Development of Composite Sustainability Performance Index for Steel Industry

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Steel is valued as a major foundation of a sustainable world. This is achieved by a financially sound industry, taking leadership in environmental, social and economic sustainability and seeking continuous improvement.
Steel – World Scenario

- Steel is the world’s third largest commodity market
- Industry has undergone radical restructuring and has become more global, more efficient and more financially viable
- World crude steel output reached 1,239.5 million metric tons in 2006
- The top three steel producing countries in 2006 were China (418 mmt), Japan (116 mmt), United States (98 mmt) and India being 7th (44 mmt).
Sustainability Issues and Challenges

- Availability of Iron Ore and Coking Coal
- Energy Efficiency, CO2 emissions and climate change
- Development of new generation products
- Technology & innovation
- Consolidation, market demand, price fluctuation
- Financial robustness and cost competitiveness
- Stakeholder engagement and community initiatives
- Skilled and trained workforce
- Health and Safety of employees
- Value creation for stakeholders
Sustainability Management

- Guided by IISI vision
- Policies
- Systems & Standards
- Management tools
- Measurement and Indicators
- Sustainability Assessment, monitoring, review, feedback
- Transparency and Reporting
- Sustainable manufacturing approaches—environment, social, economic
Aim: To create aggregate measure for sustainability assessment of industry using composite Index

Calculation of a composite indicator to monitor progress in the implementation of sustainability practices in one of the steel plant

Simplified and quantified information

New approach provide for better integration of decision making

Provides framework for Sustainability Management
Composite Sustainability Performance Index

- Environment: pilot environment performance index (WEF, 2002), index of environment friendliness (Statistics Finland, 2003), eco-indicator 99 (Pre Consultants, 2001), Life cycle index (Khan, 2004), Korean Complex environment Index, Ecological Footprint, ETHIBEL, BOVESPA, DGSI, FTSE4Good, SRI, GEM.

- Economy: combined consumption level index, Human resources development index, composite basic needs indices, composite leading indicators (OECD, 2002), internal market index (JRC, 2002), Index of economic freedom, Business climate indicator.


- Sustainability: Dow Jones sustainability index (DJSI, 2003), index of balanced sustainable development (Seljak, 2001).
Steps for Construction of Composite Index

Step 1. Developing a theoretical framework
Step 2. Selecting sub-indicators
Step 3. Brainstorming/Multivariate analysis
  - Assessing the quality of the data for sub-indicators
  - Assessing the relationship between the indicators
Step 4. Weighting
Step 5. Data collection
Step 6. Normalisation of data
Step 7. Aggregation
Step 8. Testing for Robustness and Sensitivity
Step 9. Presentation
AHP Model for Composite Sustainability Performance Index

Composite Sustainability Performance Index

Levels:
- Level-1
- Level-2
- Level-3
- Level-4

Organizational Governance
- Indicators: 1, 2, 3, 4, 5

Technical Aspects
- Indicators: 1, 2, 3, 4, 5

Economic Performance
- Indicators: 1, 2, 3, 4, 5

Environment Performance
- Indicators: 1, 2, 3, 4, 5

Social Performance
- Indicators: 1, 2, 3, 4, 5

Performance Levels:
- Outstanding
- Good
- Average
- Fair
- Poor
Development of Composite Sustainability Performance Index for Steel Industry

Steel Authority of India Ltd., Bhilai Steel Plant

Generic Hierarchy of CSPI Evaluation

1. Identification & categorization of indicators
2. Finalize key indicators using cutoff value
3. Collection of quantitative data for indicators
4. Weighting of Indicators using AHP
   - Apply Liberatore five point Rating system
   - Z score method to calculate Weighted normalized score
5. Calculation of sub-index
6. Evaluate CSPI
Five Dimensions of Sustainability

- Environment - (15 indicators)
- Economic - (5 indicators)
- Social - (14 indicators)
- Organisational Governance - (12 indicators)
- Technical Aspects - (14 indicators)

Brainstorming session was conducted amongst 15 experts for identification of key sustainability issues.
Experts were asked to rate on 5-point Likert Scale, the level of importance of each indicator:
1= not important, 5 = very important

