清華大學
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District Energy Systems in China

Options for Optimization and Diversification

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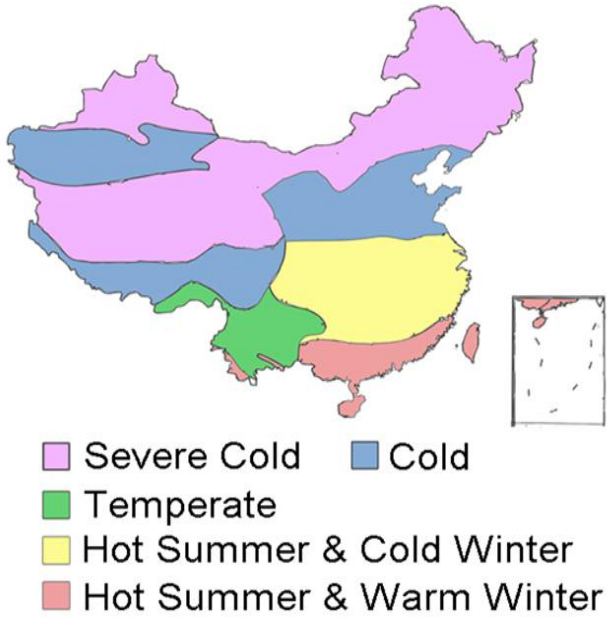
Background – Current situation

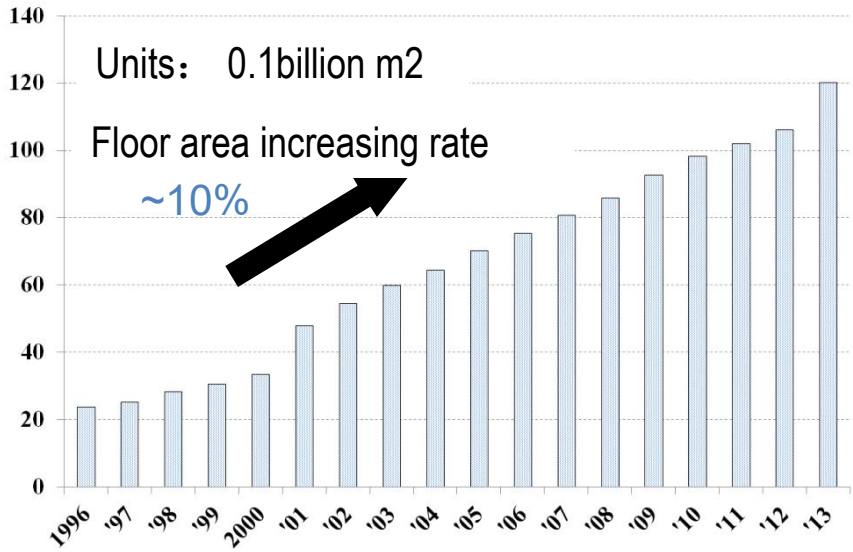
Regions in China with District Heating

- Hot Summer & Cold Winter Zone, Cold Zone and Severe Cold Zone, 16 provinces



Statistic Data in 2016

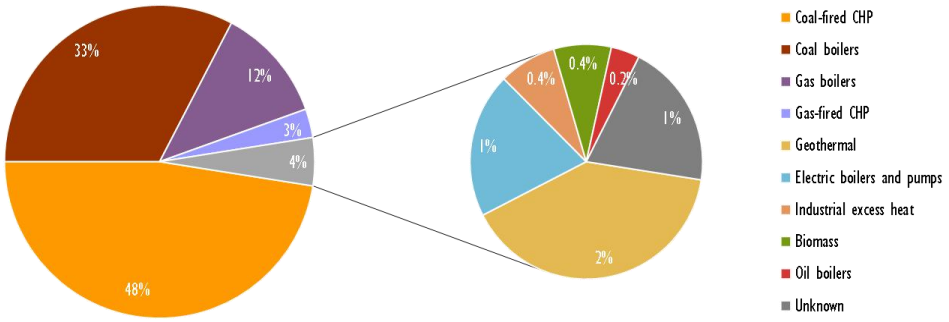
- Total building area: **13.1** billion m2
- Total heating energy consumption: **0.191** billion tce/year
- **25%** of total building energy
- **76%** of the area supplied by district heating.
- Due to the urbanization process, a lot of cities face the situation of lacking heating source.

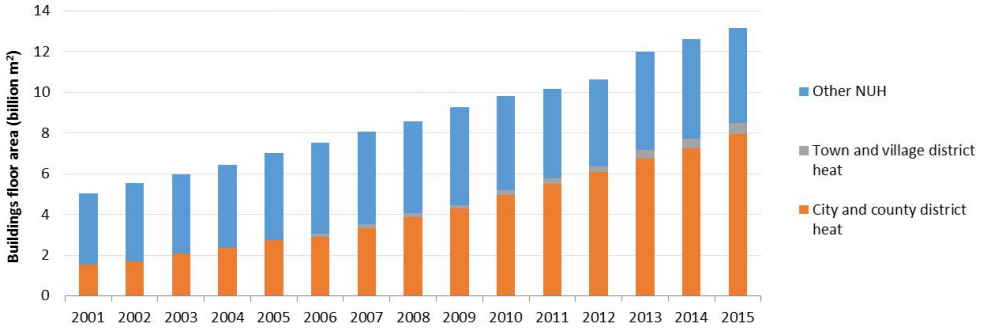


District energy systems play a key role in China

- China has the world's largest and fastest-growing district energy system
  - 192 721 km of hot water networks and 11 692 km of steam networks
  - The district heat network covers around 8.5 billion square meters (m^2), having tripled since 2005.
- Challenges for China's district energy systems
  - Coal accounts for 90% of energy consumed for district heat production
  - Energy demand for space heating and cooling is expected to grow as urbanization continues
- Opportunities for a cleaner district energy system
  - The role of renewables, energy efficiency, excess heat, nature gas
- Possible business models and pricing options

China's district energy system relies heavily on fossil fuels





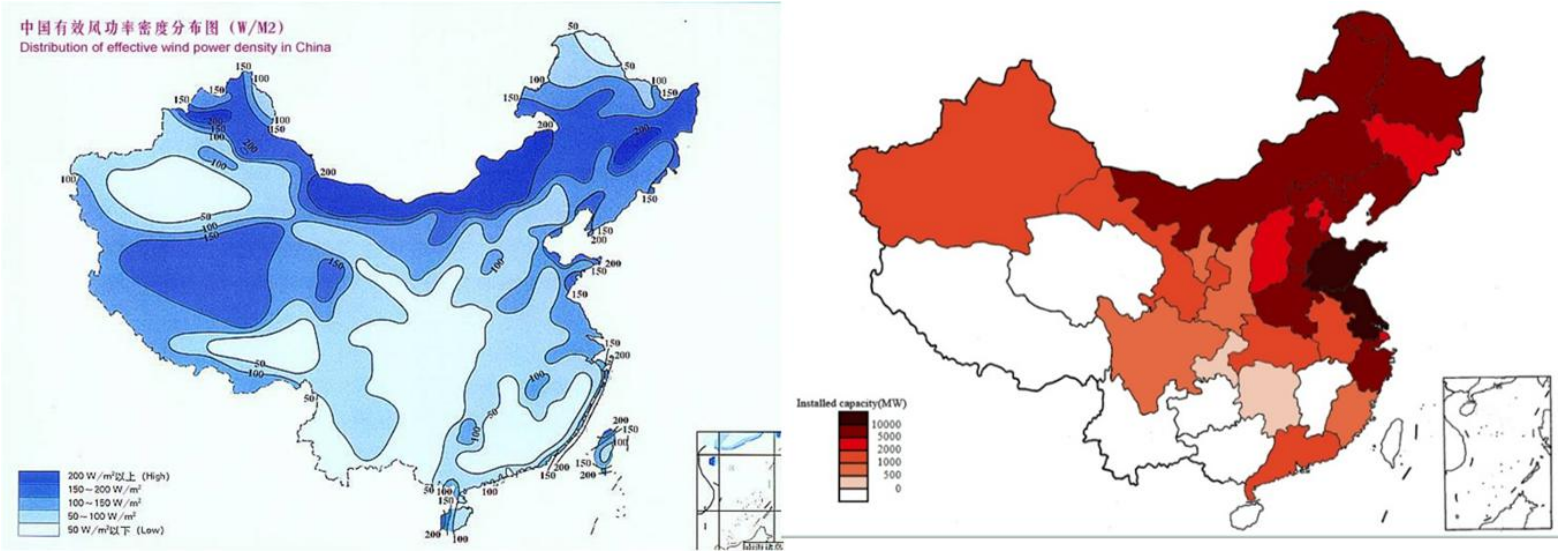
- The impact of energy use and emissions from district heating – on the Chinese economy, on local air quality and health, and on urban population well-being – is significant.
- Total buildings floor area covered by the district heating network in Northern China tripled over the last decade, representing nearly all the floor area growth in NUH China since 2005 .

