North Eastern China

Energy Integration System
National Renewable Energy Laboratory
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Our Region of Interest

Population Density

Population Vs Energy

Power plants map

Energy

People

Yellow: Coal
Green: Hydro % pump
Pink: Nuclear

Data: Wikipedia, Maps: Fusion Tables
Projection of the Energy Mix by 2030-2050

• Some increase in:
  • Wind power
  • Hydro
  • Nuclear
  • Natural gas

• Slight increase in:
  • Solar power

• Some decrease in Coal
Current Mix | Energy Mix 2030 | Energy Mix 2050
Power Flows in China

Electric Power and Energy in China By Zhenya Liu 2013
Inter-provincial Transmission Capacities

The Carbon Emission Flow

http://www.nature.com/srep/2012/120629/srep00479/fig_tab/srep00479_F2.html
Fossil Fuels
Coal

• The primary fuel behind China’s economic growth over the last decade; providing three quarters of the nation’s primary energy supply
• But coal plants only generate about 40% of their capacity
• Less integration space for renewables
• Associated with environmental and health damages
Policy for Coal

- The Small Plant Closure Program:
  - Small mines are being closed down or bought out by large energy groups
- Coal caps
- Consolidation, mostly into the hands of state-owned enterprises
Oil Fields

- Liaohe, one of China's largest heavy oil fields, produced 200,000 bbl/d in 2012.
- CNPC began using more advanced EOR methods such as steam flooding and polymer flooding on a large scale, the company hopes to restore production to around 241,000 bbl/d by 2020.
- CNPC has used hydraulic fracturing and CO₂ injection at the Jilin field to mitigate further declines in hydrocarbon output.

Challenges

• **Gas**
  • Development is geologically and technically challenging; mostly tight gas (characterized by low permeability and low pressure and usually requiring hydraulic fracturing for commercial production).

• **Oil**
  • They are mature fields; heavily exploited since the 1960s, and their output is expected to decline
Solutions

• Effectively using advanced drilling techniques and recovery methods to retrieve natural gas
• Increased gas import from Russia
• Use CO$_2$-EOR techniques to enhance recovery rates for the mature fields in this area, e.g. the Jilin oil field
Renewables

• They provide more than a quarter of China’s electricity generating capacity

• Steady increase in investments in renewables over the last decade
Wind

Wind Profiles by Province

January 4–10 (Ja1)

January 11–17 (Ja2)

January 18–24 (Ja3)

March 1–7 (Ma1)

March 8–14 (Ma2)

March 15–21 (Ma3)

Wind Power

• The fastest growing renewable energy resource
• In 2013 wind accounted for 2.7% of national generation while the curtailment rate reached 12%. (77 GW installed capacity-137 TWh annual energy generation)
• It is largely concentrated in China’s northern region
Table 10. Wind power development targets and distribution (GW)

<table>
<thead>
<tr>
<th>Regions</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
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<tbody>
<tr>
<td>West Inner Mongolia</td>
<td>6.50</td>
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<td>300</td>
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<td>East Inner Mongolia</td>
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<td>90</td>
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<td>Northeastern China provinces</td>
<td>7.31</td>
<td>30</td>
<td>38</td>
<td>60</td>
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<tr>
<td>Hebei Base</td>
<td>3.78</td>
<td>15</td>
<td>27</td>
<td>60</td>
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<tr>
<td>Gansu Base</td>
<td>1.44</td>
<td>20</td>
<td>40</td>
<td>120</td>
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<tr>
<td>Xinjiang Base</td>
<td>1.13</td>
<td>20</td>
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<td>100</td>
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<tr>
<td>Distributed land-based wind in Eastern and Central China and other areas</td>
<td>7.43</td>
<td>25</td>
<td>50</td>
<td>70</td>
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<tr>
<td>Near offshore wind</td>
<td>0.10</td>
<td>30</td>
<td>60</td>
<td>150</td>
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<td>Far offshore wind</td>
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<td>5</td>
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<tr>
<td>Total</td>
<td>31.31</td>
<td>200</td>
<td>400</td>
<td>1000</td>
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</table>

Biggest Challenge: Wind Curtailment

• Wind curtailment occurs due to technical, economic and institutional reasons; The curtailed energy is equivalent to burning 3.3 million tons of coal, (equivalent 10 million tons of CO₂ emissions)

