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UNICAMP

Environmental effects of Li-ion battery cell manufacturing in Brazil: A life cycle assessment approach.

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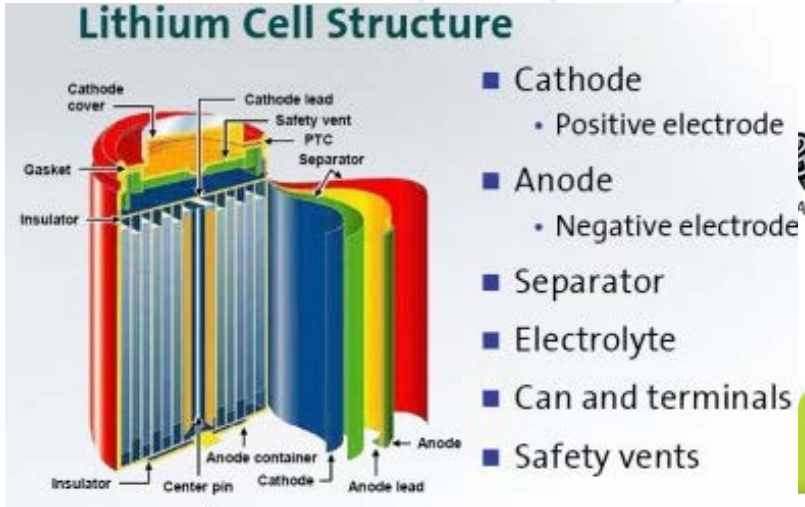
Academic Work

