Charting a pathway for effective climate action

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Introduction

Responsible steel companies need to demonstrate commitment to effective climate action

- understand the scale and urgency of the challenge, the strategic business risks and the innovative opportunities
- quantify their own emissions, including up and downstream factors
- develop detailed action plans for reductions, targets and cost/benefits
- communicate with diverse stakeholders

Businesses should be able to articulate, at least in principle, a pathway to net zero emissions

Net global emissions need to be zero before 2050 to avoid dangerous climate change (> 1.5°C)

IPCC Report, October 2018
Acknowledgements

This presentation relies heavily on learnings from:

- The Crucible Group’s history of consulting and technology development focused on sustainability driven innovation
- World Steel Association publications and advice, especially around CO2 accounting
- two contrasting EAF case studies:
  i. a specialist steel products manufacturer in a developed economy, Molycop, Australia
  ii. a basic long products steel plant in a rapidly growing, developing economy, Vietnam

Context for case studies

<table>
<thead>
<tr>
<th>Steel sector perspectives</th>
<th>National Perspectives</th>
<th>Vietnam</th>
<th>Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic crude steel production, 2018</td>
<td>14.1 Mt/a</td>
<td>5.7 Mt/a</td>
<td></td>
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<tr>
<td>2008 production</td>
<td>2.7 Mt/a</td>
<td>7.6 Mt/a</td>
<td></td>
</tr>
<tr>
<td>Estimated contribution to GDP</td>
<td>4.7%</td>
<td>0.7%</td>
<td></td>
</tr>
<tr>
<td>Estimated contribution to GHG emissions</td>
<td>11.7%</td>
<td>2.1%</td>
<td></td>
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Emissions accounting

A Measurement, Reporting and Verification system (MRV) has been developed for this study.

The methodology is based on the **worldsteel CO₂ Data Collection and Accounting System**

- ‘black box’ input-out carbon balance for a site with clearly defined boundaries
- calculates net CO₂ emissions (other Greenhouse gases are not important in iron and steelmaking)
- most accurate global average emission factors
- tracking of direct (Scope 1) and indirect (Scope 2 and 3) emissions, as well as energy consumption
- widely adopted in the steel industry globally
- supported by international standards
- ‘user friendly’ guidelines and spreadsheets
- consistent reporting and communication platform

The MRV is compatible with IPCC protocols and other reporting systems, such as the Australian NGERS *

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Baseline Assessment (2018)

For EAF operations, electricity is the largest emission source (75% for the Vietnamese plant; 61% for the Australian plant).

The electricity emission factors for Vietnam and NSW are similar, 0.87 and 0.82 tonnes CO₂ per MWh respectively, due to significant coal power within their grids.

Compared to integrated steel plants:
- the contribution of coals and fossil carbon inputs is relatively minor, around 10% of total emissions
- EAF plants do not generate heating fuels, hence Natural Gas and light oil emissions are significant

The higher emissions for the Australian case reflects the complexity of Molycop’s specialty steel product manufacturing, not poor steelmaking efficiency.

<table>
<thead>
<tr>
<th>Emission Sources</th>
<th>Emission Intensity</th>
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<tbody>
<tr>
<td></td>
<td>tonnes CO₂ per tonne crude steel</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Australia</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.57</td>
</tr>
<tr>
<td>EAF Carbon</td>
<td>0.06</td>
</tr>
<tr>
<td>Heating Fuels</td>
<td>0.05</td>
</tr>
<tr>
<td>Fluxes</td>
<td>0.04</td>
</tr>
<tr>
<td>Other sources</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.76</strong></td>
</tr>
</tbody>
</table>

- EAF Carbon covers carbon additions and pig iron
- Heating Fuels covers Natural Gas and light oils
- Results include Scope 1, 2 and 3 emissions
- Molycop includes a credit for embodied carbon in products
International perspective

Electricity is the major emission source for EAF steelmakers, but steelmakers usually have little control over their electricity supply. When making global comparisons between steel companies, worldsteel suggests the use of the global average electricity emission factor, as determined by the IEA. This is 0.504 tonnes CO₂ per MWh, or in energy terms 9.8 GJ/MWh.

On this ‘level playing field’ basis, the Vietnamese EAF case study has CO₂ emissions 18% below the world average for EAF steelmakers. This reduces the actual total emissions from the plant to 0.75 tonnes CO₂ per tonne crude steel, 33% down from the 2018 Baseline of 1.14.

In Australia, Molycop has recently entered a Power Purchase Agreement which provides for 55% renewable electricity.

Emission profiles

Globally, the main differentiators between low and high emitting EAF plants are their use of electricity and Natural Gas (worldsteel).