Approach to "Clean Heating"

- How to solve the energy and environmental problems in urban and rural area?
- The future trend of building energy?

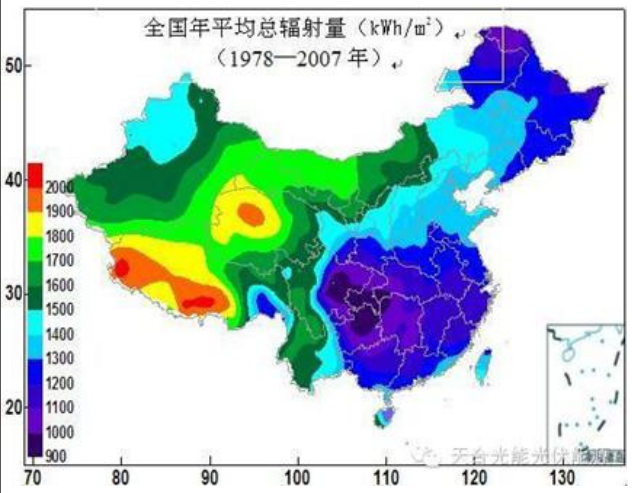
In the new phase of urbanization, energy and environmental problems are the keys to realizing sustainable development in urban and rural area!

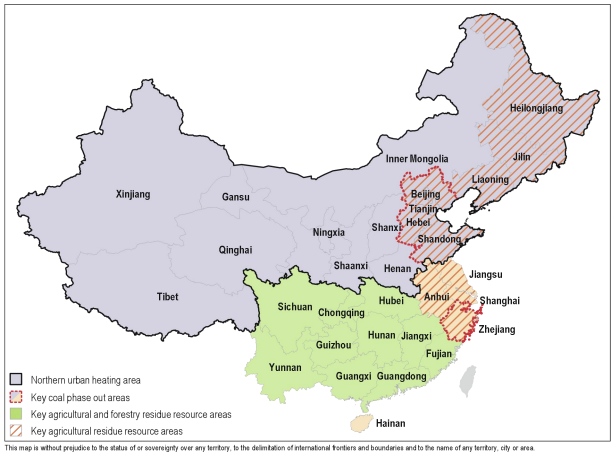
The role of renewables: potential for wind power



- Coal-fired power stations can regulate electric supply in non-heating period;
- Coal-fired power stations produced electricity according to heat demand in Heating season;
- The wind curtailment in winter accounted for 86% of the whole year

The role of renewables: potential for Solar energy, Hydropower and Biomass

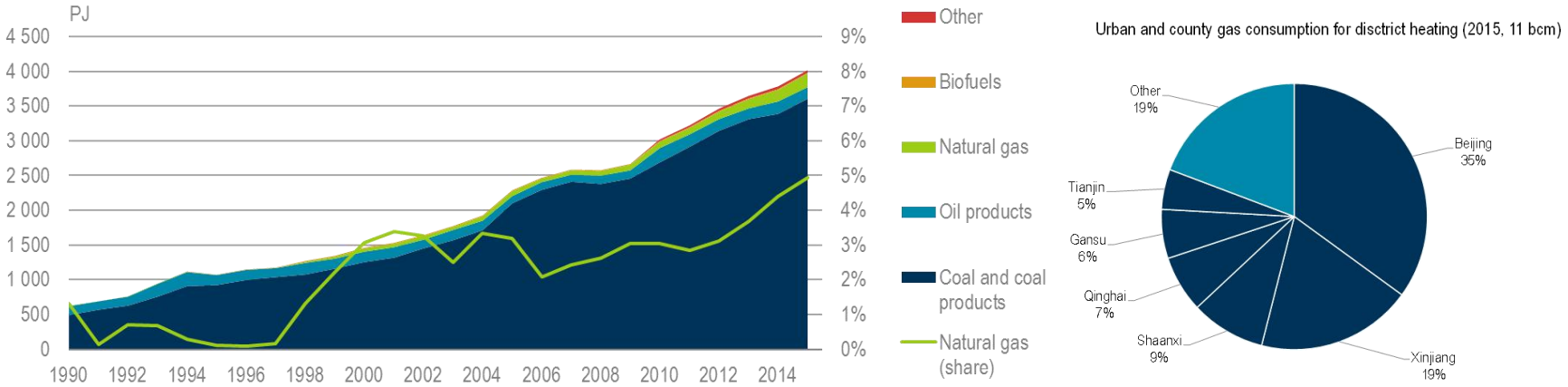




- In China, the renewables share in district heating was around 1%; IRENA suggested that in China, reaching a 24% renewable share in district heat generation by 2030 is feasible.
- Many renewable heat options find it difficult to compete against fossil fuels, and especially coal, in China.

Recent government push has increased coal-to-gas switch

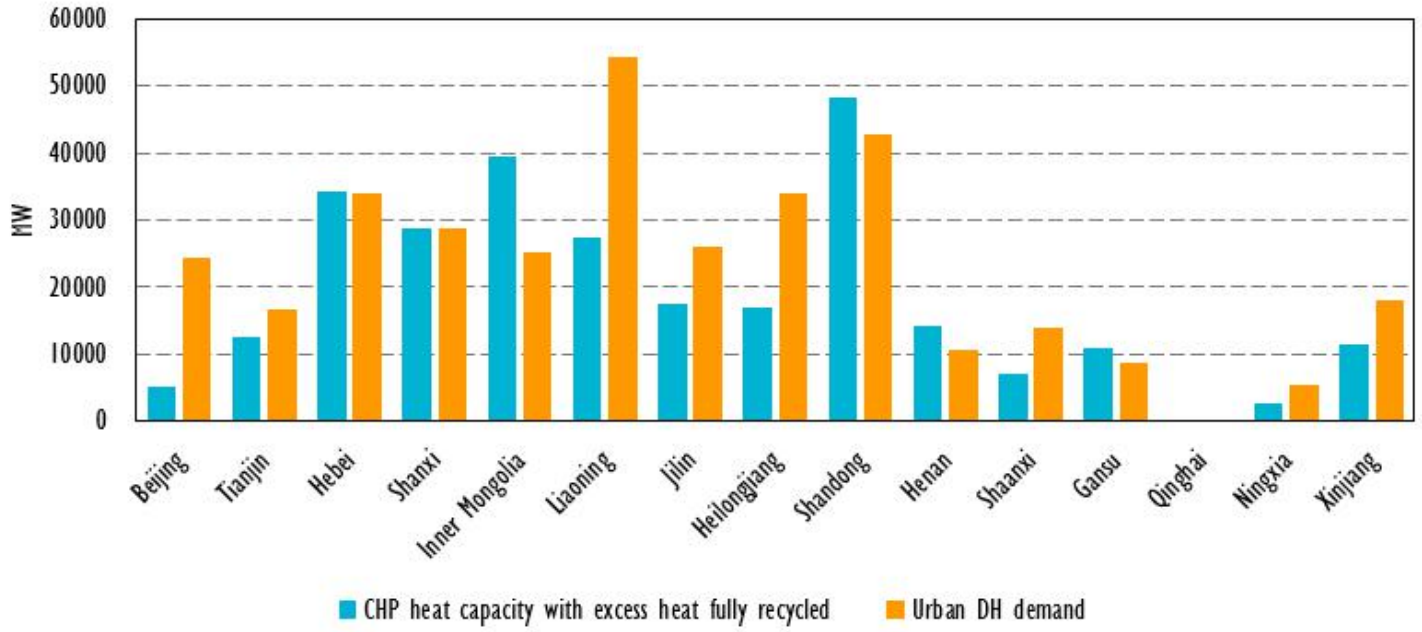
Share of natural gas in heat production in China, 1990-2015



