清華大學
Tsinghua University

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#SESAAU2019

District Energy Systems in China

Options for Optimization and Diversification

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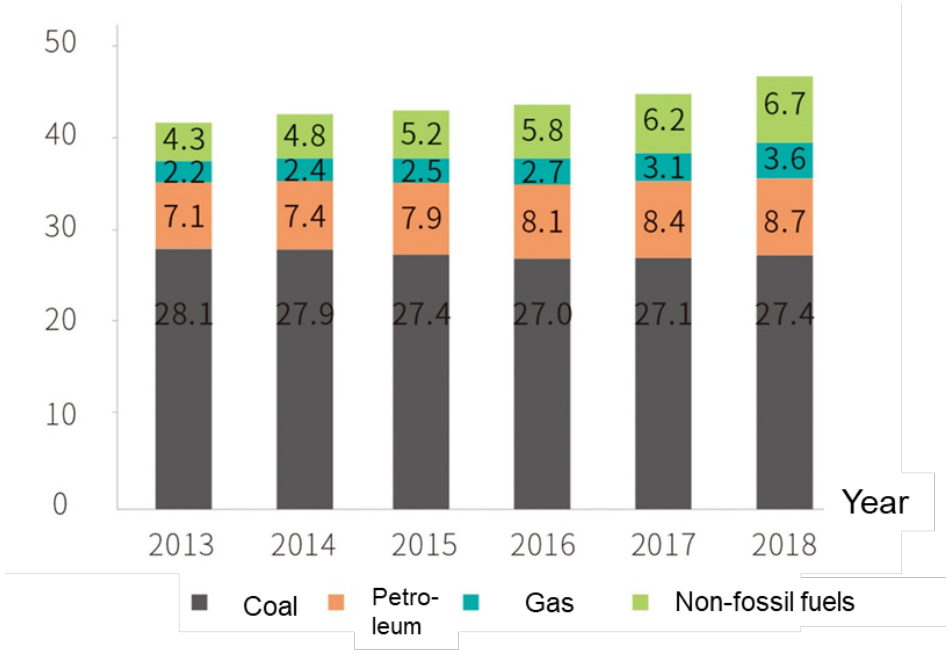
China has many reasons to pursue a more sustainable energy future

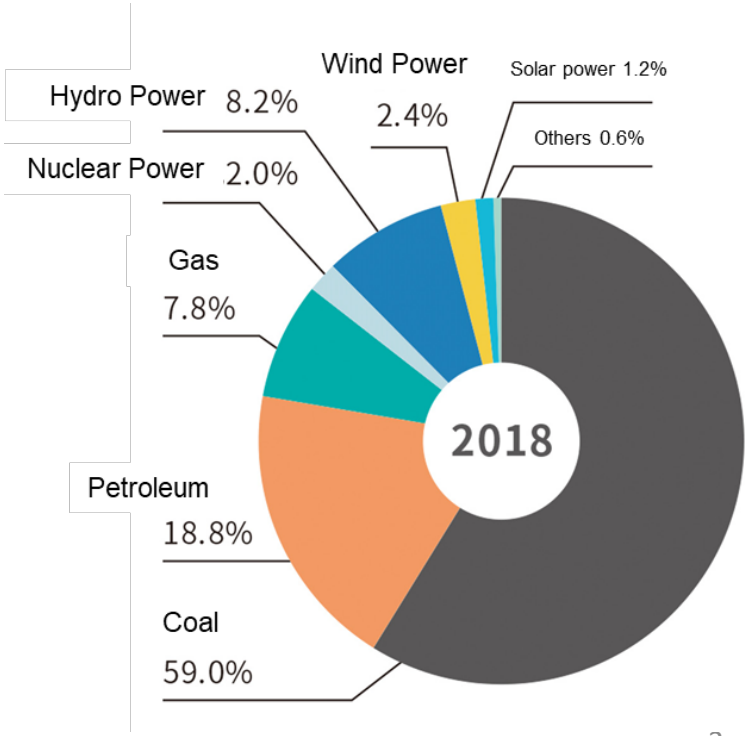
- Energy resource scarcity and security are likely to be major incentives in coming decades to curtail energy demand growth.
- Air quality is another key influence on China's increasing commitment to restrict inefficient and polluting fossil fuel combustion,
- Along with government policies to limit carbon dioxide (CO2) and other greenhouse gas (GHG) emissions

Development status-Energy consumption

In 2018,China consumes 4.64 billion tce(ton standard coal equivalents,1 tce=29.3 GJ) ,increasing 3.3% from a year earlier.

Non-fossil fuels and natural gas accounted for most of the growth in energy consumption, with each increasing 50 million tce, accounting for two-thirds of the increase in consumption.

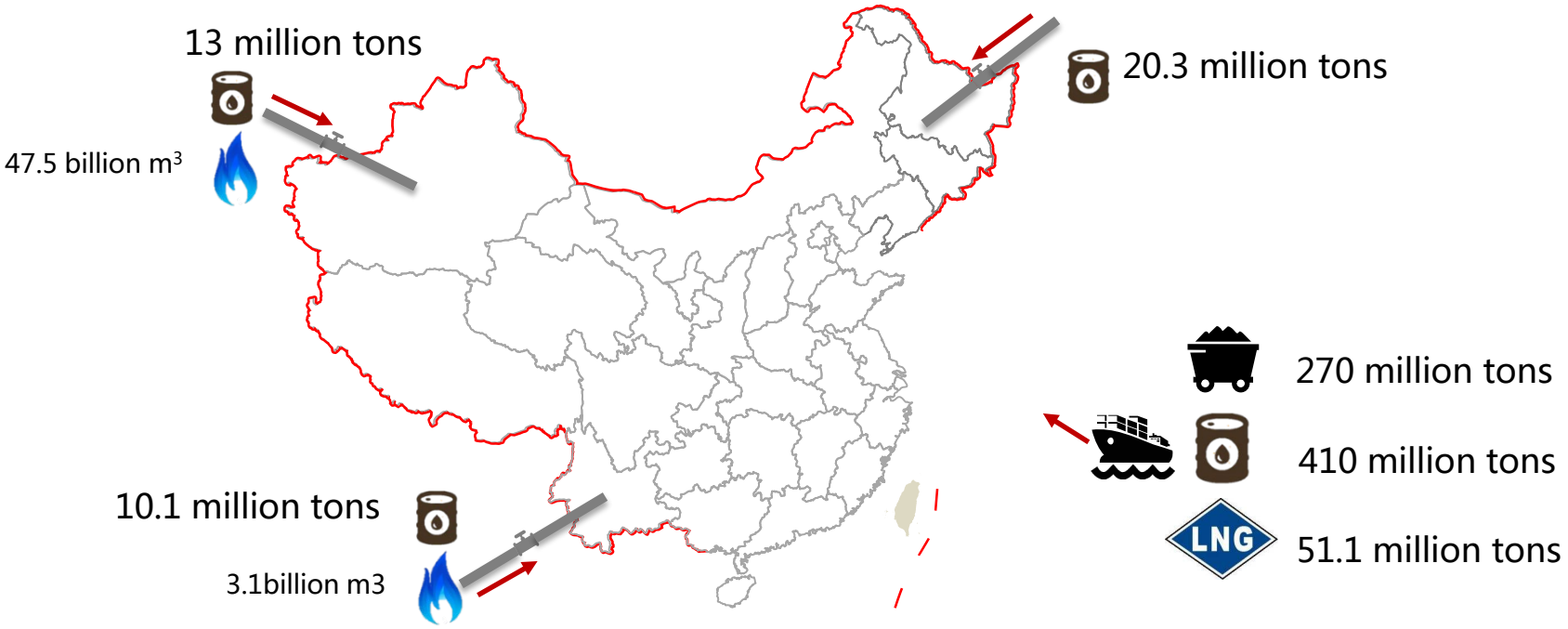




Resource: China electric power planning& Engineering Institute.<China Energy Outlook 2018>,2019

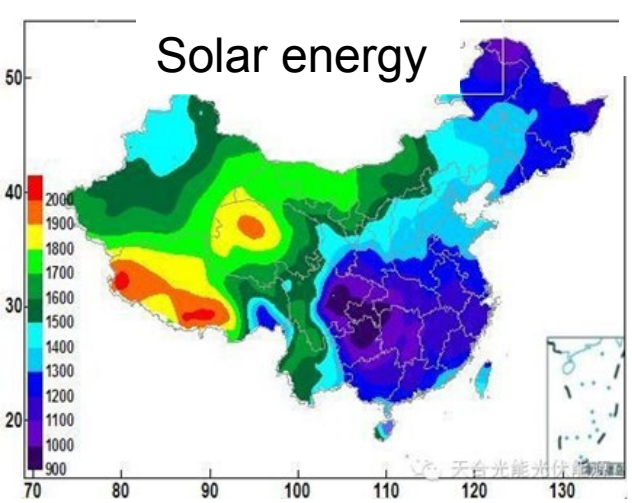
Development status-Energy supply

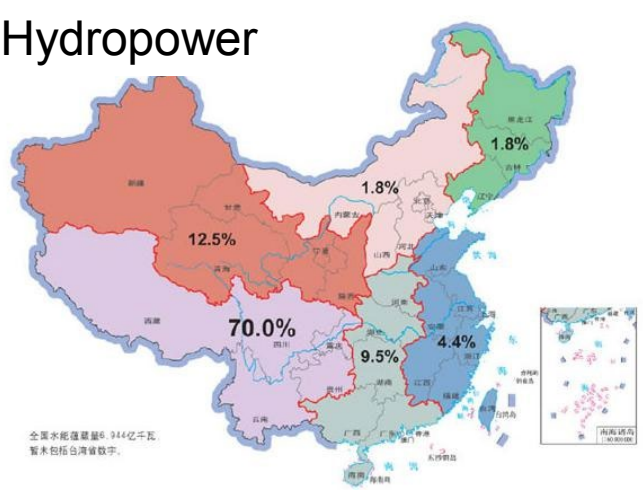
In 2018, China's net energy imports amounted to **970 million tce** (21% of the total), including **270 million tce** of coal, **460 million tce** of crude oil (71%) and **120 billion m3** of natural gas (43%).

