**Supplementary information for:**

# Embodied Carbon Emissions in China's Building Sector: Historical Track from 2005 to 2020

**Chen Zhu [1], Zhihan Yang [1], Boyu Huang [2] and Xiaodong Li [1,*]**

[1] Department of Construction Management, Tsinghua University, Beijing 100084, China
[2] Department of Building and Real Estate, Faculty of Construction and Environment, Hong Kong Polytechnic University, Hong Kong 999077, China
* Correspondence: eastdawn@tsinghua.edu.cn

The following supplementary information corresponds to the chapter in the main text.

3.3.1 Data for the P-LCA Model

(1) Fossil energy carbon emission factors

**Table S1. Carbon emission factors for 17 energy types.**

| No. | Energy types | Lower heating value (PJ/$10^4$t,$10^8$m$^3$, etc.) | Carbon emission coefficient (MtCO2/PJ) | Oxidation rate | Carbon emission factor (tCO2/t,$10^4$m$^3$, etc.) |
|---|---|---|---|---|---|
| 1 | Raw coal | 0.2091 | 0.08746 | 89% | 1.619 |
| 2 | Cleaned coal | 0.2634 | 0.08746 | 89% | 2.040 |
| 3 | Other washed coal | 0.1539 | 0.08746 | 89% | 1.192 |
| 4 | Briquettes | 0.1780 | 0.08746 | 89% | 1.378 |
| 5 | Coke | 0.2844 | 0.10429 | 97% | 2.877 |
| 6 | Coke oven gas | 1.6308 | 0.07141 | 99% | 11.530 |
| 7 | Other gas | 0.8429 | 0.07141 | 99% | 5.959 |
| 8 | Other coking products | 0.2844 | 0.09121 | 97% | 2.516 |
| 9 | Crude oil | 0.4182 | 0.07328 | 98% | 3.003 |
| 10 | Gasoline | 0.4312 | 0.06925 | 98% | 2.927 |
| 11 | Kerosene | 0.4312 | 0.07182 | 98% | 3.035 |
| 12 | Diesel oil | 0.4265 | 0.07402 | 98% | 3.094 |
| 13 | Fuel oil | 0.4182 | 0.07731 | 98% | 3.168 |
| 14 | Liquefied petroleum gas (LPG) | 0.5018 | 0.06302 | 99% | 3.131 |
| 15 | Refinery gas | 0.4606 | 0.07328 | 99% | 3.341 |
| 16 | Other petroleum products | 0.4182 | 0.07402 | 98% | 3.033 |
| 17 | Nature gas | 3.8931 | 0.05606 | 99% | 21.607 |

**(3) Material carbon emission factors**

Table S2. Comprehensive carbon emission factors for production and transportation of major building materials.

| Year | Steel ($tCO_2/t$) | Timber ($tCO_2/m^3$) | Cement ($tCO_2/t$) | Glass ($tCO_2$/ weight case) | Aluminum ($tCO_2/t$) |
|---|---|---|---|---|---|
| 2005 | 2.521 | 0.074 | 0.408 | 0.049 | 17.988 |
| 2006 | 2.466 | 0.074 | 0.394 | 0.044 | 16.806 |
| 2007 | 2.405 | 0.072 | 0.384 | 0.038 | 15.927 |
| 2008 | 2.424 | 0.082 | 0.377 | 0.037 | 14.445 |
| 2009 | 2.425 | 0.083 | 0.351 | 0.037 | 14.149 |
| 2010 | 2.360 | 0.081 | 0.339 | 0.038 | 13.522 |
| 2011 | 2.351 | 0.077 | 0.337 | 0.037 | 13.724 |
| 2012 | 2.349 | 0.079 | 0.332 | 0.036 | 13.503 |
| 2013 | 2.302 | 0.077 | 0.326 | 0.034 | 13.561 |

| | | | | | |
|---|---|---|---|---|---|
| 2014 | 2.252 | 0.073 | 0.320 | 0.033 | 12.267 |
| 2015 | 2.204 | 0.069 | 0.316 | 0.033 | 11.598 |
| 2016 | 2.196 | 0.068 | 0.311 | 0.032 | 11.195 |
| 2017 | 2.171 | 0.067 | 0.309 | 0.032 | 11.019 |
| 2018 | 2.093 | 0.066 | 0.302 | 0.031 | 10.812 |
| 2019 | 2.058 | 0.065 | 0.300 | 0.028 | 10.308 |
| 2020 | 2.025 | 0.063 | 0.292 | 0.026 | 10.080 |

3.3.2. Data for the IO-LCA Model

(1) Input-output Tables

IO tables can be categorized into non-competitive and competitive IO tables based on whether domestic products and imports are distinguished in intermediate use and end-use, as shown in Figure S1 and Figure S2.

