Overview of district heating and cooling – representative from China

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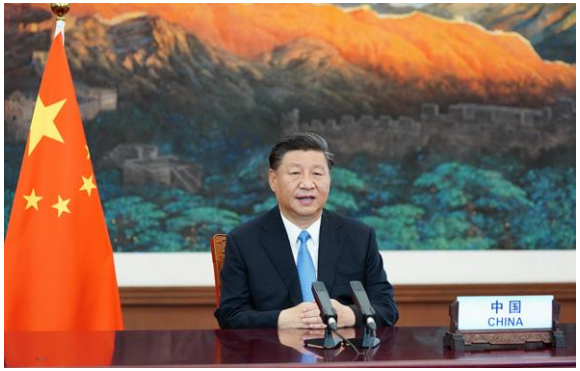
Reasons and determinations for China to pursue a more sustainable energy future

- Energy resource scarcity and security are likely to be major incentives in coming decades to curtail energy demand growth.

- Reach **CO_2 emissions peak before 2030** & achieve **carbon neutrality before 2060**

  ——President Xi, Sept 22, 2020

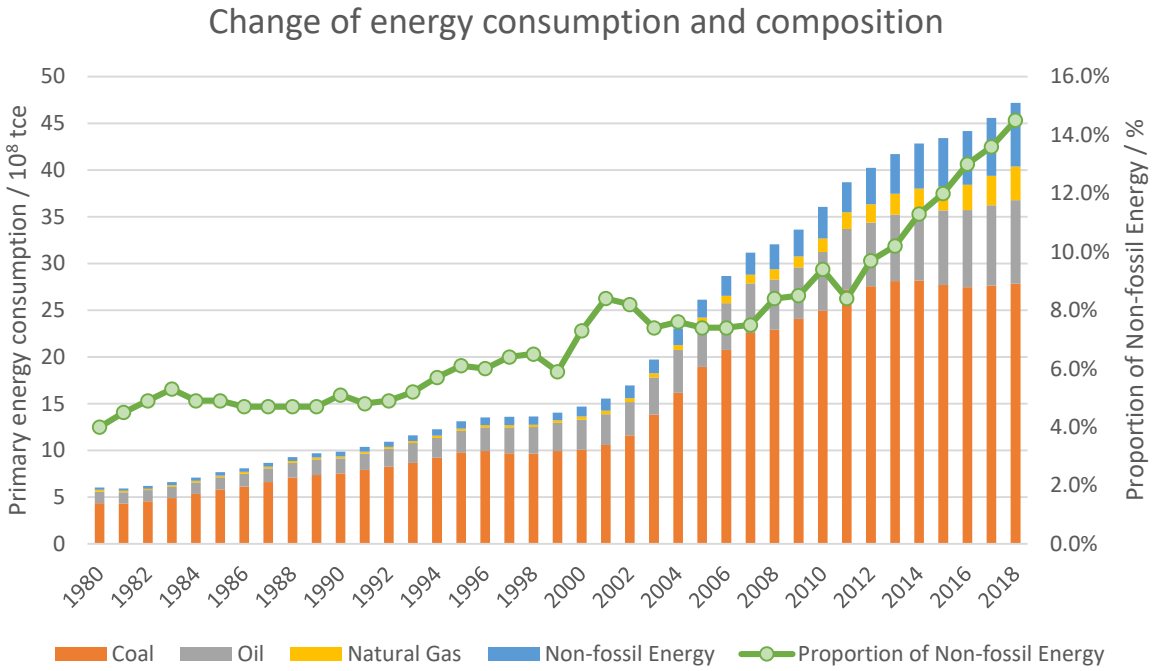


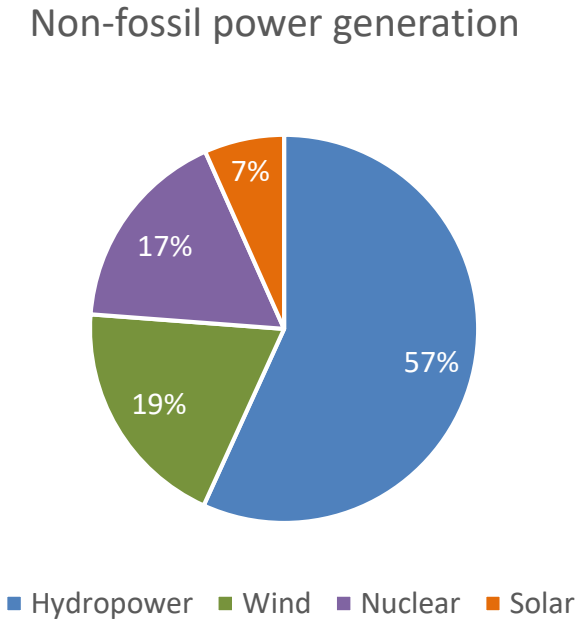
- **Non-fossil** energy reaches 20% before 2030 & 50% before 2050

"Energy production and consumption revolution strategy(2016-2030)"

Development status – Energy structure

- **Coal:** mainstay of energy consumption, accounting for **59%** of the total 47.2×10^8 tce primary energy consumption in 2018.
- 18.9% oil, 7.6% natural gas and **14.5% non-fossil energy**
- Non-fossil energy leads energy consumption growth