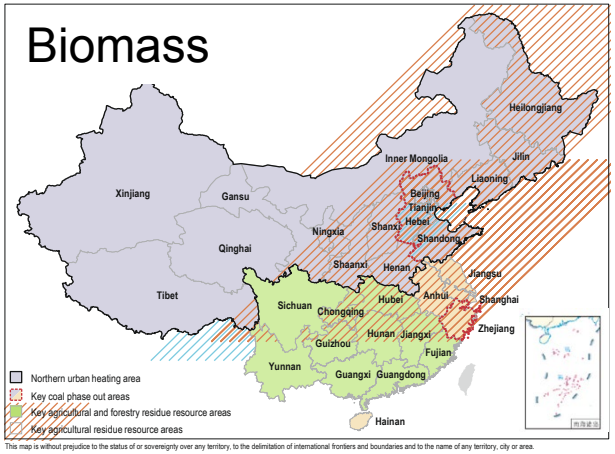


Resouce: China electric power planning& Engineering Institute.<China Energy Outlook 2018>,2019

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



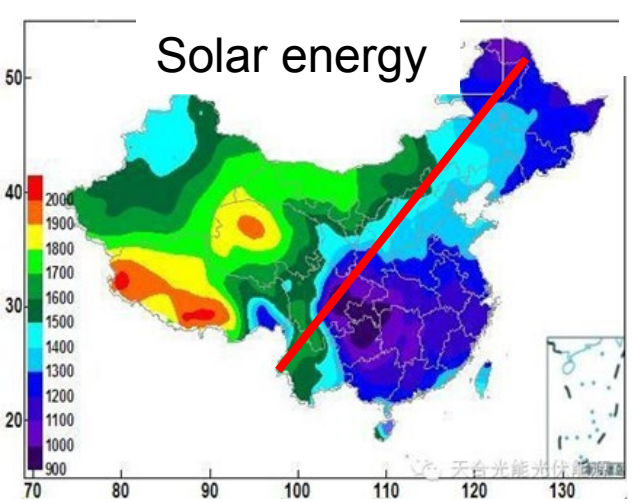


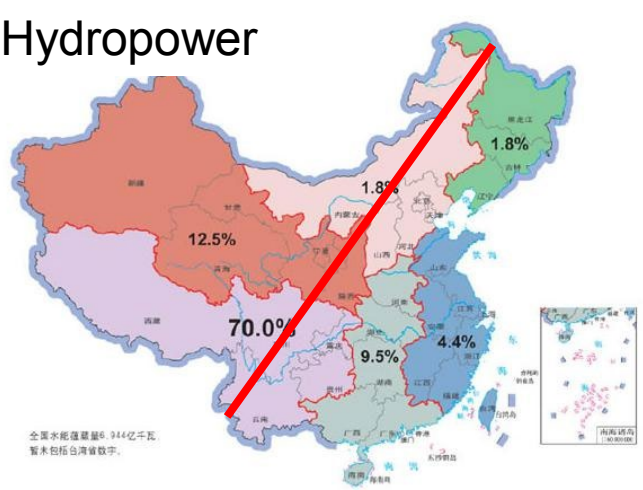


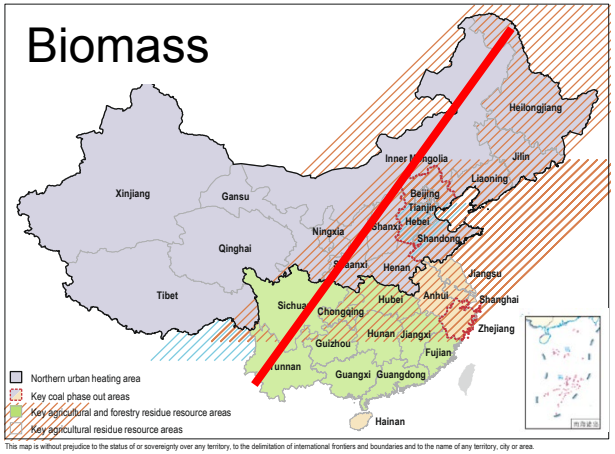
- In China, the renewables share in district heating was around 1%; IRENA suggested that in China, reaching a 24% renewable share in district heat generation by 2030 is feasible.
- Many renewable heat options find it difficult to compete against fossil fuels, and especially coal, in China.

IEA & BERC(Building energy research center, Tsinghua University).<District energy system in China: options for optimization and diversification >,2018

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







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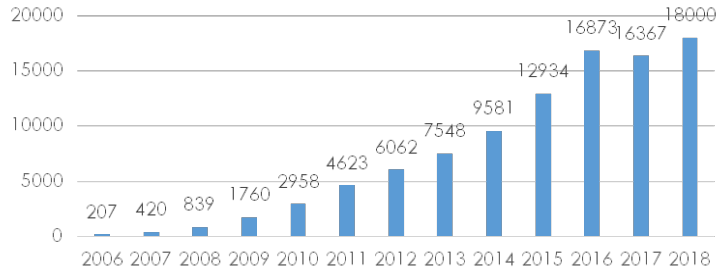
IEA & BERC(Building energy research center, Tsinghua University).<District energy system in China: options for optimization and diversification >,2018

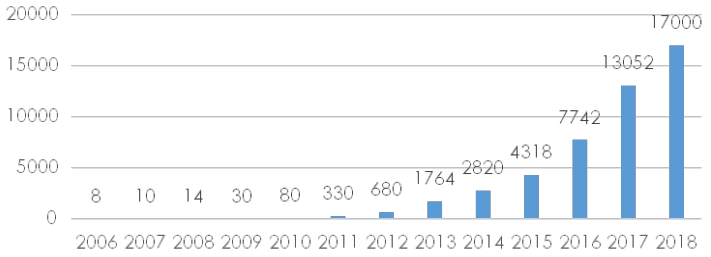
Development status-Power supply

Installed wind power capacity（10 MW）



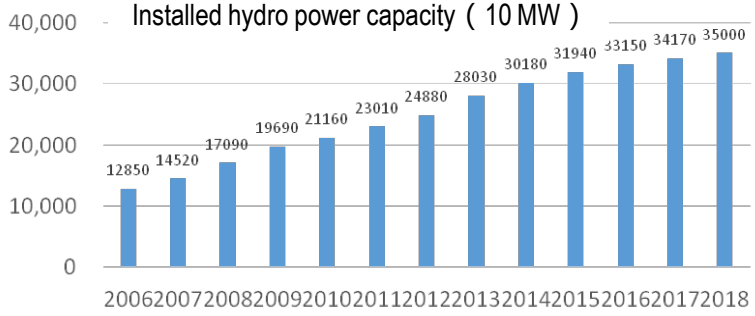
87-times increase in 12 years(2006-2018) and ranked 1st in the world in 2012

Installed solar power capacity（10 MW）



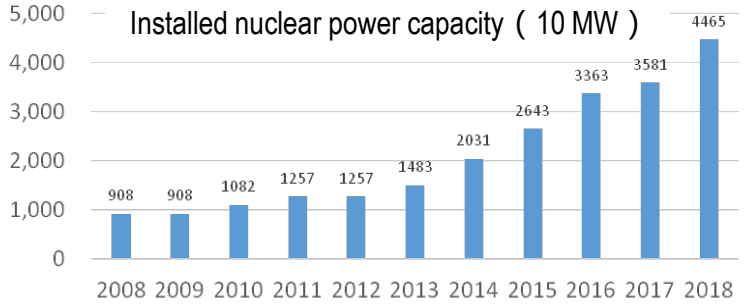
253-times increase in 12 years(2006-2018) and ranked the 1st in the world in 2015