Unlike BF-BOF plants, there is a systematic difference in emission profiles between low and high emitting EAF plants:

- As total emission intensity increases, there is a relative decrease in the contribution from Scope 2 emissions (electricity).
- Correspondingly, there is a trend towards the use of more Natural Gas (Scope 1) and more fluxes, pig iron, ferro-alloys (Scope 3) – symptomatic of more complex metallurgical operations.

For EAF plants, with a range of products, higher CO₂ emissions can be related in part to complexity, not simply inefficiency.

Molycop, as an efficient manufacturer of special steel products, is a practical example of this.
**Improvement strategies – Molycop EAF**

Molycop sees improving environmental performance as a core component of business success

Three existing strategies have the potential to reduce CO₂ emissions by a cumulative 70%

1. Molycop's Power Purchase Agreement provides for 55% renewable electricity supply; immediate reduction 33%, full potential 60% reduction

2. In collaboration with The Crucible Group, Molycop is developing bio-carbon products for EAF steelmaking - 5% potential

3. Ongoing efficiency improvements - 5% expected

A pathway to net zero emissions in the longer term can be envisaged through:

4. Substituting Natural Gas with electric heating* (with renewable electricity) and/or bio-gases – 20% potential

5. Appropriate stewardship responses to emissions associated with the upstream production of ferro-alloys, electrodes, gases, pig iron and fluxes

* Note that electric heating is already used in Molycop's international operations

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**Improvement potential – Vietnam EAF**

The MRV has been used to make a preliminary estimate of the potential scale of CO₂ emission reductions in the future for the Vietnamese EAF case study

1. **Improving Steelmaking Performance**
   
   Closing the gap between the 2018 Baseline and the low emitting EAF steel companies globally (worldsteel) – estimated 16% potential reduction in emissions

2. **Bio-derived Carbon**

   Substitution by charcoal of the fossil based carbon additions to the EAF (charge, injection and alloy carbon) – estimated 8% potential reduction

3. **Renewable Electricity**

   Assuming renewable power become available for EAF steelmaking operations – a further 63% reduction in emissions*

4. **Other sources**

   Heating fuels, alloys, fluxes and other minor sources make up the residual gap to zero net emissions

*improving steelmaking efficiency (1) will reduce the requirement for renewable electricity
Concluding remarks

Effective climate action benefits from, but is fundamentally deeper than, improving efficiency. Increasing climate urgency will drive innovation globally across the total steel system from resources to consumption. Successful steel companies will find viable pathways to significant emission reductions, based on:

1. the cost/benefits of particular initiatives
2. the explicit and implicit value placed on carbon by key stakeholders
   - customers
   - investors
   - regulators
   - society

To explore these matters further, please contact: Joe.Herbertson@thecrucible.com.au

The challenge ahead is enormous

![Image of Direct CO2 intensity in iron and steel]

IEA global data

Background on The Crucible Group’s CBC technology

The Crucible Group has taken its CBC technology from a fundamental idea to commercialisation. Our distinctive, competitive features are:

- highest yields of quality biochar and wood vinegar
- clean burning gas direct from the CBC

The first commercial project is at an advanced stage of construction.

Indicative Inputs - Outputs

<table>
<thead>
<tr>
<th>Feed Materials</th>
<th>The Continuous Biomass Converter (CBC)</th>
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<tbody>
<tr>
<td>Biomass and organic wastes and residues (1 tonne)</td>
<td>Char</td>
</tr>
<tr>
<td></td>
<td>Carbon-rich product for industry and agriculture (350 kg)</td>
</tr>
<tr>
<td>Gas</td>
<td>Clean energy for industrial heat and power (3 GJ)</td>
</tr>
<tr>
<td>Wood Vinegar</td>
<td>Water based condensate for agriculture (PA) (380 litres)</td>
</tr>
</tbody>
</table>

Strong IP portfolio

- 5 patent families covering process fundamentals, engineering, special feedstocks and applications
- 12 patents granted to date in USA (3), Europe, Canada, Australia (2), Brazil, Italy, UK, Germany, France
The CBC journey

Feed Preparation

Compact engineering

Industrial applications

Agricultural markets

Site of first commercial plant, Lismore, NSW

Commercial opportunities

The Crucible Group supplies the CBC technology and the associated specialist plant and equipment to customers under an operating licence.

We work in partnerships, including Northside Industries (authorised machine builder), BioCarbon (commercialisation) and PyroAg Pty Ltd (product market development).

We are collaborating with Molycop to develop products and practices that can utilise CBC char in EAF steelmaking.

Beyond the core CBC technology, options may exist to provide project specific support to customers, including

- balance of plant engineering
- feedstock sourcing or evaluation
- project development and financing
- regulatory approvals
- operations
- product off-takes

To explore CBC opportunities further, please contact: Joe.Herbertson@thecrucible.com.au