Steel Decarbonization in Context

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AGCI
November 2018
On average, every one of us has 220 kg of steel produced per year on our behalf.

We use it for everything, but mostly big things.

Steel has the highest emissions of any industrial sector.

Total: 8.3 GtCO₂ (2014)  
Direct Emissions Only

Total: 14.1 GtCO₂ (2014)  
Including Power Emissions

Process emissions are about half of steel emissions.

\[
Fe_3O_4 + 2 \text{ C} + \text{heat} \rightarrow 3 \text{ Fe} + 2 \text{ CO}_2
\]

Steel has a few production pathways, and they all have the same steps.

Extraction and Preparation

Mining and ore processing

Scrap collection, sorting, shredding

Reduction

Blast Furnace

Direct Reduction

Conversion and Alloying

Basic Oxygen Furnace

Electric Arc Furnace

Casting, Rolling, and Forming
Emissions reductions come in three basic categories.

\[
GHG = S \times \frac{P}{S} \times \frac{M}{P} \times \frac{GHG}{M}
\]

- **Product-Service Intensity**
  - Precision application
  - Increased product lifetimes
  - Reuse
  - Increased utilization

- **Materials Intensity**
  - Substituting low-C materials
  - Light-weighting
  - Process waste reduction
  - Recycling

- **Emissions Intensity**
  - CCS
  - Fuel switching
  - Bio-energy
  - Energy efficiency
  - Innovative processes
Opportunities abound to increase product lifetimes.

<table>
<thead>
<tr>
<th>Durable Goods</th>
<th>Typical Lifetime in China</th>
<th>Typical Lifetime in US/OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buses</td>
<td>6-7 years</td>
<td>12 years</td>
</tr>
<tr>
<td>Taxis</td>
<td>600,000 km</td>
<td>750,000+ km</td>
</tr>
<tr>
<td>Residential Buildings</td>
<td>33 years</td>
<td>75-80 years</td>
</tr>
<tr>
<td>Civil Engineering Works</td>
<td>30 years</td>
<td>60 years</td>
</tr>
</tbody>
</table>

Buildings can be reused, as well as their components.

Sources: skyscrapercentre.com, 300 Randolph St., and Allwood and Cullen (2015).
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Modern timber products can substitute for steel in many contexts.

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Economic conditions make the steel sector particularly resistant to change.

Headwinds include:
- Large-scale production
- Geographic concentration
- Trade exposure
- Long-lived capital
- Over-capacity
- Weak balance sheets