Installed hydro power capacity（10 MW）



3-times increase in 12 years(2006-2018) and ranked 1st in the world in 2001

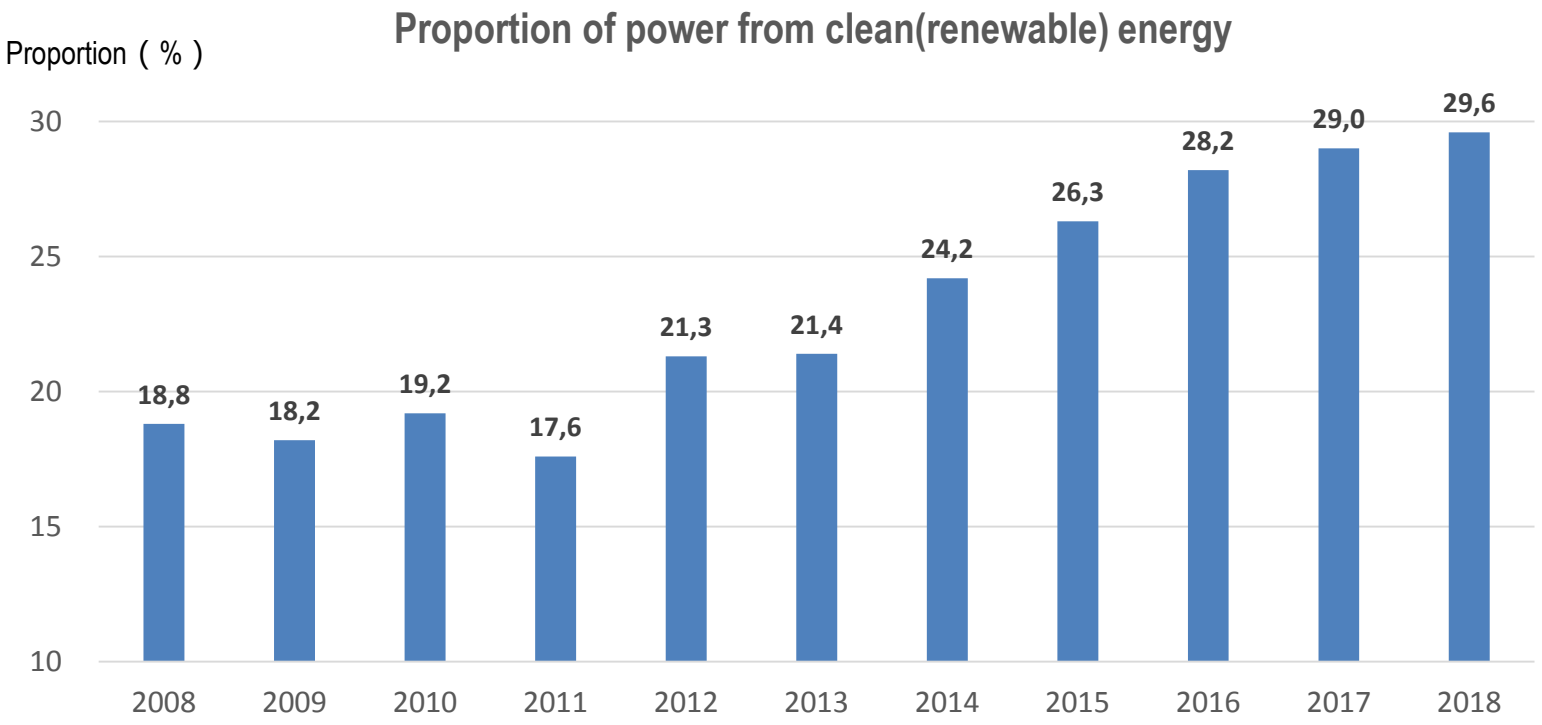
Installed nuclear power capacity（10 MW）



5-times increase in 10 years(2008-2018) and ranked the 3rd in the world in 2018

Resource: China electric power planning& Engineering Institute.<China Energy Outlook 2018>,2019

Development status-Power supply

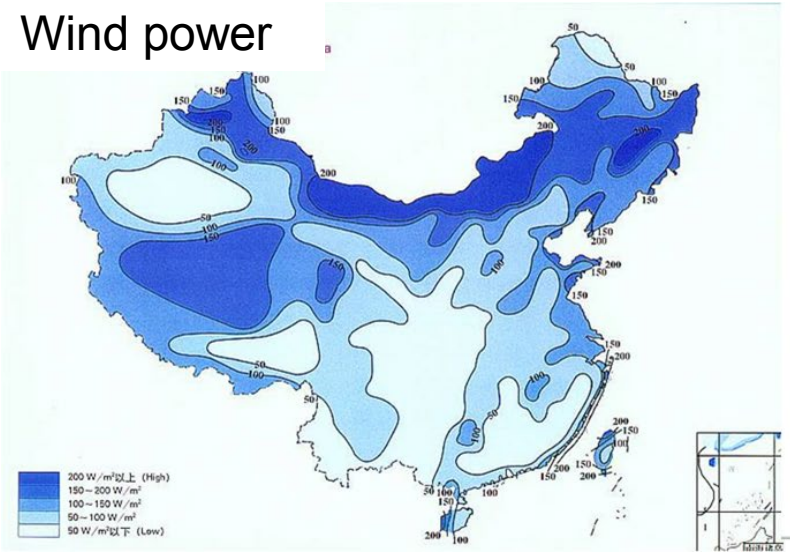


From 2008 to 2018, the proportion of clean energy power generation increased from 18.8% to 29.6%.

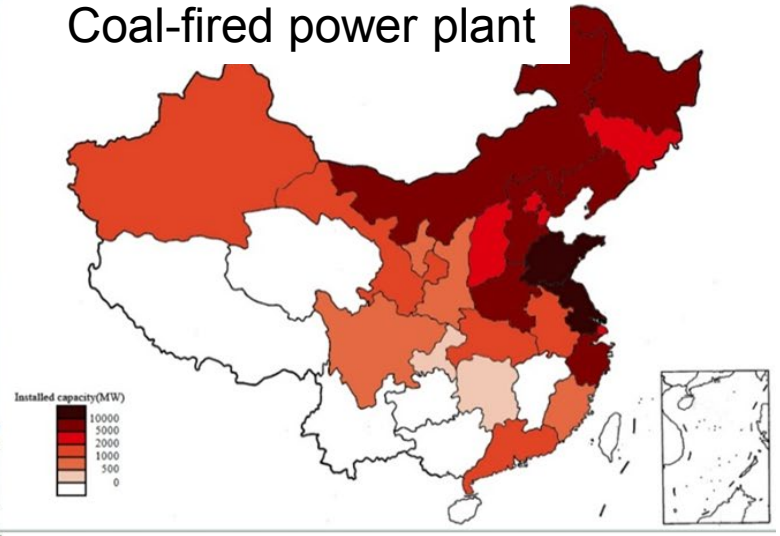
Resource: China electric power planning& Engineering Institute.<China Energy Outlook 2018>,2019

The role of renewables: potential for wind power

Wind power

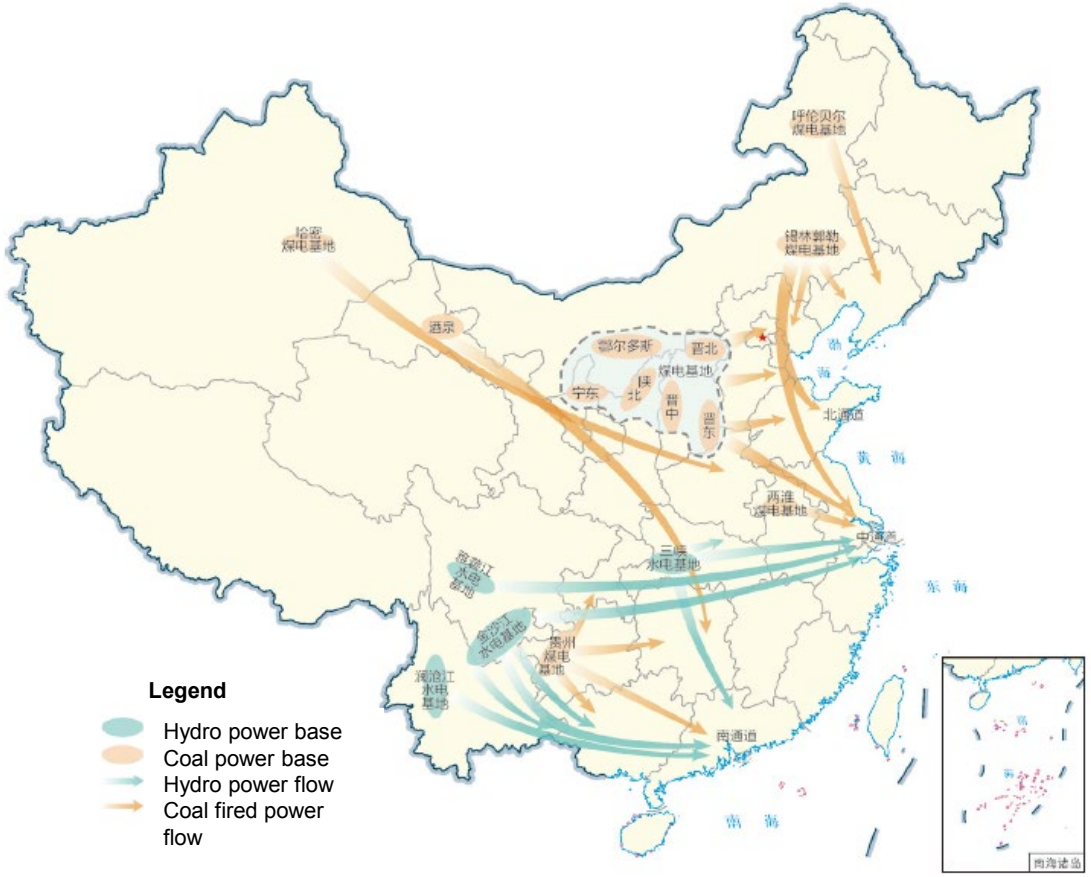


Coal-fired power plant



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

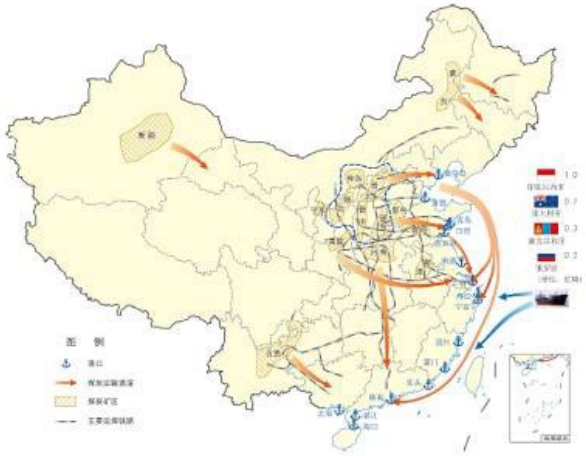
Development status-Power flow



Power flow in 2018

China electric power planning& Engineering Institute.<China Energy Outlook 2016>,2017

Development tendency-Energy consumption



Coal flow in 2016

Power flow in 2016

Crude oil flow in 2016

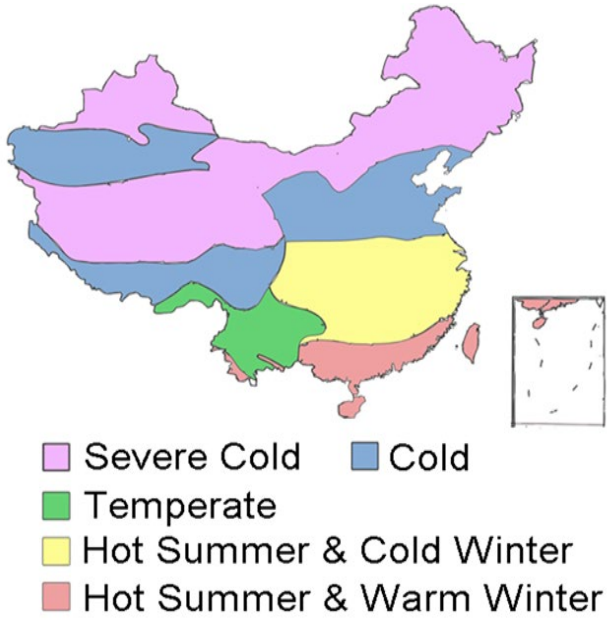
Natural gas flow in 2016

China electric power planning& Engineering Institute.<China Energy Outlook 2016>,2017