Geographical distribution of renewable resources

- **Hydropower** - Southwest

  Sichuan, Yunnan and Guizhou account for 52%

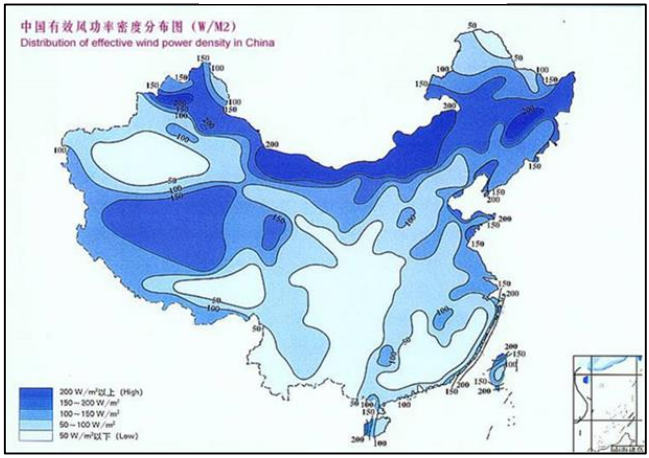
- **Wind power** - northern region

  Inner Mongolia, Xinjiang, Shanxi account for 37%

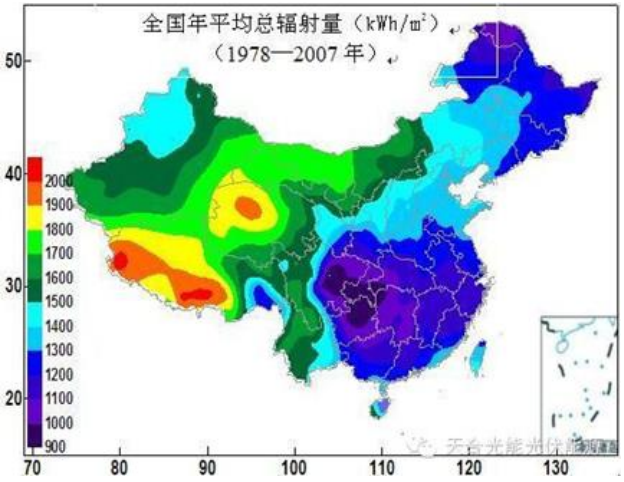
- **Solar energy** - Northwest

  Inner Mongolia, Qinghai and Xinjiang account for 70%

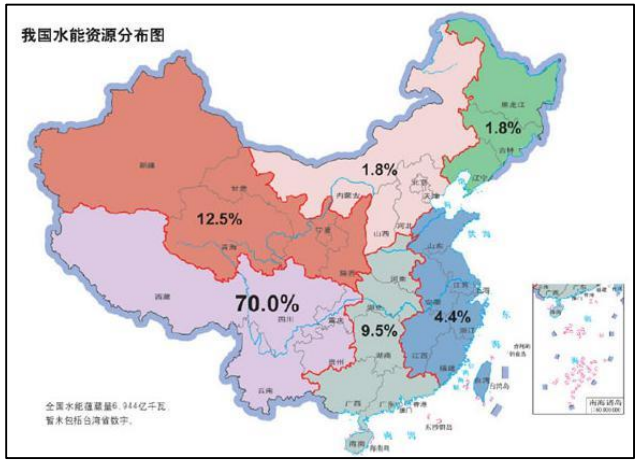
Wind power



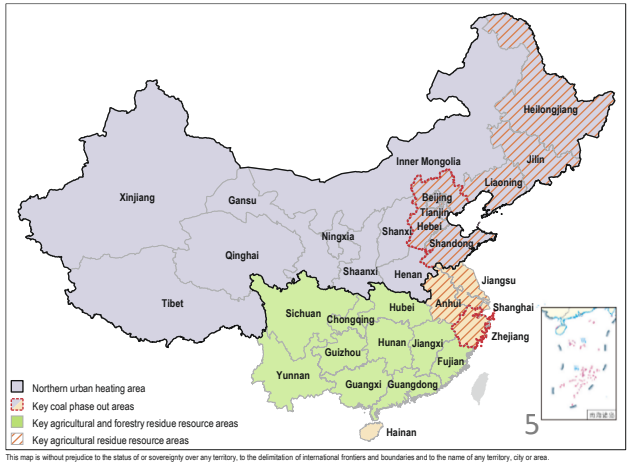
Solar energy



Hydropower

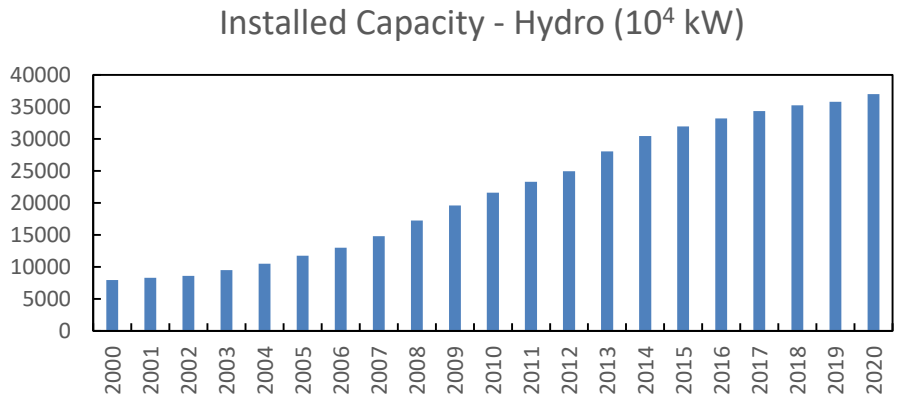


