Clean Urban/Rural Heating in China: the Role of Renewable Energy

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Outline

- Background
- Heating Technologies in urban
- Heating Technologies in rural
- Summary and future perspective

Shares of building energy use in China

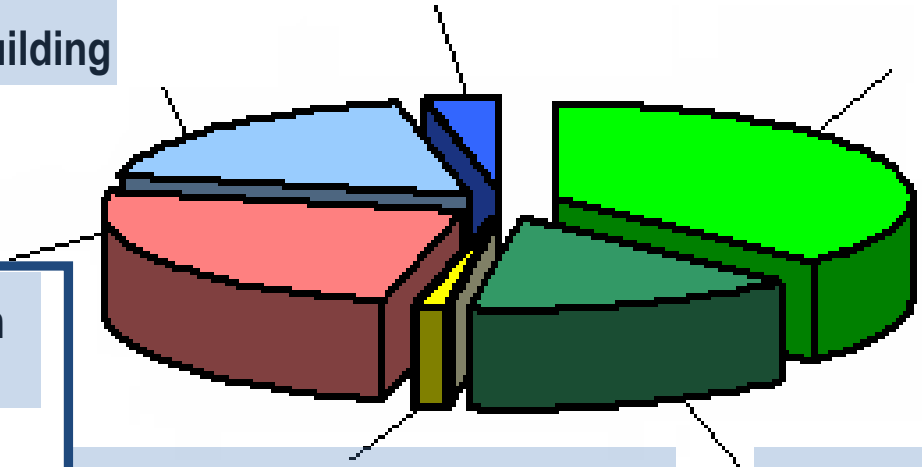
2018 Total Building Energy: 900 million tce+ 90 million tce biomass
2018 Total Building Area: 58.1 billion m2 (urban 34.8 bm2 + rural 23.3 bm2)

Large-scale commercial building

0.4 billion m^2, 3%

Normal commercial building

4.9 billion m^2, 18%



Rural building

24.0 billion m^2, 38%

Needs clean & efficient

Space heating in North China (urban)

6.4 billion m^2, 25%

Needs clean and efficient

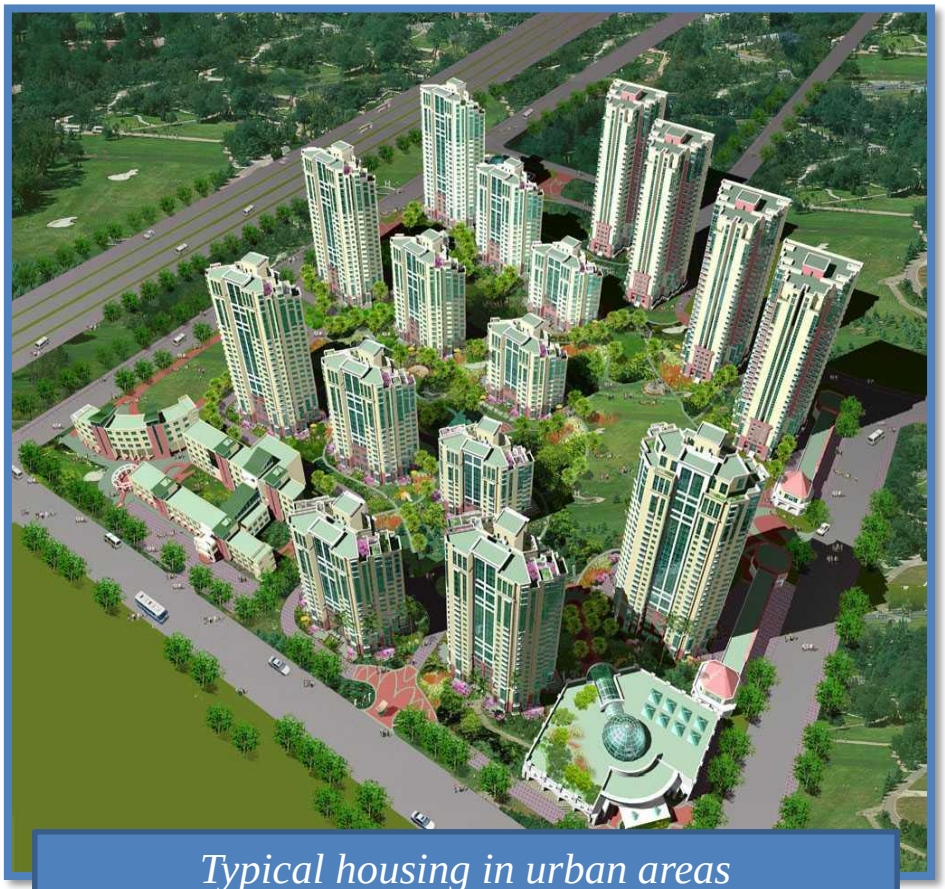
Heating of residential building in the Yangtze River region

4.0 billion m^2, 1%

Residential building (heating not included)

