Life Cycle Assessment as a tool for resource optimisation of continuous basalt fibre production in Iceland

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Content

1. Continuous Basalt Fiber production (CBF)
2. Project background
3. Comparative LCA
4. Conclusion
Continuous basalt fiber

- Basalt fibre was originally developed in the Soviet Union during the 1960's to 1980's.
- Basalt fibre production plants are mainly situated in Russia and China, with basalt mines located in the Ukraine.
- For physical properties comparable to carbon and glass fibers, basalt fibers are of a Low cost and low environmental footprint.
- Basalt fibres are expected to have special roles in various composite applications.
Continuous basalt fiber (stone + energy = fibre)

- Basalt rock is principally composed of silica, alumina, with lime, magnesium oxide and ferric oxide found in lesser percentages.
- For fabrication of continuous basalt fibres (CBF), the quantity of each material needs to be controlled.
Continuous basalt fiber production steps
GREENBAS Project Background

Iceland is 90% basalt!

• Fresh lava is being supplied every day!
• Aim is to optimize mining of the volcanic rock basalt for the production of continuous basalt fibres using available renewable energy.
• Finding suitable mines in the volcanic island is one of the targets of our project.
• Comparing the gas based heating method to the anticipated electric method using renewable electricity from the grid in Iceland.
• Study the possibility of mixing basaltic materials with other materials in the future to achieve optimum material parameters (Not presented here)
**LCA Method**

- **Goal:**
  - Evaluate the environmental impacts for the production of CBF for the Icelandic context.
  - To perform an analytical comparison of the gas-based heating method to the electric method using renewable electricity from the grid in Iceland.
  - Comparison with the Russian production
  - Comparison with other fiber material (glass and carbon fibers)

- **Scope:** The boundaries of the system are selected to include extraction of basalt raw material, transport of raw materials, and the manufacture of CBF.

- **Functional unit:** 1 kg of produced CBF

- **Life Cycle Inventory:** Two types of data have been used, REAL DATA and data from databases included in SIMAPRO with modifications to fit the Icelandic and Russian context. Impact assessment: Use of the software Simapro 8, method: CML2
• Russian Scenario: Raw material from Ukraine, Energy input for the furnace: electricity + gas
• Iceland Scenario 1: Raw material from the Icelandic quarry, Energy input for the furnace: only electricity
• Iceland Scenario 2: Raw material from the Icelandic quarry, Energy input for the furnace: electricity + gas
Analyzing 1 kg 'Continuous Basalt Fiber production (Electricity + Gas)-Russia'; Method: CML 2 baseline 2000 V2.05 / the Netherlands, 1997 / Characterization
Analyzing 1 kg 'Continuous Basalt Fiber production (Electricity + Gas)-Iceland';
Method: CML 2 baseline 2000 V2.05 / the Netherlands, 1997 / Characterization
Analyzing 1 kg 'Continuous Basalt Fiber production (Electricity only)-Iceland'; Method: CML 2 baseline 2000 V2.05 / the Netherlands, 1997 / Characterization
Comparative LCA – Energy and site production

### Impact Categories

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Unit</th>
<th>(Electricity + Gas) - Russia</th>
<th>(Electricity + Gas) - Iceland</th>
<th>(Electricity) - Iceland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abiotic depletion</td>
<td>kg Sb eq</td>
<td>2,05E-02</td>
<td>1,51E-02</td>
<td>8,84E-04</td>
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<tr>
<td>Acidification</td>
<td>kg SO2 eq</td>
<td>3,66E-03</td>
<td>1,51E-03</td>
<td>7,26E-04</td>
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<tr>
<td>Eutrophication</td>
<td>kg PO4---eq</td>
<td>6,62E-04</td>
<td>2,45E-04</td>
<td>2,52E-04</td>
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<tr>
<td>Global warming (GWP100)</td>
<td>kg CO2 eq</td>
<td>9,86E-01</td>
<td>3,41E-01</td>
<td>1,53E-01</td>
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<tr>
<td>Ozone layer depletion (ODP)</td>
<td>kg CFC-11 eq</td>
<td>2,40E-07</td>
<td>2,04E-07</td>
<td>4,63E-08</td>
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<tr>
<td>Human toxicity</td>
<td>kg 1,4-DB eq</td>
<td>2,94E-01</td>
<td>1,60E-01</td>
<td>1,49E-01</td>
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<tr>
<td>Fresh water aquatic ecotoxicity</td>
<td>kg 1,4-DB eq</td>
<td>1,31E-01</td>
<td>4,67E-02</td>
<td>6,54E-02</td>
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<tr>
<td>Marine aquatic ecotoxicity</td>
<td>kg 1,4-DB eq</td>
<td>3,57E+02</td>
<td>1,59E+02</td>
<td>1,01E+02</td>
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<tr>
<td>Terrestrial ecotoxicity</td>
<td>kg 1,4-DB eq</td>
<td>1,60E-03</td>
<td>1,12E-03</td>
<td>1,47E-03</td>
</tr>
<tr>
<td>Photochemical oxidation</td>
<td>kg C2H4 eq</td>
<td>2,00E-04</td>
<td>1,06E-04</td>
<td>4,25E-05</td>
</tr>
</tbody>
</table>
Conclusion

• An electric Icelandic production may result in lower emissions than the Russian production
• In both cases furnace energy consumption is identified as the largest contributor
• The reduction of furnace energy consumption is dependent on numerous parameters, such as type of furnace, furnace size and CBF production rate.
• Energy input decreases with increased production capacity (kWh per kg of continuous basalt fibre produced) due to the increased size of furnace, however a larger furnace requires continuous operation and takes longer to heat up.
• For most environmental indicators, carbon fibre followed by glass fibre are much less environmental friendly than CBF, including those produced in Russia.

• Future work will include:
  o a sensitivity analysis to evaluate the effect of the size of the plant
  o an economic evaluation using LCC
  o a comparison of the different fibers based on an application (e.g. building element)
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