Background – Current situation

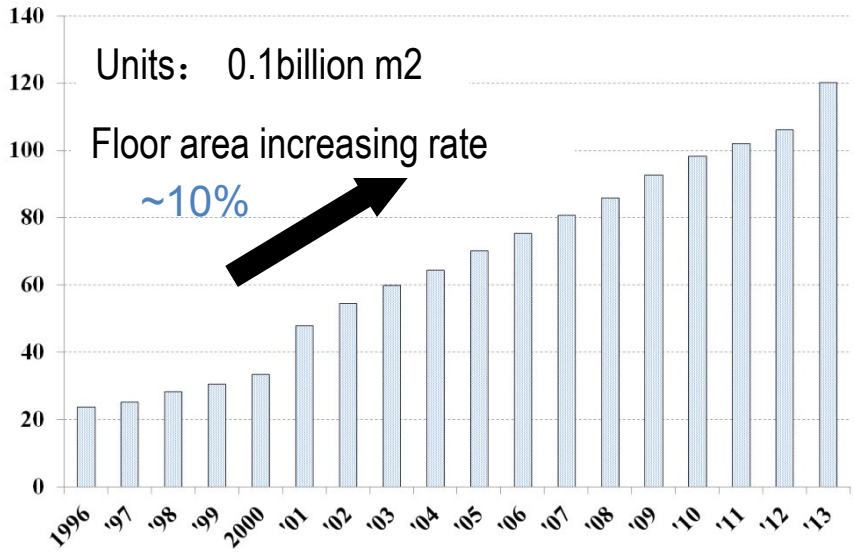
Regions in China with District Heating

- 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
- **84.5%** of the area supplied by district heating.
- Due to the urbanization process, a lot of cities face the situation of lacking heating source.

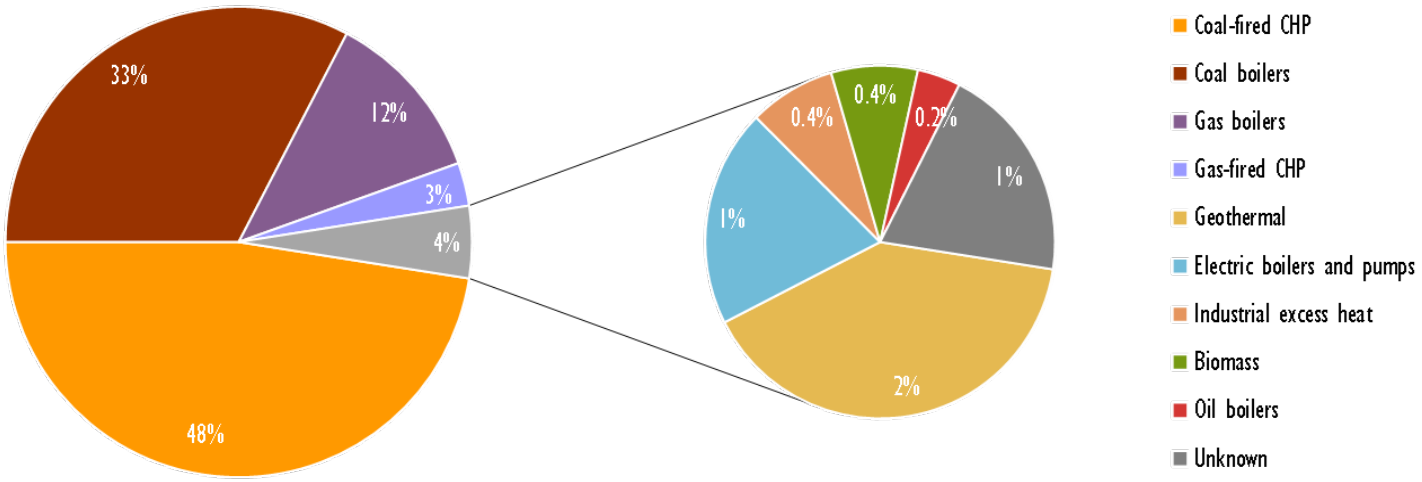


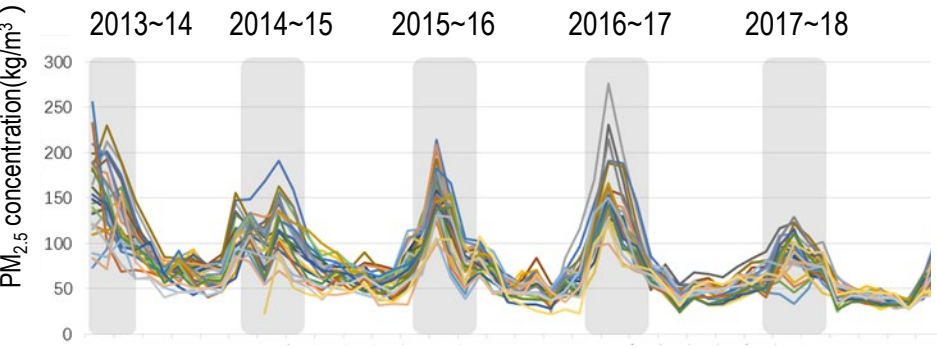
BERC.<Annual report on the development of Chinese building energy saving 2015> ,2015

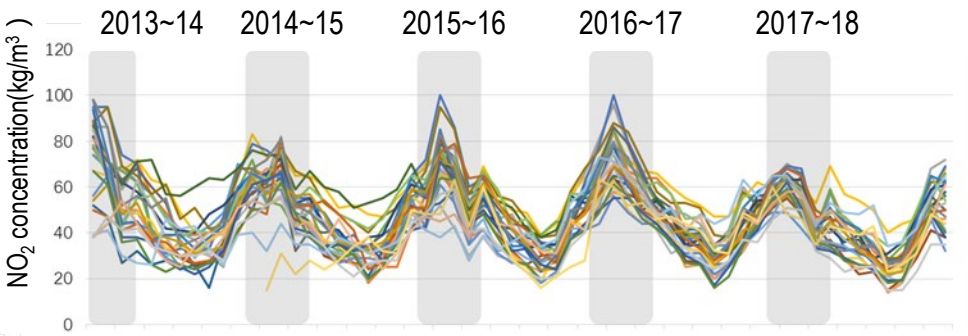
District Heating systems play a key role in China

- 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

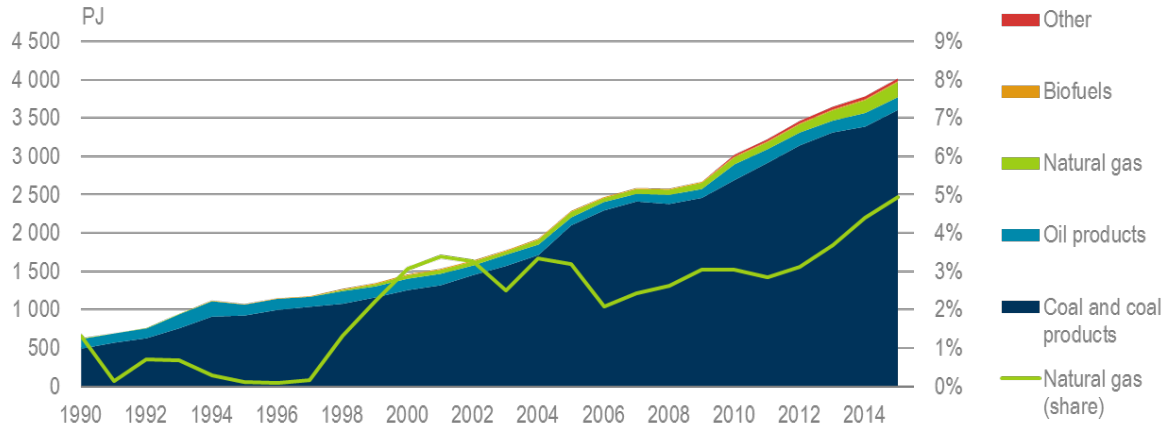


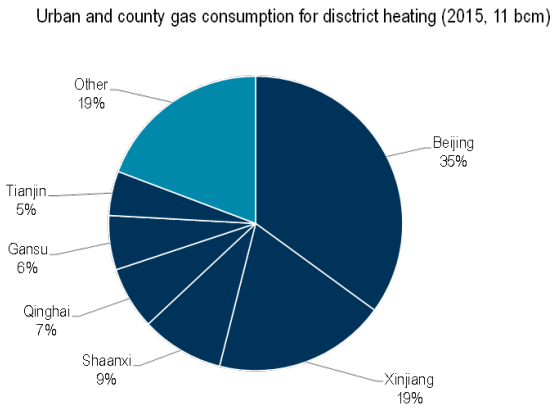




BERC.<Annual report on the development of Chinese building energy saving 2019>,2019

Recent government push has increased coal-to-gas switch





- 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.

