Process Integration: Reduction of CO₂ Emissions and Energy Consumption at BlueScope’s Port Kembla Steelworks (PKSW)

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BlueScope’s global manufacturing footprint at June 2012 (shown by FY2013 reporting)

**Notes:**
1. Tata BlueScope Steel is a 50:50 JV between BlueScope Steel and Tata Steel – metallic coating line commenced trials and paint line commenced operations at end of CY2011. Will not be included in NS BlueScope Coated Products JV with NSSMC.
2. North Star is a 50:50 JV between BlueScope Steel and North Star Steel (subsidiary of Cargill Inc.); BSL equity share 1.0mt
3. Water sites in the U.S. have been consolidated into ASC sites
4. Four sites in Malaysia, one in Singapore, one in Brunei
5. Two manufacturing sites, seven sales
6. One line has been idled, reducing available capacity by approx 230ktpa
Progress Towards BSL goal of Zero Harm

Lost Time Injury Frequency Rate

Medically Treated Injury Frequency Rate

Includes Contractors from 1996
Includes Contractor from May 2004
Includes 2007/8 acquisitions

Includes period of Australian operational restructure

Note: 1 – The MTIFR baseline has been reset from 4.4 to 6.3. This change relates to revised principles that raise the bar on BlueScope’s MTI definition
Introduction

• BlueScope and the iron and steelmaking industry have been reducing their energy consumption and emissions of greenhouse gases (GHG) for a number of decades

• Short-term: Transitional measures to implement best practice and incremental decreases

• Long-term, programs like worldSteel’s CO₂ Breakthrough aimed at substantial reduction targets
  – Technologies which aim to reduce CO₂ emissions by 50% (20-50 years)
Introduction 2

• In 2010, Australia introduced a price of $23 /tonne of CO\textsubscript{2} emitted
• In June 2013, it was announced that ETS will start July 1, 2014
• In September 2013, a new Federal Government announced that it will abolish price on C/ETS and will adopt a ‘Direct Action Policy’.
• This process will start this month in the Parliament
• Assessment of introducing short or medium term improvements, is a complex process, therefore

For a steel plant, assessment of new technologies or alternate operating scenarios should be based on **Process Integration methodologies**, which permit an integrated, inter-departmental approach rather than a localised operation-based approach
Introduction: Manufacturing Plant Mass and Energy

Scope = Gate-to-Gate Manufacturing Supply Chain
ISEEM: Integrated Steelworks Energy and Emissions Model

- ISEEM is a steady state, comprehensive mass and energy balances model of Port Kembla Steelworks
  - Various unit models are coded (e.g. BF, BOS, CO, etc.) and interlinked via distribution systems (COG, BFG, electricity, etc.)
  - Metallurgical models, for example, for the BF and BOS, are based on mass, energy, metallurgical and thermodynamic relationships
  - This is a complex flowsheet problem with many interconnections and recycles
    - > 35,000 equations
ISEEM: Integrated Steelworks Energy and Emissions Model

- The solution of equations is NOT on a unit by unit basis, but a *simultaneous* one
- Aspentech’s flowsheeting package, Aspen Custom Modeller (ACM), is used
- Dynamic aspects dealt with by running the model over a number of time slices within the desired period
UNITS

- BLAST FURNACE
- BASIC OXYGEN STEELMAKING
- SLAB CASTER
- HOT STRIP MILL
- GAS FIRED BOILER
- COKE OVENS
- BLAST FURNACE STOVES
- ELECTRIC AIR COMPRESSORS
- LIME/DOLOMITE KILN
- TURBO ALTERNATORS
- TURBO BLOWERS
- NITROGEN/OXYGEN/ARGON PLANT

High level flowsheet configuration, gate-to-gate
ISEEM Application

ISEEM can be used for:

- Understanding the complex process interactions within the steelworks

- Decision support in scenario modelling (PCI, TRT, ferrous dust treatment, etc)

- Determining where energy savings can be achieved (Co-generation plants, etc)

- A basis for future steelworks modelling advances
ISEEM – Graphical User Interface