- Annual consumption in 2016 is 208.3 billion m^3; around 6% share; 71.4 billion m^3 import , around 34% share;
- The increase in gas-fired heat generation for district heat in recent years is likely to continue in the coming decade.

The role of excess heat from co-generation

CHP heat capacity and urban DH demand

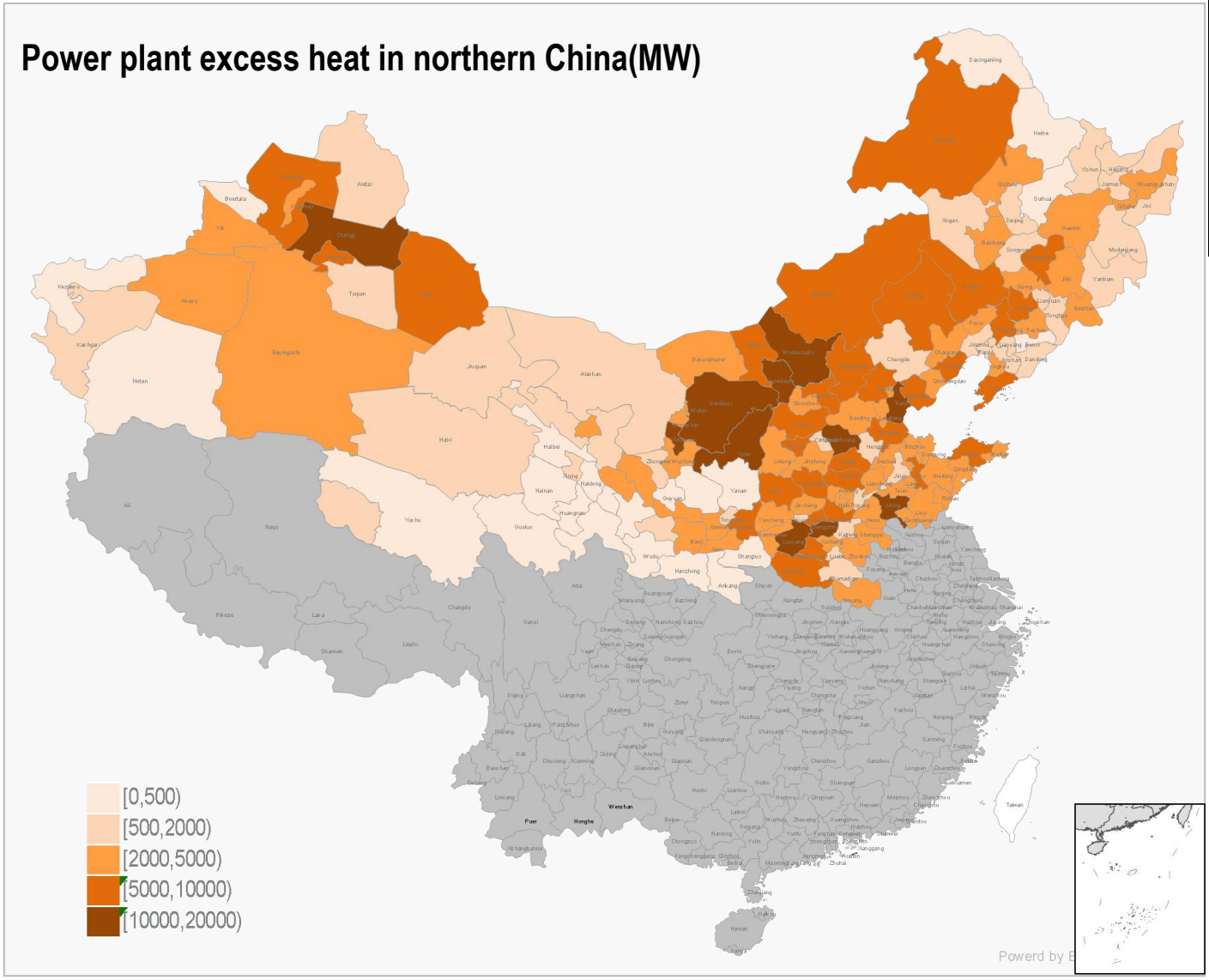


Source: Ministry of Housing and Urban-Rural Development

- Heat capacity from co-generation excess heat is equivalent to around 80% of the 2015 heat demand in district energy networks.

The role of excess heat from co-generation

➢ Power plant excess heat



Power plant excess heat （MW）	The number of prefecture-level cities
0~500	24
500~2000	37
2000~5000	55
5000~10000	31
> 10000	11

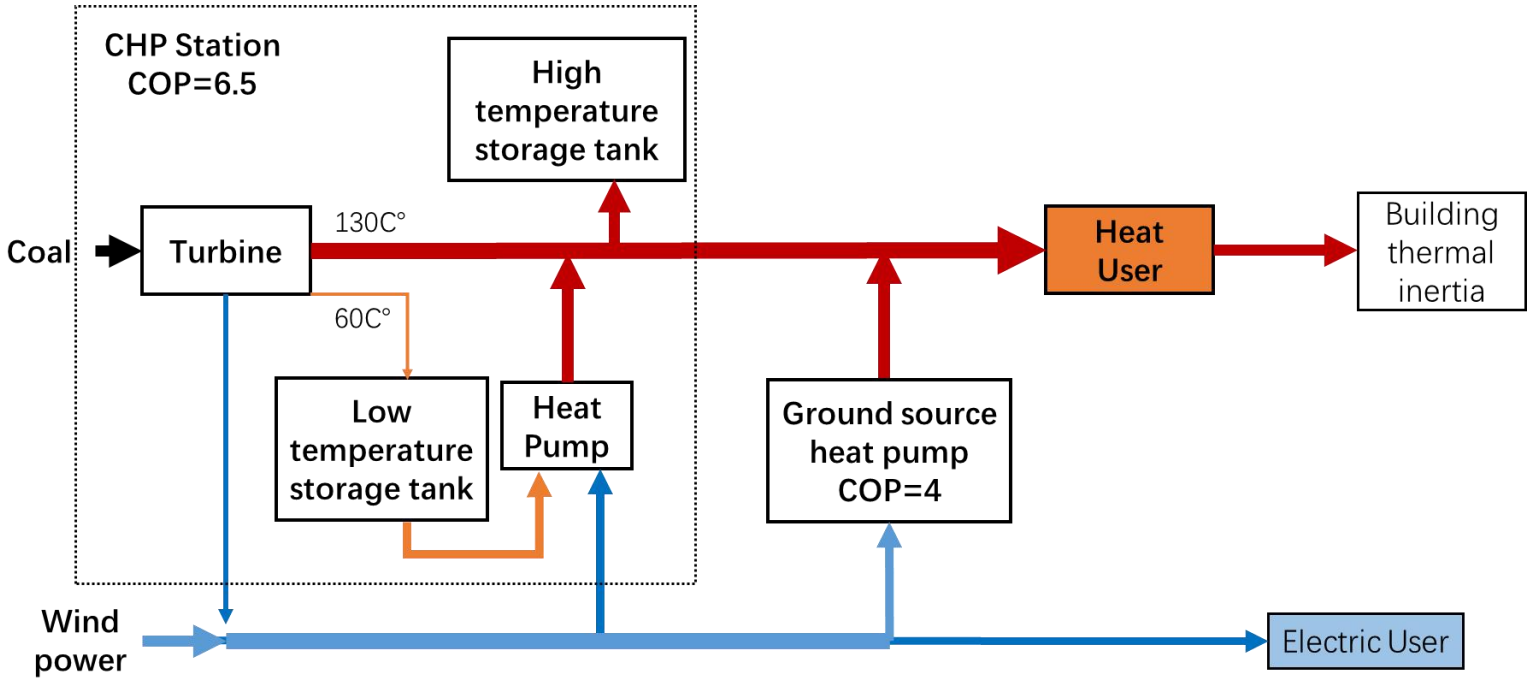
The distribution of power plant excessheat has obvious regional heterogeneity.

