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Life Cycle Assessment and Other Assessment Tools for Waste Management and Resource Optimization

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

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Engineering Conferences International (ECI) Life Cycle Assessment and Other Assessment Tools for Waste Management and Resource Optimization

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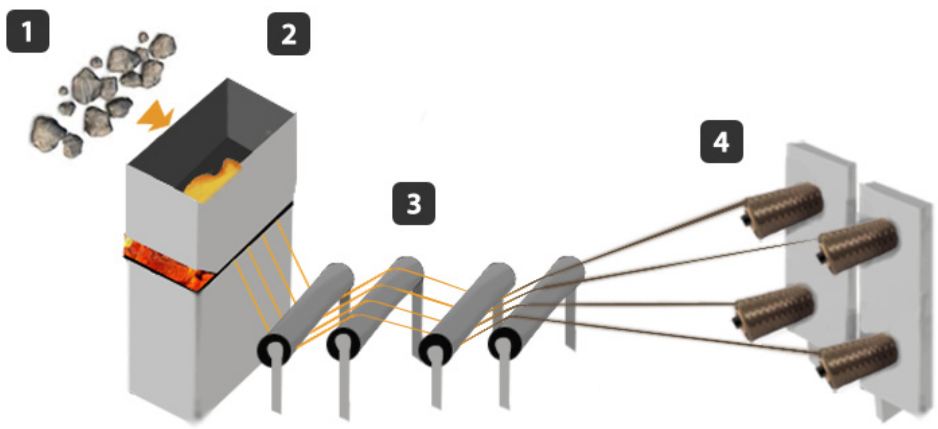
Content

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 in various composite applications

Continuous basalt fiber (stone + energy = fibre)

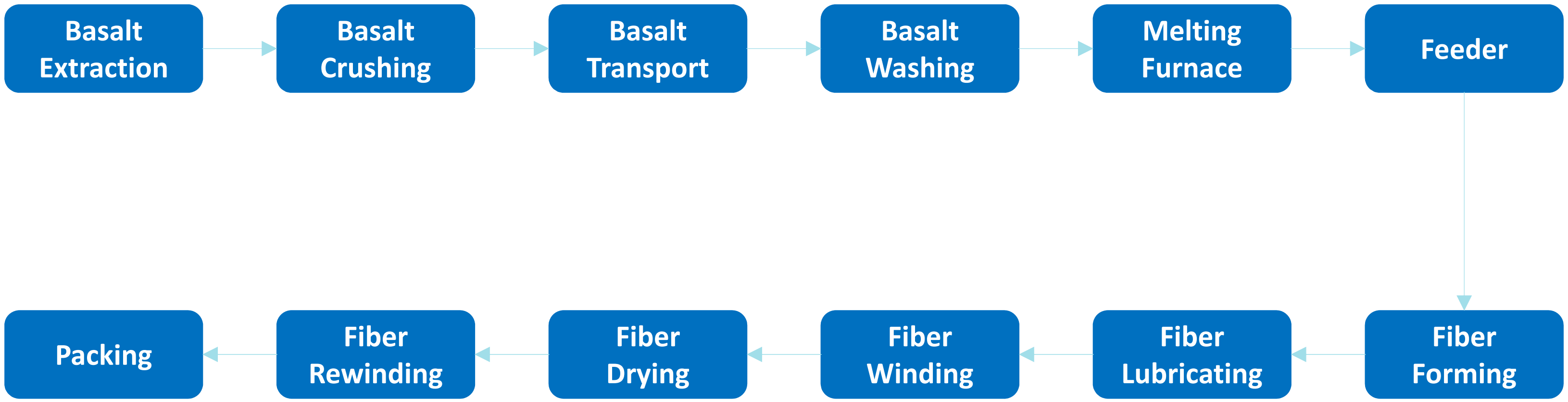


- Basalt rock is principally composed of silica, alumina, with lime, magnesium oxide and ferric oxide found in lesser percentages.
- For fabrication of continuous basalt fibres (CBF), the quantity of each material needs to be controlled.

