

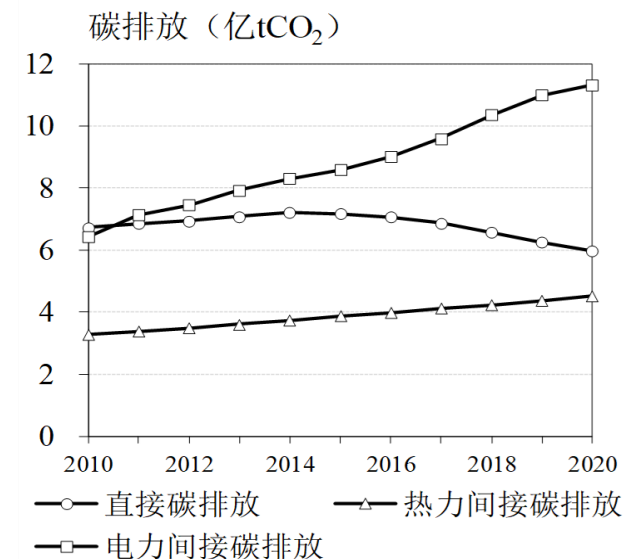
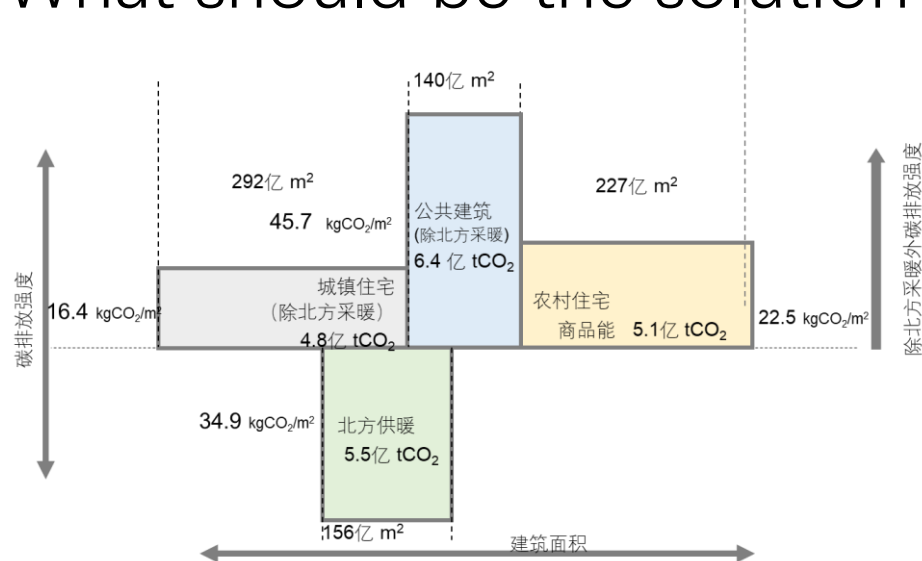
Heat pump: The carbon free solution of space heating for future

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Carbon free solution for heat demand

- The tasks of carbon free energy system of buildings:
 - Fully electrification of energy for buildings
 - Carbon free electricity supplement
 - Carbon free heat supplement for space heating
- What should be the solution for space heating?