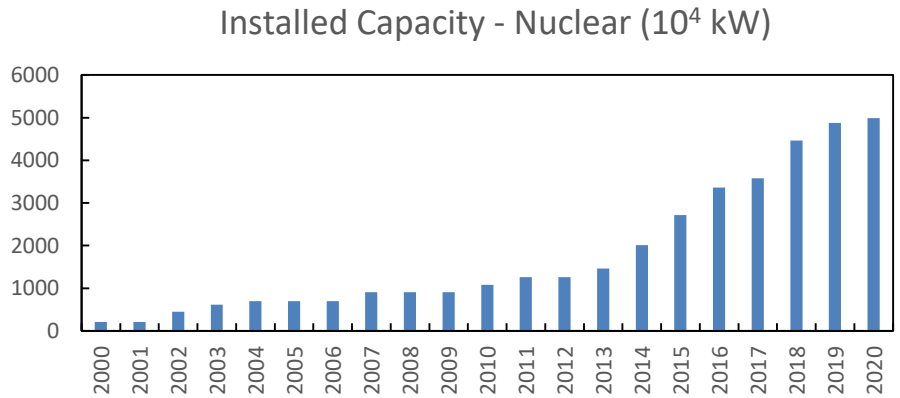
Biomass

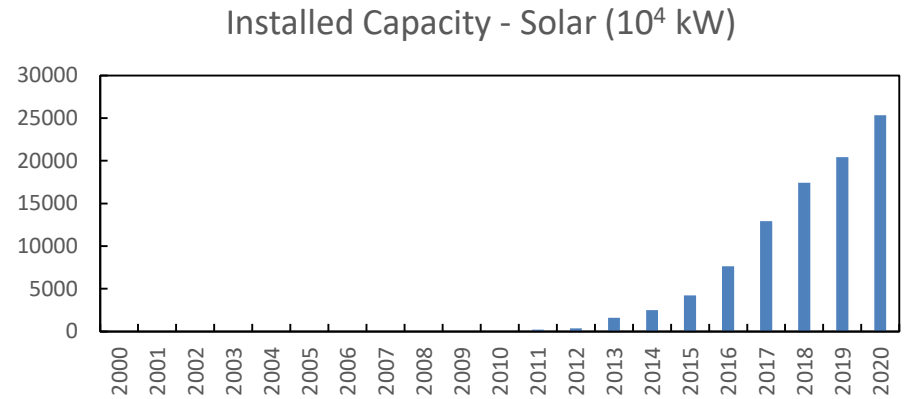


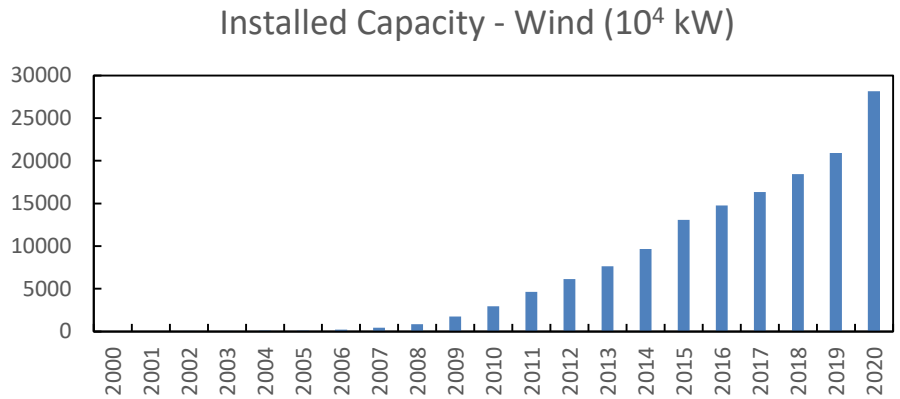
Growth trend of non-fossil power

- China's non-fossil power installed capacity is increasing year by year



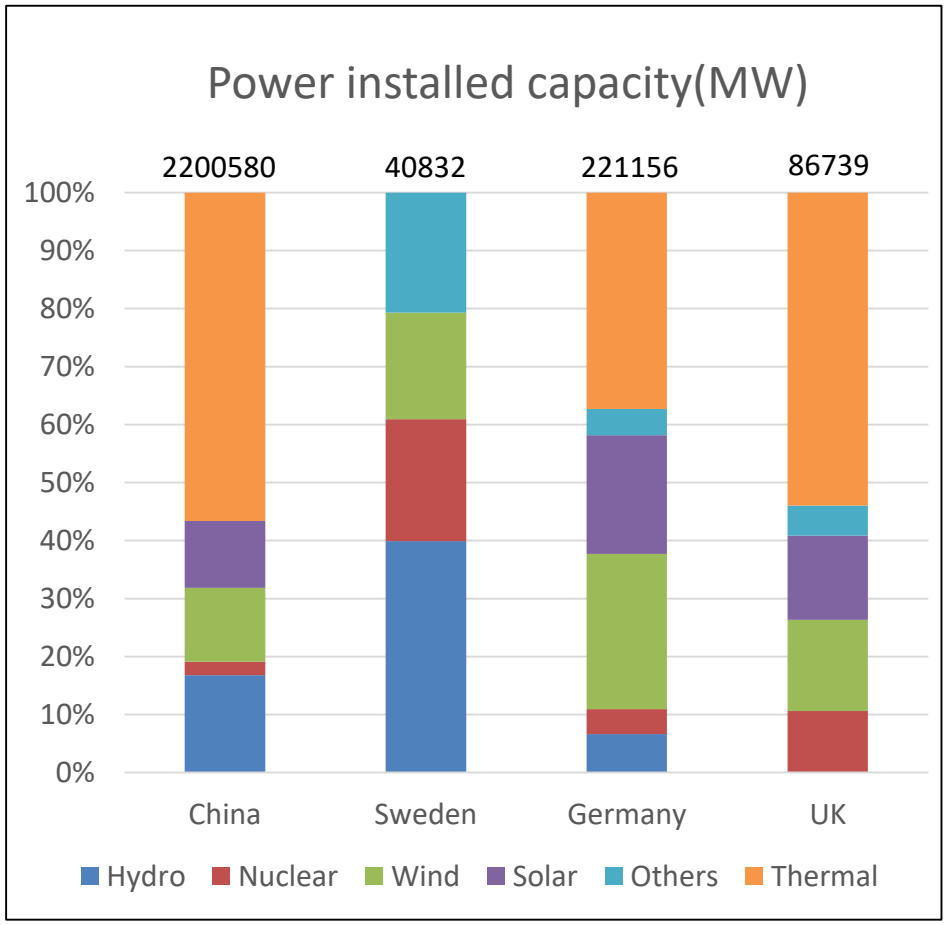


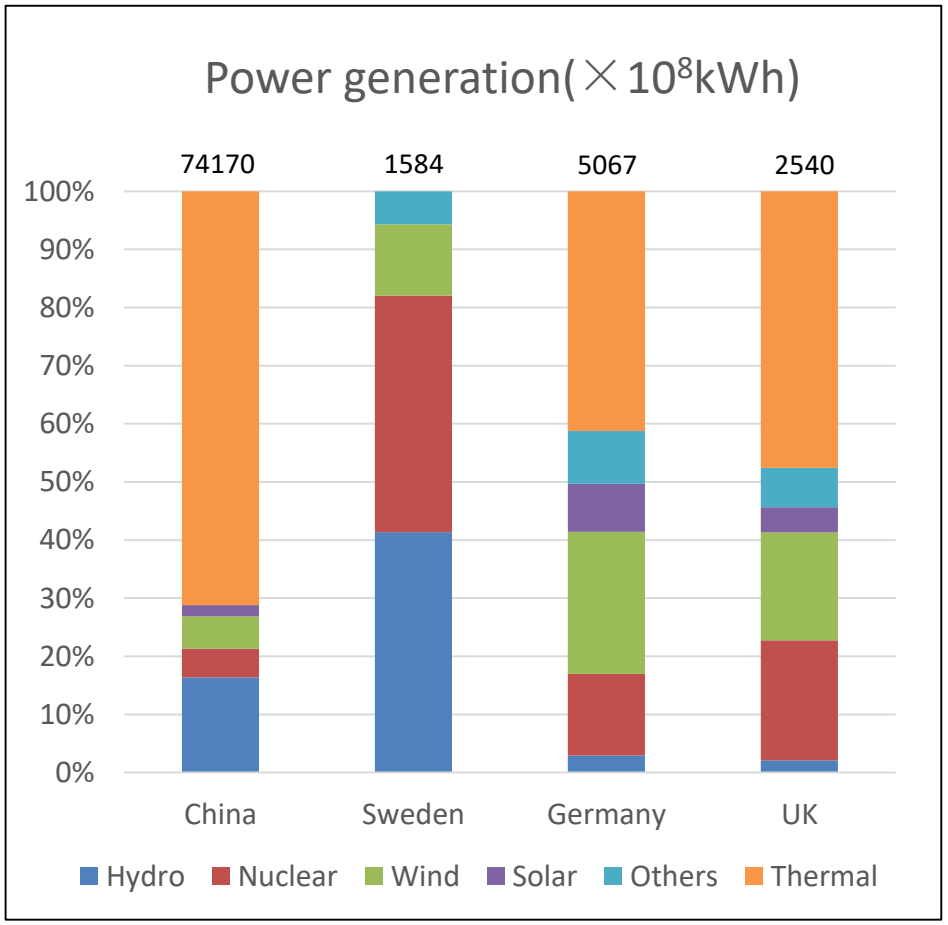




Data source: "China Energy Statistical Yearbook"

Proportion of different power source – China & European countries





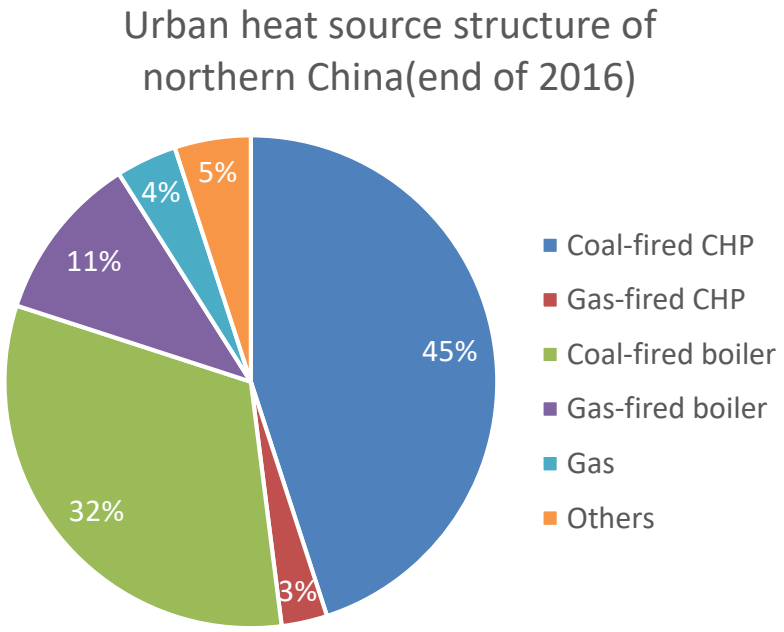
Continue to increase non-fossil power during the 14th 5-year plan