Compositional window:

Oxide	Range
SiO2	50-54% (48-56%)
Al2O3	7,5-15%
Fe2O3	7,0-15% (18%)
MgO	3,0-7,0%
TiO2	0,1-2,0%
NaKCa	0,1-18%

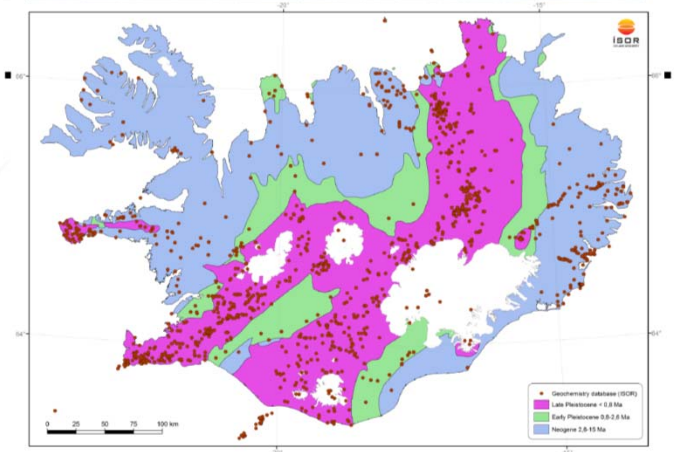
Continuous basalt fiber production steps



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)



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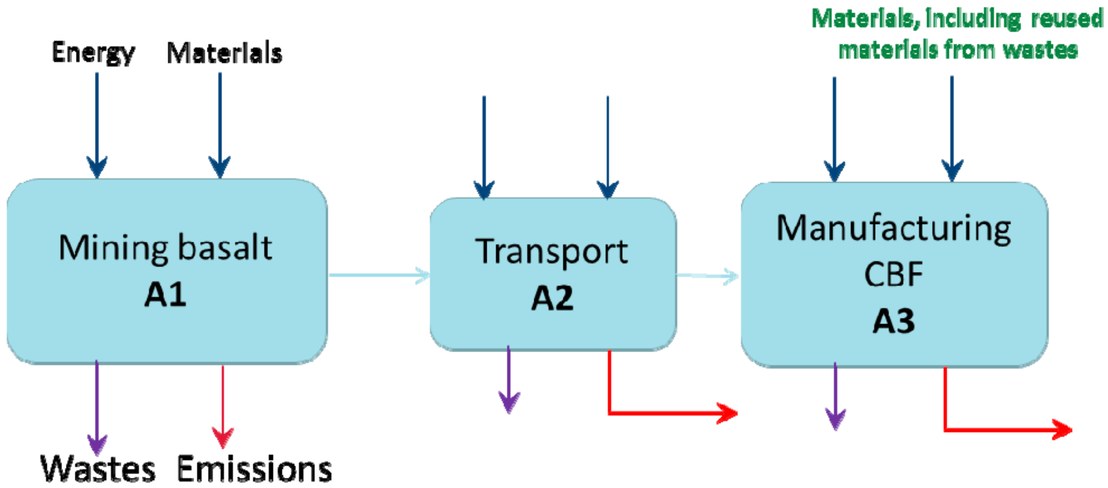
LCA Method

