EU-US Frontiers of Engineering Symposium

Steel, a sustainable material

JS Thomas, ArcelorMittal Global R&D
Context and challenges of Sustainable Development

Steel, a sustainable material?

How to capture sustainability? Methodology issues

The Sovamat Initiative: toward a sustainability metrics
1. Measure!!
2. Pro-actively anticipate and adapt offer and performance to legislation evolution and customers needs
- Context and challenges of Sustainable Development
- Steel, a sustainable material?
- How to capture sustainability? Methodology issues
- The Sovamat Initiative: toward a sustainability metrics
Steel production

- Two main routes for one product: steel
  - BF/BOF route (mainly primary)
  - EAF route (mainly secondary)
Demand steel vs. scrap offer

- Increase of steel demand
- Lack of available scrap

Percentage of primary production still high

Strong increase of the demand
Recycled content limited
Steel cycles

Steel Overall Recycling Rate ~ 90%

Steel can be indefinitely recycled in ANY type of application

Recycled content (RC)

End of life Recycling Rate (RR)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Market size</th>
<th>Overall RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>5.5%</td>
<td>66%</td>
</tr>
<tr>
<td>Automotive</td>
<td>30.2%</td>
<td>99%</td>
</tr>
<tr>
<td>Domestic Appliances</td>
<td>5.0%</td>
<td>93%</td>
</tr>
<tr>
<td>Construction</td>
<td>43.5%</td>
<td>85%</td>
</tr>
<tr>
<td>Machinery</td>
<td>15.7%</td>
<td>91%</td>
</tr>
</tbody>
</table>

Steel Overall Recycling Rates based upon North American data (Steel Recycling Institute 2005)

Steel can be indefinitely recycled in ANY type of application
Steel recycling benefits

For a 90% recycling rate:
1 ton of primary steel = 10 tons of steel used!

Sustainable stock of iron for future generations
Steel is constantly reinventing itself …

**Colonnnes S355**

**Colonnnes S460**

**Weight savings:** 17%

77 Hudson at Colgate Center, Jersey City

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**Ultra Low CO2- steelmaking**

ULCOS is the most ambitious program in the steel industry level worldwide to face the climate change issue at a radical scale.

- **Objective:** develop breakthrough steel production routes to reduce specific CO2 emissions by a factor 2 (or more)
- **Launched in 2002**
- **75 M€ spent to date**

![Graph showing EU Steel Industry Energy Consumption and CO2 Emissions per Ton of Finished Steel from 1970 to 2000.](image-url)
ULCOS: Ultra Low CO$_2$- steelmaking

- After screening: 4 routes selected for further development

<table>
<thead>
<tr>
<th>Coal &amp; sustainable biomass</th>
<th>Natural gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revamping BF</td>
<td>Brownfield</td>
<td>Revamping DR</td>
</tr>
<tr>
<td>TGR-BF</td>
<td>HIsarna</td>
<td>ULCORED</td>
</tr>
<tr>
<td>Pilot tests (1.5 t/h) Demo phase under preparation</td>
<td>Pilot plant (8 t/h) start-up 2010</td>
<td>Pilot plant (1 t/h) to be erected in 2010 ?</td>
</tr>
</tbody>
</table>
Focus on TGR-BF

Using a single capture unit!!

$\text{CO}_2$ emissions of the steel plant: - 60%

Principles

$\text{CO}_2$

$\text{O}_2$

-100 kg coke/t steel

Underground storage of $\text{CO}_2$

0.8 t/t steel
Social and economical benefits
Example of a steel bridge

- **Aestetic: Light structures**
  - Less materials, reduced foundations $\rightarrow$ **reduced cost**

- **Perennity of the material**
  - Resist to earthquakes $\rightarrow$ **safety**
  - Reduce maintenance, visible pathology, forecast inspections $\rightarrow$ **reduced cost, safety**

- **Dry workplace, reduced nuisance**
  - Impact reduction for neighbourhood $\rightarrow$ **social benefit**
  - Prefabrication in optimised places, reduced welding $\rightarrow$ **safety, reduced cost**

- **Reduced logistic and delays**
  - Millau: 8000 less trucks compared to a concrete bridge $\rightarrow$ **safety, social benefit**
  - Early brought into service $\rightarrow$ **increased pay-back, social benefits**
  - Reduction of accidents $\rightarrow$ **safety**

- **High lifespan**
  - Iron Bridge (Birmingham) : dated 1779; Millau: 120 years
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Life Cycle Analysis: a key tool for sustainable decision making …

Why is it important?

- Choices of consumers or decision-makers will be driven by the environmental performance of products and solutions
  - Environmental labeling of products
  - Environmental product declaration in construction sector
- LCA is a reference methodology to assess this performance
Case study: LCA of a two-span bridge

description

**Functional unit:** Two-span road bridge with spans of 2 x 29.27 m. Composite bridge with partially pre-fabricated bridge girders and reinforced concrete cross girders.