• Reasons:
  • Insufficient transmission investments – need to invest in transmission and
    Construction of distributed and small-scale wind farms closer to load centers
  • Wind variability and unpredictability - need for forecasting improvements
  • Inflexibility in operation of coal plants and CHPs
  • Policies incentivizing construction over grid architecture
  • Incomplete market transition
Wind Curtailment in China, US (2011)

Solar

• 70% of the growing global market in solar panels
  • aggressive pricing
  • the collapse of three U.S. competitors in the last two months

• "The days of China's PV (photovoltaic) production being purely for export are coming to an end," GTM Research said, referring to solar power technology.
Northeastern China
Potential heat map for different solar technology
CHP

• Proposed reduction in energy by 20 % → second largest country in terms of installed CHP capacity

• During the cold winters several centers are equipped with coil boilers constructed or retrofitted with CHP plants

• These plants face additional operating constraints to satisfy demand on local district heating grids, constraining the space for renewables

• They are typically smaller (each technology limited to 50 MW or less)
Water

• Water crisis is thought to worsen; the Chinese economy has grown by more than 9.5% annually over the past 3 decades (four times the rate of first world economy)

• Main causes of resource depletion: increased water demand, overuse and systematic inefficiencies, persistent pollution
From Wikimedia Commons, the free media repository
Water Demand 2030

Increase in Annual Water Demand 2005-2030 (Billion m$^3$)

<table>
<thead>
<tr>
<th>Region</th>
<th>Agriculture</th>
<th>Industry</th>
<th>Municipal and Domestic</th>
<th>Change from 2005 (%)</th>
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<tr>
<td>China</td>
<td>178</td>
<td>300</td>
<td>54</td>
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<tr>
<td>India</td>
<td>338</td>
<td>89</td>
<td>40</td>
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<tr>
<td>Sub-Saharan Africa</td>
<td>320</td>
<td>28</td>
<td>92</td>
<td>283</td>
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<tr>
<td>Rest of Asia</td>
<td>243</td>
<td>117</td>
<td>80</td>
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<tr>
<td>N America</td>
<td>181</td>
<td>124</td>
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<td>Europe</td>
<td>72</td>
<td>100</td>
<td>12</td>
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<tr>
<td>S America</td>
<td>89</td>
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<tr>
<td>MENA</td>
<td>85</td>
<td>9</td>
<td>99</td>
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<td>Oceania</td>
<td>21</td>
<td>6</td>
<td>28</td>
<td>109</td>
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</table>

Source: Charting our Water Future, 2030 Water Resources Group, December 2009
Water Energy Nexus

• China will remain highly reliant on water in 2030 with 87% of power requiring water to generate on a daily basis
Water Demand and Caps

2000-2030 Water Demand & Water Caps (billion m³)

Government Water Caps

RMB 4 trillion to be spent on water infrastructure 2011-2020
Hydropower
1. Northeast
2. Yellow River Main (North)
3. Yellow River Up Reaches
4. Yalongjiang River
5. Dadu River
6. Yangtze River Up Reaches
7. Jinshajiang River
8. Nujiang River
9. Wujiang River
10. West Hunan
11. Fujian Zhejiang Jiangxi
12. Lancangjiang River Mian
13. Nanpanjiang River and Hongshuihe River

Total: 275773
(Installed cap. > 50MW)
Nuclear Power
1 reactor operational. Capacity 1,080 MW.

5 more reactors under construction.

Integration Challenges

• Insufficient transmission infrastructure
• Lack of national grid (the Northeastern electricity suppliers are mostly state owned)
• Inflexible coal-fired plans and CHPs that limit renewable penetration (scheduled nuclear which adds to the flexibility)
• Slow transition into a market-based structure
Global Warming

- Sea level rise
- Wind shifts
- Droughts
- Altered precipitation patterns
- Heat waves
问题?
Backup Slides
Energy Integration

- Integrate renewables by building more transmission
- Build small wind farms closer to demand
- Export less solar power
- Use CO$_2$-EOR technique to enhance recovery rates for the mature oil fields
Oil & Gas Fields

• Backbone of the country's domestic production
  • In 2012, Daqing produced about 800,000 bbl/d of crude oil, according to FGE's most recent estimate, and has maintained this level for the past decade
  • Sinopec's Shengli oil field near the Bohai Bay produced about 550,000 bbl/d of crude oil during 2012: China's second-largest oil-producing field.
  • Changqing's production rose steadily this decade to 1,022 Bcf in 2012, and is anticipated to reach 1,236 Bcf by 2015.