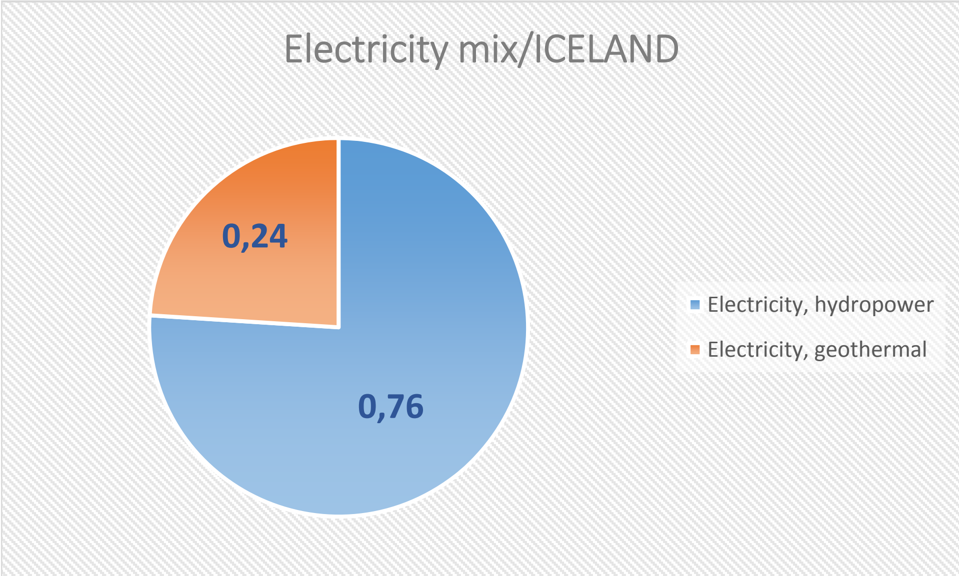
- Goal:
  - Evaluate the environmental impacts for the production of CBF for the Icelandic context.
  - To perform an analytical comparison of the gas based heating method to the electric method using renewable electricity from the grid in Iceland.
  - Comparison with the Russian production
  - Comparison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

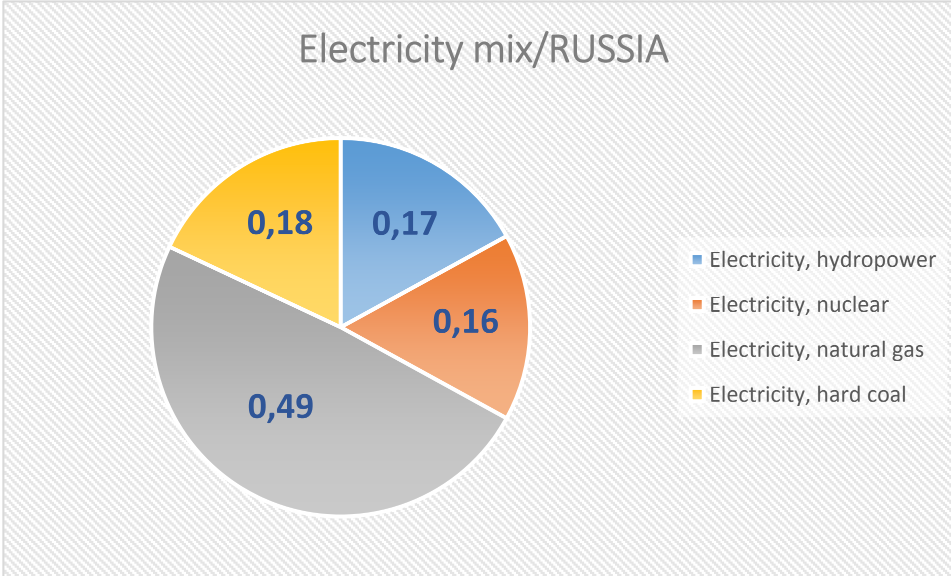
- Scope: The boundaries of the system are selected to include extraction of basalt raw material, transport of raw materials, and the manufacture of CBF.