Cut-off value = 3.00
Organizational Governance

- Leadership
- Strategic planning & resource management
- Cost competitiveness
- Management tools
- Innovation & knowledge management
- Technology & investment
- Human resource management
- Order generation, market development & customer satisfaction
- Material management
- Research & Development
- Process management
- Information technology
Sustainability Indicators

Environment

- Particulate Matter stack emission load (kg/tcs)
- Percent utilisation of total solid wastes (%)
- Specific energy consumption (Gcal/tcs)
- Specific Raw material consumption (tonnes/tcs)
- Specific water consumption (m3/tcs)
- Specific carbon dioxide emission (t/tcs)
- Specific effluent load (Kg/tcs)
- Specific refrigerant consumption (Kg/tcs)
- Specific power consumption (Kwh/tcs)
Sustainability Indicators

Environment

- Specific refractory consumption (Kg/tcs)
- Percentage green cover of total plant area (%)
- Specific hazardous waste generation (Kg/tcs)
- Specific heavy metals discharge load (Kg/tcs)
- Average noise level in the periphery of plant dB(A)
- Overall average opacity around the plant (%)

Steel Authority of India Ltd., Bhilai Steel Plant
Sustainability Indicators

Society

- Nos. of fatal accidents
- Accident frequency rate
- Absenteeism rate (% of total man days available)
- Nos. of employees trained (man-days / employee/year)
- Expenditure on peripheral development
- Employee satisfaction
- Quality of life
**Sustainability Indicators**

**Society**

- Employment generation
- Non-discrimination, diversity & opportunity
- Freedom of association
- Child, forced labour & human rights issues
- Suppliers & contractors practices
- Concern for local communities
- Customer health & safety
Technical Aspects

- Coke rate (Kg/thm)
- BF productivity
- Labour productivity
- Export tonnage ratio
- Defects (%)
- Special grades production (%)
- New product development (% of saleable steel)
- Market performance (% increase in domestic share with previous year)
Sustainability Indicators

Technical Aspects

- Customer satisfaction index
- Saving through suggestions & QC projects (Rs/tcs)
- Cost reduction (Rs/tcs)
- Equipment availability (%)
- Order compliance (%)
- No. of complaints
Sustainability Indicators

**Economic**

- Gross margin / turnover ratio
- Net profit / average capital employed
- Net profit / total income or revenue
- Investment in new processes and products (% of revenues)
- Turnover / Inventory ratio
## Composite Indicators & Weighting Methods

### Method

<table>
<thead>
<tr>
<th>Method</th>
<th>Composite Indicators</th>
</tr>
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<tbody>
<tr>
<td>Equal weights</td>
<td>Environment Sustainability Index</td>
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<tr>
<td></td>
<td>Composite Leading Indicators</td>
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<tr>
<td>Principal Component Analysis/ factor Analysis</td>
<td>Internal Market Index</td>
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<tr>
<td></td>
<td>Business climate indicator</td>
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<td>General indicator of science and technology</td>
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<td>Data Envelopment analysis</td>
<td>Human development Index : a suggestion</td>
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<td>Synthetic meta-index for sustainable development</td>
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<td>Composite indicators of health system performance</td>
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<tr>
<td>Unobserved component models</td>
<td>Governance indicators</td>
</tr>
<tr>
<td>Distance to targets</td>
<td>Human development Index</td>
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<tr>
<td>Public Opinion</td>
<td>Health System achievement Index</td>
</tr>
<tr>
<td>Analytic Hierarchy Process</td>
<td>EU New Economy Policy Indicators</td>
</tr>
<tr>
<td>Conjoint Analysis</td>
<td>Indicator of quality of life in the city of Istanbul</td>
</tr>
</tbody>
</table>
AHP is a multiple step analytical process of judgment which synthesizes a complex arrangement into a systematic hierarchial structure.