9.6 billion m^2, 15%

Different housing styles in urban/rural



Typical housing in urban areas

Typical house (Northern rural)

Typical house (Southern rural)

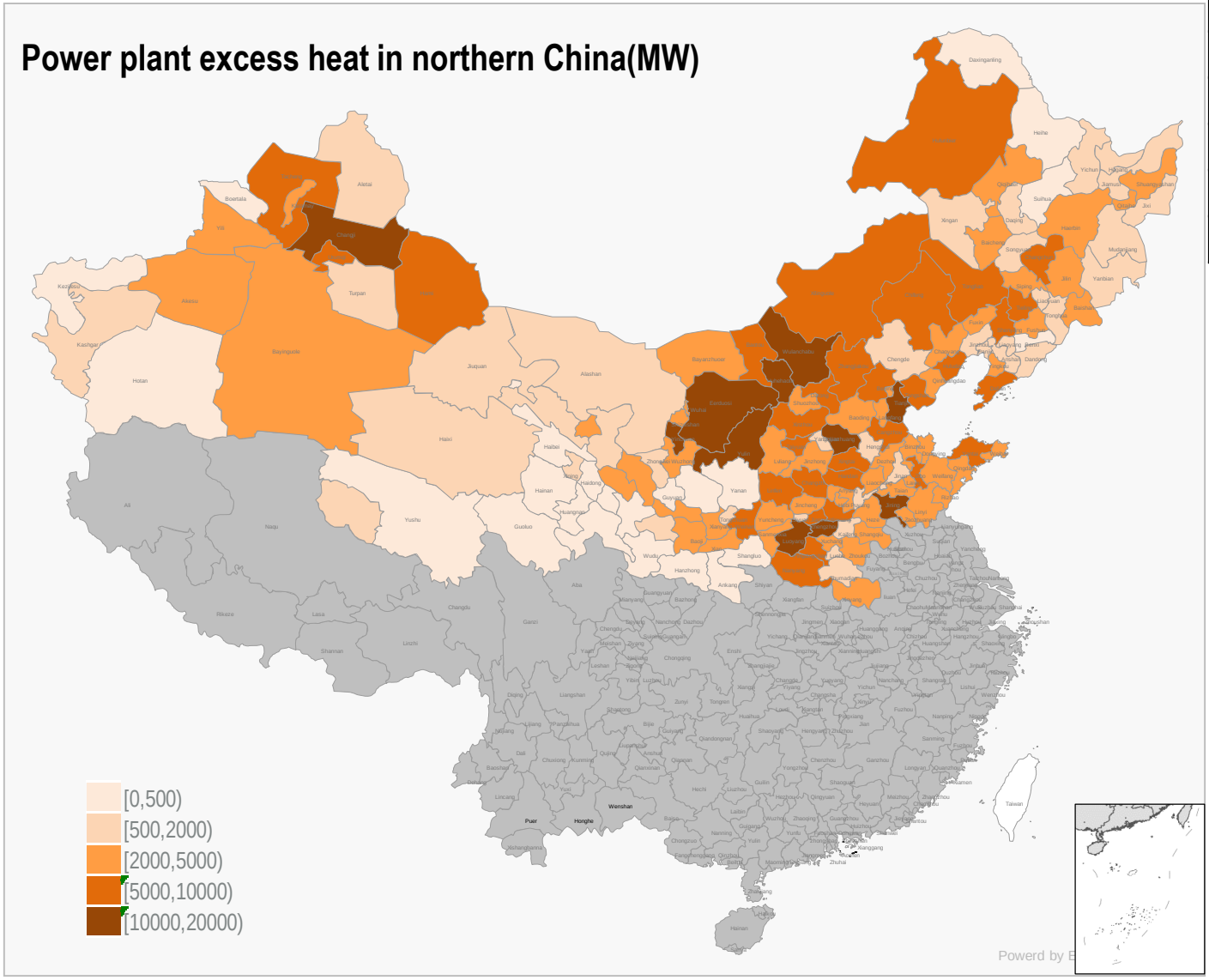
Urban district heating network

- Heating terminal
- Secondary network
- Heat Station
- Power plant/heating boiler