• An interface written in EXCEL Visual Basic has been developed for ISEEM

• The interface allows easier use of ISEEM by end users (T&E, BF, etc.)
Table 1

<table>
<thead>
<tr>
<th>Stream Description</th>
<th>INPUT value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab production</td>
<td>245.83</td>
<td>t/h</td>
</tr>
<tr>
<td>HSM Coil Production</td>
<td>275.672</td>
<td>t/h</td>
</tr>
<tr>
<td>BF5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pellet%</td>
<td>26.3</td>
<td>%</td>
</tr>
<tr>
<td>Lump%</td>
<td>15.88</td>
<td>%</td>
</tr>
<tr>
<td>PCI, kg/thm</td>
<td>111.58</td>
<td></td>
</tr>
<tr>
<td>Hot met. temp.</td>
<td>1505.63</td>
<td>ºC</td>
</tr>
<tr>
<td>Slag temp.</td>
<td>1555.63</td>
<td>ºC</td>
</tr>
<tr>
<td>SRE</td>
<td>93.6667</td>
<td></td>
</tr>
<tr>
<td>BF6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pellet%</td>
<td>26.25</td>
<td>%</td>
</tr>
<tr>
<td>Lump%</td>
<td>20.78</td>
<td>%</td>
</tr>
<tr>
<td>PCI, kg/thm</td>
<td>149.54</td>
<td></td>
</tr>
<tr>
<td>Hot met. temp.</td>
<td>1501.96</td>
<td>ºC</td>
</tr>
<tr>
<td>Slag temp.</td>
<td>1551.96</td>
<td>ºC</td>
</tr>
<tr>
<td>SRE</td>
<td>93.24755</td>
<td></td>
</tr>
<tr>
<td>Plate Mill Production</td>
<td>47.77</td>
<td>t/h</td>
</tr>
<tr>
<td>Tin Mill Production</td>
<td>31.06</td>
<td>t/h</td>
</tr>
</tbody>
</table>

Example 1 - High level input, likely to be used management
- Data shown is pre-shut down of BF5
- Current data is different
Example 1 - high level output, likely to be used by management

- Other custom made inputs/outputs are available for other units, e.g. BFs, BOS, etc.
# Plant Energy Balance

## Energy Balance Summary

<table>
<thead>
<tr>
<th>Plant Energy Input (GJ)</th>
<th>Plant Energy Output (GJ)</th>
<th>Summary (GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Coke Making</td>
<td>Total Coke Making</td>
<td>Net energy</td>
</tr>
<tr>
<td>Electricity</td>
<td>Coke</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>COG</td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>By-product (BTX and Tar)</td>
<td></td>
</tr>
<tr>
<td>Coke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry clean coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sister Plant Energy Input (GJ)</th>
<th>Sister Plant Energy Output (GJ)</th>
<th>Net energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ore Preparation Energy Input (GJ)</th>
<th>Ore Preparation Energy Output (GJ)</th>
<th>Net energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Boiler Energy Input (GJ)</th>
<th>Total Boiler Energy Output (GJ)</th>
<th>Net energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plate Mill Energy Input (GJ)</th>
<th>Plate Mill Energy Output (GJ)</th>
<th>Net energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hot Strip Mill Energy Input (GJ)</th>
<th>Hot Strip Mill Energy Output (GJ)</th>
<th>Net energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy</td>
<td>Net consumption</td>
<td></td>
</tr>
</tbody>
</table>
Slab Production vs. Relative CO$_2$ Emissions
CO$_2$ Emissions vs Rate of PCI

increase in CO$_2$ emissions (%) vs PCR (kg/t-HM)

- The way the problem is constrained is important
- Keeping AFT fixed or free makes a big difference
ISEEM Results Vs PKSW Reported Results

• Overall, results show good agreement
• Model can still be improved in many localised areas
• Some differences are still within 5%
• Ways of constraining ISEEM may need to be modified
Relative Emission Contributions of all Major Units

<table>
<thead>
<tr>
<th>Major User</th>
<th>Relative %</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF #6</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>BF #5</td>
<td>23%</td>
<td>48%</td>
</tr>
<tr>
<td>Sinter Plant</td>
<td>8%</td>
<td>56%</td>
</tr>
<tr>
<td>Battery 6</td>
<td>6%</td>
<td>62%</td>
</tr>
<tr>
<td>Battery 7</td>
<td>7%</td>
<td>69%</td>
</tr>
<tr>
<td>BFStove # 6</td>
<td>5%</td>
<td>74%</td>
</tr>
<tr>
<td>Hot Strip Mill</td>
<td>5%</td>
<td>79%</td>
</tr>
<tr>
<td>BFStove # 5</td>
<td>5%</td>
<td>84%</td>
</tr>
<tr>
<td>Battery 4</td>
<td>4%</td>
<td>89%</td>
</tr>
<tr>
<td>Battery 5</td>
<td>4%</td>
<td>93%</td>
</tr>
<tr>
<td>Lime kiln + Dol. Kiln</td>
<td>2%</td>
<td>95%</td>
</tr>
<tr>
<td>Plate Mill</td>
<td>1%</td>
<td>96%</td>
</tr>
<tr>
<td>Boiler 25</td>
<td>1%</td>
<td>97%</td>
</tr>
<tr>
<td>Boiler 24</td>
<td>1%</td>
<td>98%</td>
</tr>
<tr>
<td>Boiler 21</td>
<td>1%</td>
<td>99%</td>
</tr>
<tr>
<td>Boiler 22</td>
<td>1%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Target Setting and reduction Studies

