Towards a Globally Competitive Steel Industry in ASEAN

Strategies and Risk Mitigations As We Grow

Abhijit Sarkar
Vice President

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Hatch

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An Enviable Client Roster

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- Over 800 engineers in India and international offices
- 60% of our major clients have been with us for over 20 years
The Future of ASEAN Steel
Challenges on the Growth Path to Sustainability and Profitability

1. **Consumption Growth**
   - Driven by demographic factors and pro growth policies

2. **Supply Side**
   - North Asia success stories
   - POSCO, BaoSteel and CSC have not been replicated yet. Balancing Imports from competitive suppliers clearly prudent

3. **Trade Barriers**
   - Have been Instrumental in supporting younger steelmakers stronger mature steelmakers in down cycles

4. **Project Risk**
   - A phased and analytical approach needs to be taken, learning from experiences in other developing countries to mitigate risk and long term profitability

5. **Energy + Emissions Strategy**
   - Environmentally sustainable operations are essential for cost competitiveness

6. **Product Strategy**
   - As end use diversifies away from construction, product mix needs to consider both saleability in ASEAN and exportability to de-risk investments
“Developing ASEAN” growth healthy

Low base, urbanization, pro growth policies…

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>6.4%</td>
<td>4.4%</td>
<td>5.4%</td>
<td>5.5%</td>
<td>5.7%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Malaysia</td>
<td>6.1%</td>
<td>7.2%</td>
<td>4.6%</td>
<td>5.2%</td>
<td>4.9%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Philippines</td>
<td>1.8%</td>
<td>2.9%</td>
<td>4.8%</td>
<td>5.9%</td>
<td>6.5%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Singapore</td>
<td>7.8%</td>
<td>7.2%</td>
<td>5.9%</td>
<td>3.8%</td>
<td>3.2%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Thailand</td>
<td>7.9%</td>
<td>4.7%</td>
<td>4.6%</td>
<td>2.9%</td>
<td>3.3%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Vietnam</td>
<td>5.9%</td>
<td>7.6%</td>
<td>6.8%</td>
<td>5.9%</td>
<td>6.1%</td>
<td>6.0%</td>
</tr>
<tr>
<td><strong>World Average</strong></td>
<td>3.4%</td>
<td>3.3%</td>
<td>3.9%</td>
<td>3.5%</td>
<td>3.8%</td>
<td>3.7%</td>
</tr>
<tr>
<td>China</td>
<td>9.3%</td>
<td>10.4%</td>
<td>10.5%</td>
<td>7.8%</td>
<td>6.2%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Japan</td>
<td>4.6%</td>
<td>1.1%</td>
<td>0.8%</td>
<td>0.7%</td>
<td>0.7%</td>
<td>0.5%</td>
</tr>
<tr>
<td>India</td>
<td>5.6%</td>
<td>5.6%</td>
<td>7.6%</td>
<td>6.6%</td>
<td>7.6%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Korea</td>
<td>9.9%</td>
<td>7.0%</td>
<td>4.4%</td>
<td>3.0%</td>
<td>2.8%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Source: POSCO Research Institute
ASEAN steelmakers need to increase cost competitiveness in downstream industry

Global Avg. Conversion cost\(^1\) curve comparison for HR Bar

**Cash Cost in USD/MT, Q1 2016**

- Source: Metal Bulletin, Dastur

1 Conversion cost = Billet to HR Bar

2 Iran, Saudi Arabia, Syria, UAE, Qatar

3 Thailand

HR Bar Production in MTPA
Project Risk
Comprehensive project engineering and management for structuring, managing and financing medium to large engineering projects is essential to managing schedule and cost risk.
Shaping and Structuring becomes Vital in Steel Projects

<table>
<thead>
<tr>
<th>Fundamental Drivers of Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shaping and Planning</td>
</tr>
<tr>
<td>2. Investment in upfront work: FEL</td>
</tr>
<tr>
<td>3. Structuring Projects: EPC Vs Discrete</td>
</tr>
</tbody>
</table>

Successful implementation of large complex Engineering Projects need understanding, characterizing, quantifying, measuring and managing of risks, and hence cost and time.
The Challenge of “Wholesale Risk Transfer” through EPC Contracts

- Wholesale risk transfers from sponsors to EPC contractors in large projects is difficult
  - Contractors are not capitalized to absorb wholesale risk transfers in larger projects
  - Contractor concentration in large-project leadership -> fewer choices for the sponsor
  - EPC contract value is a floor not a ceiling, the cost risk remains

