Current Status and Reduction on Potential for Materials Use in Buildings Construction in China

Da Yan
School of Architecture, Tsinghua University
2018.03.09
Background

The energy used to produce building materials such as cement, steel, aluminum, glass, et. al, plays an important role in energy system and is worthy to be focused on.

In order to get a better understanding, some researches on the material use situation and trends are needed.

Methodology

Increase of building floor area

Increase demand of building materials

Limit on new construction

Increase of energy consumption

Improve efficiency
Methodology

- Increase of building floor area
- Increase demand of building materials
- Increase of energy consumption
- Limit on new construction
- Improve efficiency
Current Status for China’s Buildings Construction

- With economic development and increasing living standards, China’s building construction industry has maintained a steady growth.

- China’s new annually completed buildings were around 1.5 billion m\(^2\) in 2001, and 2.6 billion m\(^2\) in 2016.

- Among the new buildings built in 2016, about 66% are residential buildings.

Current Status for China’s Buildings Construction

The growing floor space has led to the rapid growth of China’s buildings stock.

In 2016, China's total floor area was approximately 58.3 billion m\(^2\), in which urban residential floor area was 23.1 billion m\(^2\), rural residential floor area was 23.5 billion m\(^2\) and public and commercial floor area was 11.7 billion m\(^2\).

For residential buildings, China’s floor area per capita (FAPC) is 28.9 m$^2$ in urban areas and 40.4 m$^2$ in rural areas. (2016)

The FAPC in the US, Canada and Australia are all above 50 m$^2$ while that of most other OECD member countries is around 40 m$^2$.

Data for China is in 2016 while others in 2014.
Current Status for China’s Buildings Construction

- Average commercial floor area per capita in China is 8.5 m\(^2\), while that in US above 25 m\(^2\) and in most developed economics above 15 m\(^2\).

- There is still a big potential for public and commercial building stock growth, therefore related energy efficiency policy still has to focus on new-constructed buildings.

For different building types, the situation of floor area per capita (FAPC) is also different.

Methodology

- Increase of building floor area
- Increase of energy consumption
- Increase demand of building materials
- Limit on new construction
- Improve efficiency
Current Status for China’s Buildings Material Use

With the increasing building floor area, the use of building material also increased in the past years.

* In this part, the materials include both buildings and infrastructures.
With the increasing building floor area, the use of building material also increased in the past years.

* In this part, the materials include both buildings and infrastructures.
Current Status for China’s Buildings Material Use

With the increasing building floor area, the use of building material also increased in the past years.

* In this part, the materials include both buildings and infrastructures.

With the increasing building floor area, the use of building material also increased in the past years.

* In this part, the materials include both buildings and infrastructures.

Methodology

- Increase of building floor area
- Increase demand of building materials
- Increase of energy consumption
- Limit on new construction
- Improve efficiency
The total embodied energy consumption for the construction of buildings and infrastructure, including building materials production and construction, was 1.07 billion tce in 2015, accounting for 25% of China's total primary energy consumption.

93% of the energy consumption was for the production of materials (buildings and infrastructure).

Current Status for China’s Buildings Material Use

In 2015, the energy consumption for buildings construction was 0.45 billion tce, while that of infrastructure construction 0.77 billion tce.

The steel and cement are the materials consuming most energy.

The production of these materials was responsible for a lot of CO$_2$ emission. Besides, CO$_2$ is also a by-product during the production of cement.

In 2015, about 2 billion tones GHG emission was from building construction sector (including direct and indirect emission).
Methodology

Increase of building floor area

Increase demand of building materials

Increase of energy consumption

Limit on new construction

Improve efficiency
How many buildings are needed in China?

If the floor area keeps increasing in the next 15 years, the total building floor area in China may be more than 100 billion, which is not affordable in energy and environment.
Potential on Building Floor Area

Residential Buildings:

- The FAPC in urban area around 35 m²/cap while in rural area around 40 m²/cap may be suitable.
- With this scenario, the residential floor area in urban area would be around 35 billion m² while in rural area 19 billion m².

Data source: IEA-ETP database.
**Potential on Building Floor Area**

**Commercial Buildings:**

- For office buildings, the floor area is relatively enough;
- For public service buildings such as education and health care, more buildings are still needed;
- The FAPC around 10 to 15 m²/cap may be suitable.

<table>
<thead>
<tr>
<th></th>
<th>Building stock (billion m²)</th>
<th>FAPC (m²/cap)</th>
<th>Building stock (billion m²)</th>
<th>FAPC (m²/cap)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Office buildings</strong></td>
<td>4.31</td>
<td>3.1</td>
<td>5.00</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>Lodgings</strong></td>
<td>0.49</td>
<td>0.4</td>
<td>0.88</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Mercantile buildings</strong></td>
<td>2.17</td>
<td>1.6</td>
<td>2.79</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Education buildings</strong></td>
<td>1.63</td>
<td>1.2</td>
<td>3.53</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Health care buildings</strong></td>
<td>0.46</td>
<td>0.3</td>
<td>1.18</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>2.68</td>
<td>1.9</td>
<td>4.56</td>
<td>3.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>11.7</td>
<td>8.5</td>
<td>18.0</td>
<td>12.2</td>
</tr>
</tbody>
</table>

With suitable policy measures, the total floor area could be controlled under 80 billion m².

Comparing with the BAU scenario, this scenario is affordable for energy and environment, and possible to support living standard improvement and economic development.
The control of floor area may reduce about 75% of energy use for materials used in building construction.

* The energy use in this figure excludes the materials for infrastructures.
Reduce on Potential for Material Use Intensity

In the 13th five-year plan for promoting green buildings, the reduce of building material is also included.

In 2020, the buildings using green material should be more than 20% of total buildings, and more than 15% of newly-built buildings should be prefabricated building.

China’s Green building

Energy saving
Material saving
Water saving
Land saving
Environmental protection

Prefabricated building
Potential on Material Production Efficiency

Improve the energy efficiency of building materials

In the past years, the energy use intensity of building materials has decreased a lot, but still has room for the most efficient case.

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>2000</th>
<th>2016</th>
<th>Global advanced level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparable steel-sector</td>
<td>kgce/t</td>
<td>784</td>
<td>640</td>
<td>576</td>
</tr>
<tr>
<td>Primary aluminum smelting</td>
<td>kWh/t</td>
<td>15418</td>
<td>13599</td>
<td>12900</td>
</tr>
<tr>
<td>Cement</td>
<td>kgce/t</td>
<td>172</td>
<td>135</td>
<td>97</td>
</tr>
<tr>
<td>Building ceramics</td>
<td>kgce/m²</td>
<td>8.6</td>
<td>6.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Flat glass</td>
<td>kgce/weight case</td>
<td>25.0</td>
<td>14.4</td>
<td>13.0</td>
</tr>
</tbody>
</table>

Conclusion

- The newly completed buildings lead the increase of building material use.

- The total embodied energy consumption for the construction was 1.07 billion tce in 2015, accounting for 25% of China’s total primary energy consumption.

- In next 30 years, controlling floor area, promote green materials and prefabricated buildings, as well as improve the efficiency of material production can all contribute to the reduce of material.
Thanks for your attention!

yanda@tsinghua.edu.cn