- After the goal of carbon neutrality was put forward, China's main power enterprises have stepped up the development of renewable energy

Enterprise	Planned increase in renewable power installed capacity
China Energy Investment (国能)	**70~80 million kW**
Three Gorges (三峡)	**70~80 million kW**
Huaneng (华能)	**80~100 million kW**
State Power Investment Corporation (国电投)	Approximately **110 million kW**
Huadian (华电)	**75 million kW**
Datang (大唐)	not lower than other enterprises

Development status – District heating

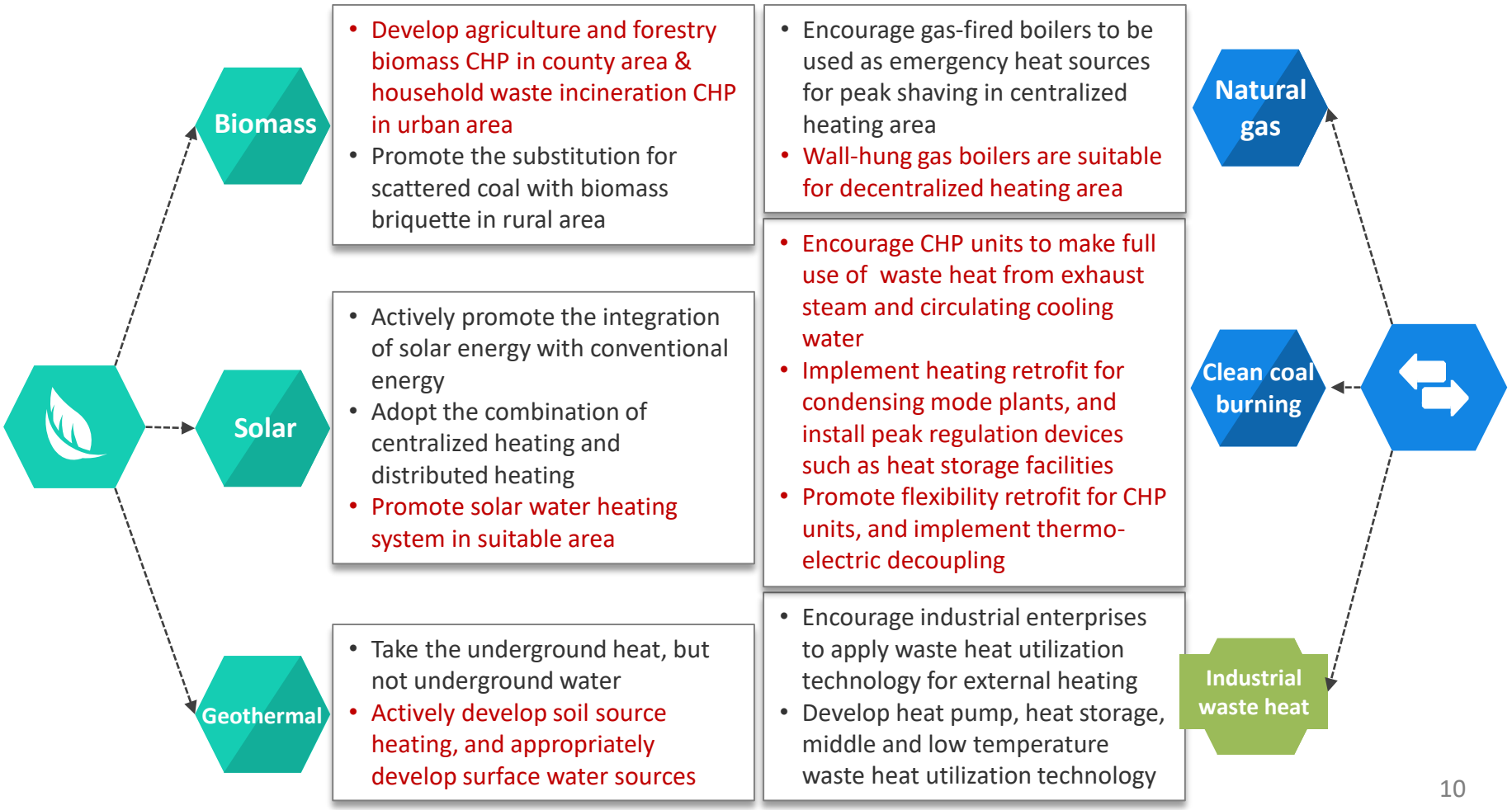
- Hot Summer & Cold Winter Zone, Cold Zone and Severe Cold Zone, **16** provinces
- Total heating area: **10.8** billion m^2
- Total heating energy consumption: **0.191** billion tce/year
- **25%** of total building energy
- **77%** of the heat comes from coal



☐ **China is developing towards clean district heating**

"Clean Winter Heating Planning in Northern Areas (2017-2021)" NDRC, NEA, et al.2017.12 clearly defined the strategic objectives and development path

☐ Clean heat sources



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Low-carbon development path of district heating

◆ **Building energy conservation is the foundation: "The energy saved is the cleanest energy"**

☐ China's standards and requirements for building energy efficiency is becoming increasingly strict

- JGJ26-86, 1986: First introduced "energy saving percentages", "baseline building energy consumption"
- JGJ26-95, the Ministry of Construction, 1995
- JGJ26-2010, 2010: Divided China into several thermal regions
- GB/T 51161-2016, 2017: first national restriction on building operational energy consumption based on actual data

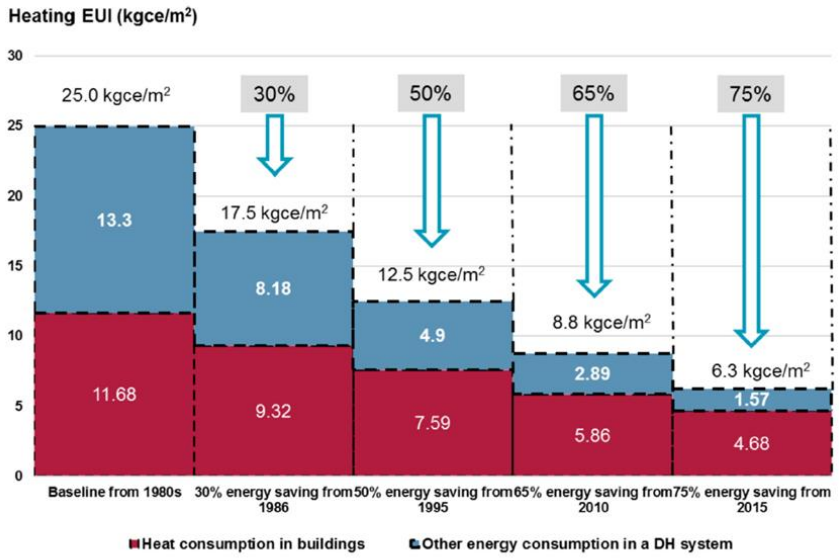


Fig. 4. Theoretical energy consumption of different percent of energy saving buildings in Beijing.