- Risk transfer by sponsor is sometimes a “responsibility” transfer mechanism

- Risk is dynamic and not very well understood in medium – large projects
  - Turnkey suppliers extract the value through change control in execution
  - If risk is not well understood – what would you transfer?
Contract Type and Large Engineering Projects Outcomes

Success by contract type

Patterns of outcome by contract type

Discrete/Mixed Contracts offer the optimal mix

Source: IPA
### Case Study: Plant in MENA region

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Packages</th>
<th>Customer Estimate</th>
<th>EPC Tenderer # 1</th>
<th>EPC Tenderer # 2</th>
<th>Actual Cost (Discrete Turnkey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Process package (EAF, LF, CCM, Material handling and dedusting system)</td>
<td>37.39</td>
<td>39.47</td>
<td>39.47</td>
<td>39.47</td>
</tr>
<tr>
<td>2</td>
<td>BOP Packages</td>
<td>31.45</td>
<td>71.22</td>
<td>79.82</td>
<td>48.95 (↓)</td>
</tr>
<tr>
<td>3</td>
<td>Administration cost during construction</td>
<td>24.63</td>
<td>21.07</td>
<td>21.07</td>
<td>21.06</td>
</tr>
<tr>
<td>4</td>
<td>Project Management Consultancy</td>
<td>2.97</td>
<td>2.67</td>
<td>2.67</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total 1 to 4</strong></td>
<td><strong>96.44</strong></td>
<td><strong>134.42</strong></td>
<td><strong>143.02</strong></td>
<td><strong>112.46</strong></td>
</tr>
<tr>
<td>5</td>
<td>Project Contingency</td>
<td>3.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Project Cost</td>
<td>100</td>
<td>134.42</td>
<td>143.02</td>
<td>112.46 (↓)</td>
</tr>
</tbody>
</table>

Considering Customer estimate of project cost to be 100

**Cost Advantage of Discrete Contract**
Competitive benchmarking and initiatives

Comprehensive facility wise benchmarking, gains prioritization for cost improvements
Sustained competitiveness requires world-class operations

ASEAN plants need to benchmark against Best-In-Class (B-I-C) KPIs

<table>
<thead>
<tr>
<th>Metric</th>
<th>Current</th>
<th>B-I-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Energy Consumption Gigacalories</td>
<td>4.5</td>
<td>3.8</td>
</tr>
<tr>
<td>CO₂ Emissions Ton/TCS</td>
<td>2.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Coke Rate Kg/TCS</td>
<td>500</td>
<td>125</td>
</tr>
<tr>
<td>Specific Water Consumption Ton/TCS</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Slag and Waste Processing Percentage (%)</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>BF Productivity T/Wm³/Day</td>
<td>1.6</td>
<td>1.2</td>
</tr>
<tr>
<td>BOF Productivity No of heats/Converter/year</td>
<td>8000</td>
<td>4000</td>
</tr>
<tr>
<td>Labor Productivity T/Man Year</td>
<td>300</td>
<td>1200</td>
</tr>
</tbody>
</table>

Source: Dastur, UNIDO
Energy savings directly translate to cost savings across process units

<table>
<thead>
<tr>
<th>Process Unit</th>
<th>SECS</th>
<th>Savings Potential</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAF</td>
<td>0.21 Gcal /tcs</td>
<td>$5/tcs</td>
<td>Dastur Energy Audit, CSTEP report., Lawrence Berkeley Lab</td>
</tr>
<tr>
<td>Coke Oven</td>
<td>0.17 Gcal /tcs</td>
<td>$4/tcs</td>
<td></td>
</tr>
<tr>
<td>Blast Furnace</td>
<td>0.4 Gcal /tcs</td>
<td>$9/tcs</td>
<td></td>
</tr>
<tr>
<td>SMS+CCM</td>
<td>0.35 Gcal /tcs</td>
<td>$8/tcs</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>0.95 Gcal /tcs</td>
<td>$22/tcs</td>
<td></td>
</tr>
</tbody>
</table>

- **SECS**: Specific Energy Consumption savings potential for plant units in EM

**EAF**
- Scrap Pre heating
- Bottom stirring gas injections
- Improved process control
- Foamy slag practices
- Adjustable Speed Drives

**Coke Oven**
- Operating battery at Optimum coking Time
- Revamping Cooling towers
- Reducing screen loss at BF’s end
- Recovering heat through coke dry quenching
- Energy efficient motors