- Allows both quantitative and qualitative criteria
- Decomposing the dataset into smaller elements
- Construction of hierarchy
- Conducting pair-wise comparative judgments
- Measurement and data collection
- Determining Normalized weights
- Synthesis-finding solution to the problem
## Intensity of Preference

<table>
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<th>Factor of Preference (p)</th>
<th>Importance</th>
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<tr>
<td>1</td>
<td>Equally preferred</td>
</tr>
<tr>
<td>2</td>
<td>Equally to moderately preferred</td>
</tr>
<tr>
<td>3</td>
<td>Moderately preferred</td>
</tr>
<tr>
<td>4</td>
<td>Moderately to strongly preferred</td>
</tr>
<tr>
<td>5</td>
<td>Strongly preferred</td>
</tr>
<tr>
<td>6</td>
<td>Strongly to Very Strongly preferred</td>
</tr>
<tr>
<td>7</td>
<td>Very strongly preferred</td>
</tr>
<tr>
<td>8</td>
<td>Very to Extremely Strongly preferred</td>
</tr>
<tr>
<td>9</td>
<td>Extremely preferred</td>
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## Pair-wise Comparison Matrix for Sustainability

<table>
<thead>
<tr>
<th>Dimensions of Sustainability</th>
<th>OG</th>
<th>TA</th>
<th>ECO</th>
<th>ENV</th>
<th>SOC</th>
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<tbody>
<tr>
<td>Organizational Governance (OG)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.33</td>
<td>3.00</td>
<td>2.00</td>
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<tr>
<td>Technical Aspect (TA)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.50</td>
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<tr>
<td>Economic (ECO)</td>
<td>3.00</td>
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<td>3.00</td>
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<tr>
<td>Environment (ENV)</td>
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<td>0.33</td>
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<tr>
<td>Society (SOC)</td>
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<td>0.50</td>
<td>0.33</td>
<td>1.00</td>
<td>1.00</td>
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## Pair-wise Comparison and Normalized Matrix

<table>
<thead>
<tr>
<th></th>
<th>OG</th>
<th>TA</th>
<th>ECO</th>
<th>ENV</th>
<th>SOC</th>
<th>Relative Weights</th>
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<td><strong>Organisational governance (OG)</strong></td>
<td>1.00</td>
<td>1.00</td>
<td>0.33</td>
<td>3.00</td>
<td>2.00</td>
<td><strong>0.205</strong></td>
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<tr>
<td><strong>Technical aspects (TA)</strong></td>
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<td>2.00</td>
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<td><strong>Economic (ECO)</strong></td>
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<td>1.00</td>
<td>3.00</td>
<td>3.00</td>
<td><strong>0.390</strong></td>
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<tr>
<td><strong>Environment (ENV)</strong></td>
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<td>0.33</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td><strong>Society (SOC)</strong></td>
<td>0.50</td>
<td>0.50</td>
<td>0.33</td>
<td>1.00</td>
<td>1.00</td>
<td><strong>0.106</strong></td>
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<table>
<thead>
<tr>
<th></th>
<th><strong>OG</strong></th>
<th><strong>TA</strong></th>
<th><strong>ECO</strong></th>
<th><strong>ENV</strong></th>
<th><strong>SOC</strong></th>
<th><strong>Relative Weights</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Org (OG)</td>
<td>0.17</td>
<td>0.20</td>
<td>0.13</td>
<td>0.30</td>
<td>0.22</td>
<td><strong>0.205</strong></td>
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<tr>
<td>Tech (TA)</td>
<td>0.17</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.22</td>
<td><strong>0.199</strong></td>
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<tr>
<td>Econ (ECO)</td>
<td>0.51</td>
<td>0.40</td>
<td>0.40</td>
<td>0.30</td>
<td>0.33</td>
<td><strong>0.390</strong></td>
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<tr>
<td>Environ (ENV)</td>
<td>0.06</td>
<td>0.10</td>
<td>0.13</td>
<td>0.10</td>
<td>0.11</td>
<td><strong>0.100</strong></td>
</tr>
<tr>
<td>Soc (SOC)</td>
<td>0.09</td>
<td>0.10</td>
<td>0.13</td>
<td>0.10</td>
<td>0.11</td>
<td><strong>0.106</strong></td>
</tr>
</tbody>
</table>
The Consistence Index ($CI$) of $n$ criteria

$CI = (\lambda_{\text{max}} - n)/n-1$ where $\lambda_{\text{max}}$ is the largest eigen value of an $n \times n$ pair-wise comparison matrix.