Low-carbon development path of district heating- Path 1: Based on waste heat

◆ **Planning background assumptions: China still retains some thermal power units in the future**

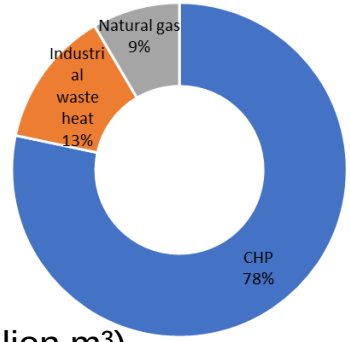
- Vigorously develop renewable electricity such as hydropower, wind power, and solar energy
- Reasons for the existence of thermal power:
  - Peak shaving of renewable electricity
  - High power demand and poor renewable resource endowments in eastern China

China's energy supply and demand planning [1]		Electricity consumption（trillion kWh）		Non-electric fuel consumption（10^8 tce）	
		2017	2050	2017	2050
Demand Forecast	Industry	3.8	5.0	16	12
	Building	1.7	2.5	4.5	3.5
	Traffic	0.5	2.0	5	2.5
Sum		6.0	9.5	25.5	18
Supply planning	**Hydropower**	**1.2**	**1.5**	Biogas	3.5
	Wind	**0.24**	**1.5**	Biosolid fuel	5.5
	Solar	**0.07**	**1.0**	fossil fuel	9
	Nuclear	**0.2**	**1.0**		
	Thermal	**4.3**	**4.5**	**Waste heat by-product**	**3.7 billion GJ**
Sum		6.0	9.5	25.5	18

[1] Data sources: Research Center for Building Energy Efficiency, Tsinghua University. China Building Energy Efficiency Annual Development Research Report 2019

Low-carbon development path of district heating- Path 1: Based on waste heat

China's central heating source planning structure [1]



- **20 billion m² : 80% centralized heating +20% Decentralized heating**

◆ **80% centralized heating : 16 billion m²**

- **Retained CHP waste heat**: 3.7 billion GJ, 80% recovered (3 billion GJ)
- **Industrial waste heat** (iron and steel, metallurgy, chemical industry, etc.): 1 billion GJ, 50% recovery (500 million GJ)
- **Peak shaving of natural gas boilers** during severe cold period: 300 million GJ (11 billion m³)
- Electricity: 40 billion kWh of transmission and distribution system + 120 billion kWh of steam and electricity required to extract low-grade heat

✓ Fossil energy consumption is 53 million tce (160 billion kWh + 11 billion m³ natural gas), and the unit heating energy consumption is 3.5 kgce/㎡, which is only 1/4 of the current situation

◆ **20% decentralized heating : 4 billion m²**

- Electric heat pump + gas boiler
- Half of the two methods: 80 billion kWh + 20 billion m³ natural gas (total 55 million tce)

The total fossil energy consumption : 108 million tce, 54% of the current (14 billion m²)

[1] Research Center for Building Energy Efficiency, Tsinghua University. China Building Energy Efficiency Annual Development Research Report 2019

Low-carbon development path of district heating- Path 1: Based on waste heat

☐ Issues that need resolving

- ◆ The distribution of heat sources (CHP and industrial waste heat plants) does not match the geographical distribution of heat load
- Long distance distribution: The matching between heat generation and heating demand can be achieved within a transmission radius of 150km

Industrial waste heat:

- ▲ Steel plant
- ■ Non-ferrous metals smelting works
- ◆ Chemical plant
- ▲ Oil refining and coking plant
- ⬟ Cement plant

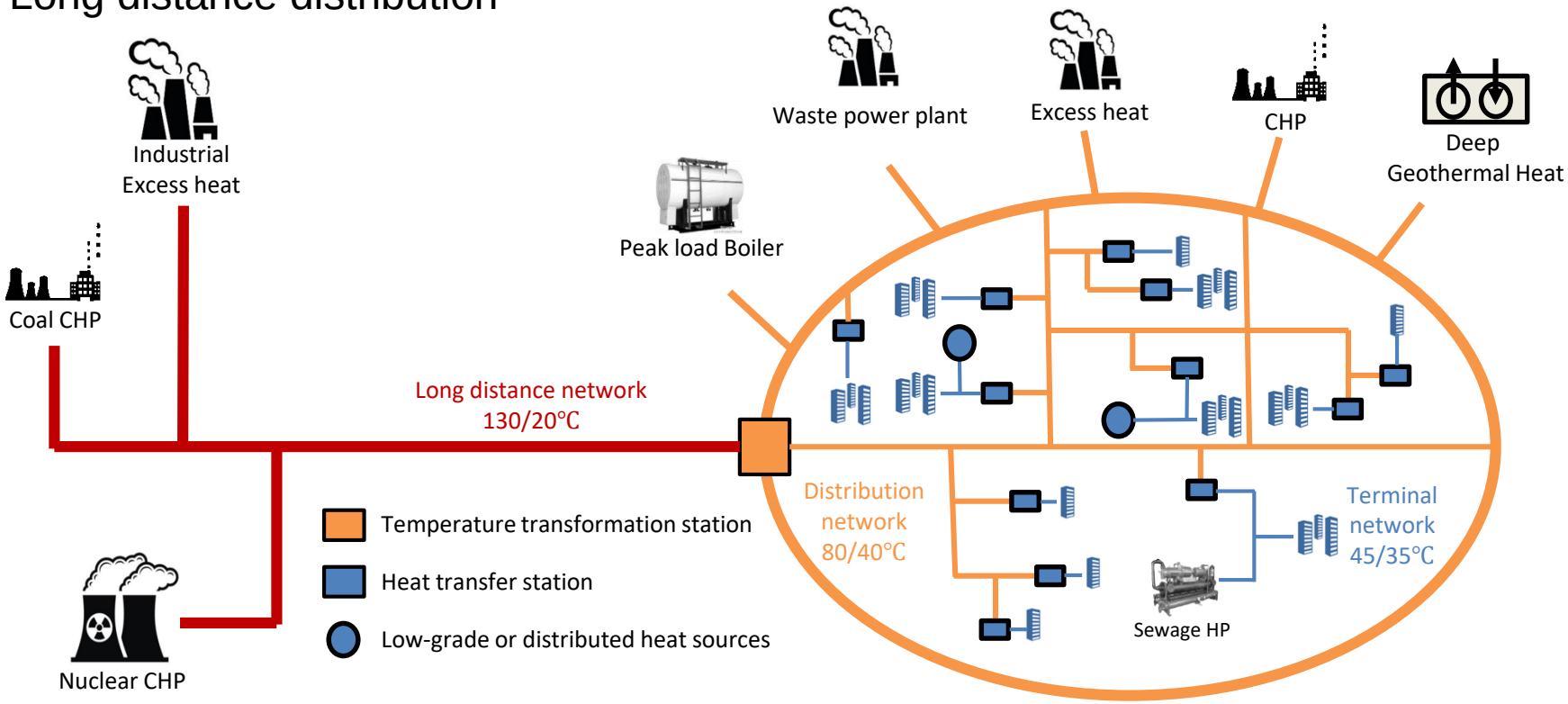
Note: Chemical plant only includes fertilizer plant

