Evaluation of Reduction of CO\textsubscript{2} Emission and Environmental Benefits under various scenarios
A case study of Jinan, China

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Air pollution is becoming a serious issue.
Carbon Reduction is a big challenge.

Fig. 1 Air quality of 338 cities in China in 2017

Fig. 2 China's primary energy consumption from 1965 to 2017
Air pollution is also a serious issue in Jinan.

Fig. 3 Location and air quality of Jinan in 2017
Try to Answer:

- Energy demands of Jinan from 2016 to 2050 under PC, LC, and ELC scenarios?
- Environmental benefits of Jinan from 2016 to 2050 under PC, LC, and ELC scenarios?
METHODOLOGY

✓ An Integrated Model Based-on LEAP & LCA
Fig. 4. The Integrated LEAP & LCA Model Framework
The data of social, economic, sector in model from the status of Jinan and its development plans

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>2016</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2050</th>
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<tbody>
<tr>
<td>Population</td>
<td>Million</td>
<td>8.61</td>
<td>10.35</td>
<td>12.00</td>
<td>12.73</td>
<td>13.50</td>
<td>13.37</td>
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<td>Urbanization rate</td>
<td>%</td>
<td>68.13</td>
<td>72.00</td>
<td>80.00</td>
<td>85.00</td>
<td>90.00</td>
<td>90.00</td>
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<tr>
<td>Households</td>
<td>Million</td>
<td>3.08</td>
<td>3.74</td>
<td>4.41</td>
<td>4.73</td>
<td>5.10</td>
<td>5.18</td>
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<tr>
<td>Urban</td>
<td>Million</td>
<td>2.16</td>
<td>2.76</td>
<td>3.60</td>
<td>4.08</td>
<td>4.64</td>
<td>4.72</td>
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<td>Rural</td>
<td>Million</td>
<td>0.93</td>
<td>0.98</td>
<td>0.81</td>
<td>0.66</td>
<td>0.46</td>
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<td>Per capita GDP</td>
<td>Thousand yuan</td>
<td>84.09</td>
<td>96.58</td>
<td>110.47</td>
<td>134.20</td>
<td>154.68</td>
<td>261.71</td>
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<td>GDP</td>
<td>billion</td>
<td>723.89</td>
<td>1000</td>
<td>1325.65</td>
<td>1708.08</td>
<td>2088.15</td>
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<td>Primary industry</td>
<td>%</td>
<td>5.10</td>
<td>4.01</td>
<td>3.41</td>
<td>2.90</td>
<td>2.66</td>
<td>2.03</td>
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<td>The secondary industry</td>
<td>%</td>
<td>37.60</td>
<td>36.97</td>
<td>35.54</td>
<td>34.10</td>
<td>32.81</td>
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<td>The tertiary industry</td>
<td>%</td>
<td>57.30</td>
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<td>61.04</td>
<td>63.00</td>
<td>64.53</td>
<td>68.90</td>
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METHODOLOGY

Four scenarios:
- Business-as-usual scenario (BAU)
- Low-carbon policy scenario (LC)
- Pollution control policy scenario (PC)
- Enhancing low carbon policy scenario (ELC)
In 2050, primary energy demands in PC, LC and ELC scenarios will decline by 4.1%, 13.6% and 55.8% compared to BAU scenario. From 2016 to 2030, the PC policies work more powerfully than the LC policies in terms of energy demand.
RESULT AND DISCUSSION

Energy demand

- From 2016 to 2030, pollutant control policy will be more effective than LC. Because of the sustainable promotion of energy-saving buildings, primary energy demand in LC scenario will be less than those in PC scenario after 2030.

- In ELC, the primary energy demand of industry will fall by 45% compared with 2016. The steel industry is largest energy demand sector in 2016, which was 28.53 Mtce. However, its proportion will drop from 44.41% in 2016 to 0.85% in 2030 and even to 0.1% in 2050.