| Input \ Output | | Intermediate use | | | | Final use | Import | Total output |
|---|---|---|---|---|---|---|---|---|
| | | Sector 1 | Sector 2 | … | Sector $n$ | | | |
| Intermediate input | Sector 1 | $z_{11}$ | $z_{12}$ | … | $z_{1n}$ | $y_1$ | $M_1$ | $x_1$ |
| | Sector 2 | $z_{21}$ | $z_{22}^d$ | … | $z_{2n}$ | $y_2$ | $M_2$ | $x_2$ |
| | … | … | … | … | … | … | … | … |
| | Sector n | $z_{n1}$ | $z_{n2}$ | … | $z_{nn}$ | $y_n^d$ | $M_n$ | $x_n$ |
| Primary input | | $v_1$ | $v_2$ | … | $v_n$ | | | |
| Total input | | $x_1$ | $x_2$ | … | $x_n$ | | | |

Figure S1. The basic structure of the competitive input-output table.

| Input \ output | | | Intermediate use | | | | Final use | Import | Total output |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sector 1 | Sector 2 | … | Sector $n$ | | | |
| Intermediate input | Domestic products | Sector 1 | $z_{11}^d$ | $z_{12}^d$ | … | $z_{1n}^d$ | $y_1^d$ | | $x_1$ |
| | | Sector 2 | $z_{21}^d$ | $z_{22}^d$ | … | $z_{2n}^d$ | $y_2^d$ | | $x_2$ |
| | | … | … | … | … | … | … | | … |
| | | Sector n | $z_{n1}^d$ | $z_{n2}^d$ | … | $z_{nn}^d$ | $y_n^d$ | | $x_n$ |
| | Imported products | Sector 1 | $z_{11}^m$ | $z_{12}^m$ | … | $z_{1n}^m$ | $y_1^m$ | $M_1$ | |
| | | Sector 2 | $z_{21}^m$ | $z_{22}^m$ | … | $z_{2n}^m$ | $y_2^m$ | $M_2$ | |
| | | … | … | … | … | … | … | … | |
| | | Sector n | $z_{n1}^m$ | $z_{n2}^m$ | … | $z_{nn}^m$ | $y_n^m$ | $M_n$ | |
| Primary input | | | $v_1$ | $v_2$ | … | $v_n$ | | | |
| Total input | | | $x_1$ | $x_2$ | … | $x_n$ | | | |

Figure S2. The basic structure of the non-competitive input-output table.

Since the sectoral energy data collected from *China Energy Statistical Yearbook* only involves domestic production, non-competitive IO tables are the matching data. However, only non-competitive IO tables for 2017, 2018, and 2020 are available. Most of the previous studies on building EC using the IO-LCA method did not consider the mismatch of accounting data in this aspect. To ensure data consistency, we transform the competitive IO table to the non-competitive one using the scale decomposition method. The specific decomposition and transformation ideas are as follows. First, it is assumed that domestic products and imported products in the same sector have the characteristic of homogeneity, and the relative proportion of intermediate use and final use remains unchanged. Then, the following equations can be obtained according to the proportional relationship.

$$\frac{z_{ij}^d}{z_{ij}^m} = \frac{\sum z_{ij}^d}{\sum z_{ij}^m} = \frac{y_i^d}{y_i^m} = \frac{\sum z_{ij}^d + y_i^d}{\sum z_{ij}^m + y_i^m}$$

$$\frac{z_{ij}^d}{z_{ij}} = \frac{z_{ij}^d}{z_{ij}^m + z_{ij}^d} = \frac{\sum z_{ij}^d + y_i^d}{\sum z_{ij}^d + y_i^d + \sum z_{ij}^m + y_i^m} = \frac{x_i}{x_i + M_i}$$

$$\frac{y_i^d}{y_i} = \frac{y_i^d}{y_i^m + y_i^d} = \frac{\sum z_{ij}^d + y_i^d}{\sum z_{ij}^d + y_i^d + \sum z_{ij}^m + y_i^m} = \frac{x_i}{x_i + M_i}$$

where $z_{ij}^d$, $z_{ij}^m$ and $z_{ij}$ denote the domestic, imported, and total intermediate use from sector i to sector j, respectively; $y_i^d$, $y_i^m$ and $y_i$ denote the domestic, imported, and total final use, respectively; $x_i$ denotes the total domestic output; $M_i$ denotes the total imports.

Based on these equations, the intermediate use $z_{ij}$ and the final use $y_i$ in the competitive IO table can be split to obtain the non-competitive IO data required for EC accounting.