The Consistency ratio is calculated using the formula:

$CR = CI/RI$

The acceptable CR range varies according to the size of matrix i.e. 0.05 for a 3 x 3 matrix, 0.08 for a 4 x 4 matrix and 0.1 for all larger matrices $n \geq 5$ (Saaty, 2000).
## Weights for Sustainability Indicators

### Composite Sustainability Performance Index

#### Level-1

- **Organizational Governance (0.181)**
- **Technical Aspects (0.175)**
- **Economic Performance (0.329)**
- **Environment Performance (0.140)**
- **Social Performance (0.175)**

#### Level-2

1. **Organizational Governance (0.181)**
   - **LEAD** (0.095/0.017)
   - **SPRM** (0.080/0.015)
   - **CC** (0.080/0.014)
   - **MT** (0.049/0.009)
   - **IKM** (0.071/0.013)
   - **TI** (0.072/0.013)
   - **HRM** (0.057/0.010)
   - **OGMDCS** (0.175/0.032)
   - **MM** (0.044/0.008)
   - **RD** (0.045/0.008)
   - **PM** (0.186/0.034)
   - **IT** (0.045/0.008)

2. **Technical Aspects (0.175)**
   - **CR** (0.092/0.016)
   - **BFP** (0.088/0.015)
   - **LP** (0.069/0.012)
   - **ER** (0.056/0.010)
   - **DEF** (0.113/0.020)
   - **SGP** (0.039/0.007)
   - **NPD** (0.033/0.006)
   - **MP** (0.113/0.020)
   - **CSI** (0.079/0.014)
   - **SSSQC** (0.036/0.006)
   - **CR** (0.085/0.015)
   - **EA** (0.088/0.015)
   - **OC** (0.064/0.011)
   - **COMP** (0.047/0.008)

3. **Economic Performance (0.329)**
   - **GMTR** (0.231/0.076)
   - **NPACE** (0.379/0.125)
   - **NPRR** (0.146/0.048)
   - **INPP** (0.083/0.027)
   - **TIR** (0.162/0.053)

4. **Environment Performance (0.140)**
   - **PMEL** (0.137/0.019)
   - **PUSW** (0.111/0.016)
   - **SECR** (0.111/0.016)
   - **SRMC** (0.119/0.017)
   - **SWC** (0.079/0.011)
   - **SCDE** (0.069/0.010)
   - **SEL** (0.059/0.008)
   - **SRC** (0.022/0.003)
   - **SPC** (0.046/0.006)
   - **SRFC** (0.031/0.004)
   - **PGC** (0.037/0.005)
   - **SHWG** (0.044/0.006)
   - **SHMDL** (0.040/0.006)
   - **ANL** (0.032/0.005)
   - **OAO** (0.062/0.009)

5. **Social Performance (0.175)**
   - **NFA** (0.141/0.025)
   - **AFR** (0.084/0.015)
   - **ABR** (0.043/0.007)
   - **NET** (0.052/0.009)
   - **EPD** (0.104/0.018)
   - **ES** (0.077/0.013)
   - **QOL** (0.090/0.016)
   - **EG** (0.117/0.021)
   - **NDDO** (0.049/0.009)
   - **FOA** (0.052/0.009)
   - **CFL** (0.053/0.009)
   - **SCP** (0.031/0.005)
   - **CLC** (0.076/0.013)
   - **CHS** (0.031/0.005)

**Weights for Sustainability Indicators**

- **LW** : Local Weights, **GW** : Global Weights
Theoretical Methodology

Sub-Index = $S_i$
where $i$ = dimensions of sustainability i.e. OG, TA, ECO, ENV & SOC

Sub-Index for Organizational governance (OG) : $S_{IOG}$
Sub-Index for Technical Aspects (TA) : $S_{ITA}$
Sub-Index for Economic Performance (ECO) : $S_{IECO}$
Sub-Index for Environment Performance (ENV) : $S_{IENV}$
Sub-Index for Societal Performance (SOC) : $S_{SOC}$

Global weights : $GW_{ij}$ where $j$ = indicator 1, 2, 3 ……, n.
Local Weights : $LW_{ij}$

Weight for sustainability (1st level): $WS_i$ where $i$=OG, TA, ECO, ENV & SOC.
Local weight for criteria’s (2nd level): $LW_{ij}$ where $i$= OG, TA, ECO, ENV & SOC and $j=1, 2……., n$ indicators
Methodology # 1 for Normalization – Liberatore rating

Methodology # 1: Liberatore Score method
Rating is decided based on target & benchmark by expert