Fig.6. Energy demands by sectors of PC, LC and ELC in Jinan
In 2050, PM$_{2.5}$ emission will be 4.82%, 16.23% and 78.09% lower in PC, LC and ELC scenarios than that in BAU scenario. NMVOC$_S$ emission will be 3.45%, 4.80% and 60.13% lower in PC, LC and ELC scenarios than those in BAU scenario.
RESULT AND DISCUSSION

Pollutants and CO$_2$ emission

In 2050, PM$_{10}$ emission will be 4.15%, 17.38% and 79.67% lower in PC, LC and ELC scenarios than those in BAU scenario. SO$_2$ emission will be 5.82%, 16.33% and 88.87% lower in PC, LC and ELC scenarios than those in BAU scenario.

Fig.8. PM$_{10}$ and SO$_2$ emissions of all scenarios in Jinan
RESULT AND DISCUSSION

Pollutants and CO₂ emission

In 2050, CO₂ emission will be 6.63%, 14.63% and 79.17% lower in PC, LC and ELC scenarios than that in BAU scenario. NOₓ emission will be 5.71%, 13.89% and 82.51% lower in PC, LC and ELC scenarios than that in BAU scenario.
RESULT AND DISCUSSION

Pollutants and CO$_2$ emission

In 2050, CO emission will be 1.03%, 10.54% and 61.88% lower in PC, LC and ELC scenarios than that in BAU scenario.

Fig. 10. CO emission of all scenarios in Jinan
RESULT AND DISCUSSION

Pollutants and CO$_2$ emission

Fig.11. CO$_2$, PM$_{10}$, PM$_{2.5}$ and NO$_X$ emission from sector of ELC in Jinan
RESULT AND DISCUSSION

Pollutants and CO$_2$ emission

Fig. 12. CO and NMVOC$_S$ emission from sector of ELC in Jinan

The iron and steel industry is the major contributing sector of CO$_2$, PM$_{10}$, PM$_{2.5}$, NO$_X$ and SO$_2$ emission before 2030, and transportation is the major contributing sector of CO and NMVOC$_S$ emission during 2016-2050.
RESULT AND DISCUSSION

Environmental benefits

In 2050, GWP will be 6.62%, 14.60% and 79.10% lower in PC, LC and ELC scenarios than that in BAU scenario. HTP will be 5.61%, 14.05% and 82.20% lower in PC, LC and ELC scenarios than that in BAU scenario.

Fig.13. GWP and HTP of all scenarios in Jinan
RESULT AND DISCUSSION

Environmental benefits

In 2050, POCP will be 5.14%, 14.09% and 82.14% lower in PC, LC and ELC scenarios than that in BAU scenario. PMFP will be 5.56%, 15.60% and 85.21% lower in PC, LC and ELC scenarios than that in BAU scenario.

Fig. 14. POCP and PMFP of all scenarios in Jinan
RESULT AND DISCUSSION

Environmental benefits

In 2050, AP will be 5.80%, 15.84% and 87.58% lower in PC, LC and ELC scenarios than that in BAU scenario.

Fig. 15. AP of all scenarios in Jinan
RESULT AND DISCUSSION

Environmental benefits

The share of transportation to POCP increases from 21.34% in 2016 to 50.70% in 2025, and will become the greatest contributor.
RESULT AND DISCUSSION

Environmental benefits

Fig. 17. GWP, HTP, PMFP and AP in sectors of ELC in Jinan
In 2050, primary energy demands under PC, LC and ELC scenarios will decline by 4.1%, 13.6% and 55.8% compared to BAU scenario.

In 2050, under PC, LC and ELC, GWP will be 6.62%, 14.60% and 79.10% lower scenarios than that in BAU scenario.

In terms of energy demand, from 2016 to 2030, the PC policies work more powerfully than the LC policies, while from 2030 to 2050 the LC policies will affect more powerfully.

under ELC scenario, energy demand will decrease significantly, it will be 55.8% lower than that in BAU scenario in 2050. CO₂, PM₁₀, PM₂.⁵, NOₓ and SO₂ will reduce by 79.17%, 79.67%, 78.09 %, 82.51% and 88.87%, respectively.
ACKNOWLEDGMENTS

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Thank You For Your Attention!