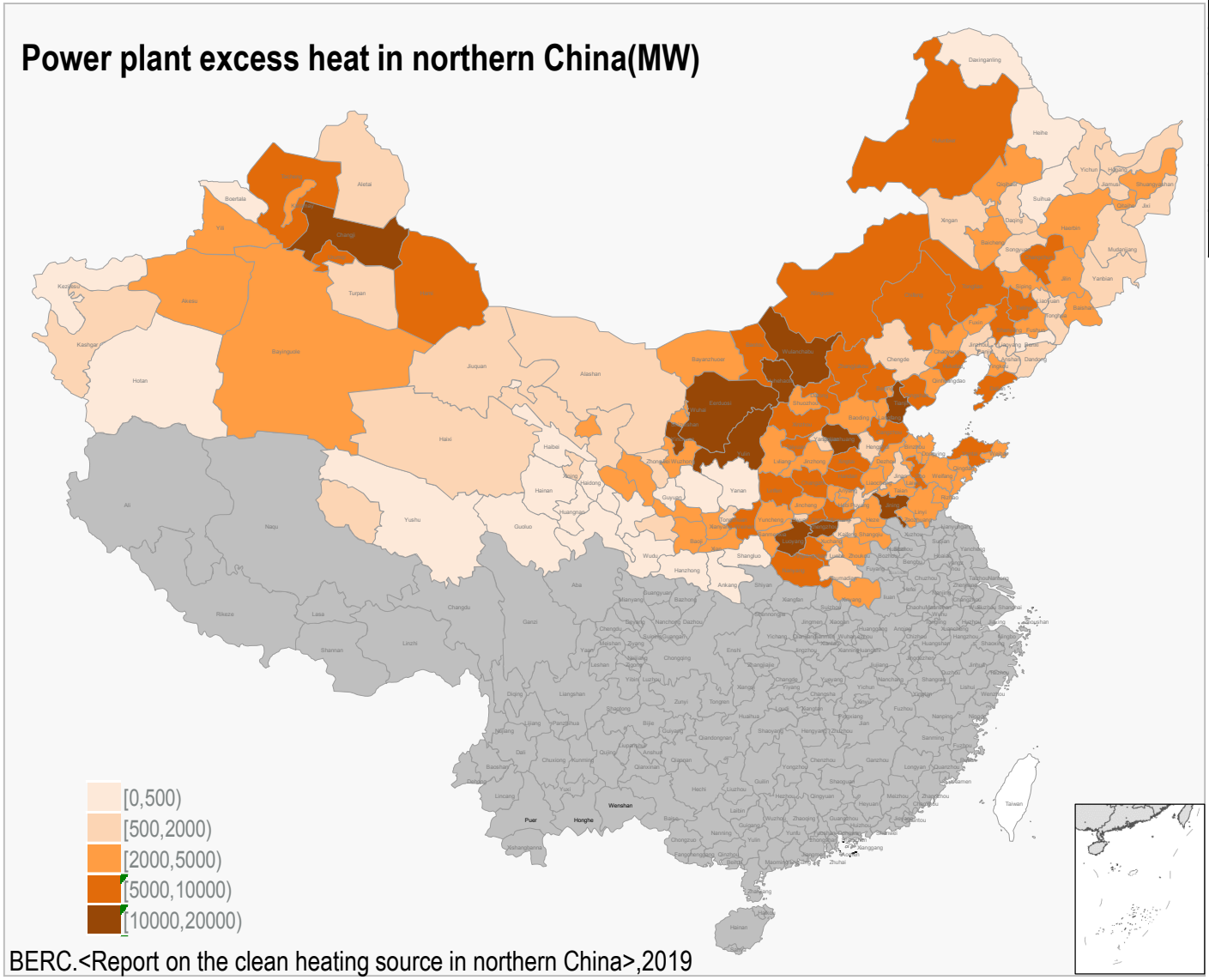
IEA & BERC.<District energy system in China: options for optimization and diversification >,2018

China Clean Heating 2025- roadmap

- Surplus heat application- clean heating resources
- Long-distance distribution
- Low return temperature system
- Thermal-electric synergy
- Gas based peak load regulation

The role of surplus heat from power plant

➢ Power plant excess heat



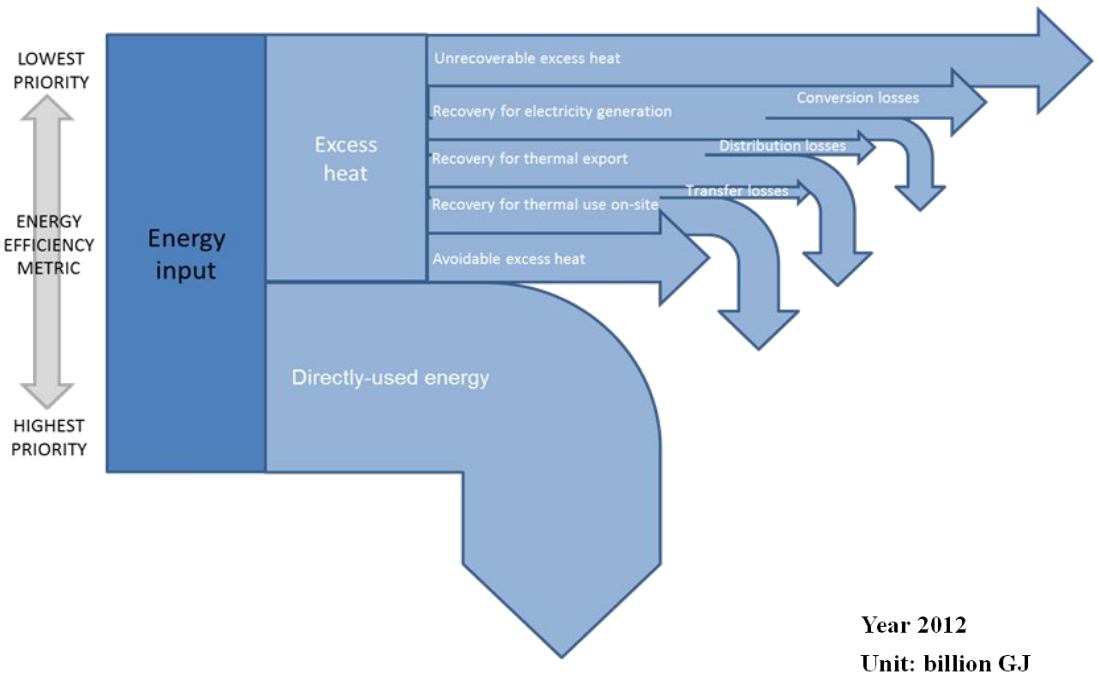
BERC.<Report on the clean heating source in northern China>,2019

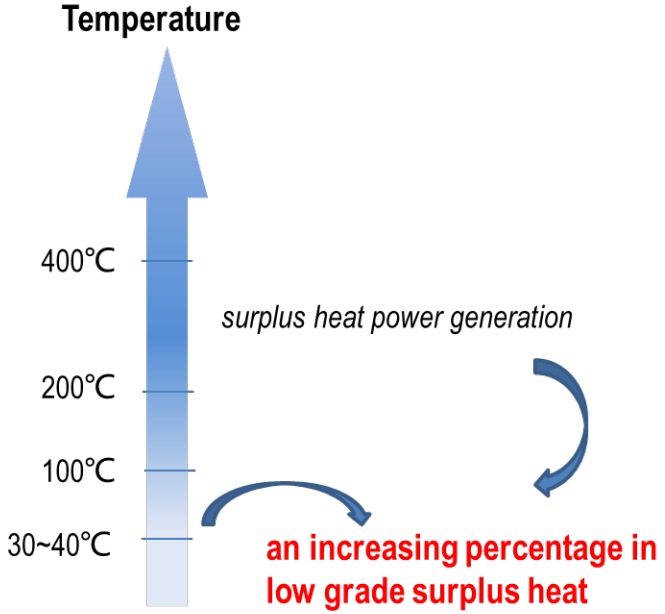
Power plant excess heat （MW）	The number of prefecture-level cities
0~500	24
500~2000	37
2000~5000	55
5000~10000	31
> 10000	11

The distribution of power plant excessheat has obvious regional heterogeneity.

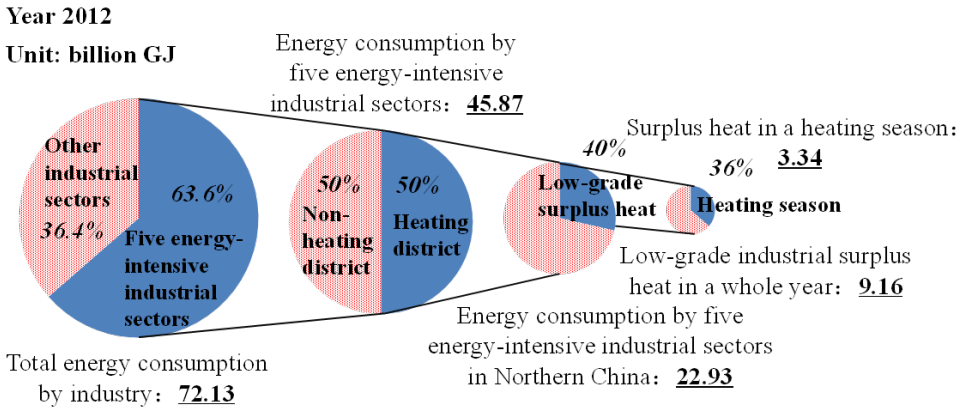
It's mainly distributed in Henan, Inner Mongolia, Shandong, Hebei, Xinjiang, Shanxi etc

The role of surplus heat from industry





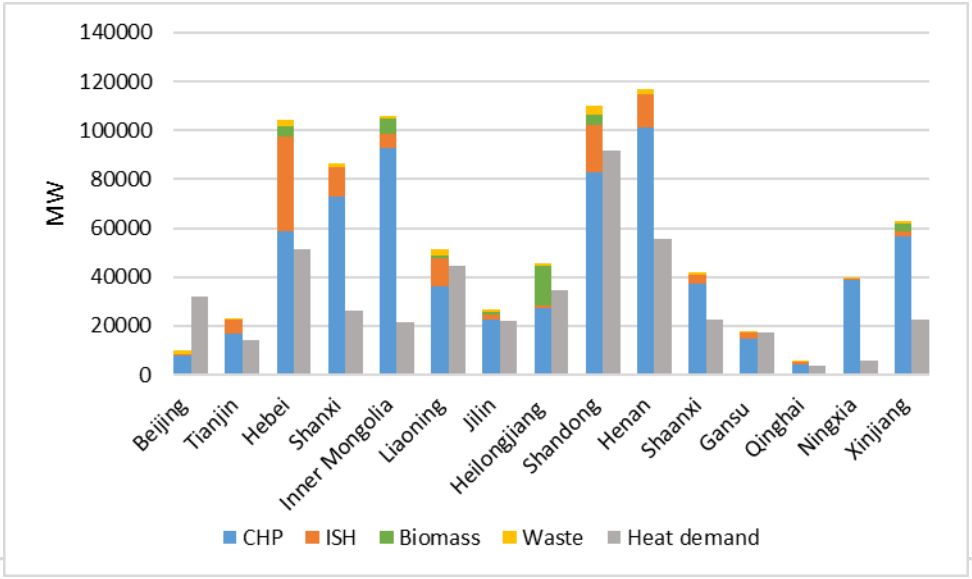
- In China, energy consumed by manufacturing industries accounts for 2/3 of the social total energy, compared to the global average 1/3, the Great Britain 1/4, and the USA 1/5.