**Blast Furnace**
- Pulverized coal injection
- Top pressure recovery turbine
- Replacing generator sets with Thyristor controlled drives for skip motors

**SMS+CCM**
- Torpedo car
- Slag stopper for LS tapping in SMS 1
- Ingot casting facility to continuous casting facility in SMS
- Yield improvement with sequence casting
- Variable Speed Drives for machine cooling pumps

**Others**
- Sinter Plant
- Heat recovery after cooling of Sinter
- HSM
- Minimization of skin losses in furnaces
- Variable Speed Drives or De-scaler pumps
- Variable speed drives for Roll cooling pumps
- Recuperator servicing/replacing

1 Specific Energy Consumption savings potential for plant units in EM

Source: Dastur Energy Audit, CSTEP report., Lawrence Berkeley Lab
Achievable Energy and Emissions

Benchmarking and audits need to be converted into initiatives for iterative improvement and flow through to P&L
Getting a 360-degree Sustainability Framework in place

1. Environmental

2. Social

3. Economic

<table>
<thead>
<tr>
<th>UNIT</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Greenhouse Emission</td>
<td>tonnes CO₂/tonne crude steel cast</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>2. Energy Intensity</td>
<td>GJ/t crude steel cast</td>
<td>20.1</td>
<td>20.2</td>
</tr>
<tr>
<td>3. Material Efficiency</td>
<td>% of materials converted to products and by-products</td>
<td>96.4</td>
<td>97.5</td>
</tr>
<tr>
<td>4. EMS Systems</td>
<td>% of employees and contractors working in registered production facilities</td>
<td>90.2</td>
<td>94.0</td>
</tr>
</tbody>
</table>

Source: WorldSteel, Sustainable Steel, 2016
2DS\textsuperscript{1} Targets Energy Intensity of Global Steel producing countries

Energy Transfer Perspective project

- "2 Degrees Scenario" cap global temperature increase at 2C with 80% probability
- Reduce carbon emissions by 30% while growing steel volumes 51% by 2030
Nucor (USA): Environment advantages, but needs economical scrap

CRITERIA POLLUTANTS (LBS PER TON)

<table>
<thead>
<tr>
<th></th>
<th>PARTICULATE MATTER</th>
<th>SULFER OXIDES</th>
<th>NITROGEN OXIDES</th>
<th>CARBON MONOXIDE</th>
<th>VOLATILE ORGANIC COMPOUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECYCLING MINI MILL</td>
<td>.30</td>
<td>.7</td>
<td>.1</td>
<td>4.0</td>
<td>.4</td>
</tr>
<tr>
<td>BLAST FURNACE</td>
<td>39.8</td>
<td>5.0</td>
<td>.5</td>
<td>44.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

ENERGY CONSUMPTION (MBTU PER TON)

- 2009: 4.74 MBTU/tcs
- 2011: 4.05 MBTU/tcs
- 2013: 4.26 MBTU/tcs
- 2015: 4.13 MBTU/tcs

DIRECT GREENHOUSE GAS EMISSIONS

- 12 TON CO2/TON STEEL
- 0.2 TON CO2 (EQ)/TON STEEL

100% PROCESS WATER RECYCLED MULTIPLE TIMES

Source: Nucor Steel Annual Report 2015

CO₂: 0.2t/tcs vs. 1.2 US, 1.9 global avg
Energy: ~5 GJ/tcs vs. 20 GJ/tcs
Additionally, BF-BoF offers lower production costs for larger plants.

Cost of Production through EAF based route
USD/MT of Liquid Steel, Q3 2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost of Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASEAN1</td>
<td>372</td>
</tr>
<tr>
<td>US</td>
<td>349</td>
</tr>
<tr>
<td>India</td>
<td>361</td>
</tr>
<tr>
<td>China</td>
<td>390</td>
</tr>
</tbody>
</table>

Cost of Production through BoF based route
USD/MT of Liquid Steel, Q3 2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost of Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASEAN</td>
<td>281</td>
</tr>
<tr>
<td>US</td>
<td>218</td>
</tr>
<tr>
<td>India</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>292</td>
</tr>
</tbody>
</table>

Beneficiated Iron ore reserves + pelletization can produce steel at ~ $270-280/Mt

1 Thailand, Philippines, Indonesia, Malaysia

Source: Metal Bulletin, Dastur Analysis
State of the art Solid and Liquid Discharge strategies and a phased approach to reach it..
State of the Art in Waste Recycling: the Nippon Steel example