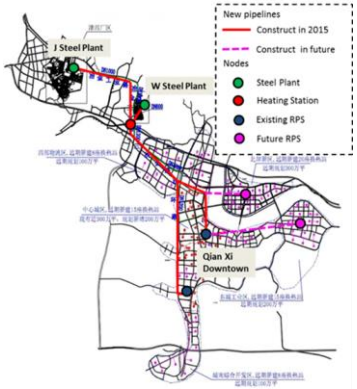
Power plant：

- ~1000MW
- ~1700MW（except: Guojin Touneng 2600MW，Caoqiao2100MW）
- ~3700MW（except: Suizhong 4300MW）

Low-carbon development path of district heating- Path 1: Based on waste heat

Long distance distribution

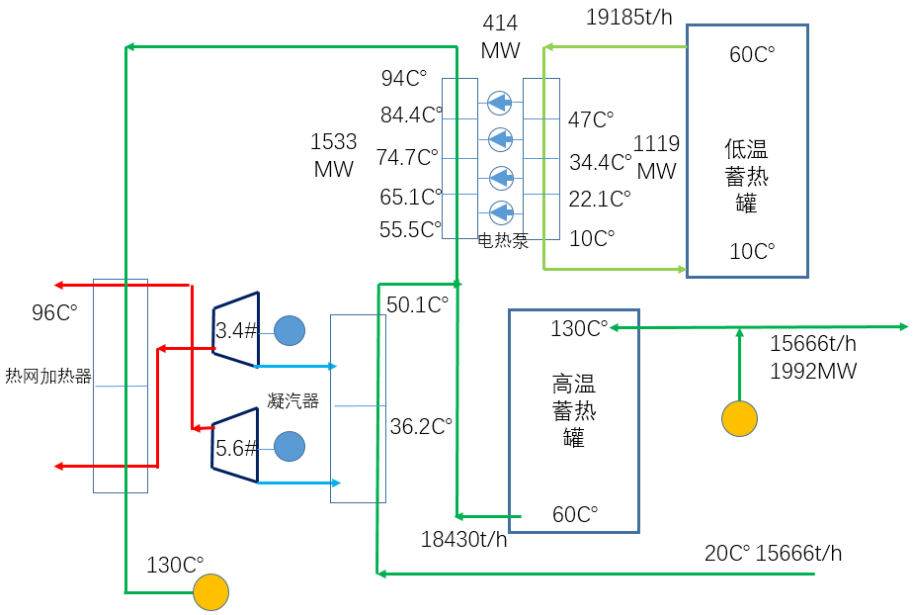




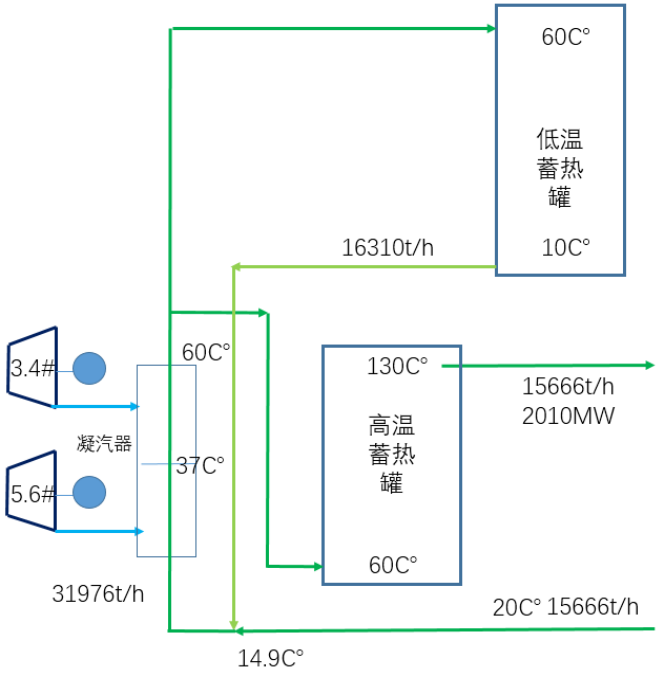
Issues that need resolving

- The main function of the future thermal power plant is power peak shaving. CHP needs to meet the demand for power peak shaving while undertaking building heating

- Completely change the current cogeneration mode of thermal power plants, from the current "fixed electricity by heat" to "co-generation of heat and power"



Minimum power supply conditions
- Power: 577MW, Heating:2010MW
- **Heat-to-power ratio: 3.5**



Maximum power supply conditions
- Power: 1206MW, Heating:2010MW
- **Heat-to-power ratio: 1.7**

Low-carbon development path of district heating- Path 1: Based on waste heat

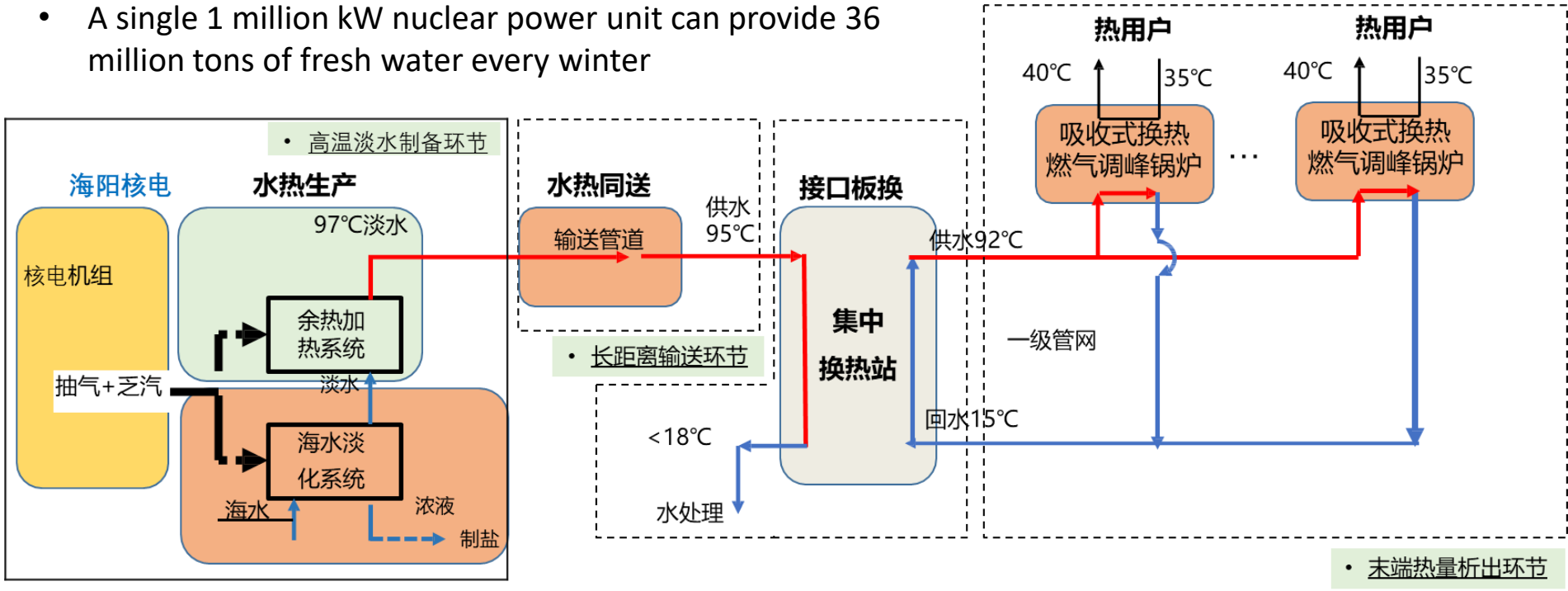
☐ nuclear energy CHP

- Single 1 million kW nuclear power unit: 1.1 million kW heat (12 million GJ, 30 million m^2)
- **100 million kW nuclear power can heat all cities and towns within 200 kilometers of the coastline (about 3 billion ㎡)**

