Energy use and CO2 emissions of China’s industrial sector

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China primary energy increased by 5.5 times, 70% from industry sectors, HEI sectors accounts for 73%

How about future trend and pathway?
Depend on the major player of industry sector

Note: 1kWh convert by coal consumption per kWh,
HEI sectors: Steel, cement, chemical, nonferrous, paper
IAEA data shows 50% share in China and 30% of OECD
Existing research overview on China industrial energy

- Studies before 2005 under-estimated, Nowadays, a tendency to over-estimate future energy demand.
- Most high aggregated and detail information not available for industry sector in China for integrated assessment model.
- Not including possible industrial structure change, especially peak output of HEI sectors.
- Not reflect latest situations in China, such as dramatic increase change from 2005 to 2010, carbon intensity reduced by 40-45% in 2020, etc.
GCAM existing work and my work

**GCAM existing work:**
- 11 sub-industrial sectors and 6 end-uses for each sector.
- Other regions only **one aggregated industrial sector** with cement separated.

**My work: similar structure and** focus on China industry sector
- Add CCS technologies in industry sector.
- China latest data (2005-2010): industry structure, efficiency, energy supply mix, expected peak output (steel, cement), etc.
- **data availability:** Update end-use allocation share based on US MECS 2006.
Sub sectors and end-uses for each sector

<table>
<thead>
<tr>
<th>11 subsectors</th>
<th>6 end-use:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Iron and steel,</td>
<td>(1) boilers general</td>
</tr>
<tr>
<td>(2) Chemicals</td>
<td>(2) process heat</td>
</tr>
<tr>
<td>(3) aluminum and nonferrous metals,</td>
<td>(3) machine drive,</td>
</tr>
<tr>
<td>(4) other nonmetallic minerals,</td>
<td>(4) electrochemical</td>
</tr>
<tr>
<td>(5) other manufacturing</td>
<td>(5) other end uses</td>
</tr>
<tr>
<td>(6) pulp paper and wood</td>
<td>(6) feedstock</td>
</tr>
<tr>
<td>(7) Agriculture</td>
<td></td>
</tr>
<tr>
<td>(8) Construction</td>
<td>• For agriculture, constriction, and mining sectors,</td>
</tr>
<tr>
<td>(9) Mining</td>
<td>aggregated into one energy end-use due to data</td>
</tr>
<tr>
<td>(10) Food processing</td>
<td>availability and simplify</td>
</tr>
<tr>
<td>(11) <strong>Cement is separated due to process CO2 emission</strong></td>
<td></td>
</tr>
</tbody>
</table>

*For agriculture, constriction, and mining sectors, aggregated into one energy end-use due to data availability and simplify*
Increase very fast and more than 50% of world in 2010 can not continue any more, because saturation effect in residential building and infrastructure construction. China steel and cement peak output and 2050 level.

<table>
<thead>
<tr>
<th></th>
<th>Estimated Peak year</th>
<th>Peak output (Mt/yr)</th>
<th>Peak output t/ per capita</th>
<th>2050 level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>2015</td>
<td>650-820</td>
<td>0.47-0.54</td>
<td>Low:0.42(WEU 2005), High: 0.65(Japan 2005 ); Middle: 0.52</td>
</tr>
<tr>
<td>Cement</td>
<td>2015</td>
<td>2200-2400</td>
<td>1.60-1.75</td>
<td>Low: 0.51(WEU 2005), High: 0.73(Japan 1995);Middle: 0.62</td>
</tr>
</tbody>
</table>
Key driver of per capita GDP in China is only 44% of the developed regions level in 2050

Same to reference scenario and policy scenario
Policy scenario: carbon tax imposed globally: Since 2015: $15/ tCO2 (2005 price), increase rate per year: 3%
Industrial energy use reaches peak about 2040 towards low energy-intensive and high valued production

Energy use reduced by 5% in 2050, 10% in 2095
HEI share: 73% in 2005, 58% in 2050, 55% in 2095
Before 2040, steel is the major consumer.
Cement is the most affected sector by the carbon tax, reduced by 22% in 2050, due to high carbon intensity.

coal continue dominate the fuel supply;
In 2050, carbon tax leads a 23% reduction in coal and switch to low carbon fuels.
Energy consumption by end uses and fuels
Industrial electrification plays a smaller role than expected

Major energy use in China is for boilers, process heat, and feedstock, electricity is not likely to displace fossil fuels even at high carbon prices
CCS potential in industry sector is huge and cost-competitive

Somewhat lower than existing assessments

Ctax scenario: 446 MtCO2 in 2050 and 937 MtCO2 in 2095.

Cement reasons:

production, CCS cost, alternative options, limited end uses and sectors or feedstock included
Industrial total CO2 emissions reaches peak in 2035

Reference scenario: Peaks about 9 GtCO2—two times of 2005 level, only 20% increase of 2010 level. Indirect emissions from grid electricity: 23-30%.

Policy scenario, CO2 emission decreased by 24% in 2050, and further decreased by 66% in 2095.
Summary

1. Peak energy consumption and emissions are reached between 2030 and 2040 in China
2. HEI sectors energy share will decrease gradually in the future
3. Coal use continues to dominate industrial fuel supply
4. Industrial electrification plays a smaller role than expected, due to boilers, process heat fuelled by coal fuel
5. CHP and CCS are promising and cost-competitive options and huge potential