- Primary Network

- Second source
- Pump

The role of surplus heat from power plant



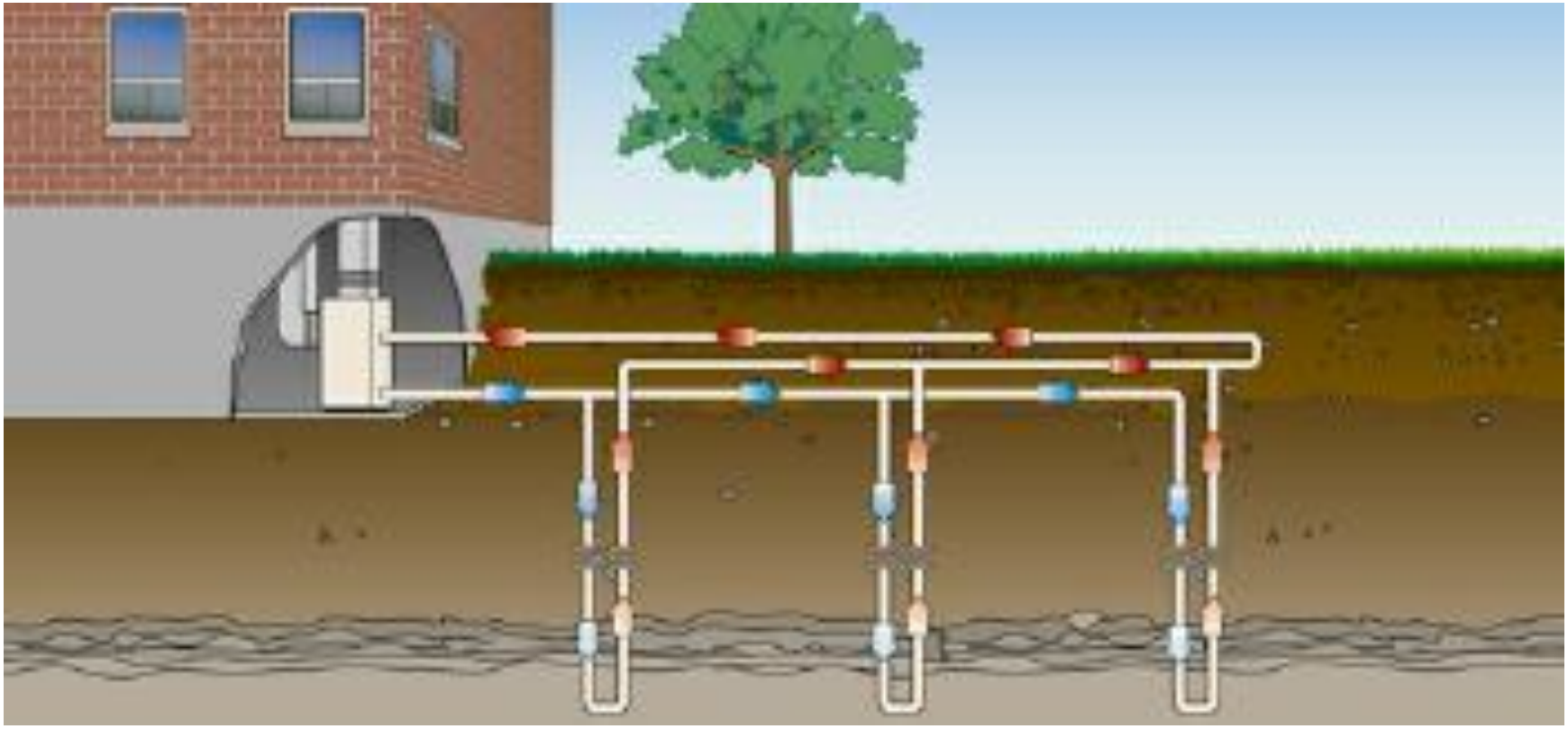
Power plant excess heat （MW）	The number of prefecture-level cities
0~500	24
500~2000	37
2000~5000	55
5000~10000	31
> 10000	11

The distribution of power plant excess heat has obvious regional heterogeneity.