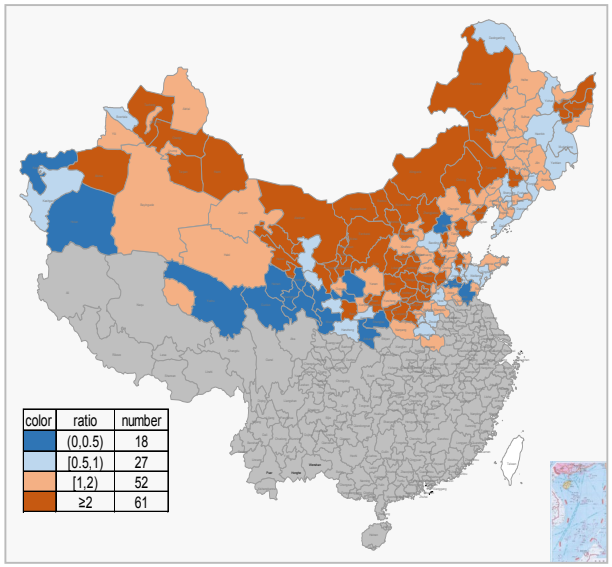


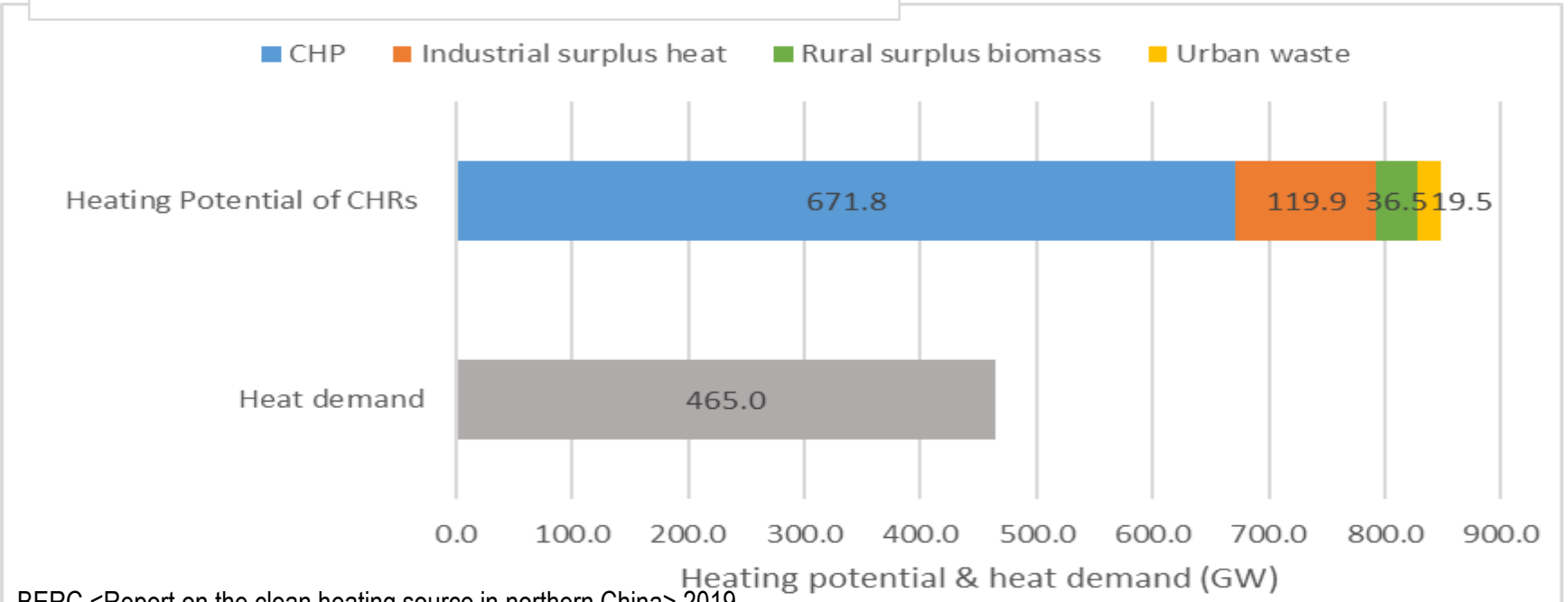
- Policies to maximise energy efficiency would improve management of surplus heat, including its use for district energy networks in China.

BERC.<Annual report on the development of Chinese building energy saving 2015>,2015

The role of Clean heating resources







BERC.<Report on the clean heating source in northern China>,2019

Long distance distribution

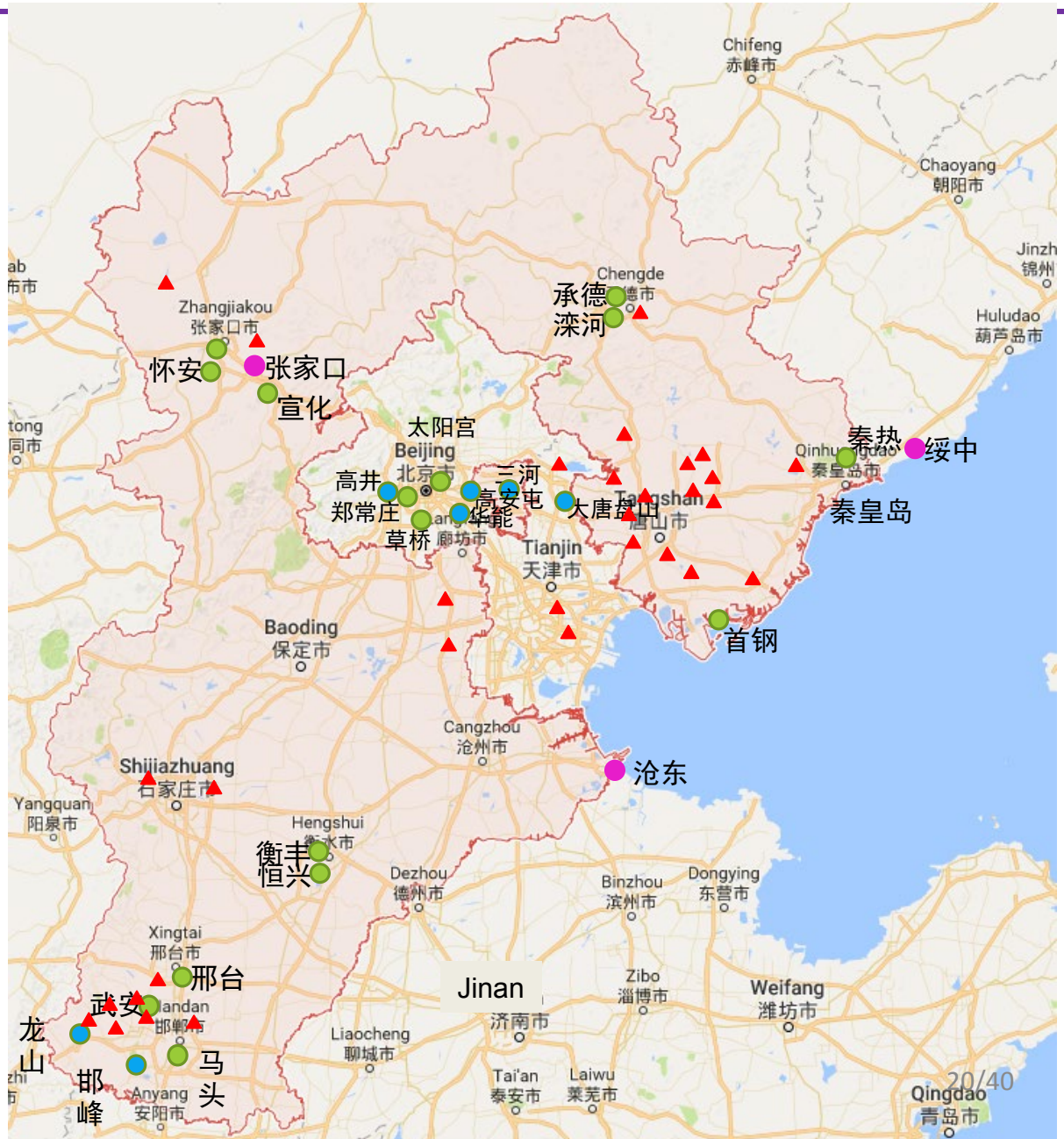
Industrial waste heat:

- 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）



BERC.<Report on potential of industrial waste heat for city heating in northern China>(in Chinese),2016