It's mainly distributed in Henan, Inner Mongolia, Shandong, Hebei, Xinjiang, Shanxi etc

Thermal-electric synergy Technology

In high wind power load and low electric demand:

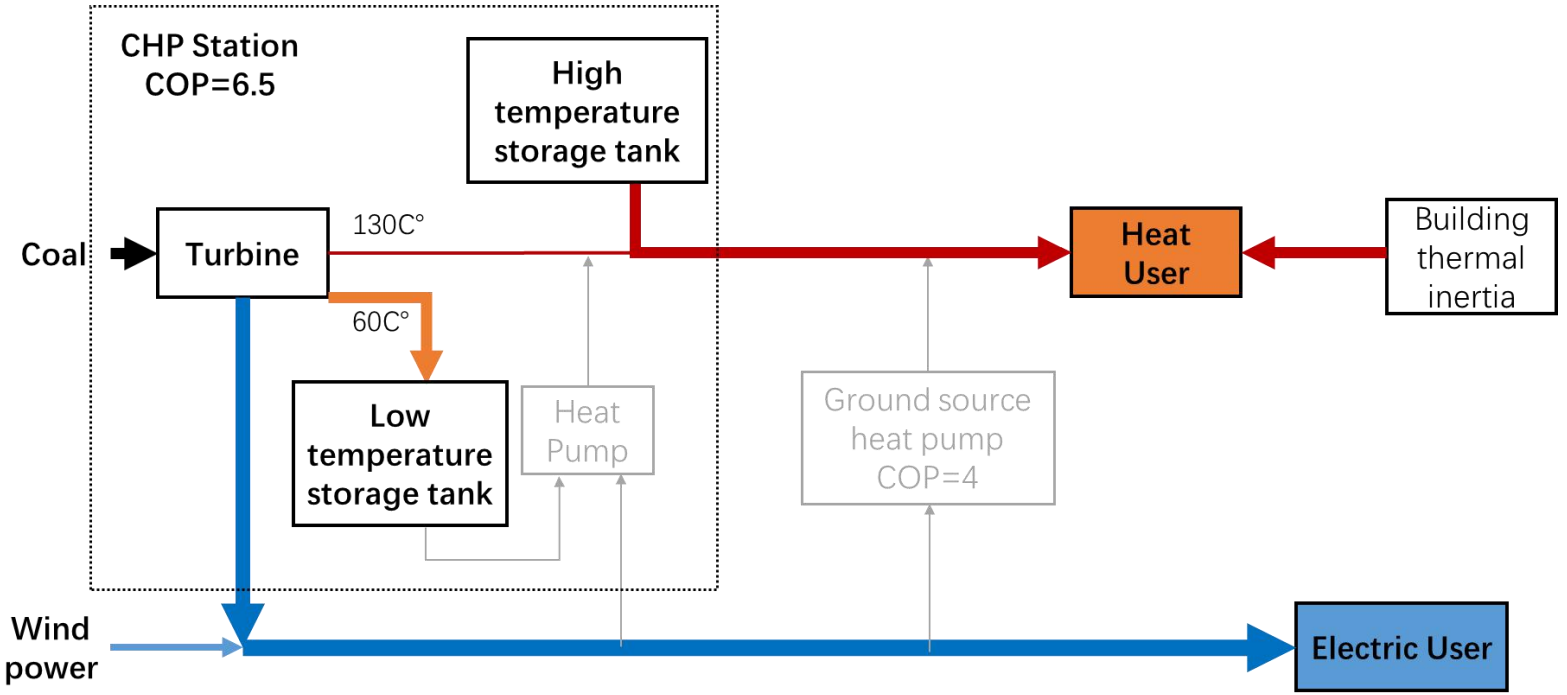
- CHP system increases the flow of extraction steam and starts heat pumps to recycle the excess heat stored in low-temperature storage tank
- Start the ground source heat pumps
- Use high temperature storage tank and building thermal inertia to store the excess heat



Thermal-electric synergy Technology

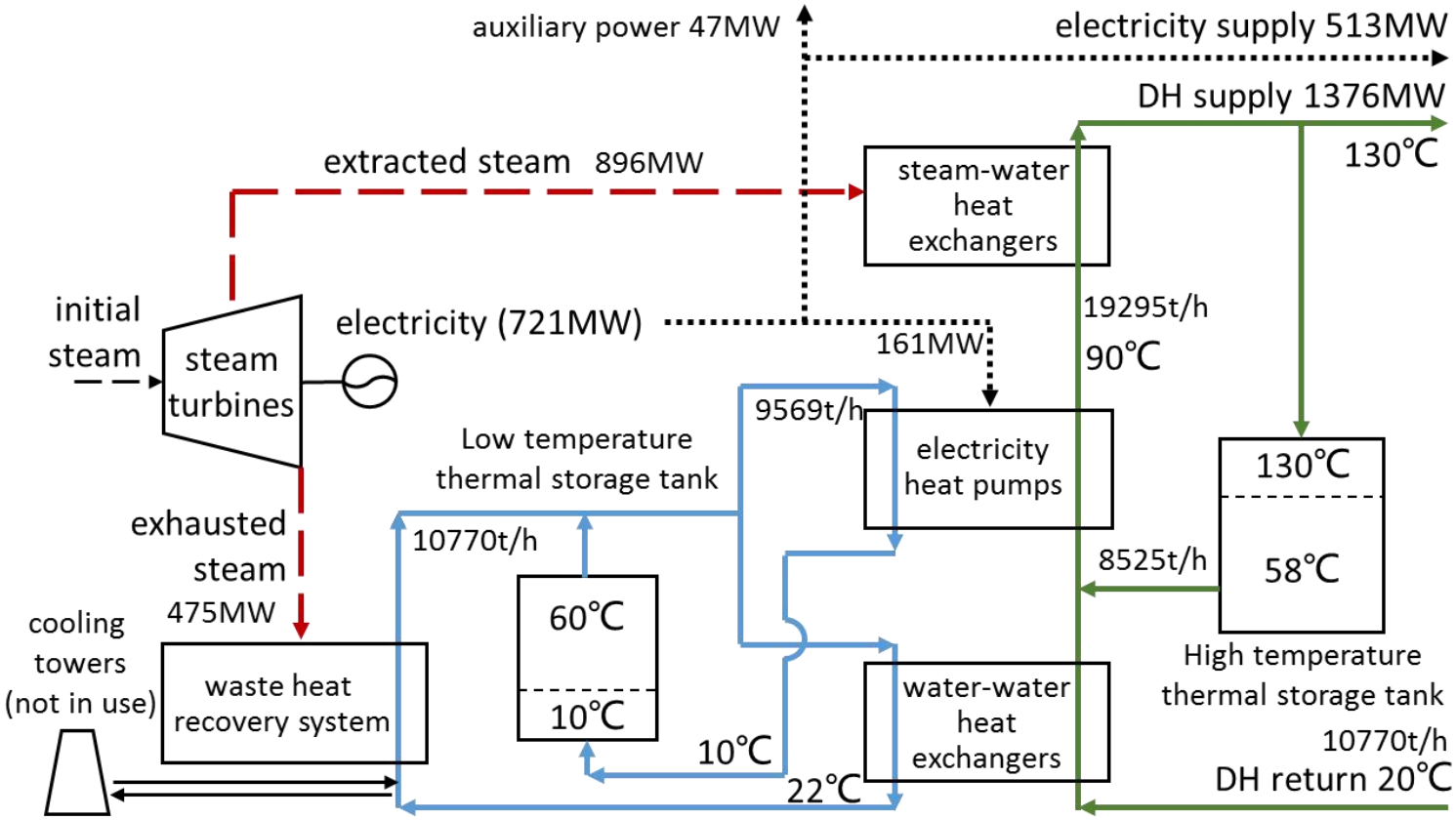
In low wind power load and high electric demand:

- CHP system stops extracting steam and turns down heat pumps
- Stop the ground source heat pumps
- Maintain the indoor temperature by using the high temperature storage tank and building thermal inertia



Thermal-electric synergy Technology

- The COP of the excess heat recycle system is more than 6
- The electric supply load is able to regulate between 55% to 100%, without reducing the heat supply

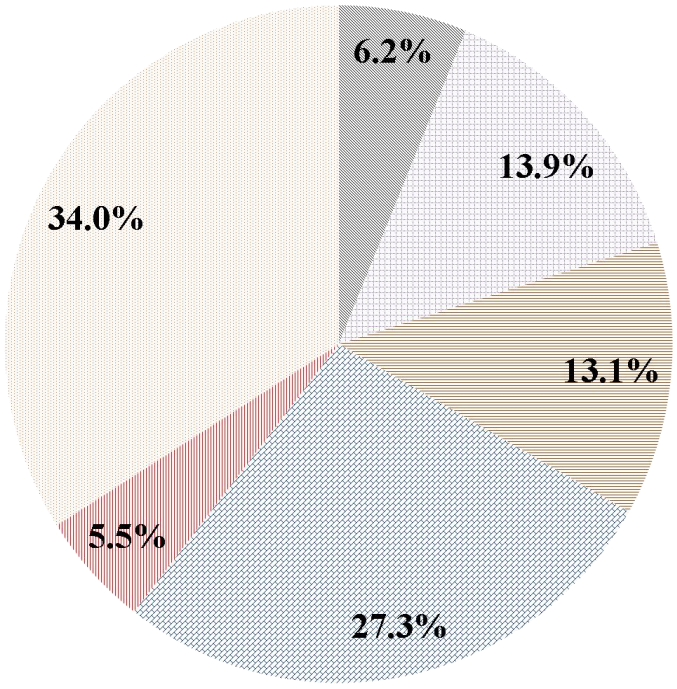


Heating potential of CHP

- 35% of the thermal power stations are non-CHP, in charge of peak shaving. If the thermal-electric synergy is applied, these stations are able to supply heat.
  - Panshan, Tianjin 2200 MW
  - Zhangjiakou 2000 MW
  - Tangshan 3600 MW
  - Togtoh, Inner Mongolia 2000 MW
- 80% of the CHP waste the excess heat in cooling tower
- Nuclear power stations can be transformed into CHP

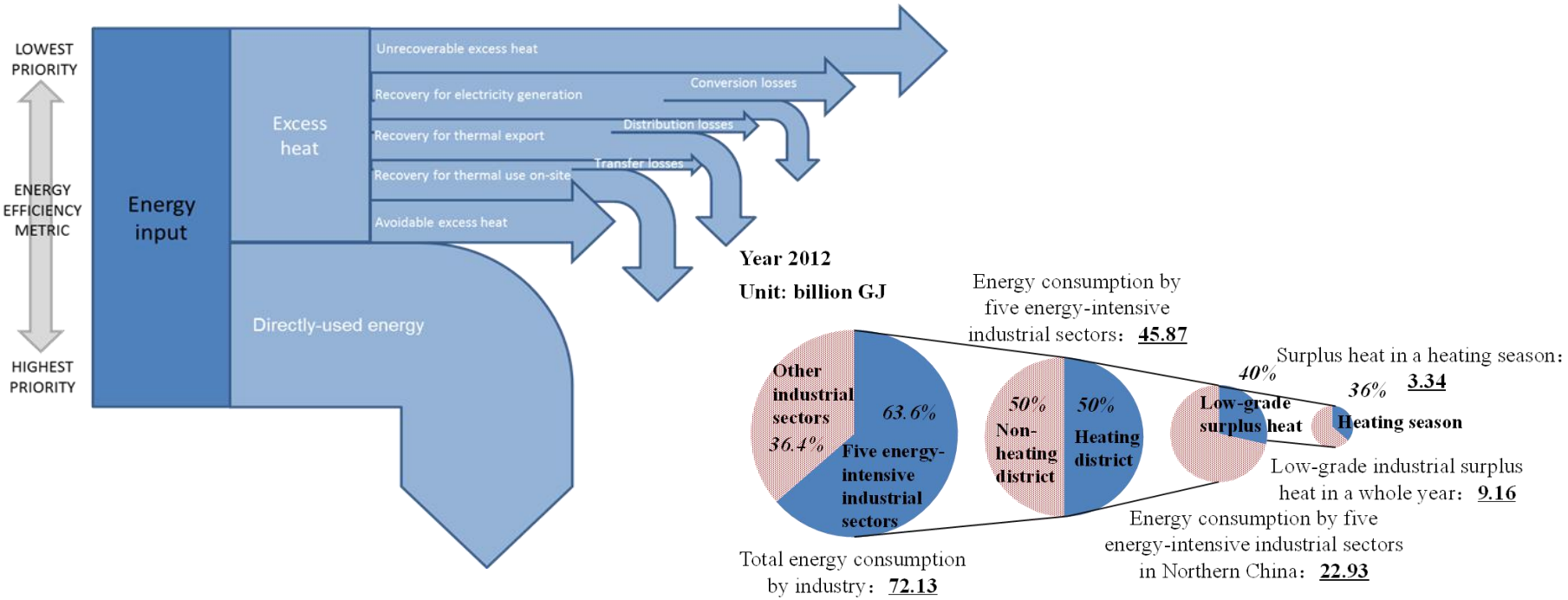
Industry → Manufacturing industries → Top 5 Energy-intensive industrial sectors

- In China, energy consumed by manufacturing industries accounts for ***2/3*** of the social total energy, compared to the global average ***1/3***, the Great Britain ***1/4***, and the USA ***1/5***.
- Huge amount of waste heat is discharged to the ambient in the industry processing.