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

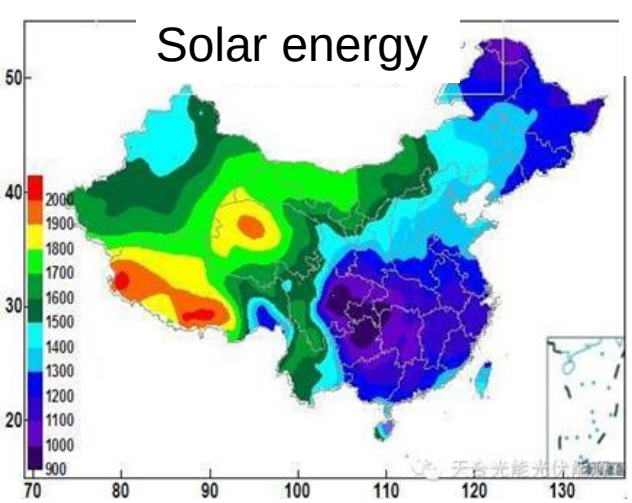
Industrial waste heat utilization

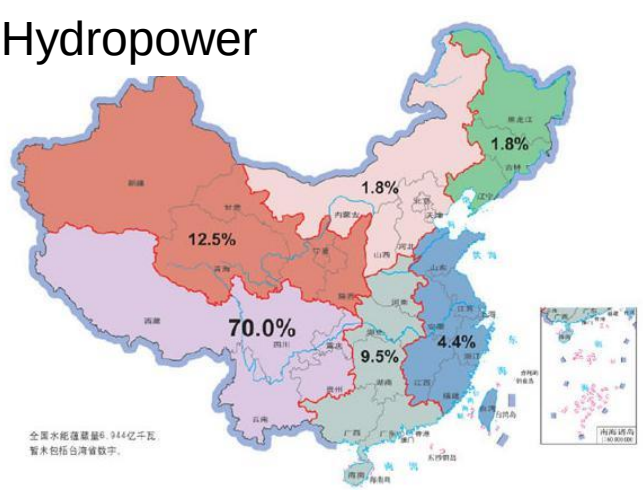
Geothermal energy: shallow or deep

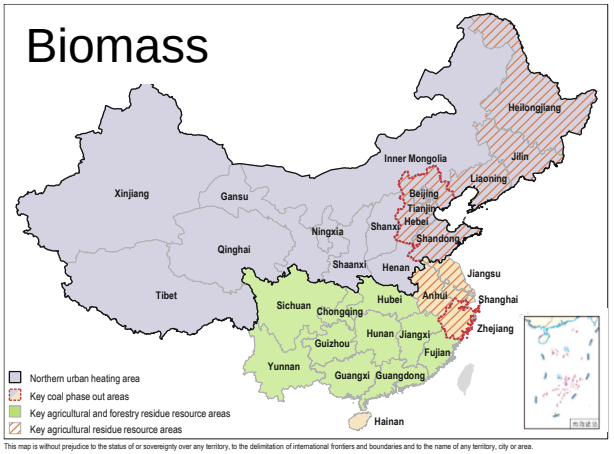


Heat pump to provide heating: 50 million m2 in 2005, 230 million m2 in 2010

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







- In China, the renewables share in district heating was **only 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.

Solid fuels consumed for heating in rural China

Coal

Coal heating stove

TOTAL coal: (120.3 million tons/year)

Coal: ***104.8(North)***

15.5(South)

Raw biomass

Chinese Kang

TOTAL biomass: (82.8 million tons/year)

Firewood: ***16.1(North)***

29.5(South)

Straws: ***33.3(North)***

3.9(South)

1. **X. Yang**, et al. Energy and environment in Chinese rural housing: current status and future perspective, Frontiers of Energy and Power Engineering in China 4 (1) (2010) 35-46.

2. Tsinghua University Building Energy Research Center (**THUBERC**), Annual Report on China Building Energy Efficiency 2012, China Architecture & Building Press, Beijing, China, 2012.

Solid fuels consumed for cooking in rural China

Coal

Coal stove

TOTAL coal: (68.3 million tons/year)

Coal: ***50.7(North)***

17.6(South)

Raw biomass

Biomass stove

TOTAL biomass: (88.5 million tons/year)

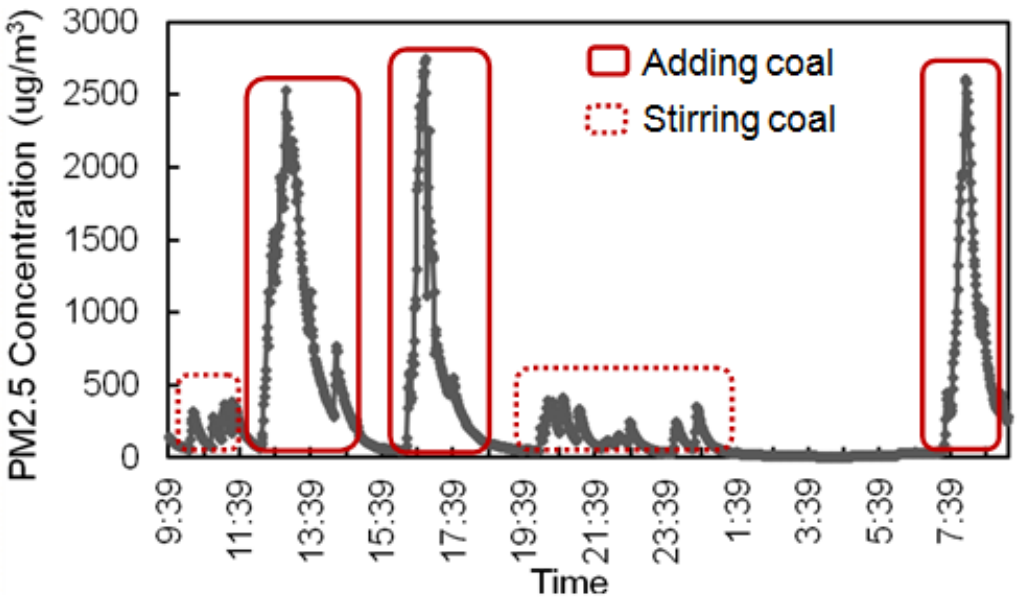
Firewood: ***10.7(North)***

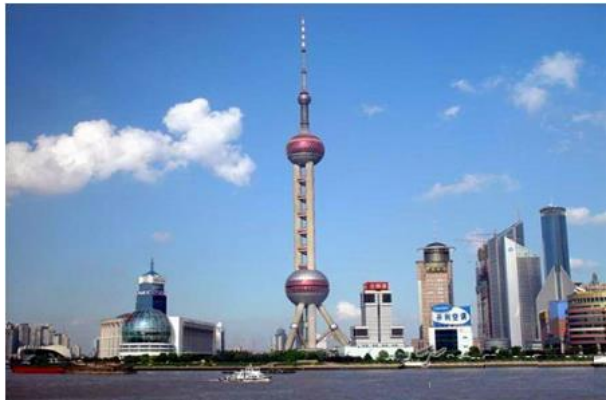
32.8(South)

