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 m², 3%

Normal commercial building
4.9 billion m², 18%

Space heating in North China (urban)
6.4 billion m², 25%
Needs clean and efficient

Heating of residential building in the Yangtze River region
4.0 billion m², 1%

Rural building
24.0 billion m², 38%
Needs clean & efficient

Residential building (heating not included)
9.6 billion m², 15%
Different housing styles in urban/rural

Typical housing in urban areas

Typical house (Northern rural)

Typical house (Southern rural)
Urban district heating network

- Power plant/heating boiler
- Heat Station
- Primary Network
- Secondary network
- Heating terminal
- Second source
- Pump
The role of surplus heat from power plant

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 m$^2$ in 2005, 230 million m$^2$ 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**
- TOTAL coal: (120.3 million tons/year)
  - Coal: 104.8 (North)
  - Coal: 15.5 (South)

**Biomass**
- TOTAL biomass: (82.8 million tons/year)
  - Firewood: 16.1 (North)
  - Firewood: 29.5 (South)
  - Straws: 33.3 (North)
  - Straws: 3.9 (South)

Solid fuels consumed for cooking in rural China

**Coal:**
- Total coal: **(68.3 million tons/year)**
  - Coal: 50.7 (North)
  - 17.6 (South)

**Raw biomass:**
- 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°C
- Indoor avg temp: 15.4°C
- Pellet consumed per day: 30kg
Air source heat pump: Technology innovation

Improved double stage enthalpy-added compressor

- 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℃

Traditional single stage compressor (one cylinder)

(Two cylinders)

(Three cylinders)
• Low cost: ~5000 CNY/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 gerris, Mongolia

1. Time: 2018.02.02——2018.03.05
2. Outdoor temperature range: -6°C ~ -28°C;
3. Indoor temperature setting: 18°C ~ 28°C;
4. Actual indoor temperature: 16°C ~ 29°C.
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.
- Reprodu.

= 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?

<table>
<thead>
<tr>
<th></th>
<th>Scenario</th>
<th>Description</th>
<th>CO2 emissions (million tCO₂)</th>
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<tbody>
<tr>
<td>1</td>
<td>No control</td>
<td>No improvement on building envelopes, wide use of coal and other non-renewable energy, biomass totally replaced by coal</td>
<td>1300</td>
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<tr>
<td>2</td>
<td>10% villages reach “zero coal”</td>
<td>Percentage of total villages to adapt to the “zero coal”, sustainable development mode</td>
<td>1190</td>
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<td>3</td>
<td>50% villages reach “zero coal”</td>
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<td>780</td>
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<tr>
<td>4</td>
<td>80% villages reach “zero coal”</td>
<td></td>
<td>460</td>
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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