Low-carbon development path of district heating- Path 1: Based on waste heat

☐ Long-distance heating of nuclear CHP: combined heat and water system

- ◆ Combining seawater desalination and waste heat heating : "one medium, two uses“
- ◆ "Zero energy" seawater desalination, low-cost heat and water transfer
- • A single 1 million kW nuclear power unit can provide 36 million tons of fresh water every winter

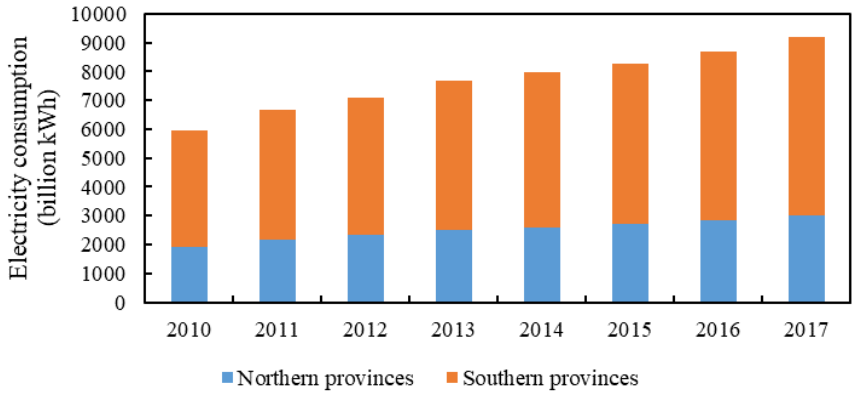


Low-carbon development path of district heating- Path 2: Based on renewable electricity

☐ Path 2： Electric heat pump

- Heating area of cities and towns in northern China in the future: **20 billion m²**
- If all the heat sources are electric heat pumps, it needs about **800 billion kWh**, while the entire society in northern China used 3,019 billion kWh in 2017.

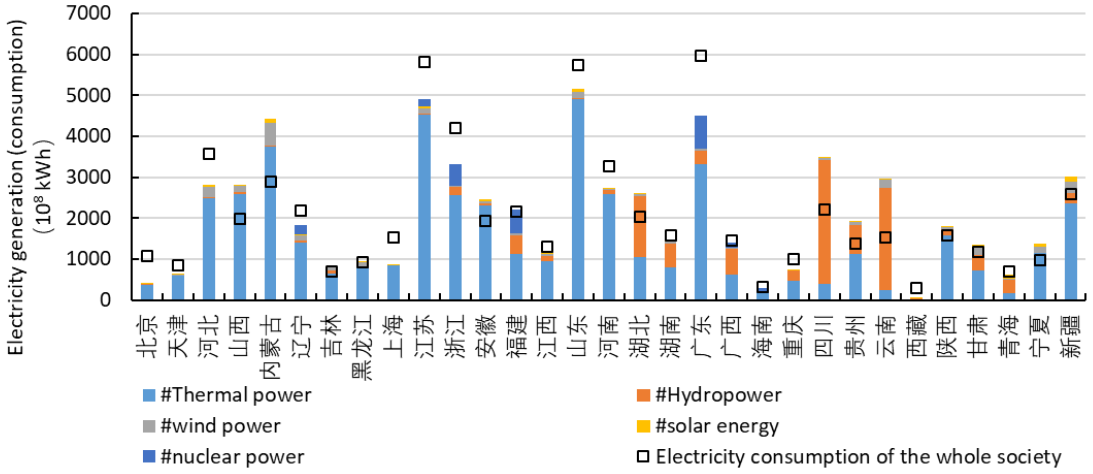
Electricity consumption in China's northern and southern provinces



☐ Issues that need resolving

- **Non-fossil power needs to grow substantially**
  - thermal power accounted for 85% of northern power generation in 2017
- **Volatility of renewable power**
  - Increase the construction of energy storage facilities: battery storage or hydrogen storage

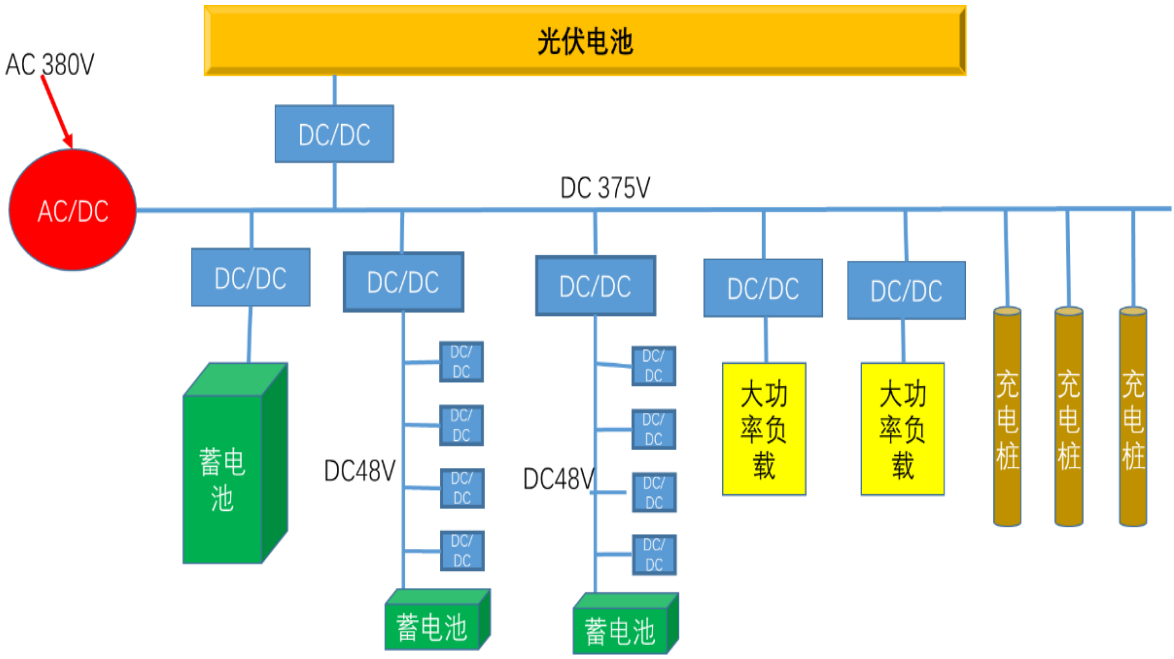
Power generation by provinces in China (2017)