Straws: ***31.1(North)***

13.9(South)

Indoor and outdoor air pollution due to rural energy use





Priority areas for cleaner energy in rural China

Solar energy

Solar thermal: solar hot water, solar heating, solar cooking

Solar power: solar photovoltaic

Clean biomass

Crop residuals, wood and forest waste

Human/animal waste, biogas

Natural energy (heat pump) and waste heat

Air energy (air source heat pump)

Geothermal energy

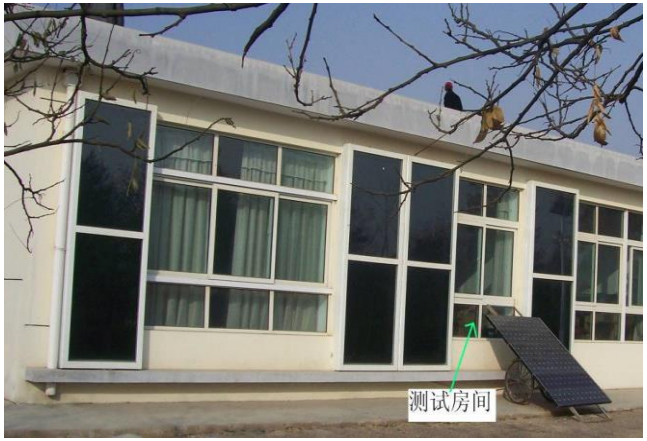
Waste heat from industrial plant/CHP

Solar hot water

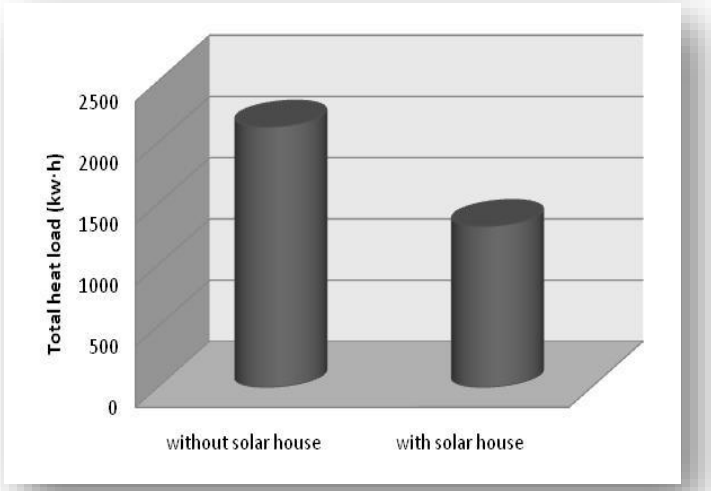
Domestic solar hot water: till 2010, 168 million m2 solar collector area, 80 million household units