<table>
<thead>
<tr>
<th>Liberatore rating (LR_{ij})</th>
<th>O Outstanding</th>
<th>G Good</th>
<th>F Fair</th>
<th>A Average</th>
<th>P Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liberatore rating value: LR_v</td>
<td>0.513</td>
<td>0.261</td>
<td>0.129</td>
<td>0.063</td>
<td>0.034</td>
</tr>
</tbody>
</table>

SILR_i = Sub-Index based on Liberatore Score
Liberatore Score: LS_{ij}

GW_{ij} = WS_i \times WL_{ij}
LS_{ij} = LR_v \times GW_{ij}

Liberatore Maximum Score (LMAX_{ij}) = 0.513 \times GW_{ij}
SILR_i = 10 \times (\Sigma LS_{ij} / \Sigma LMAX_{ij})
## Liberatore's Five Point rating scale

<table>
<thead>
<tr>
<th>Rating scale</th>
<th>O</th>
<th>G</th>
<th>A</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding (O)</td>
<td>1.000</td>
<td>3.000</td>
<td>5.000</td>
<td>7.000</td>
<td>9.000</td>
</tr>
<tr>
<td>Good (G)</td>
<td>0.333</td>
<td>1.000</td>
<td>3.000</td>
<td>5.000</td>
<td>7.000</td>
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<tr>
<td>Average (A)</td>
<td>0.200</td>
<td>0.333</td>
<td>1.000</td>
<td>3.000</td>
<td>5.000</td>
</tr>
<tr>
<td>Fair (F)</td>
<td>0.143</td>
<td>0.200</td>
<td>0.333</td>
<td>1.000</td>
<td>3.000</td>
</tr>
<tr>
<td>Poor (P)</td>
<td>0.111</td>
<td>0.143</td>
<td>0.200</td>
<td>0.333</td>
<td>1.000</td>
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<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>G</th>
<th>A</th>
<th>F</th>
<th>P</th>
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<tr>
<td>Outstanding (O)</td>
<td>0.560</td>
<td>0.642</td>
<td>0.524</td>
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<tr>
<td>Good (G)</td>
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<td>0.214</td>
<td>0.315</td>
<td>0.306</td>
<td>0.280</td>
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<tr>
<td>Average (A)</td>
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<td>0.071</td>
<td>0.105</td>
<td>0.184</td>
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<tr>
<td>Fair (F)</td>
<td>0.080</td>
<td>0.043</td>
<td>0.035</td>
<td>0.061</td>
<td>0.120</td>
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<tr>
<td>Poor (P)</td>
<td>0.062</td>
<td>0.031</td>
<td>0.021</td>
<td>0.020</td>
<td>0.040</td>
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<tr>
<td>Indicators</td>
<td>Local Weights (Lw_{ij})</td>
<td>Global Weights (Gw_{ij})</td>
<td>Overall Rating (Lr_{ij})</td>
<td>Rating Value (LR_{ij})</td>
<td>Score (Ls_{ij})</td>
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<tr>
<td>------------------------------------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
<td>------------------------</td>
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<tr>
<td>Particulate Matter stack emission load (Kg/tcs)</td>
<td>0.137</td>
<td>0.019</td>
<td>O</td>
<td>0.513</td>
<td>0.010</td>
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<tr>
<td>Percent utilisation of total solid wastes (%)</td>
<td>0.111</td>
<td>0.016</td>
<td>A</td>
<td>0.129</td>
<td>0.002</td>
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<tr>
<td>Specific energy consumption (Gcal/tcs)</td>
<td>0.111</td>
<td>0.016</td>
<td>G</td>
<td>0.261</td>
<td>0.004</td>
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<tr>
<td>Specific Raw material Consumption (tonnes/tcs)</td>
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<td>0.017</td>
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<td>0.261</td>
<td>0.004</td>
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<tr>
<td>Specific water consumption (m3/tcs)</td>
<td>0.079</td>
<td>0.011</td>
<td>O</td>
<td>0.513</td>
<td>0.006</td>
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<td>Specific carbon dioxide emissions (t/tcs)</td>
<td>0.069</td>
<td>0.010</td>
<td>A</td>
<td>0.129</td>
<td>0.001</td>
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<tr>
<td>Specific effluent load (kg/tcs)</td>
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<td>0.008</td>
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<td>0.261</td>
<td>0.002</td>
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<td>Specific refrigerant consumption (kg/tcs)</td>
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<td>0.003</td>
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<td>0.001</td>
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<tr>
<td>Specific power consumption(Kwh/tcs)</td>
<td>0.046</td>
<td>0.006</td>
<td>A</td>
<td>0.129</td>
<td>0.001</td>
</tr>
<tr>
<td>Specific refractory consumption (kg/tcs)</td>
<td>0.031</td>
<td>0.004</td>
<td>A</td>
<td>0.129</td>
<td>0.001</td>
</tr>
<tr>
<td>Percentage green cover of total plant area (%)</td>
<td>0.037</td>
<td>0.005</td>
<td>O</td>
<td>0.513</td>
<td>0.003</td>
</tr>
<tr>
<td>Specific Hazardous waste generation (kg/tcs)</td>
<td>0.044</td>
<td>0.006</td>
<td>A</td>
<td>0.129</td>
<td>0.001</td>
</tr>
<tr>
<td>Specific Heavy metals discharge load (gm/tcs)</td>
<td>0.040</td>
<td>0.006</td>
<td>G</td>
<td>0.261</td>
<td>0.001</td>
</tr>
<tr>
<td>Average Noise level in the periphery of plant</td>
<td>0.032</td>
<td>0.005</td>
<td>G</td>
<td>0.261</td>
<td>0.001</td>
</tr>
<tr>
<td>Overall average Opacity around the plant (%)</td>
<td>0.062</td>
<td>0.009</td>
<td>A</td>
<td>0.129</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\[
\text{SILR}_{i} = 10 \times \left( \frac{\sum Ls_{ij}}{\sum LMAX_{ij}} \right)
\]