Heat pump is the solution for space heating

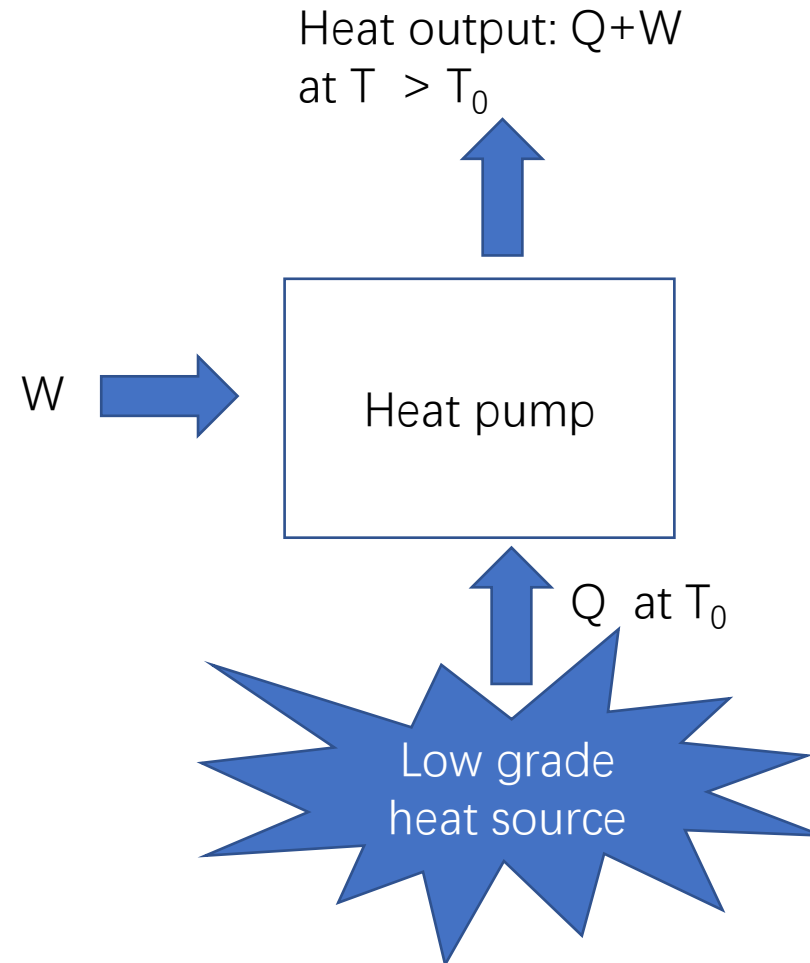
Input electricity W can provide heat $Q+W$,
where Q come from low grade heat

$$\text{COP} = \frac{Q+W}{W} = \frac{T}{T-T_0} \eta$$

$T_0=20^\circ\text{C}$, $T=50^\circ\text{C}$, $\eta=0.6$ 时, $\text{COP}=6$
 $T_0=20^\circ\text{C}$, $T=100^\circ\text{C}$, $\eta=0.6$ 时, $\text{COP}=2.8$

$T_0=0^\circ\text{C}$, $T=50^\circ\text{C}$, $\eta=0.6$ 时, $\text{COP}=4$
 $T_0=0^\circ\text{C}$, $T=100^\circ\text{C}$, $\eta=0.6$ 时, $\text{COP}=2.2$

$T_0=-10^\circ\text{C}$, $T=50^\circ\text{C}$, $\eta=0.6$, $\text{COP}=3.3$
 $T_0=-10^\circ\text{C}$, $T=100^\circ\text{C}$, $\eta=0.6$, $\text{COP}=2.0$



Key problem for hp applications: heat source

- Where can the low grade heat source be obtained?
- Outdoor air:
 - Universal existed, no limitation
 - Low temperature means low efficiency
 - Variation with seasons, performance varies
 - Frosting problem when outdoor temperature around 0°C
 - Cannot support for high density heat demand such as high density buildings, high density industry processes heat demand
- Suitable applications:
 - Space heating for low density building area, etc.
 - Industry process with small heat demand

Key problem for hp applications: heat source

- Surface water: lake, sewage, sea water, etc.
 - Suitable if the temperature of water above zero annually, otherwise freeze will make troubles
 - Cannot be provided everywhere, it is not possible in most cases
 - Should be put as the priority for selection

Key problem for hp applications: heat source

- Underground: water circulation, U-tube, etc.
 - Underground environment protection
 - Principle: obtain low grade heat / heat storage underground?
 - It dependent on the underground water transfusion
 - With large amount of transfusion underground: heat can be obtained annually
 - Without enough transfusion: it is a kind of heat storage system, annual heat balance has to be considered carefully
 - Cannot support high density heat demand due to limited volume underground

Other heat sources for HP application?