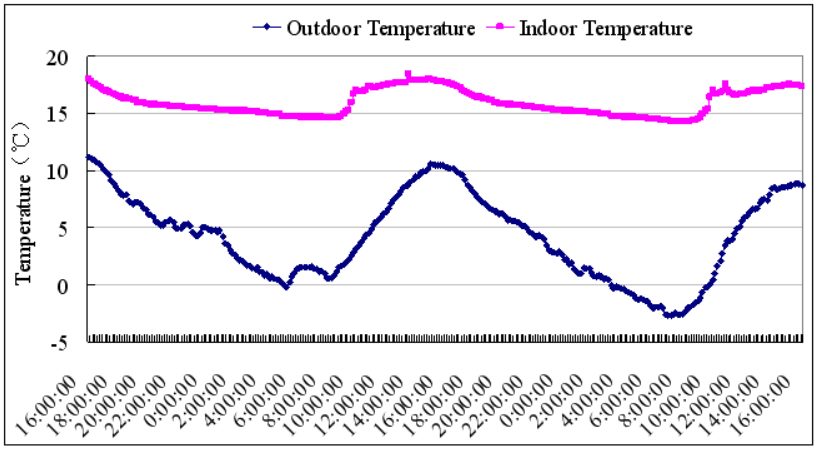
Passive solar heating

Solar house in Beijing



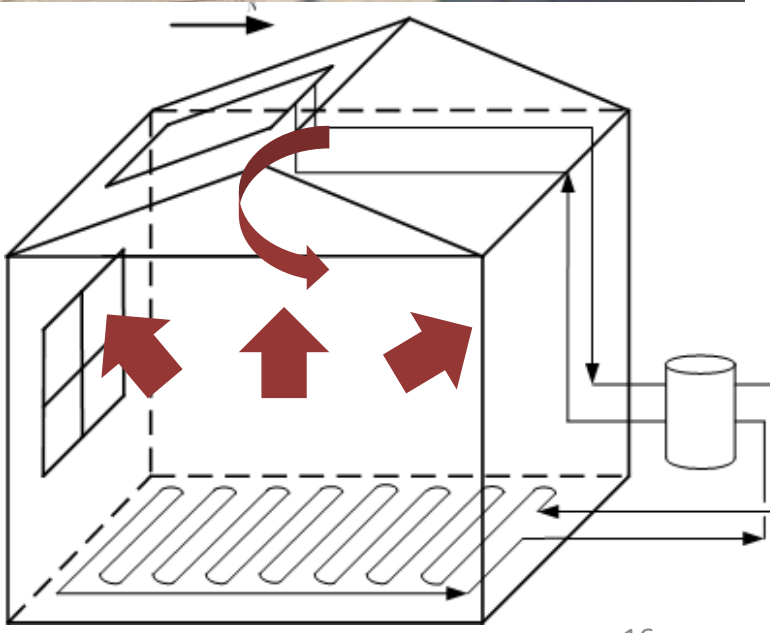
Solar collecting walls and windows in Gansu Province





Solar heating (passive 10 million m2 + active)

Active solar heating



Clean biomass utilization

Crude biomass

Biomass pellets

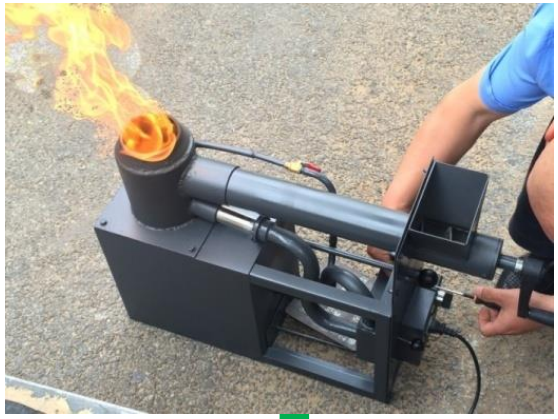
Stoves using biomass pellets instead of coal:

Stove for cooking

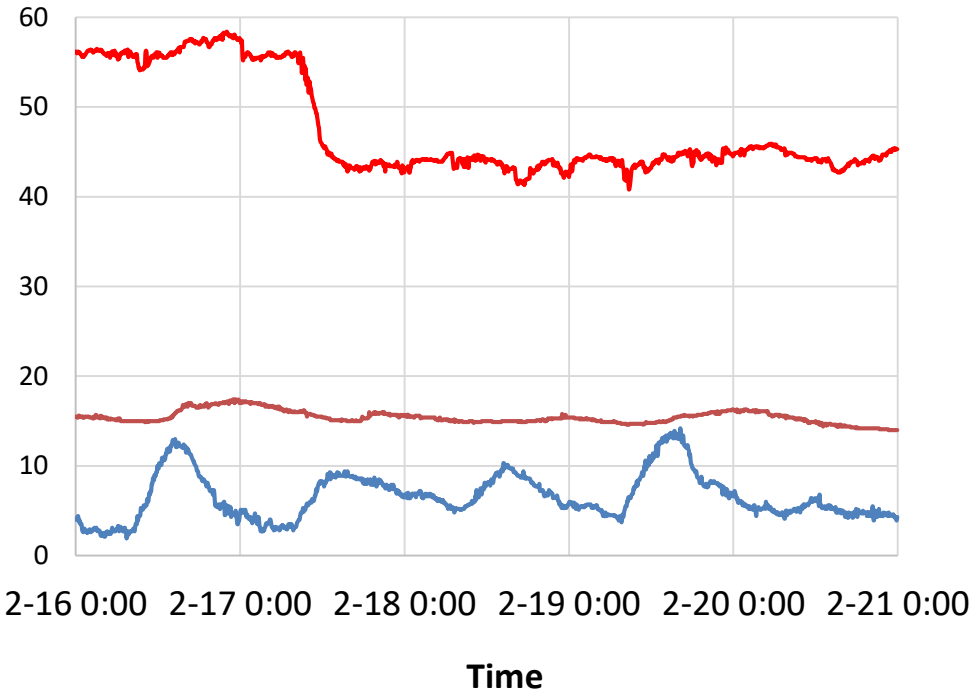
Stove for heating Chinese kang

Stove for space heating

A new cooking burner integrated with existing cooking pot and structure



Biomass pellet heating+cooking stoves in real household



- **Heating area: 80m²**
- **Outdoor avg temp 6.6℃**
- **Indoor avg temp: 15.4℃**
- **Pellet consumed per day: 30kg**