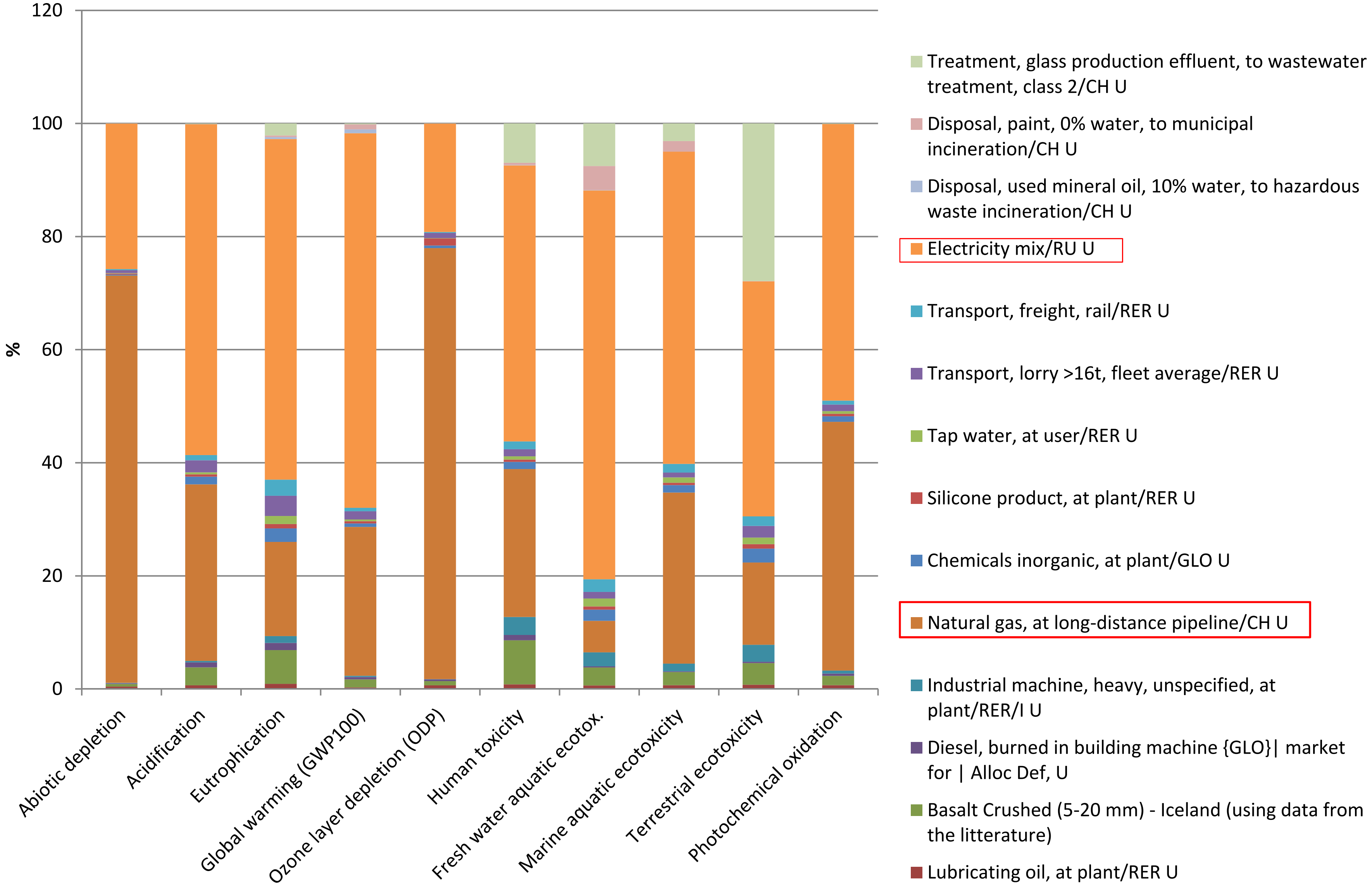
- Functional unit: 1 kg of produced CBF

- 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

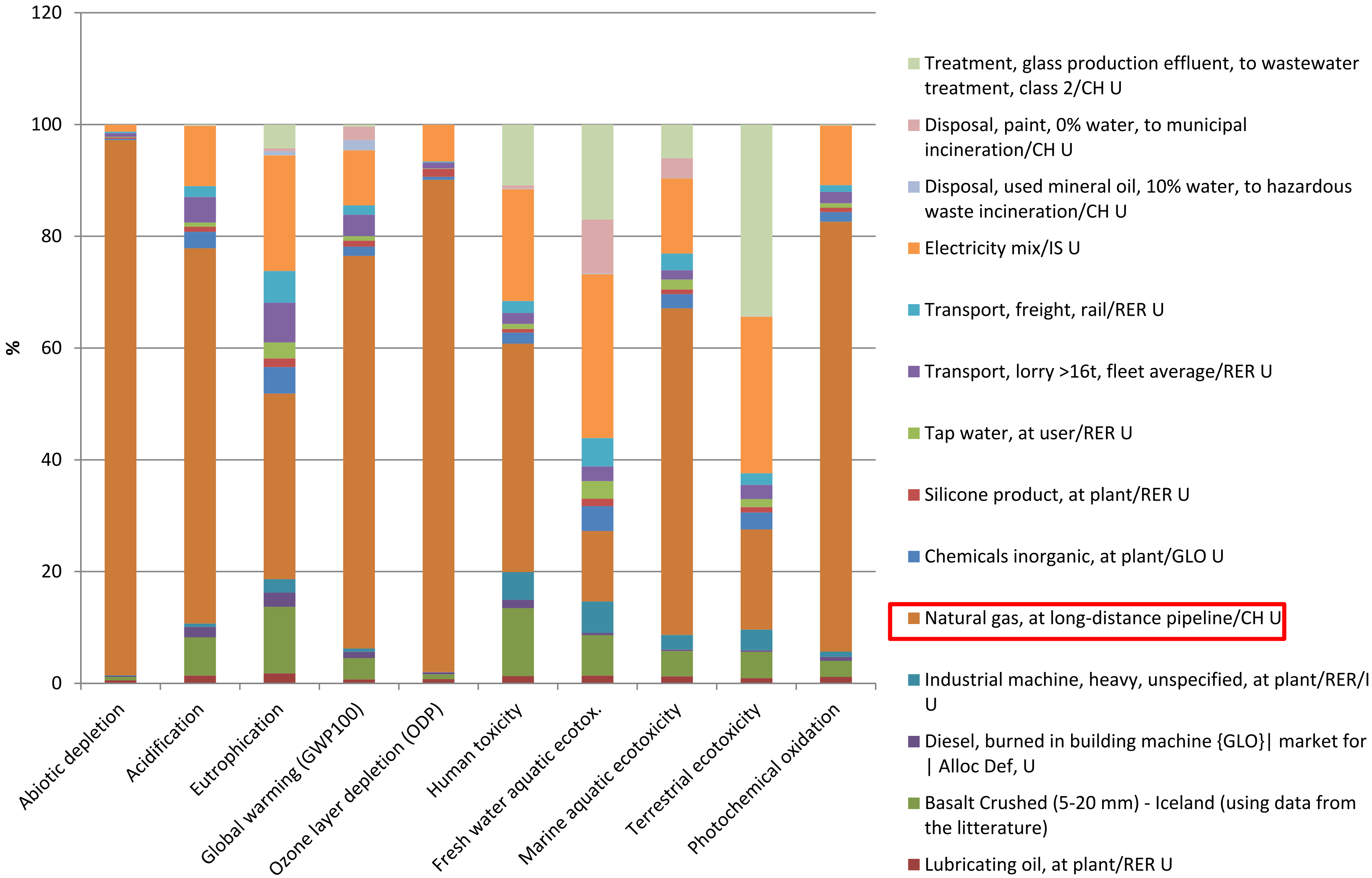




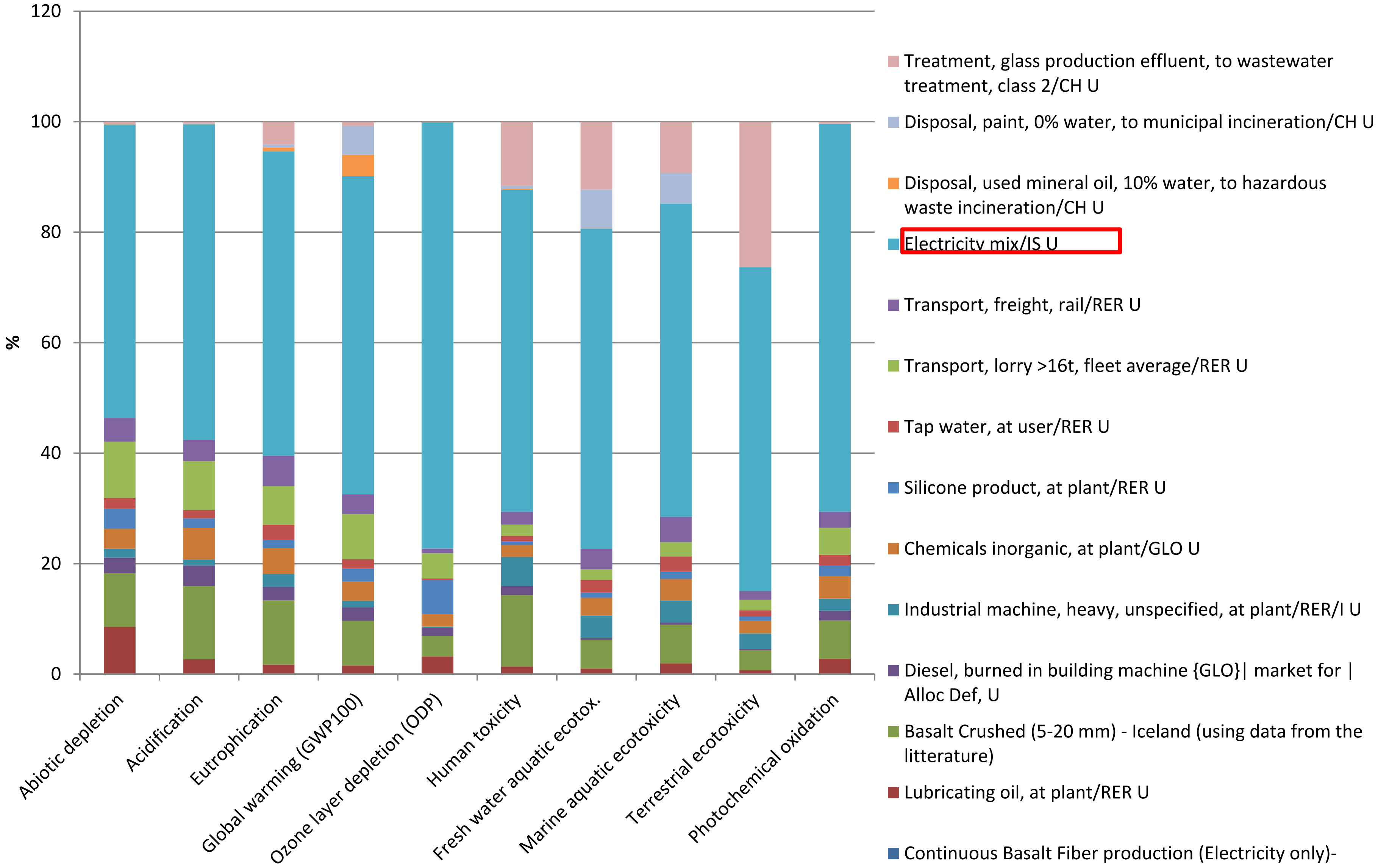
- Russian Scenario: Raw material from Ukraine, Energy input for the furnace: electricity + gas
- Iceland Scenario 1: Raw material from the Icelandic quarry, Energy input for the furnace: only electricity
- Iceland Scenario 2: Raw material from the Icelandic quarry, Energy input for the furnace: electricity + gas



Analyzing 1 kg 'Continuous Basalt Fiber production (Electricity + Gas)-Russia';
Method: CML 2 baseline 2000 V2.05 / the Netherlands, 1997 / Characterization