- Low density settlement, low temperature heat source for heat pumps can be solved through either air or water
- For high density settlement such as Chinese large cities in North , heat pump with natural low-grade heat sources cannot be the major solution, can hardly meet the high-density heat demand
- Low-grade heat can be found in heat exhausted from industries
- Heat released from industries: power, iron & steel, chemistry, etc.
- Total amount of heat released is enough for space heating and some industries process demand

Low grade heat sources in North China

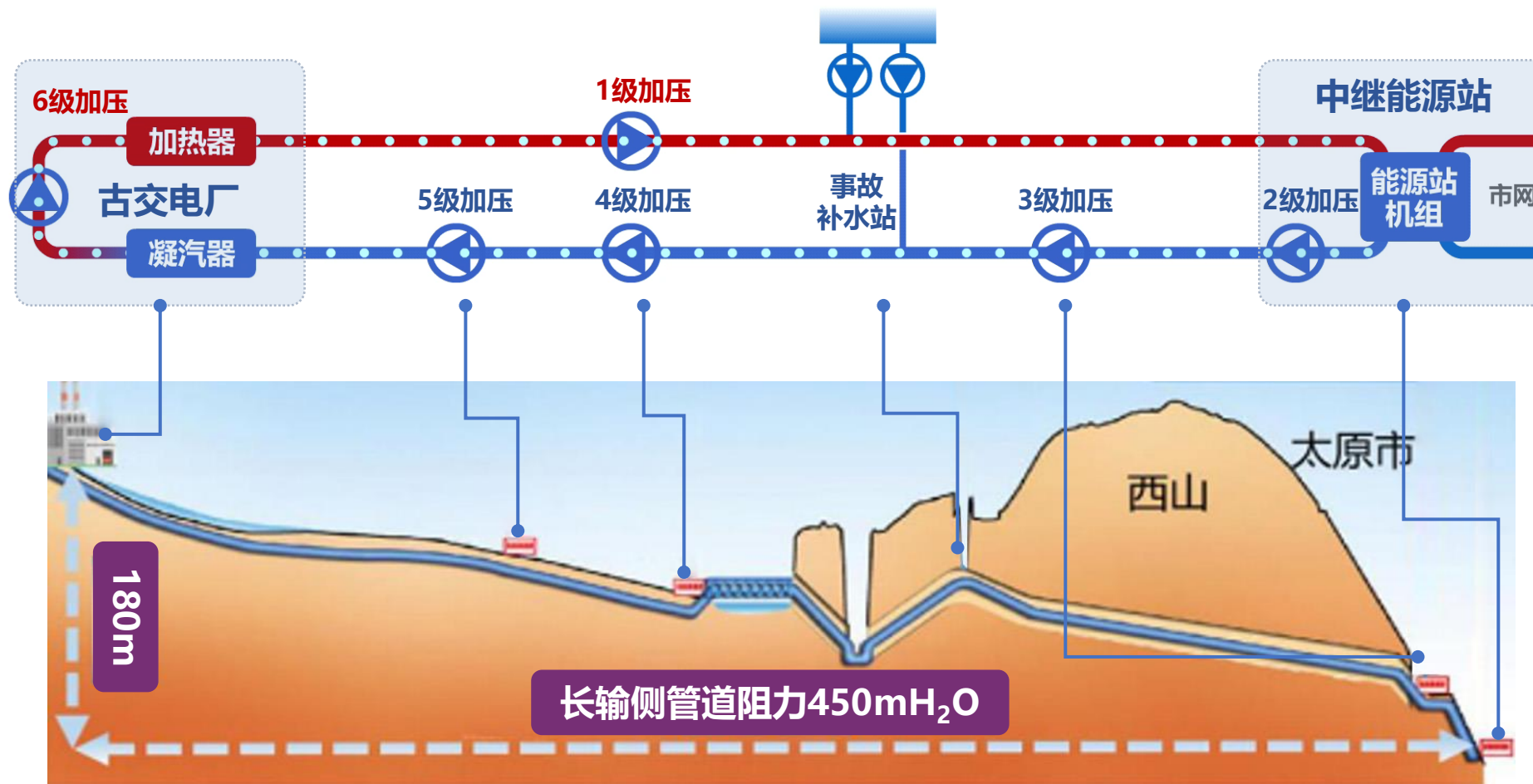
	Capacity in power MW	Exhaust heat power MW	Annual heat output GJ
Nuclear power in the North	100 GW in power	120 GW exhaust heat	3000 PJ
Thermal power for peak load in the North	300 GW in power	360 GW exhaust heat	2000 PJ
Iron & steel, chemistry, cement, etc.		70 GW exhaust heat	1500 PJ
Data center, refuse burning		40GW exhaust heat	1000 PJ
Total		590 GW	7500 PJ
If 70% can be applied		410 GW	5300 PJ