<table>
<thead>
<tr>
<th>Material</th>
<th>Tonnage [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled sections</td>
<td>39</td>
</tr>
<tr>
<td>End plates</td>
<td>4</td>
</tr>
<tr>
<td>Shear studs</td>
<td>1.56</td>
</tr>
<tr>
<td>Concrete</td>
<td>~860</td>
</tr>
<tr>
<td>Steel reinforc</td>
<td>47</td>
</tr>
</tbody>
</table>

Bill of materials
Case study: LCA of a two-span bridge steel production and end-of-life

Raw materials extraction (iron ore, coal, limestone…)
Beneficiation
Transport to production site
Production of steel sections
Production of steel plates
Production of steel rebars
Finishing
Transport of steel elements to the construction site
Construction of the composite bridge
Use phase
Demolition
Recycling of steel elements
Transport of steel elements to the recycling site
Recycling process

WorldSteel data [2010]

<table>
<thead>
<tr>
<th></th>
<th>LCI</th>
<th>GWP [kg CO2-eq/t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WO-Sections – 99%</td>
<td></td>
<td>930</td>
</tr>
<tr>
<td>WO-Rebars– 99%</td>
<td></td>
<td>830</td>
</tr>
<tr>
<td>WO-Plates– 99%</td>
<td></td>
<td>1073</td>
</tr>
<tr>
<td>WO-Rebars– 65%</td>
<td></td>
<td>1348</td>
</tr>
</tbody>
</table>

65% Partial valorisation of concrete sorted
99% Recovery of steel rebars
65% Transport of reinforced concrete to sorting plant
99% Direct landfill of reinforced concrete
65% Landfill of concrete sorted
99% Transport of reinforced concrete to landfill

WorldSteel data [2010]
Case study: LCA of a two-span bridge
life cycle results

- Materials production is the largest contributor to climate change
- The environmental benefit brought by steel recycling
  - emissions reduces by 21% (88to CO2-eq)
  - savings equivalent to ~ 700 000km driven by regular car!
Limits of LCA as a ‘sustainability tool’

- Do not valorize positive impacts (social and environmental)
- Difficulty to address technical issues like allocation for recycling in particular
- Social impacts: still a partial approach
- LCA = static approach, How to take time into account?
- Global impacts OK, Local impacts No
- LCA = micro-economic evaluation, what about up-scaling?

LCA can’t manage and solve complexity of sustainable decision alone!
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The Sovamat Initiative: toward a sustainability metrics
The Sovamat initiative

• The SOVAMAT initiative aims at:
  – **Develop the methodology tools** to evaluate the economic, environmental and social impacts and benefits of our process/products/services
  – Integrate this **new sustainability metrics** in our developments/process/decisions to address the **challenges** of tomorrow’s society (climate change, biodiversity, water stress, demography, energy and material needs, …)

• A network of more than **100 partners** has been developed in all disciplines.
• A **web site** has been built to reinforce the networking, to be recognised, to promote the Sovamat Initiative ideas, and to host projects we are involved in. **www.sovamat.org**
Toward a new metrics: axes of research

- Introduce time dimension (dynamic LCA & MFA, …)
- Develop prospective & foresight scenarios
- Definition and formulation of social value of materials
- Improve micro-scale tools (LCA, env. assessment, biodiversity, …)
- Develop macro-economic dimension (MFA, env. economics, …)
- New metrics for integrated sustainable decision-making

CIRAIG LCA Chair of Research

SAM seminars

PACT project
The Society And Materials seminars

Free, low costs, highly interactive and refreshing

SAM2 Nantes
- 80 participants
- 37 presentations

SAM1 Seville
- 85 participants
- 47 presentations

SAM3 Freiberg
- 50 participants
- 28 presentations

SAM4 Nancy
- 65 participants
- 28 presentations
PACT Project: Pathways for carbon transition

• A collaborative project in the 7th Research EU FP
• Project objectives
  – To shape what a sustainable post-carbon society would look like
  – How we could reach it within the next 50 years
  – Focus first on what shapes the energy demand and evolution, from two viewpoints:
    - infrastructures, (urbanisation and land-use schemes),
    - life-styles and behaviours, in relation to the technologies that should be available
  – Objective for us: to crosslink scenarios at 2050 horizon with demand for structuring materials – metals, cement at least
  – Next deadline: draft report by the end of this year
PACT Project: some results and perspectives

<table>
<thead>
<tr>
<th>Service</th>
<th>Specific Technologies</th>
<th>Main materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction/Maintenance</td>
<td>Dry building works</td>
<td>Steel, Concrete – broke – stone, Wood</td>
</tr>
<tr>
<td></td>
<td>Assembling-based technologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Green roof</td>
<td></td>
</tr>
<tr>
<td>Thermal comfort</td>
<td>Thermo-bridges avoidance</td>
<td>Insulation materials, Glass, Metal, Wood</td>
</tr>
<tr>
<td></td>
<td>Thermal insulation control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solar radiation control</td>
<td></td>
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<tr>
<td>Lighting</td>
<td>LEDs</td>
<td>Plastic/polymer, Metal, Wood</td>
</tr>
<tr>
<td>Sanitary comfort</td>
<td>Damp control</td>
<td>Metal, Plastic, Metal, Wood</td>
</tr>
<tr>
<td></td>
<td>Air exchange</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating/cooling pump</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storages fuel cells</td>
<td></td>
</tr>
<tr>
<td>Energy supply</td>
<td>Solar panels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windmills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biomass</td>
<td></td>
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</tbody>
</table>

SA Sector Average, BAT Best Available Technology, BP Best Practice, JPB my estimate, BT R&D Breakthrough R&D, BT D Breakthrough demonstrator (present stage of ULCOS), ES Expert Suggestion (like IEA), RM Roadmap, NT Normative Target, IP Incremental Progress
Conclusions and Perspectives

• Steel is a sustainable material, with high social value
• Steel is constantly reinventing itself to be part of the solution, not part of the problem

• Environment is not the only stake
  – Social benefits, economical stakes have to be part of the process of sustainable development

• Current methods are limited and not perfect, they have to evolve
  • Necessary to question the current methods
  • The world is complex, so are decisions
  • Necessity to develop new metrics for sustainability assessment
“The world cannot succeed without business as a committed solution provider to sustainable societies and ecosystems”

WBCSD President Bjorn Stigson