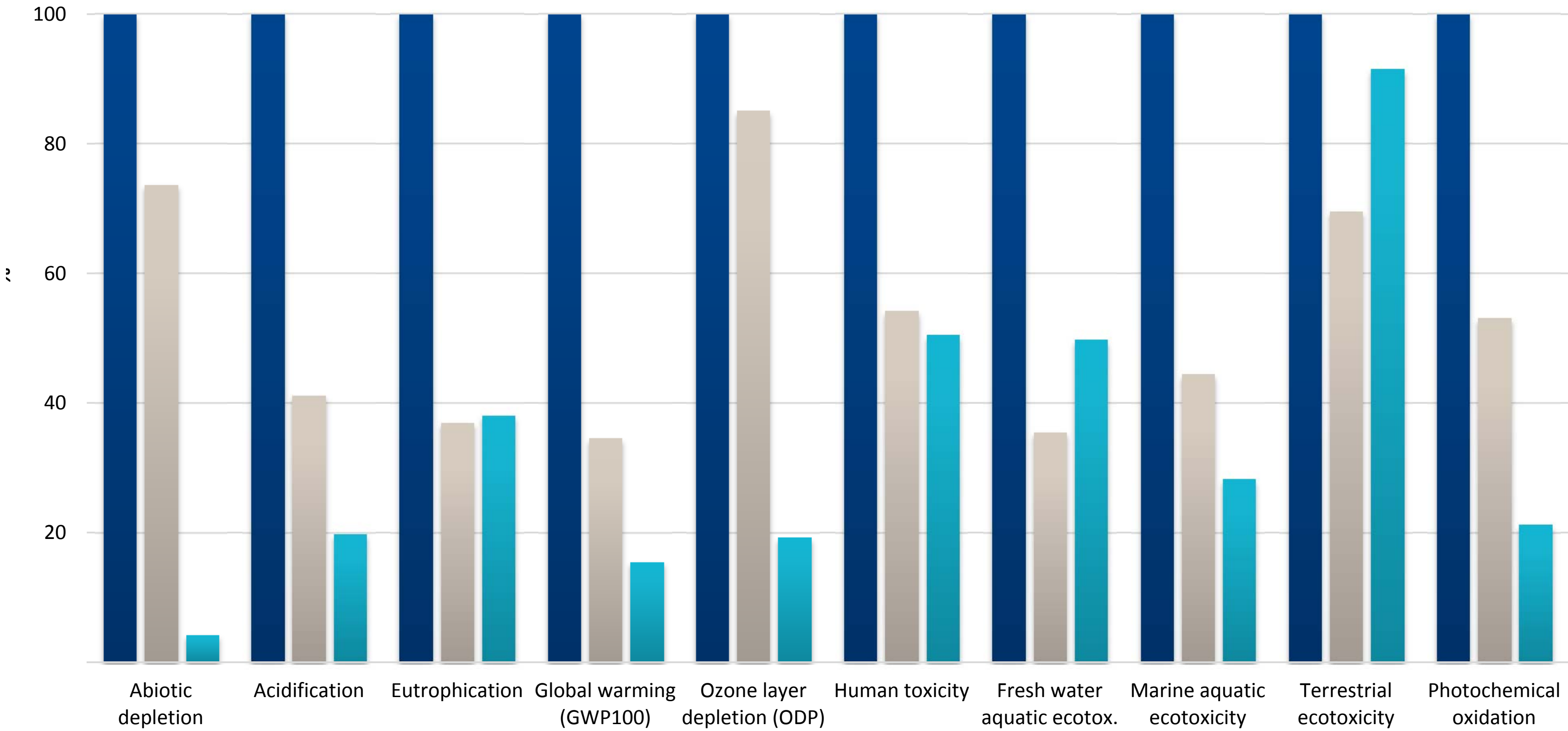
Analyzing 1 kg 'Continuous Basalt Fiber production (Electricity + Gas)-Iceland';
Method: CML 2 baseline 2000 V2.05 / the Netherlands, 1997 / Characterization