Demand: 20 billion m² building need 600 GW in power and 5000 PJ total heat,
Exhaust heat cannot meet the demand in power, but can provide enough heat if counting in annually 8

Challenges to fully use the low-grade heat

- Three challenges to fully use the low- grade heat
 - Unmatched in the time between production & demand
large scale seasonal heat storage is required
 - Unmatched in the location between supply and demand
Long distance heat transportation at low cost is required
 - Unmatched in heat parameters
Heat transformers are required to convert heat between different parameters, just like transformers in power system

Long distance heat transportation system

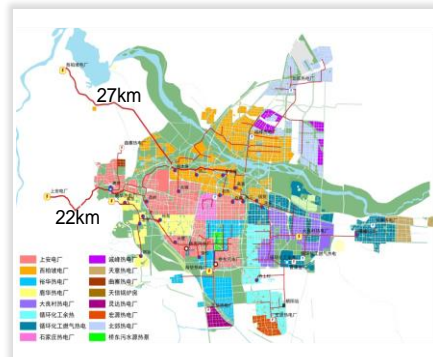


构建**六级**泵循环加压工艺，实现了**长输侧直连高差 180m**的热网安全经济运行。

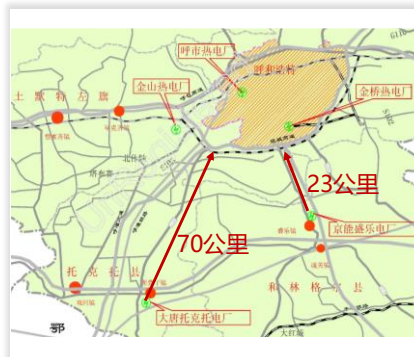
Long distance heat transportation projects in China