\[
\text{SILR}_{\text{ENV}} = 5.395
\]

\[
\text{Sum} = 0.039 \quad 0.0721
\]
### Development of Composite Sustainability Performance Index for Steel Industry

Sub-Index – Based on Liberatore rating

<table>
<thead>
<tr>
<th>Dimensions of Sustainability</th>
<th>03-04</th>
<th>04-05</th>
<th>05-06</th>
<th>06-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Governance(OG)</td>
<td>4.21</td>
<td>5.31</td>
<td>5.024</td>
<td>5.98</td>
</tr>
<tr>
<td>Technical Aspects (TA)</td>
<td>4.17</td>
<td>4.221</td>
<td>3.561</td>
<td>4.441</td>
</tr>
<tr>
<td>Environmental performance(ENV)</td>
<td>5.40</td>
<td>5.306</td>
<td>5.464</td>
<td>4.917</td>
</tr>
<tr>
<td>Societal Performance(SOC)</td>
<td>4.59</td>
<td>4.36</td>
<td>3.764</td>
<td>4.372</td>
</tr>
<tr>
<td>Economic Performance(ECO)</td>
<td>7.67</td>
<td>8.8</td>
<td>4.875</td>
<td>8.071</td>
</tr>
</tbody>
</table>
Sub-Index for Sustainability – Method # 1

Organisational Governance (OG)
Technical Aspects (TA)
Environmental performance (ENV)
Societal Performance (SOC)
Economic Performance (ECO)

03-04 04-05 05-06 06-07
Z Score method – indicative of improvement in trend

- Indicators Value: $I_{V_{ijt}}$ where $t = year\ 1,\ 2,\ 3\ \ldots\ \ldots\ n$
- Average Indicator Value: $AIV_{ij}$
- Normalized Score ($NS_{ij}$)
- Weighted Normalized Score ($WNS_{ij}$)
- $SIZS_i = \text{Sub-Index based on normalized Z score}$
- $AIV_{ij} = \sum I_{V_{ijt}} / n$

- $NS_{ij} = +\ or\ -\ (I_{V_{ijt}} - AIV_{ij})/\sigma$ ; (+) or (-) chosen based on type of indicators
- $WNS_{ij} = GW_{ij} * NS_{ij}$
- $SIZS_i = 100* (\sum WNS_{ij} / n)$
## Environment Performance Indicators