<table>
<thead>
<tr>
<th>By-product</th>
<th>Amount generated (wet weight – million tons)</th>
<th>Recycling application</th>
<th>Recycling rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FY2014</td>
<td>FY2015</td>
<td></td>
</tr>
<tr>
<td>Blast furnace slag</td>
<td>13.46</td>
<td>12.65</td>
<td>Blast furnace cement, fine aggregate, road base, etc.</td>
</tr>
<tr>
<td>Steelmaking slag</td>
<td>6.28</td>
<td>5.65</td>
<td>Road base, civil engineering materials, fertilizer, etc.</td>
</tr>
<tr>
<td>Dust</td>
<td>3.38</td>
<td>3.41</td>
<td>Raw materials for use in-house and also zinc refining</td>
</tr>
<tr>
<td>Sludge</td>
<td>0.39</td>
<td>0.40</td>
<td>Raw materials for in-house use</td>
</tr>
<tr>
<td>Coal ash</td>
<td>0.53</td>
<td>0.51</td>
<td>Cement raw materials</td>
</tr>
<tr>
<td>Waste furnace materials</td>
<td>0.28</td>
<td>0.28</td>
<td>Reuse, road base, etc.</td>
</tr>
<tr>
<td>Others</td>
<td>1.73</td>
<td>1.82</td>
<td>In-house use, others</td>
</tr>
<tr>
<td></td>
<td>26.05</td>
<td>24.71</td>
<td>Total recycling rate</td>
</tr>
</tbody>
</table>

Source: Nippon Steel Sustainability Report 2015

42.2 mt crude steel + 24.7 mt by-products
- 99% recycling rate
- only 360k industrial waste
- 90% recycled water, 10% freshwater use
Zero Liquid Discharge methods to scale development in a sustainable manner

Key Effluent treatment methods

<table>
<thead>
<tr>
<th>Conventional Treatment</th>
<th>Effluent Collected in Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Claiifoculator</td>
</tr>
<tr>
<td></td>
<td>Pressure sand filter</td>
</tr>
<tr>
<td></td>
<td>UF and Reverse Osmosis</td>
</tr>
<tr>
<td></td>
<td>Soft water Makeup</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High End Treatment</th>
<th>Effluent discharged outside Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use for low end purpose: dust suppression, etc.</td>
</tr>
<tr>
<td></td>
<td>Treat at Central effluent treatment Plant</td>
</tr>
</tbody>
</table>

| Tubular Membrane Filtration | 2 stage Reverse osmosis module |

Fresh water consumption with Captive Power plant  
Cum/ton of CS, 2015-2016

- High End Treatment
- Conventional Treatment
- Current

Current Consumption: 6.5
Consumption after Conservation: 4.4

Source: Dastur Analysis
Complete Environment Roadmap for A Leading Steel Plant

Zero Liquid Discharge
- Recovery of waste water; treatment by common effluent treatment plant with UF & RO and recycling into the process

Solid Waste Utilization
- Inventorization & Management of process solid wastes aiming at 100% utilization
- Management techniques
  - De-oiling of mill scale and sludge for use in Sinter Plant
  - Homogenization & conveying of revert fines
  - Blast Furnace GCP sludge dewatering system
  - Magnetic drum separator for metal recovery at BOF slag processing plant
  - BOF Slag processing plant for accelerated weathering of BOF slag

Rain Water Harvesting
- Collection and utilization of rainwater by
  - Groundwater recharge wells
  - Storm water harvesting structures for in-plant use

Fugitive Dust Control
- Control of fugitive dust generation by installation of
  - Dry fog dust suppression system
  - Dust extraction system
  - Water sprinkler system
  - Industrial vacuum cleaning system
  - Vehicle tyre washing units
  - Up-gradation of secondary emission system of BOF shops
  - Wind breaker

Greenery Development
- Increasing the foliage cover in and around the plant site, landscaping and reclamation of waste dump areas by
  - Identification of suitable planting location through satellite imagery & ground survey
  - Selection & plantation of suitable plant species
Summary

1. ASEAN consumption growth is there, production needs to be more broad based reducing construction concentration.

2. Lack of natural resources and cost competitive exporters means upstream capacity should be added judiciously, but value added steels competitively manufactured.

3. From an owner’s perspective discrete turnkey project planning and implementation is optimal for risk mitigation, schedule and cost overruns.

4. 360 degree energy-efficiency and cost competitiveness are synonyms, best practices are available.

5. Stewardship aside, environment and profitability often have a high correlation as well.
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