling 4GDH

Network modernization for temperature reduction

- Modernization of current systems aiming at improving existing distribution networks and substations

Renewable energy source generation

- Renewable heat and low-temperature resources integration
  - Variety of baseload sources
  - Geographic availability

Reduction of existing temperature demands

- Energy efficiency measures in buildings and industry
  - Retrofitting Low-energy, nearly zero-energy buildings

Planning frameworks

- Requires planning and strategic development of RES
- Strategic development of new 4GDH networks