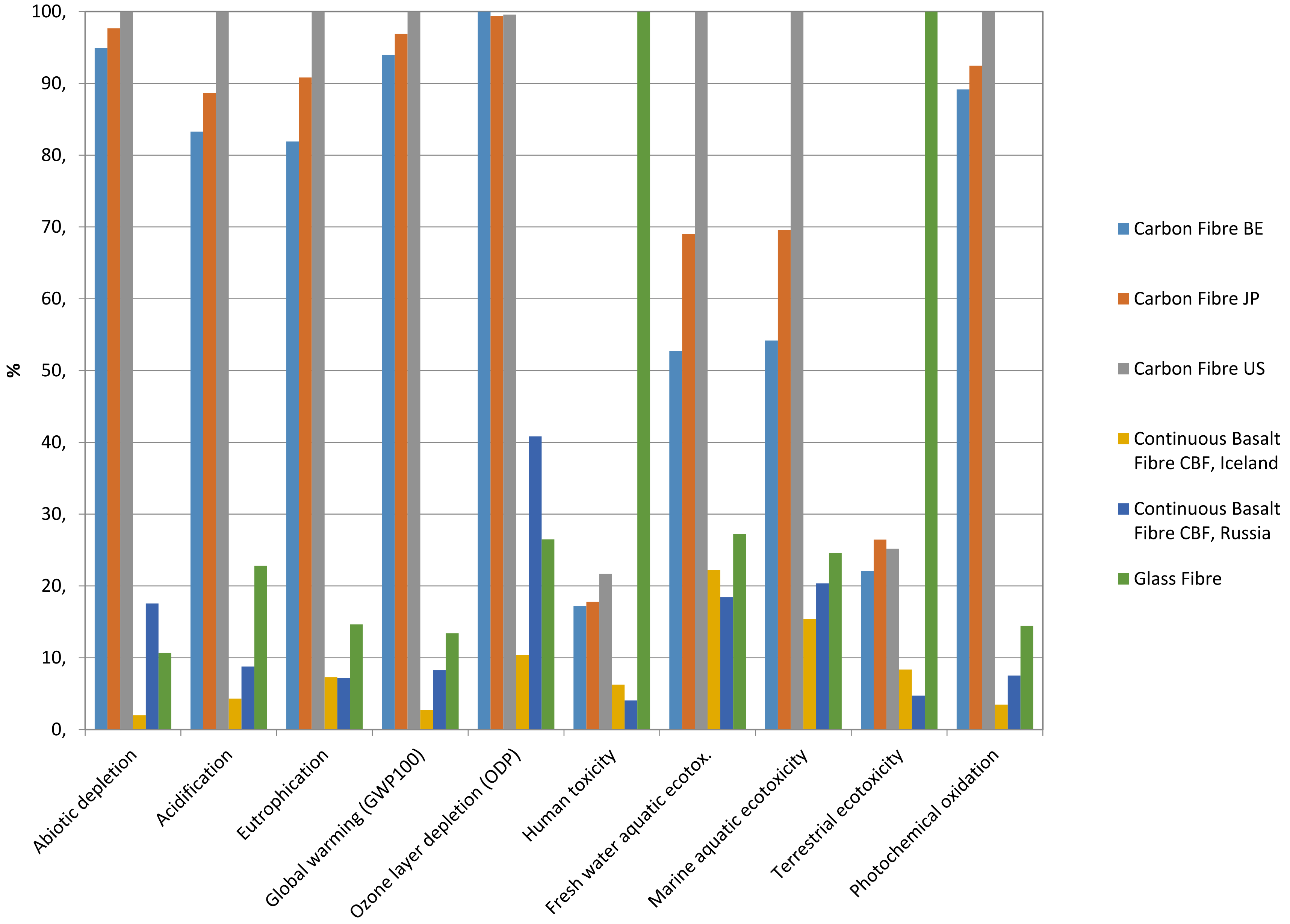


Analyzing 1 kg 'Continuous Basalt Fiber production (Electricity only)-Iceland';
Method: CML 2 baseline 2000 V2.05 / the Netherlands, 1997 / Characterization

Comparative LCA – Energy and site production

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




100,
90,
80,
70,
60,
50,
40,
30,
20,
10,
0,
%
Abiotic depletion
Acidification
Eutrophication
Global warming (GWP100)
Ozone layer depletion (ODP)
Human toxicity
Fresh water aquatic ecotox.
Marine aquatic ecotoxicity
Terrestrial ecotoxicity
Photochemical oxidation
Carbon Fibre BE
Carbon Fibre JP
Carbon Fibre US
Continuous Basalt Fibre CBF, Iceland
Continuous Basalt Fibre CBF, Russia
Glass Fibre

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

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Thank you