Taiyuan
供热面积: 10600万 m²



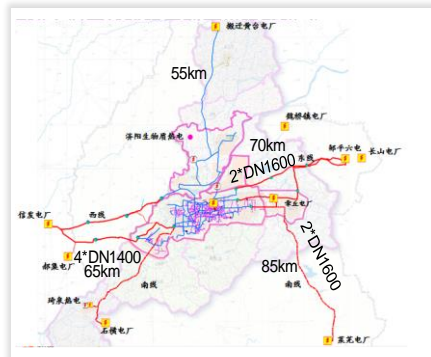
Shijiazhuang
供热面积: 18500万 m²



Huhehaote
供热面积: 9000万 m²



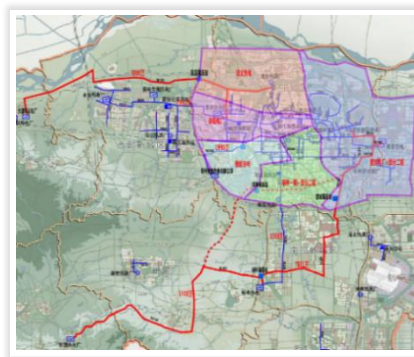
Xian
供热面积: 7500万 m²



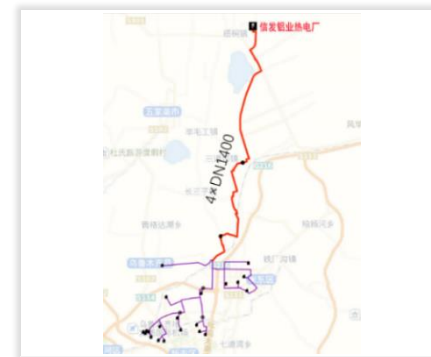
Jinan
供热面积: 28000万 m²



Yinchuan
供热面积: 11219万 m²



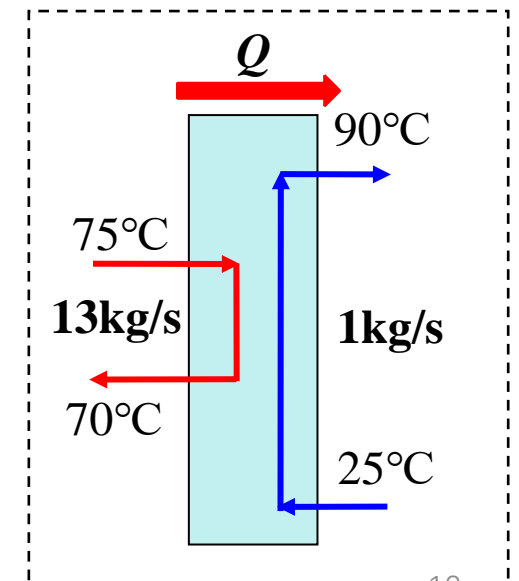
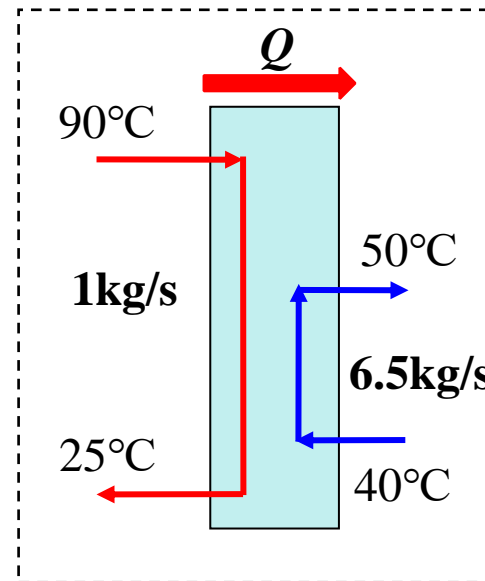
Zhengzhou
供热面积: 12000万 m²