The objectives of the study were to:

- Part I: Assess the capability of BlueScope to reduce GHG emissions

- Part II: Set a target for future GHG emissions, by:
  - Assessing the current status of GHG and energy emission for BSL.
  - The emissions inventory was audited and its accuracy was assessed. This formed a base level for comparison against suitable benchmarks.
Target Setting Study

• **Part 1 provided:**

1. An estimate of energy consumptions and GHG emissions for a baseline period

2. An Energy Audit. The audit was taken to the level of the lowest practical user, and included all major energy sources and users.
Target Setting Study

• Part 2

- Detailed benchmarking and target setting exercise for a selected sample of business units.

- A sample of Business Units was used to determine a suitable target for BSL.

- The sample was representative of the BSL’s complete operations

- This included iron making, steelmaking, rolling, metal coating, steel processing and logistics.

- All selected units were *analysed* for its energy use, and *normalised* for their equipment configuration and raw materials.
Plant emissions were placed into three scopes. These are:

**Scope 1:** Direct emissions from site consumed by BSL. Examples include coal, coke and natural gas.

**Scope 2:** Indirect energy emissions on site. Examples include electricity and compressed air purchased and consumed by BSL.

**Scope 3.** All emissions beyond control of plant, but linked to operations. Examples: contracted gases (not generated on site) such as O$_2$ and N$_2$. 
Target Study: Scenarios Modelled

- BF
  - TRT
  - Top Gas Pressure
  - Coal Moisture
  - Blast Temperature
- CO
  - Coal drying
  - Improved efficiencies
- Post Re-line
- Post Sinter Plant Upgrade
- Best of Class
- Best of Similar Class
Comparison of CO$_2$ Total Emissions per Tonne of Steel for Various Scenarios
Comparison of Total Energy Consumption for Various Scenarios

![Bar Chart]

- **Base Case**
- **Base Case + TRT**
- **Base Case + TRT + TGP**
- **Post OPUP**
- **Post Reline - low SRE**
- **Post Reline - High SRE**
- **Best of Similar Class**
- **Best of Class**

**Total Energy Consumption as % of Base Case**
Water Fall Chart

- Best practice
- BOS gas utilisation
- CDQ
- TRT
- Coal drying
- Thinslab casting
- Waste heat
- Others
- PKSW

GJ/t-steel as % of Base Case
Port Kembla Steelworks New Configuration

- In Oct 2011
- BSL took a decision to:
  - shut down one of its two BFs
  - Cut down its production by half
  - Shut down CO4
- Changes were also made to power and steam generating facilities
Requirements of a PI Model

- Process Integration (IETS first w/shop)
  - Methodology
  - Tools
  - Data

- Requirements of a PI model
  - Flexible
  - Robust
  - Realistic
  - Has optimising capability
Introducing major changes raises new questions about the model:

- Model is configured in a particular way
- Tin Mill was successfully deleted
- Boilers deleted successfully
- Coke oven also deleted
- Other peripheral units
- BF6 was more difficult but deleted

This raises other questions:

- Constraining the model – backward or forward calculations?
- Sequential or simultaneous convergence?
- Constraining a sub model: BF minimum and maximum production rates? Model vs reality
More Questions

• Which platform to use?
  – Aspen Custom Modeller (equation solver)
  – AspenPlus or AspenHysys (process simulation package – friendly but not to I&SM industry)
  – Excel
  – Other
Conclusions

1. Process integration model is used extensively to evaluate a wide range of scenarios, including:
   - Changes in raw materials
   - Operation conditions
   - Energy consumption and CO₂ emissions reduction measures
   - Shutting down units

2. As PI is becoming more commonly used, it will be useful to re-visit the basics:
   - Methodology
   - Tools & platforms
   - Optimisation
   - Data

3. This forum is an excellent starting point
Thank You

Questions?