Low-carbon development path of district heating- Path 2: Based on renewable electricity

☐ Demand side response: new building power distribution methods help power peak regulation

- Change the internal power distribution of the building to DC, and connect it with photovoltaics, batteries, charging piles and various electrical devices
- The AC/DC at the entrance of the external network adjusts the bus voltage according to the required input power to meet the transient power requirements
- When a battery of sufficient capacity is configured and sufficient charging piles are connected, the input power of the external network can be flexibly adjusted within the range of 0~100% to meet the needs of grid peaking



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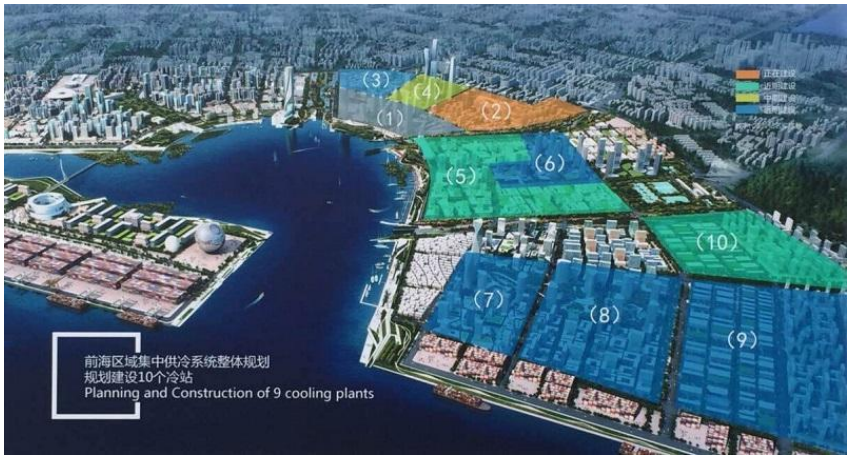
District cooling - Frantic development trend in Southern China

- Traditional cooling mode in China: split AC & small-scale centralized cooling
- In 2003, Guangzhou Higher Education Mega Center was completed as the first large-scale district cooling project.
- The number and scale of district cooling projects is increasing.
- Considered as energy-saving technology, district cooling projects are strongly supported or subsidized by the government.



Service Industry Cooperation Zone in Qianhai, Shenzhen

Zhuhai Hengqin New District Cogeneration Project

No district cooling system is economical and energy-saving in China

- EER: 3 for split AC, above 4 for “one building-one cooling station” system
- Energy efficiency: generally lower than traditional mode, few can be even
- Economy: higher initial investment and cooling costs than traditional mode

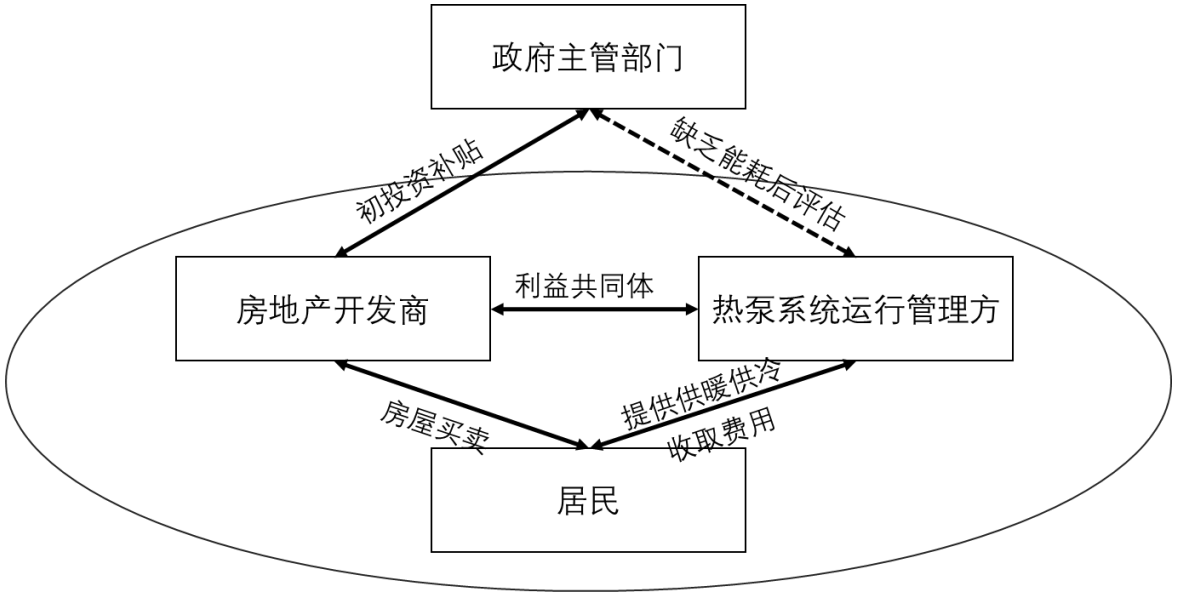
项目	占地面积 (公顷)	区域供冷面积 (万m^2)	区域供冷部分容积率	冷冻水总管长 (km)	电价 (元/kWh)		冷价 (元/kWh)
C-1 (校园)	1800	500	0.28	120	0.61	0.97	0.61
					0.61	0.78	0.78
					1.02	1.09	0.94
C-2 (商建)	140	124.4	0.89	10	0.847	1.32	0.64
C-3 (商建)	51.4	40.5	0.79	5	0.623	0.88	0.71
晴海Triton广场	61	43.5	7.1		COP= -- / 3.13		
新宿副都心	243	222.3	9.1	4	COP = 2.13 / 2.21		

Comparison of energy saving effects between district heating and district cooling

	District heating	District cooling
Load characteristics	Steady	Intermittent
Transmission flow	Temperature difference of 70℃, small flow	Temperature difference of 10℃, large flow
Heat dissipation for pump	Positive effect	Negative effect
Source equipment	Large coal-fired boilers have higher efficiency	Large chillers have no variation in efficiency
Cheap source	Can make full use of power plant exhaust heat and industrial waste heat	Difficult to obtain cheap natural cold source

Reasons for implementing non-energy-saving projects

- Government: Pursue “renewable energy consumption”, lacking post-evaluation
- Real estate developers: Receive subsidies and more income through promotion
- Operation managers: Obtain stable cash flow through monopoly operation
- Residents: Vulnerable group, bear all the loss



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Conclusions

- Coal accounts for a relatively large proportion of China‘s energy structure and heat source structure, which brings difficulties to the low-carbon transition.
- The Chinese government attaches great importance to the sustainable development of energy and proposes the goal of carbon peaking and carbon neutrality.
- Building energy conservation is the foundation: "The energy saved is the cleanest energy"
- Proposed 2 low-carbon development paths for central heating
    - Path 1 (Based on waste heat): The key technology is long-distance heating and synergy of heat and power, which has strong operability, but still has carbon emissions
    - Path 2 (Based on renewable electricity): zero carbon emissions, but too high requirements for the power system, poor feasibility
- District cooling: apply cautiously, may lead to extra energy consumption

Thank you for your attention

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