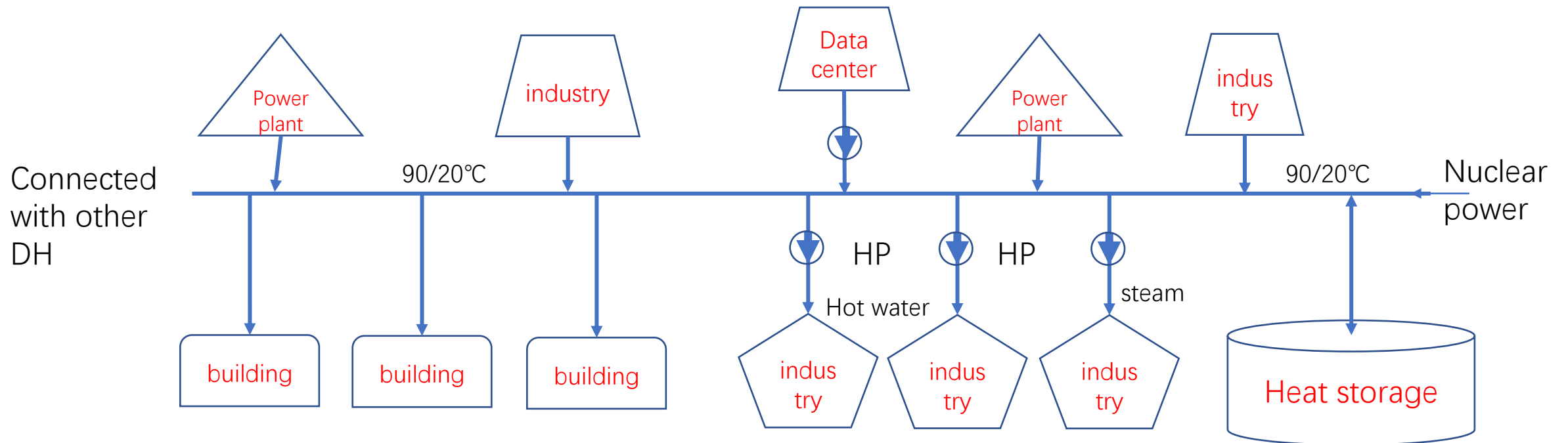
Wulumuqi
供热面积: 6000万 m²

Heat transformers

- Two type of heat transformers have been developed and been widely used
- It can make high efficiency heat transfer when the flow rate at two sides is in very difference
- Combined with heat pump, heat transformers can be developed also for make heat transfer with different temperature levels



Heat sharing system based on low grade heat



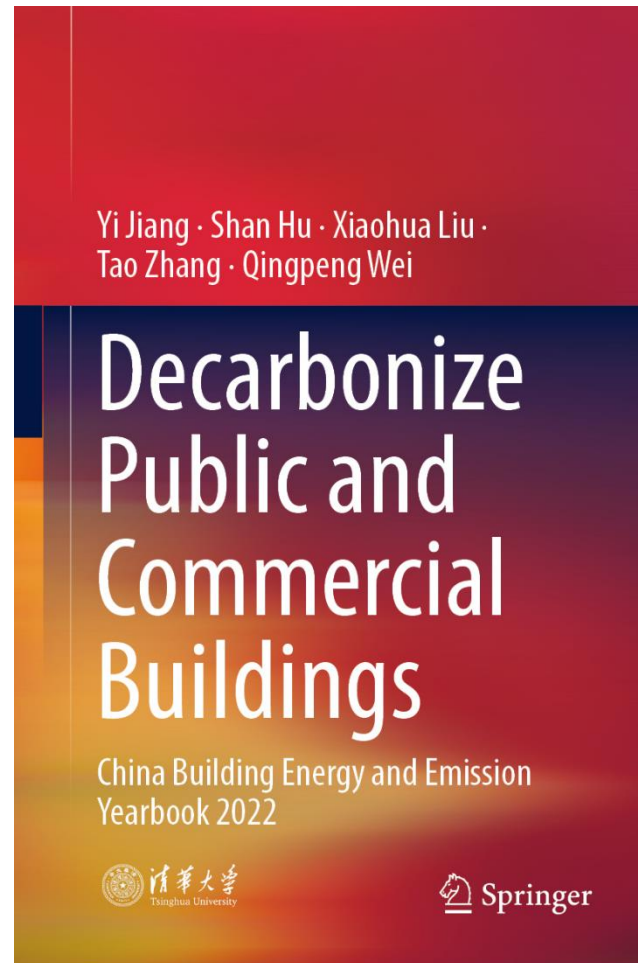
Comparison with 5G DHC in Europe

- Low grade heat sources
 - More heat from industries and from thermal power in China
 - The temperature of exhausted heat is higher in China than in Europe normally
- Heating only or H & C?
 - District heating rather than district heating & cooling in China
 - There is not natural cooling source in China in most cases, DC should not applied
- The importance of large scale heat storage system
 - To fully use the exhaust heat, large scale seasonal heat storage is essential, however it is not emphasized in 5GDHC

Conclusion

- Heat pump will play very important rule in the low carbon society
- Carbon free heat supplement can be achieved by HP plus carbon free electricity
- Low grade heat source is the key for heat pumps application and for the technology of heat pump selected
- Exhausted heat from power station as well as from industries would be the most suitable low grade heat sources for HP
- Heat sharing system for fully use the exhausted heat should be developed for space heating in high density urban area

Release of the China Building Energy and Emission Yearbook 2022



Thank you

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