- Petrochemical and coking industry
- Inorganic chemical industry
- Non-metallic manufacturing industry
- Ferrous metal smelting industry
- Non-ferrous metal smelting industry
- Other 40 industrial sectors

The role of excess heat from industry

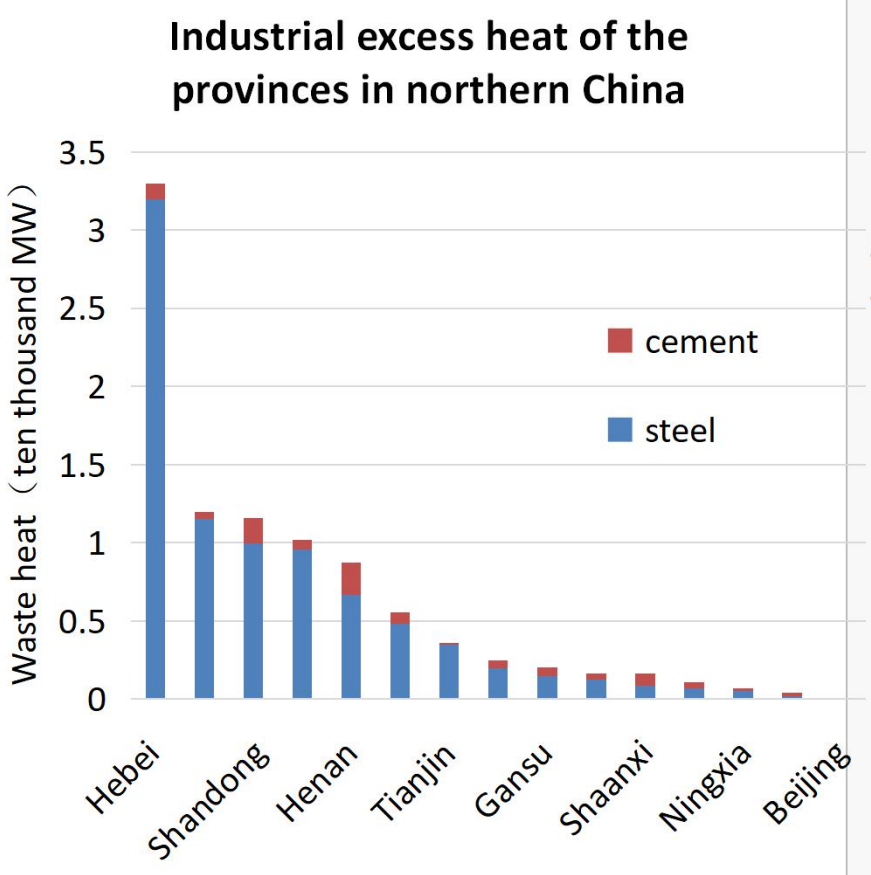


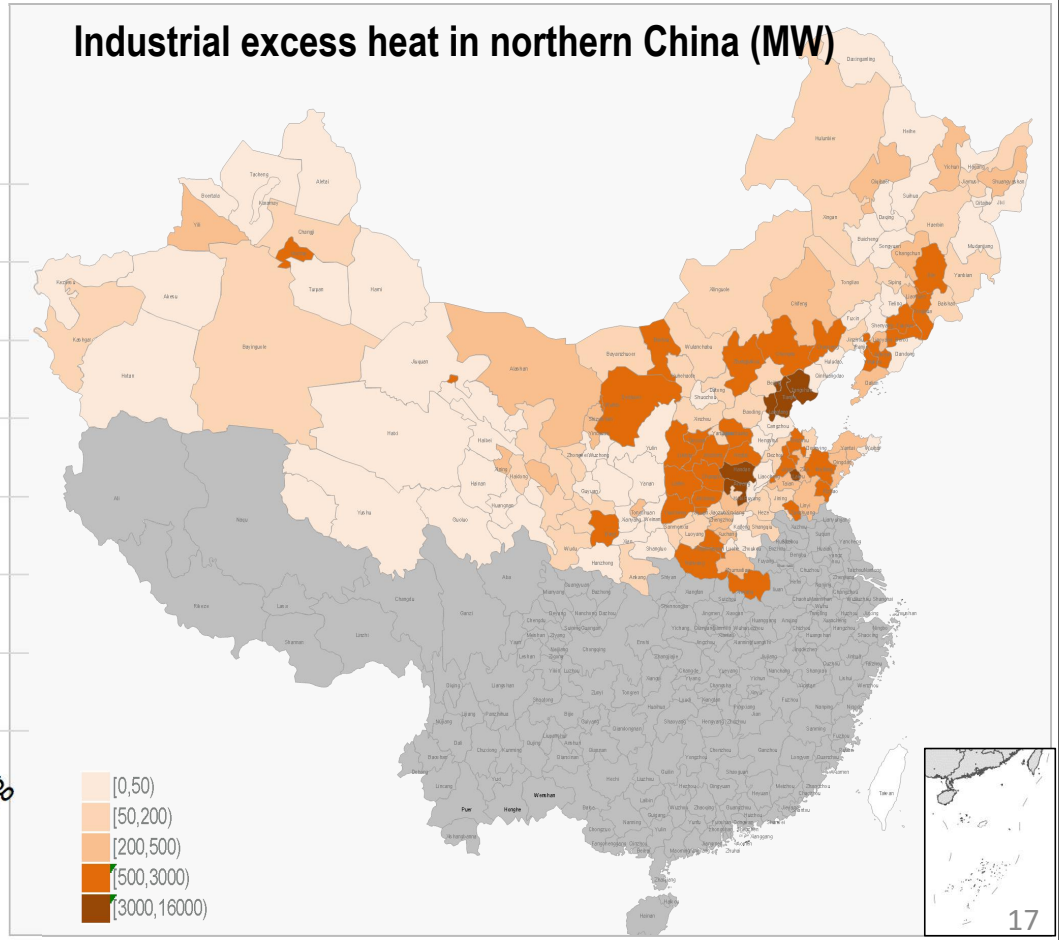
- Policies to maximise energy efficiency would improve management of excess heat, including its use for district energy networks in China.

The role of excess heat from industry

➢ Industrial excess heat

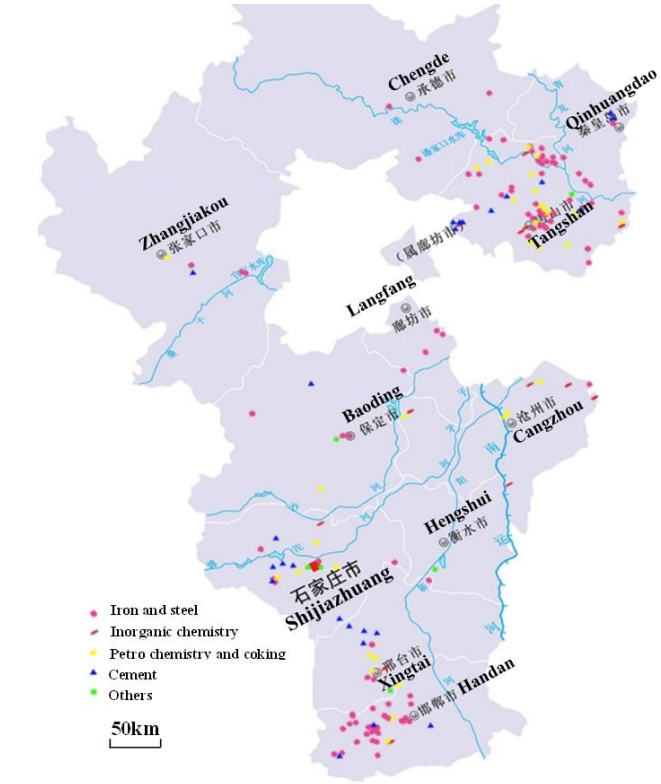
In general, industrial waste heat shows obvious heterogeneity in geographical distribution. Hebei, Shanxi, Shandong, Liaoning and Henan have the most industrial waste heat. Among them, Hebei has a particularly obvious advantage of industrial waste heat due to its developed steel industry.