### Development of Composite Sustainability Performance Index for Steel Industry

#### Environmental performance (ENV) - Weight (WS<sub>ENV</sub>) : 0.140

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>2001-02</th>
<th>2002-03</th>
<th>2003-04</th>
<th>Sign</th>
<th>Avg</th>
<th>Std. dev</th>
<th>Norm. Score</th>
<th>Weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter stack emission load (Kg/tcs)</td>
<td>kg/tcs</td>
<td>1.5</td>
<td>1.32</td>
<td>1.1(-)</td>
<td>1.3</td>
<td>0.20</td>
<td>1.03</td>
<td>0.0199</td>
<td></td>
</tr>
<tr>
<td>Percent utilisation of total solid wastes (%)</td>
<td>%</td>
<td>68.5</td>
<td>77.6</td>
<td>79 (+)</td>
<td>75.03</td>
<td>5.70</td>
<td>0.70</td>
<td>0.0109</td>
<td></td>
</tr>
<tr>
<td>Specific energy consumption (Gcal/tcs)</td>
<td>Gcal/tcs</td>
<td>7.07</td>
<td>6.84</td>
<td>6.86 (-)</td>
<td>6.92</td>
<td>0.13</td>
<td>0.50</td>
<td>0.0078</td>
<td></td>
</tr>
<tr>
<td>Specific Raw material Consumption (tonnes/tcs)</td>
<td>t/tcs</td>
<td>3.24</td>
<td>3.07</td>
<td>3.16 (-)</td>
<td>3.16</td>
<td>0.09</td>
<td>-0.04</td>
<td>-0.0007</td>
<td></td>
</tr>
<tr>
<td>Specific water consumption (m3/tcs)</td>
<td>m3/tcs</td>
<td>4.74</td>
<td>3.54</td>
<td>3.98 (-)</td>
<td>4.09</td>
<td>0.61</td>
<td>0.18</td>
<td>0.0019</td>
<td></td>
</tr>
<tr>
<td>Specific carbon dioxide emissions (t/tcs)</td>
<td>t/tcs</td>
<td>2.69</td>
<td>2.6</td>
<td>2.6 (-)</td>
<td>2.63</td>
<td>0.05</td>
<td>0.58</td>
<td>0.0056</td>
<td></td>
</tr>
<tr>
<td>Specific effluent load (kg/tcs)</td>
<td>kg/tcs</td>
<td>0.1713</td>
<td>0.1977</td>
<td>0.1948 (-)</td>
<td>0.19</td>
<td>0.01</td>
<td>-0.47</td>
<td>-0.0039</td>
<td></td>
</tr>
<tr>
<td>Specific refrigerant consumption (kg/tcs)</td>
<td>kg/tcs</td>
<td>0.013</td>
<td>0.011</td>
<td>0.08 (-)</td>
<td>0.03</td>
<td>0.04</td>
<td>-1.15</td>
<td>-0.0036</td>
<td></td>
</tr>
<tr>
<td>Specific power consumption(Kwh/tcs)</td>
<td>kwh/tcs</td>
<td>436</td>
<td>422</td>
<td>402 (-)</td>
<td>420.00</td>
<td>17.09</td>
<td>1.05</td>
<td>0.0068</td>
<td></td>
</tr>
<tr>
<td>Specific refractory consumption (kg/tcs)</td>
<td>kg/tcs</td>
<td>14.36</td>
<td>14.3</td>
<td>13.7 (-)</td>
<td>14.12</td>
<td>0.36</td>
<td>1.15</td>
<td>0.0050</td>
<td></td>
</tr>
<tr>
<td>Percentage green cover of total plant area (%)</td>
<td>%</td>
<td>15</td>
<td>16</td>
<td>16 (+)</td>
<td>15.67</td>
<td>0.58</td>
<td>0.58</td>
<td>0.0030</td>
<td></td>
</tr>
<tr>
<td>Specific Hazardous waste generation (kg/tcs)</td>
<td>kg/tcs</td>
<td>1.5</td>
<td>1.6</td>
<td>1.7 (-)</td>
<td>1.60</td>
<td>0.10</td>
<td>-1.00</td>
<td>-0.0062</td>
<td></td>
</tr>
<tr>
<td>Specific Heavy metals discharge load (gm/tcs)</td>
<td>gm/tcs</td>
<td>10</td>
<td>8</td>
<td>8 (-)</td>
<td>8.67</td>
<td>1.15</td>
<td>0.58</td>
<td>0.0033</td>
<td></td>
</tr>
<tr>
<td>Average Noise level in the periphery of plant (dB)</td>
<td>dB</td>
<td>55</td>
<td>55</td>
<td>54 (-)</td>
<td>54.67</td>
<td>0.58</td>
<td>1.15</td>
<td>0.0052</td>
<td></td>
</tr>
<tr>
<td>Overall average Opacity around the plant (%)</td>
<td>%</td>
<td>94</td>
<td>94.5</td>
<td>96 (+)</td>
<td>94.83</td>
<td>1.04</td>
<td>1.12</td>
<td>0.0097</td>
<td></td>
</tr>
</tbody>
</table>

