Options to supply the UK steel demand and meet the CO$_2$ targets

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Global industrial CO$_2$ emissions, 2005

- Steel, 25%
- Cement, 19%
- Aluminium, 3%
- Plastic, 4%
- Paper, 4%
- Other, 44%

(Allwood et al., 2012)

Global crude steel production

- +70%

Mt


(World Steel Association, 2014)
Reducing steel industrial emissions and supply future demand

How can steel industry emissions be reduced?

1. Switching to more efficient production routes;
2. Increasing the efficiency of current production routes;

In the UK:

- The Government has committed to a reduction of UK GHG emissions to 80% of the 1990 levels by 2050.
- **How to supply future demand for steel in the UK and meet this climate target?**
Steel flow to supply the UK demand, 2007
Steel flow to supply the UK demand, 2007

Iron and Steel Sector

Iron Ore

End-of-Life Scrap

DR: Direct reduction
BF: Blast furnace
OHF: Open hearth furnace
BOF: Basic oxygen furnace
EAF: Electric-arc furnace
FIC: Foundry of iron casting
IC: Ingot casting
CC: Continuous casting
SPC: Steel product casting

Rolling/Forming

Other Industry Sectors

UK Stock Added

Vehicles

Industrial Equip.

Construction

Metal Products

Legend

- Iron Ore used in the Rest of the World [Mt]
- UK Production [Mt]
- Crude Iron produced in the Rest of the World [Mt]
- Scrap in the Rest of the World [Mt]
- Steel produced in the Rest of the World [Mt]
- Losses [Mt]
In-use stock saturation

Stock added (per capita)

2030+

Metal goods

Vehicles

Industrial Equipment

Buildings and infrastructure

Stock removed (per capita)
Estimating future UK crude steel demand

<table>
<thead>
<tr>
<th>Product categories</th>
<th>Saturation stock [tonnes per capita] (Pauliuk et al., 2013)</th>
<th>Average lifetime [years] (Pauliuk et al., 2013)</th>
<th>Demand for new steel additions to stock [Mt]</th>
<th>Demand for crude steel [Mt]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>1.3</td>
<td>20</td>
<td>5.4</td>
<td>7.4</td>
</tr>
<tr>
<td>Industrial equipment</td>
<td>0.9</td>
<td>30</td>
<td>2.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Buildings and infrastructure</td>
<td>10.0</td>
<td>75</td>
<td>13.3</td>
<td>16.4</td>
</tr>
<tr>
<td>Metal goods</td>
<td>0.6</td>
<td>15</td>
<td>3.3</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12.8</strong></td>
<td><strong>24.5</strong></td>
<td><strong>31.7</strong></td>
<td></td>
</tr>
</tbody>
</table>
Options for future UK steel production
Options for future UK steel production

<table>
<thead>
<tr>
<th>Iron sources</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot metal from BF</td>
<td>67%</td>
<td>84%</td>
<td>5%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>DRI</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>Scrap</td>
<td>33%</td>
<td>16%</td>
<td>95%</td>
<td>75%</td>
<td>50%</td>
</tr>
</tbody>
</table>
UK Carbon Plan Pathways

4 pathways for a low carbon future:

- **Core MARKAL** (cost optimisation)
  - Higher renewables; more energy efficiency
  - Higher nuclear; less energy efficiency
  - Higher CCS; more bioenergy
Emissions for the UK steel industry in 2050

- CoreMARKAL
- + CCS, + Bioenergy
- + Renewables, + Energy Ef.
- + Nuclear, - Energy Ef.

Mt CO₂

Without CCS in steel industry
With CCS in steel industry
## UK Steel scenarios / Energy pathways

<table>
<thead>
<tr>
<th>A: Current Scrap / BF – BOF</th>
<th>B: BF – BOF</th>
<th>C: 95% Scrap – EAF</th>
<th>D: 75% Scrap / 25% DRI – EAF</th>
<th>E: 50% Scrap / 50% DRI – EAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoreMARKAL</td>
<td>High CCS, more bioenergy</td>
<td>High renewables, more energy efficiency</td>
<td>High nuclear, less energy efficiency</td>
<td></td>
</tr>
</tbody>
</table>

Total CO$_2$ emissions (in UK or other countries) required to supply UK steel demand in 2050, in terms of:

- UK production / steel imports required;
- Use of CCS in UK steel industry;
- Levels of UK electricity decarbonisation;
- Share of end-of-life scrap recycled;
- Products’ lifetime.
UK steel production / steel imports required

- CoreMARKAL
- + CCS, + Bioenergy
- + Renew., + Energy Ef.
- + Nuclear, - Energy Ef.

UK production Imports
Use of CCS in the UK steel industry
Change in products’ lifetime in the UK

- CoreMARKAL
  - + CCS, + Bioenergy
  - + Renew., + Energy Ef.
  - + Nuclear, - Energy Ef.

Mt CO₂

- A
- B
- C
- D
- E

- +50%
- +20%
- Baseline (Pauliuk, 2013)
- -20%
- UK emissions

Baseline (Pauliuk, 2013)
Conclusions

Best solutions to **minimise global CO\textsubscript{2} emissions** caused by steel purchased in the UK and to **reduce dependence on imports**:

- Maximise domestic end-of-life scrap in UK steel production;
- Deployment of direct reduced iron – electric arc furnace route in the UK;
- Extending products’ lifetime in the UK.
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