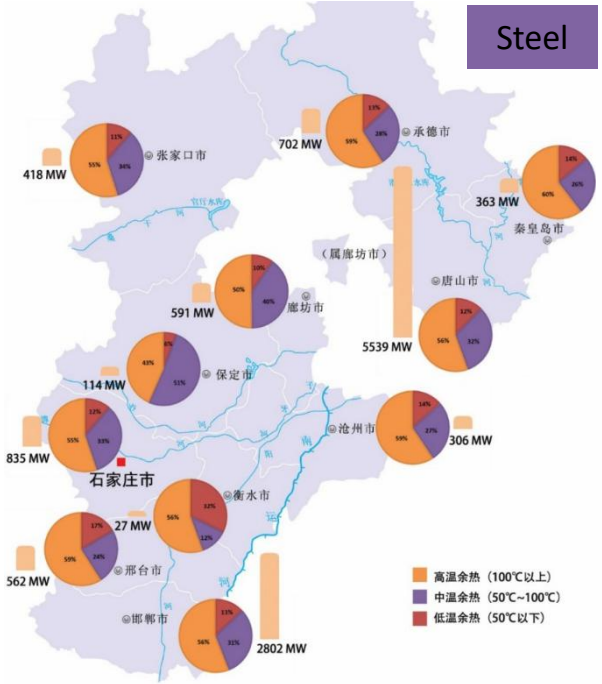


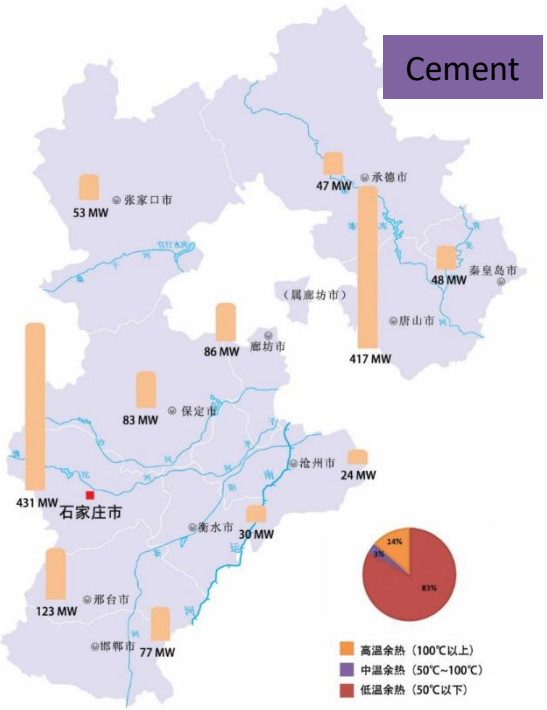


Low-grade excess heat investigation in major cities of Jingjinji Area

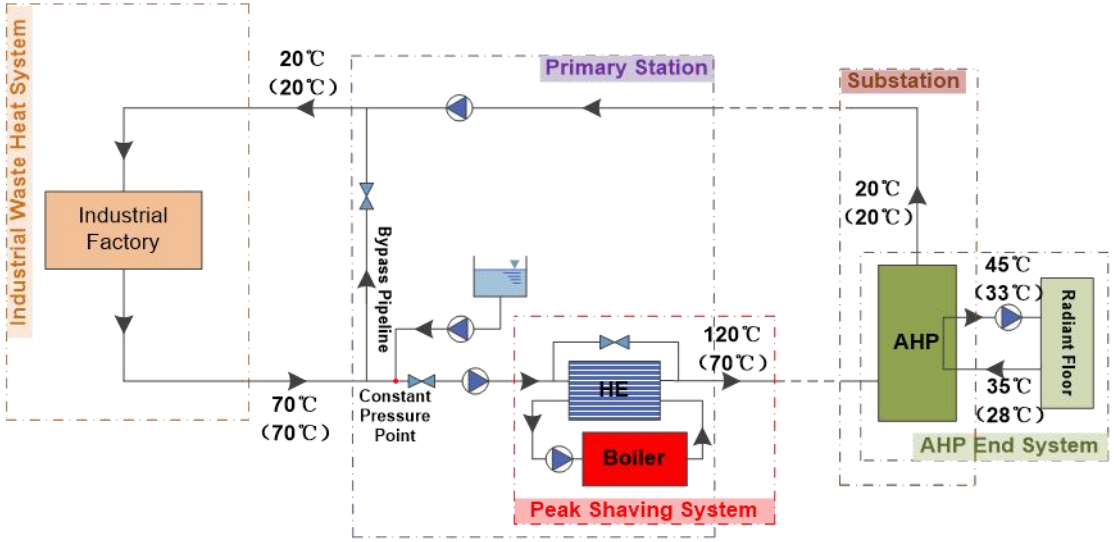
Investigation made by Tsinghua University ,Energy Foundation, China Energy Conservation Association and NDRC Energy Institute in 2014