Long distance distribution

Heating radius ≈200km

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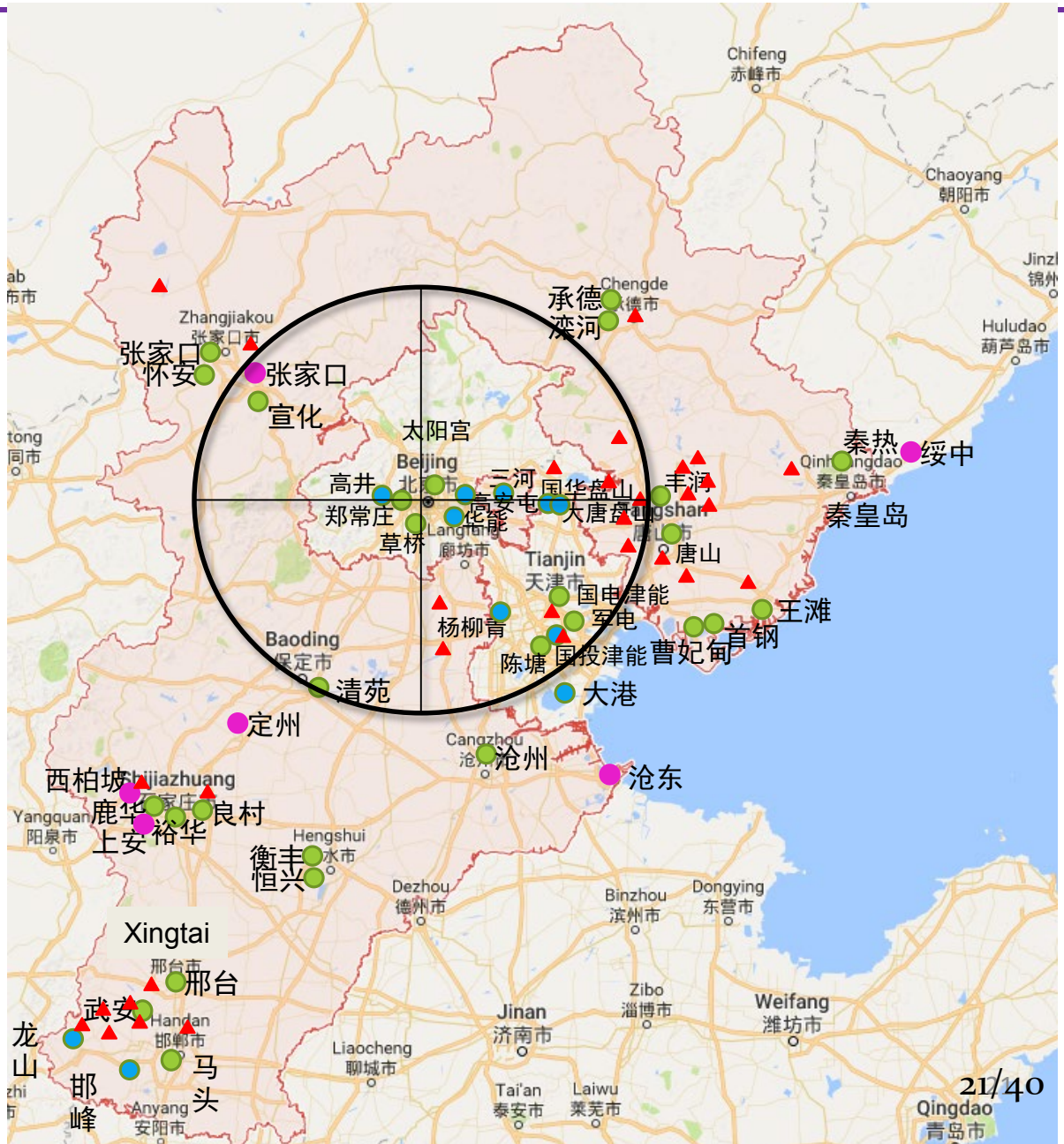

BERC.<Report on potential of industrial waste heat for city heating in northern China>(in Chinese),2016

Heating network between Cities

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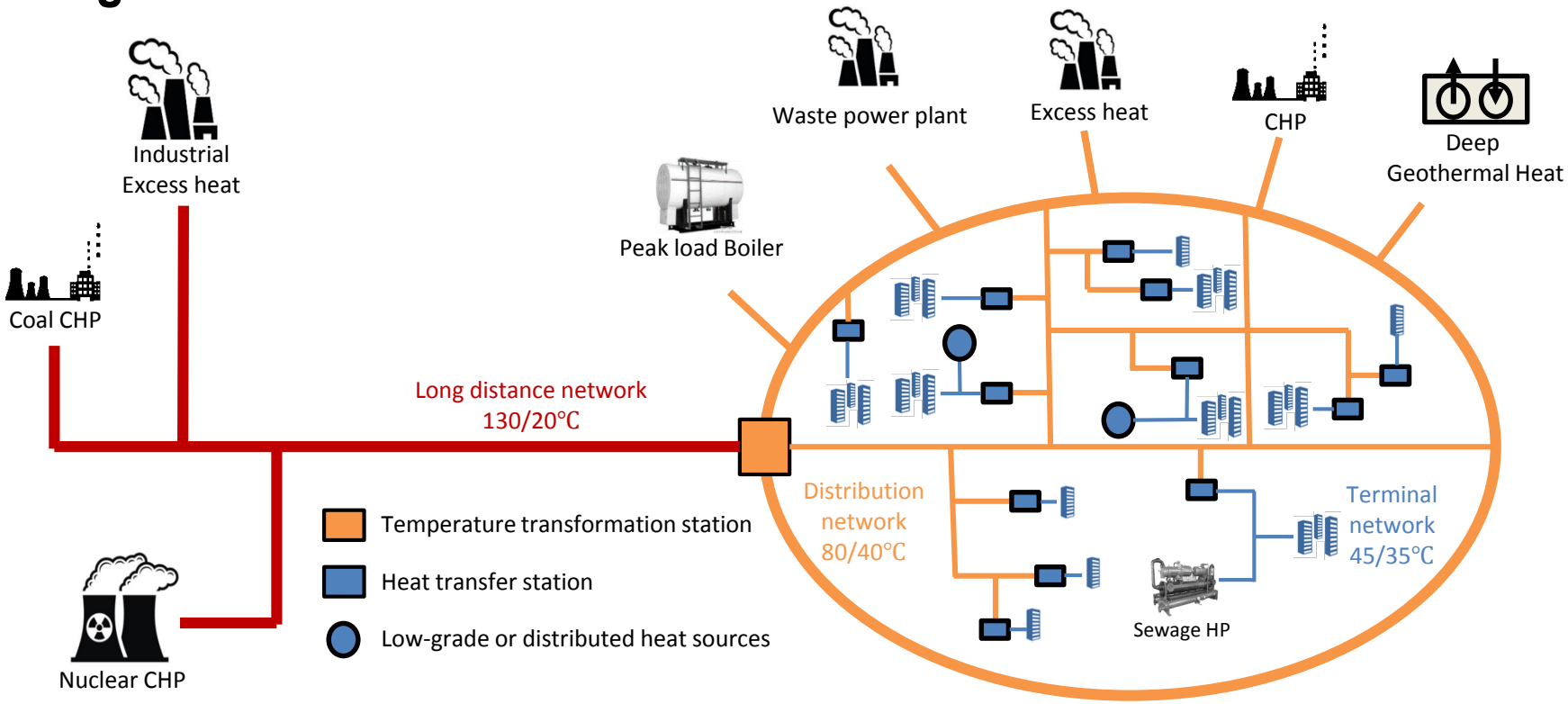
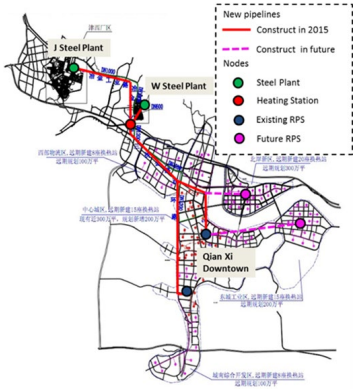
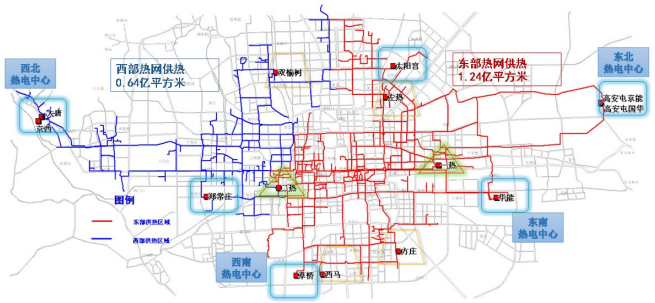
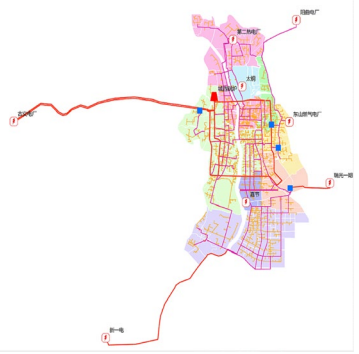
Integration of heating network