Air source heat pump: Technology innovation

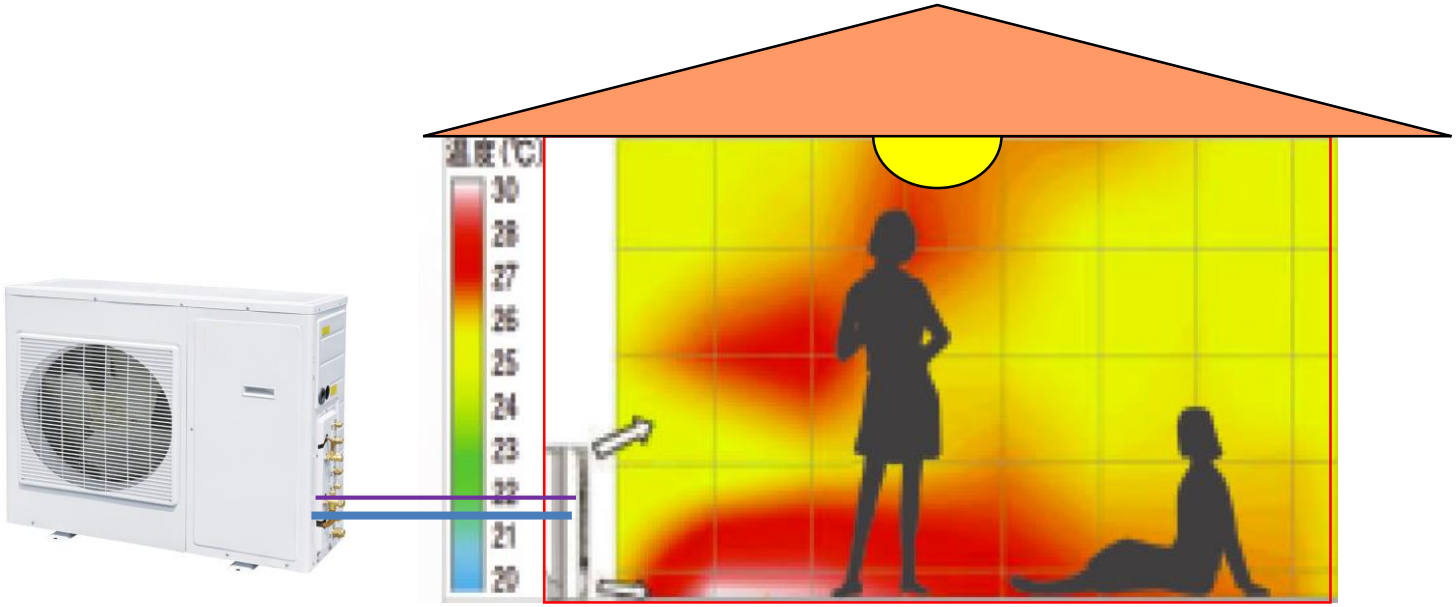
Improved double stage enthalpy-added compressor

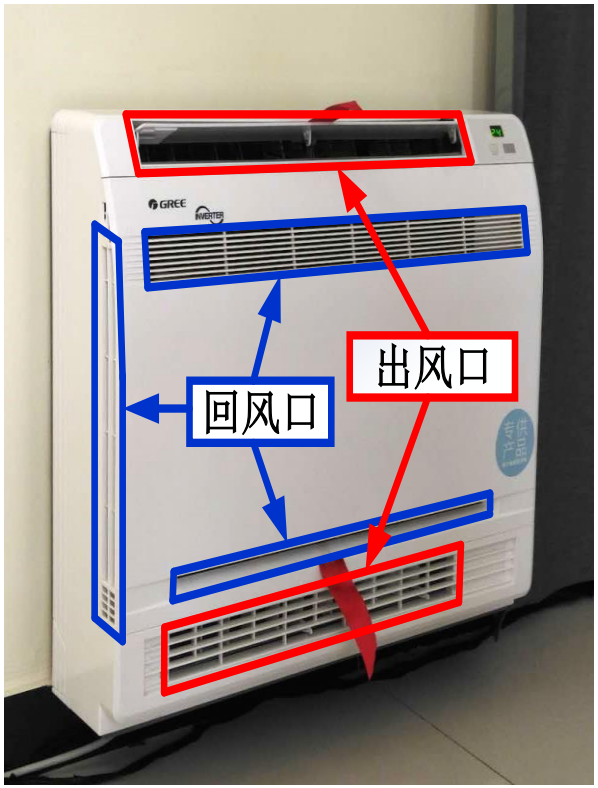
Traditional single stage compressor (one cylinder)

(Two cylinders)

(Three cylinders)

- **Enhanced capacity in cold ambient conditions**
- **COP is up to 2.0+ at the outdoor temperature of -20℃**
- **Can run normally at the outdoor temperature of -35℃**





- **Low cost: ~5000CNY/unit**
- **High COP: ≥3.0 in Beijing**
- **Low operating cost:**

  15-40 kWh/m²•winter

  8-20 CNY/m²•winter

- **First technical standard developed**
- **Market penetration till 2019: 1 million units**