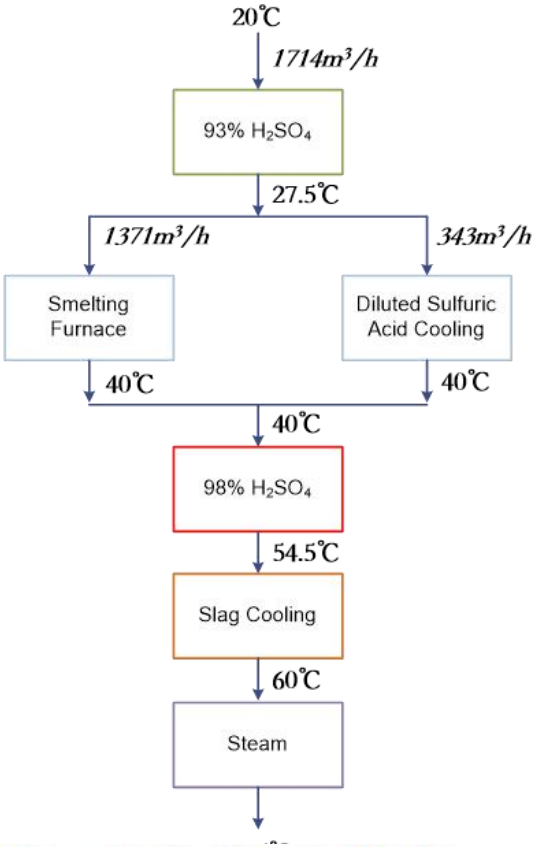


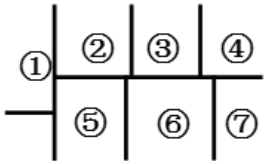


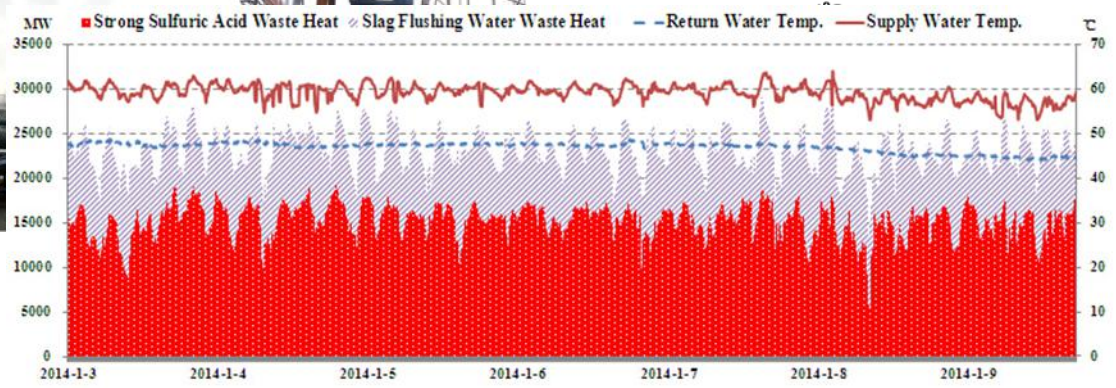


Case study 1: Cupper factory excess heat application

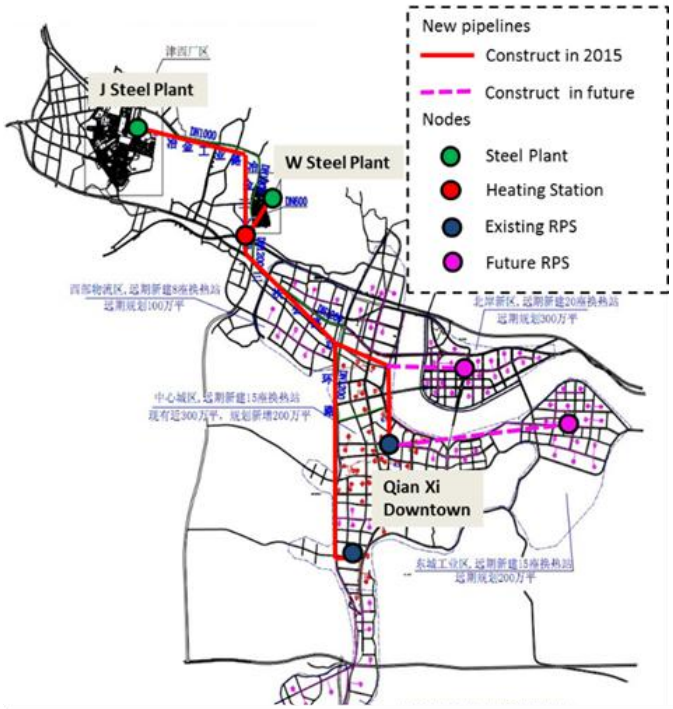


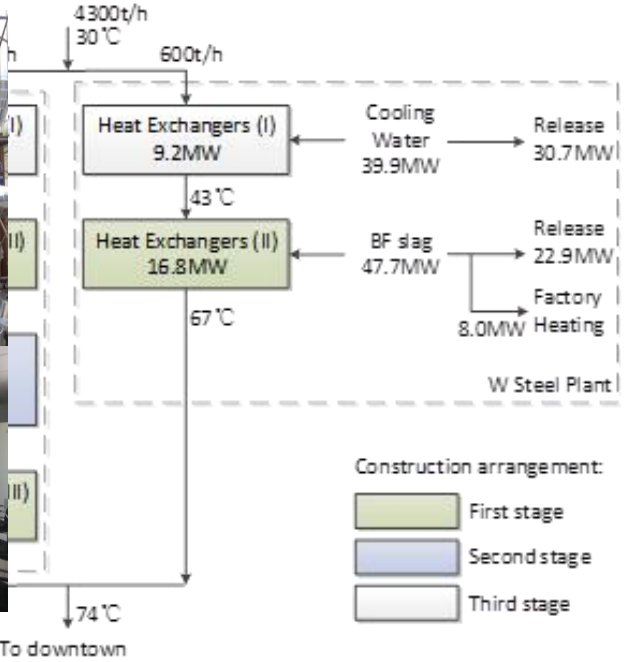


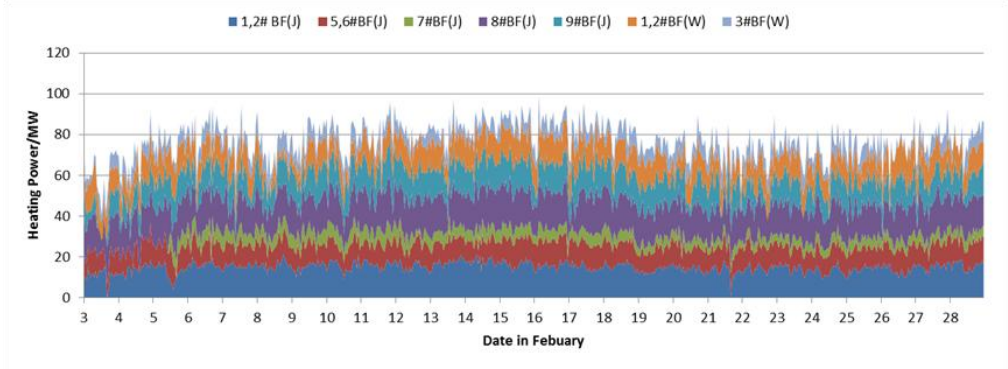


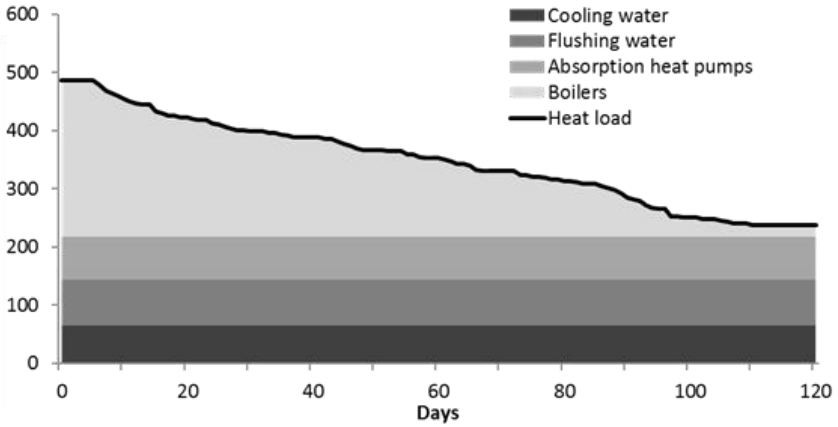


Case study 2: Steel factory excess heat application









- Total heating area 10 million m2
- Total investment is around 450 Million RMB;
- Saving 150,000 tce and 1.29 million ton of water per year;

Recommendations

- Policies and planning: Prioritise locally based and tailored solutions
  - Local governments could be required to carry out heat mapping and assessments of demand and resources.
  - District heating networks could be improved through urban planning that increases densities and distributed (i.e. decentralised) energy potential.
- Policies and market: Gradually promote fair prices with government support
  - A clear policy framework and predictable market context are needed to support cost-effective diversification of heat sources, including renewables and IEH.
  - Clean energy sources need positive price signals, such as taxes on heat from coal for new districts, to become competitive with coal.
- Demand side: Develop adequate solutions based on assessed demand
  - Development of new district energy should be demand-based.
  - Education on behaviour and energy conservation can support better demand-side management.
- Supply side: progressively develop cleaner sources
  - Excess heat and renewable sources, including geothermal and biomass, should be promoted according to locally available resources.
  - To integrate a higher share of renewables, a variety of sources are needed, often requiring business models (e.g. third-party access) that allow for variable heat generation.

Conclusion

- Improving energy performance of the buildings to reduce the heating demand;
- In big cities: coal-fired CHP and industry excess heat as the base heat load in district heating system, and using natural gas as the peak heat load regulator;
- Rural area: electric heat pump, solar energy, and biomass as main heat sources in the rural area
- Air source heat pump to place low-efficiency coal-fired stoves in Beijing, Tianjin, Hebei, Shanxi, Shandong, and Henan.
- Promoting passive solar house and active solar heating technology in Xinjiang, Qinghai, Gansu, Shaanxi, Ningxia, ant Tibet.
- Promote biomass and high-efficiency combustion equipment in Heilongjiang, Jilin, Inner Mongolia, and Liaoning

谢谢！

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