Long distance distribution

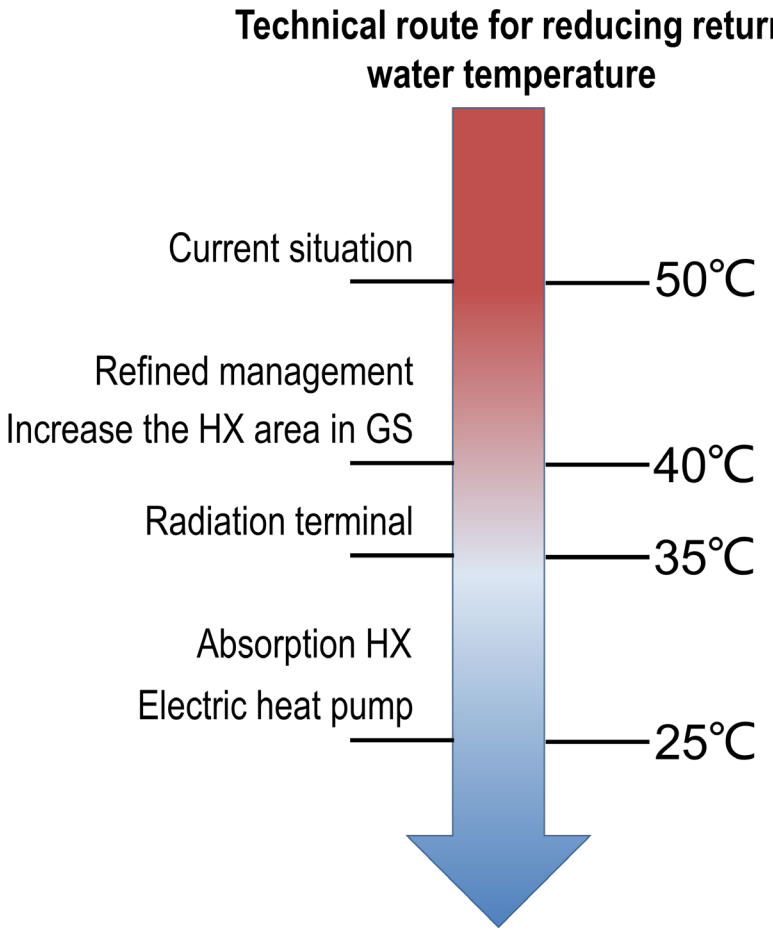


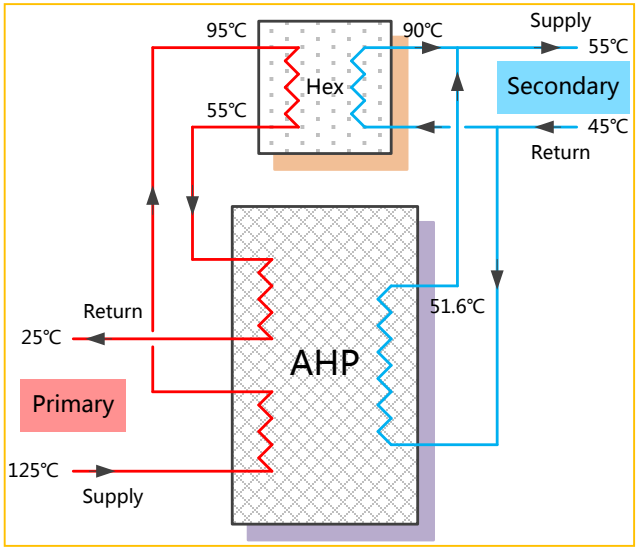


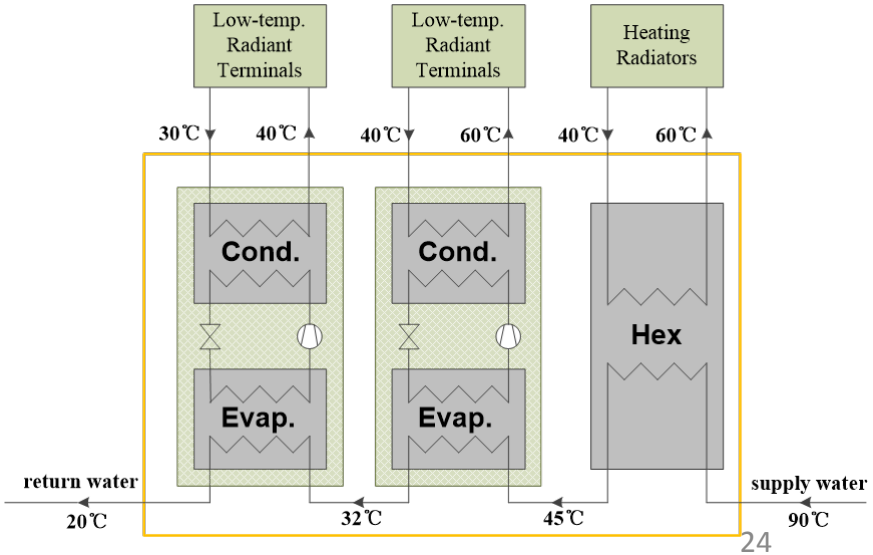




Technical solution for reducing return water temperature

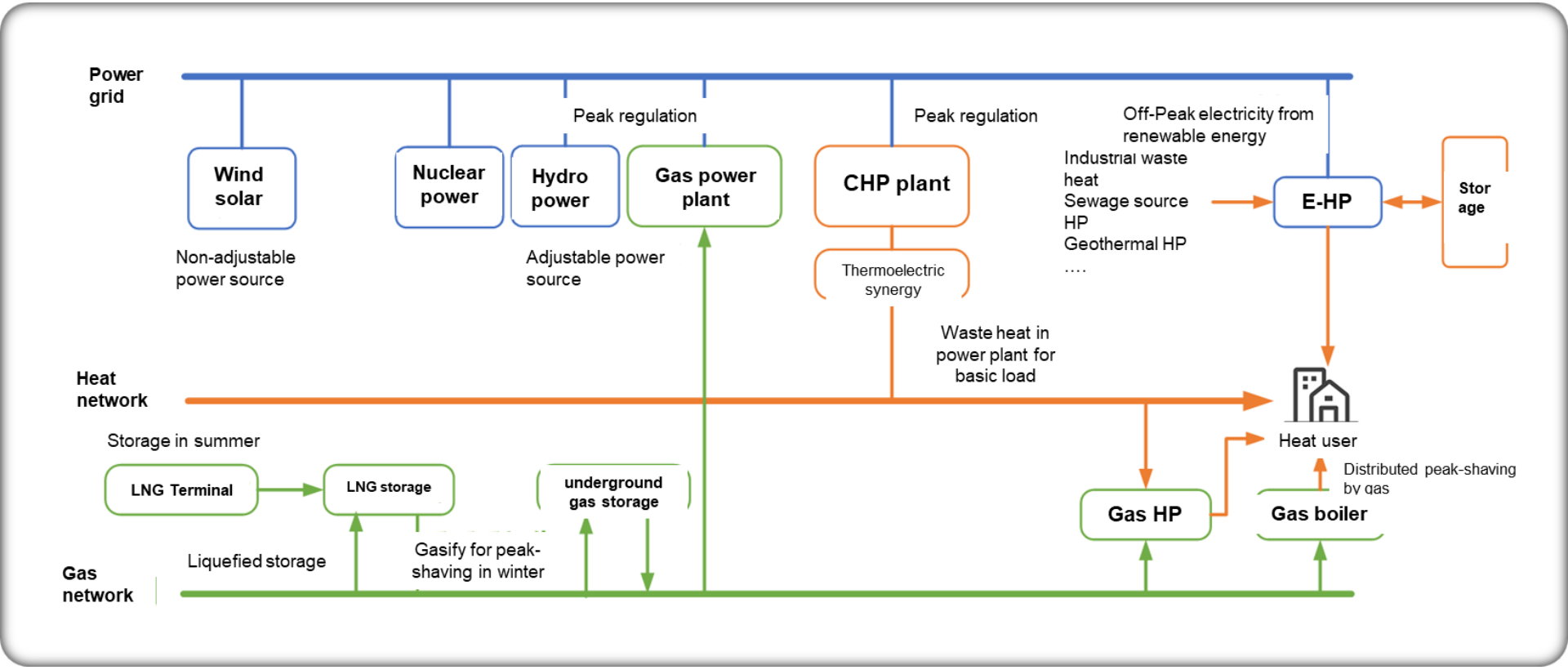






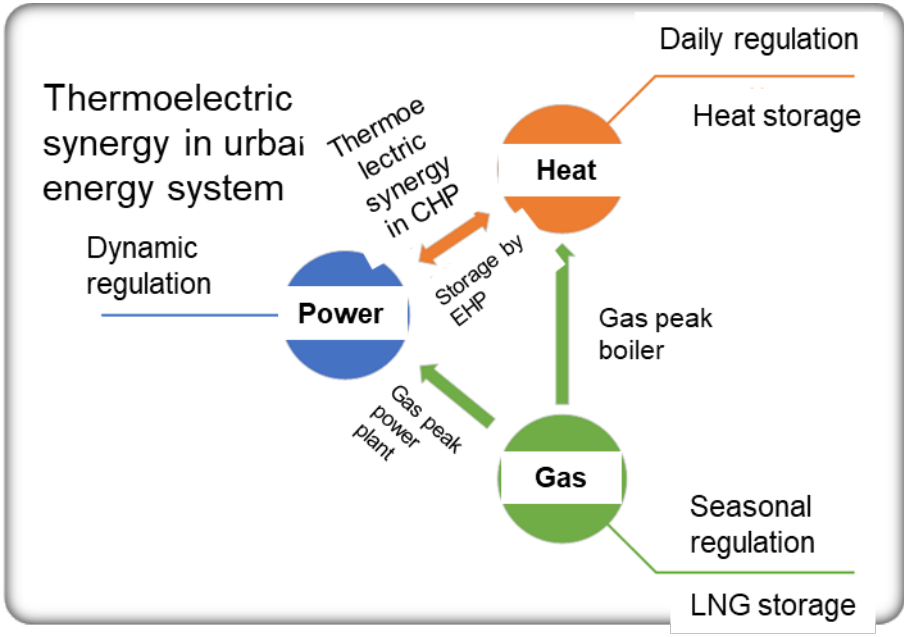
Integrated energy and regional planning could boost district energy

Interconnections and potential energy synergies within an integrated energy system



Synergies across electricity and thermal energy systems offer numerous opportunities for deeper integration but require appropriate planning and policy frameworks.

Gas based peak load regulation



- Peak-shaving in DH system by gas
  - Economical and energy-use efficiency of DH system based on waste heat in power plant get greatly increased by above mode
- Peak-shaving in electricity system by gas
  - Make full use of advantage like large adjustment range and fast regulating speed of gas power plant to regulate for power grid

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.

Thank you for your attention

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