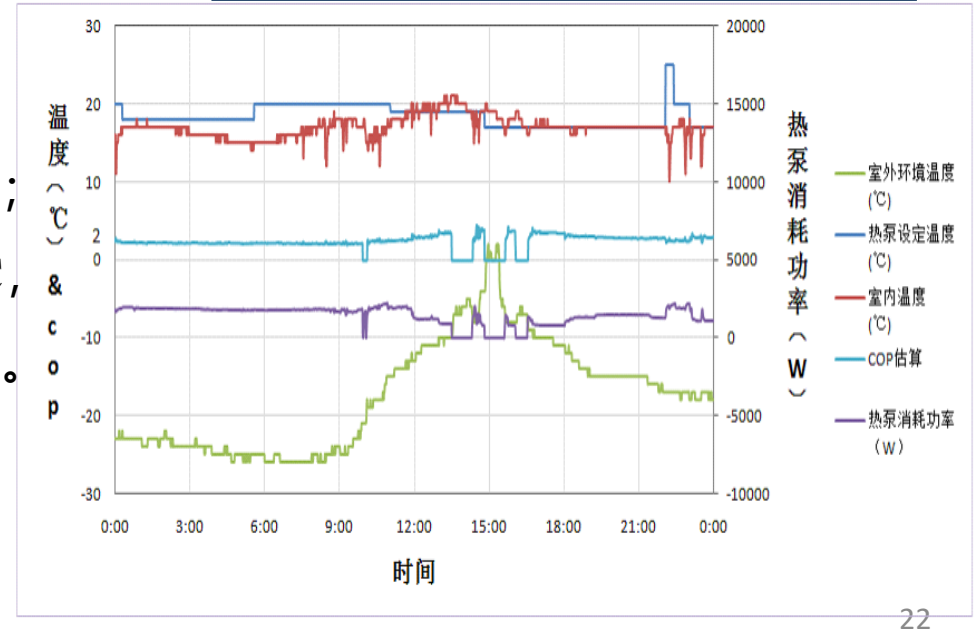
Heat pump heating in gerrs, Mongolia

1 Time：2018.02.02——2018. 03.05

2 Outdoor temperature range :-6℃ ~ -28℃；

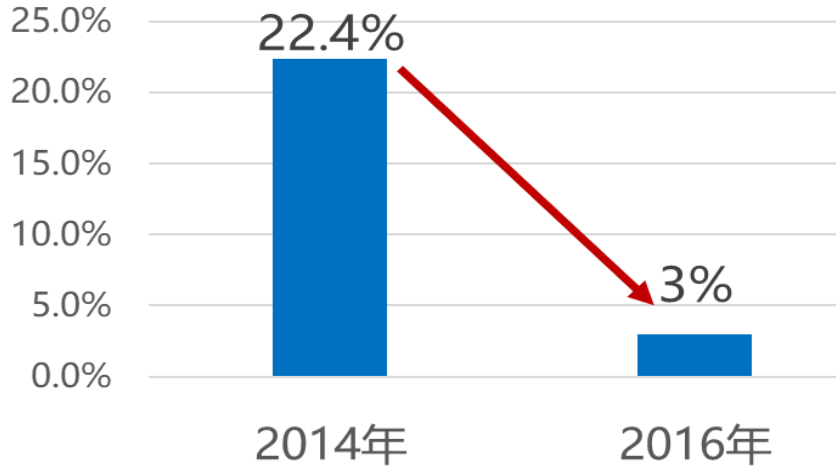
3 Indoor temperature setting：18℃ ~ 28℃，

4.Actual indoor temperature：16℃ ~ 29℃。



Coal to clean energy: Environmental benefit in Beijing

- More than 1 million small coal boilers removed
- 300 million ton coal reduced, 12 k-ton PM2.5, 8.60 m-ton CO2, 4.6 k-ton SO2, 7.6 k-ton NOx



Rural household energy transition in China

It is happening NOW

Low cost + High effic. + Easy maint. + Re-produ. = Suitable

Initial cost: 10K Annual cost: 1k Use: 1key Implem: 1 plan

Environmental impact due to rural energy in China

2010: **710 million** tons CO2 emissions

2030: 1.3 billion tons or 460 million tons?

	Scenario	Description	CO2 emissions（million tCO_2）
1	No control	No improvement on building envelopes, wide use of coal and other non-renewable energy, biomass totally replaced by coal	1300
2	10% villages reach “zero coal”	Percentage of total villages to adapt to the “zero coal”, sustainable development mode	1190
3	50% villages reach “zero coal”		780
4	80% villages reach “zero coal”		460

Summary

- Renewable energy application has gone through rapid growth in China in recent years
- Emphasis should be given to renewable energy use in Chinese rural buildings
- “Zero coal” “low carbon” buildings and communities are possible with the aid of renewables
- Affordable technologies, financial support, and various incentives are needed to make the above a reality

China has many reasons to pursue a more sustainable energy future

- Resources depletion
- Environment deterioration
- Ecosystem degradation
- Energy security

- **Go sustainable**
- **Go renewable**
- **Go clean**

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