\[
SIZ_{Si} = 100 \left( \frac{\sum WNS_{ij}}{n} \right)
\]

\[
SIZ_{ENV} = 0.4313
\]
### Sub-Index – Based on Z Score Method

#### Development of Composite Sustainability Performance Index for Steel Industry

<table>
<thead>
<tr>
<th>Dimensions of Sustainability</th>
<th>03-04</th>
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<th>05-06</th>
<th>06-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Governance (OG)</td>
<td>1.16</td>
<td>1.22</td>
<td>1.19</td>
<td>1.34</td>
</tr>
<tr>
<td>Technical Aspects (TA)</td>
<td>1.10</td>
<td>1.43</td>
<td>1.22</td>
<td>1.18</td>
</tr>
<tr>
<td>Environmental performance (ENV)</td>
<td>0.44</td>
<td>0.79</td>
<td>0.71</td>
<td>0.83</td>
</tr>
<tr>
<td>Societal Performance (SOC)</td>
<td>1.13</td>
<td>1.01</td>
<td>0.98</td>
<td>1.21</td>
</tr>
<tr>
<td>Economic Performance (ECO)</td>
<td>7.16</td>
<td>7.97</td>
<td>7.18</td>
<td>8.1</td>
</tr>
</tbody>
</table>
Development of Composite Sustainability Performance Index for Steel Industry

Sub-Index for Sustainability – Method # 2

Organisational Governance (OG)  Technical Aspects (TA)  Environmental performance (ENV)  Societal Performance (SOC)  Economic Performance (ECO)

03-04  04-05  05-06  06-07

Steel Authority of India Ltd., Bhilai Steel Plant
Development of Composite Sustainability Performance Index for Steel Industry

Steel Authority of India Ltd., Bhilai Steel Plant

\[ SI_i = \frac{(SILR_i + SIZSi)}{2} \]

where

- \( SILR_i \) = Sub-Index based on Liberatore Score
- \( SIZSi \) = Sub-Index based on normalized Z score
- \( CSPI = \sum SI_i \)

### Dimensions of Sustainability

<table>
<thead>
<tr>
<th>Dimensions of Sustainability</th>
<th>03-04</th>
<th>04-05</th>
<th>05-06</th>
<th>06-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Governance(OG)</td>
<td>2.68</td>
<td>3.27</td>
<td>3.11</td>
<td>3.66</td>
</tr>
<tr>
<td>Technical Aspects (TA)</td>
<td>2.63</td>
<td>2.83</td>
<td>2.39</td>
<td>2.81</td>
</tr>
<tr>
<td>Environmental performance(ENV)</td>
<td>2.92</td>
<td>3.05</td>
<td>3.09</td>
<td>2.87</td>
</tr>
<tr>
<td>Societal Performance(SOC)</td>
<td>2.86</td>
<td>2.69</td>
<td>2.37</td>
<td>2.79</td>
</tr>
<tr>
<td>Economic Performance(ECO)</td>
<td>7.41</td>
<td>8.39</td>
<td>6.03</td>
<td>8.09</td>
</tr>
<tr>
<td><strong>Composite Sustainability Performance Index</strong></td>
<td><strong>18.51</strong></td>
<td><strong>20.21</strong></td>
<td><strong>16.98</strong></td>
<td><strong>20.22</strong></td>
</tr>
</tbody>
</table>
Future Work

- Testing for robustness
- Uncertainty analysis
- Sensitivity analysis
- Collection of data from other steel industries
- Ranking of steel plants


Thank You