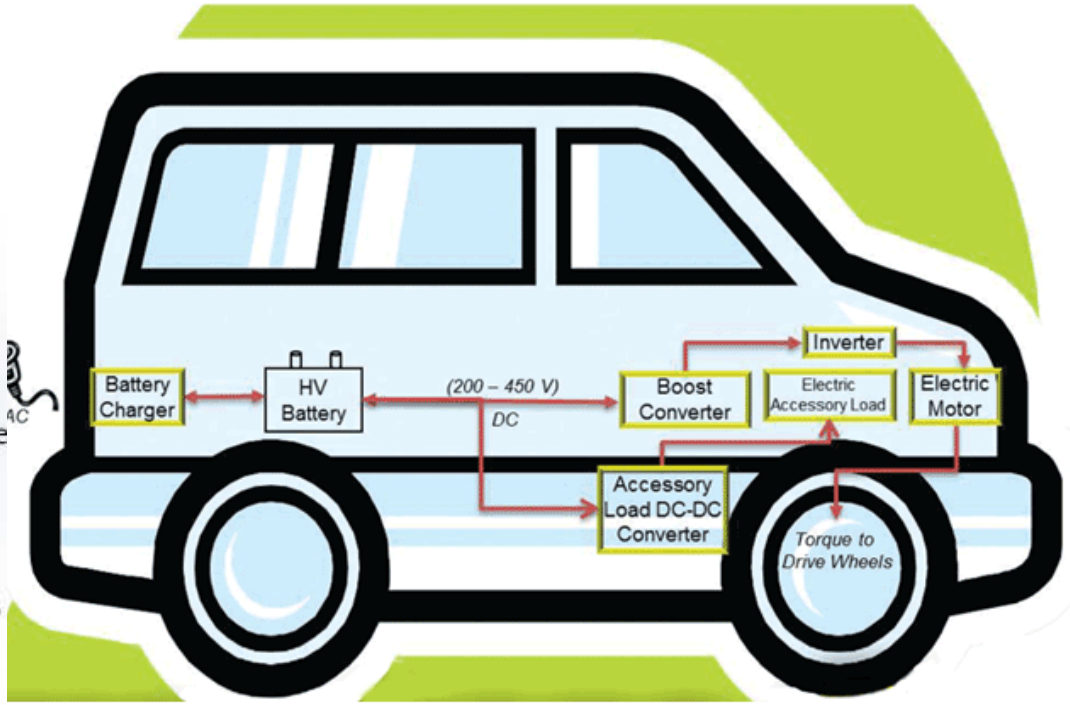
Motivation

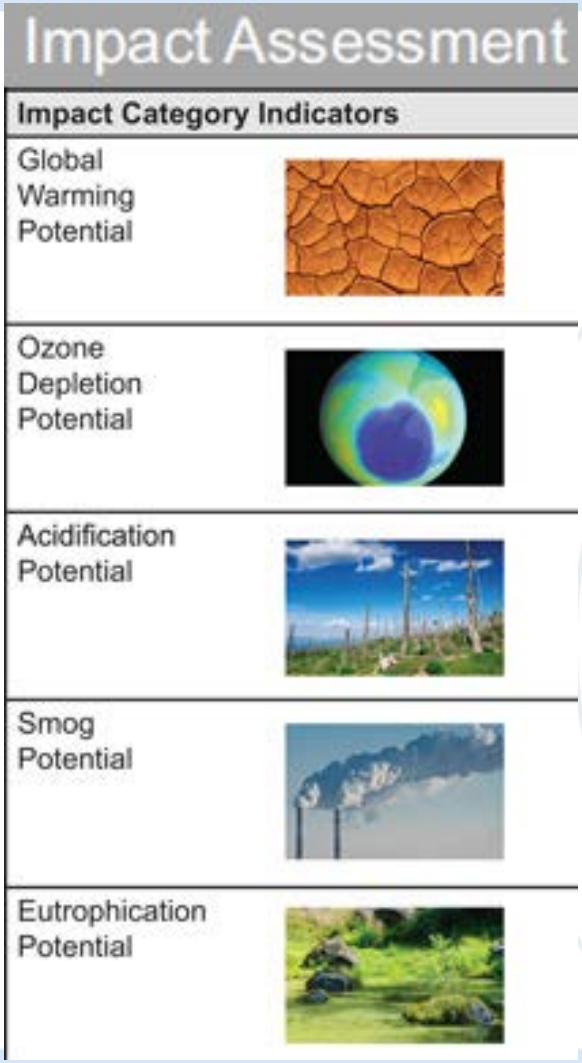
The interest in reducing greenhouse gases (GHGs) emissions and many other pollutants has promoted the adoption of electric vehicles. However, the potential environmental benefits of adopting electric cars will strongly depend on several factors like electricity generation matrix, the use of the car and the manufacturing phase, in other words, depends on the **whole life cycle**

Electric vehicle components

- Powertrain
- Glider
- Battery pack
  - Battery cell







Life cycle assessment

Eight categories of environmental impact were evaluated:

- Global warming
- Ozone layer depletion
- Human toxicity
- Terrestrial ecotoxicity
- Photochemical oxidation
- Acidification
- Eutrophication
- Abiotic depletion

Objectives

This study aimed to compare the potential environmental impacts -throughout the whole lifecycle- of manufacturing Li-ion battery cells in Brazil instead of manufacturing it abroad*

Additionally, it is intended to establish a theoretical list of stakeholders in the project, focusing specifically on the viability of partnerships with suppliers of raw materials based on their geographic location and market trajectory.

*Global inventory represents a global average

Methodology

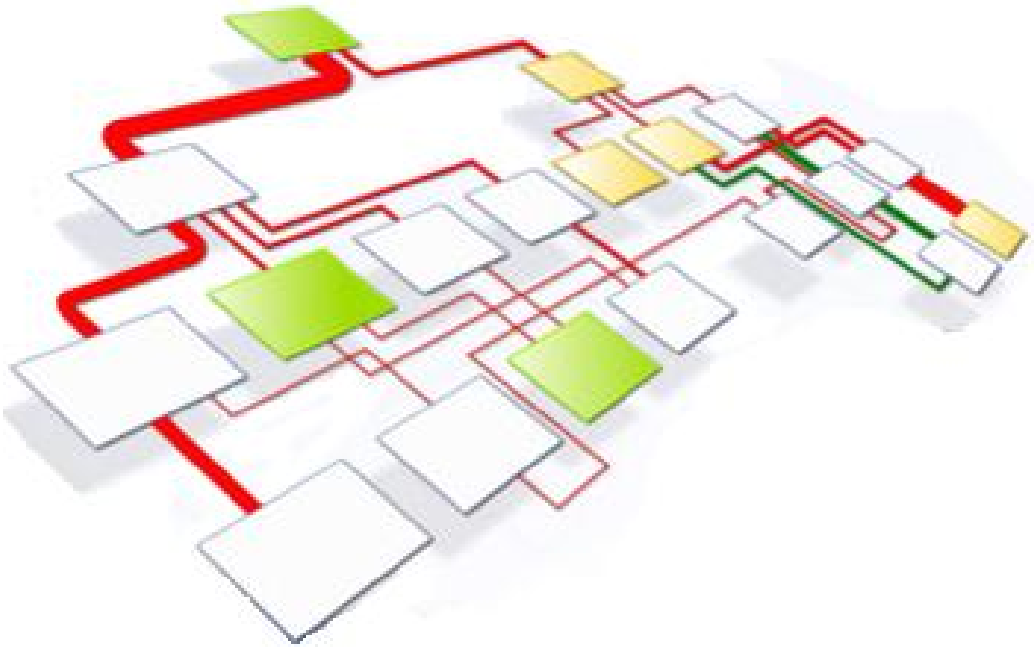
A fundamental part of any LCA is the construction of the Life Cycle Inventory (LCI). The LCI collect the data and information that will be used in the LCA.

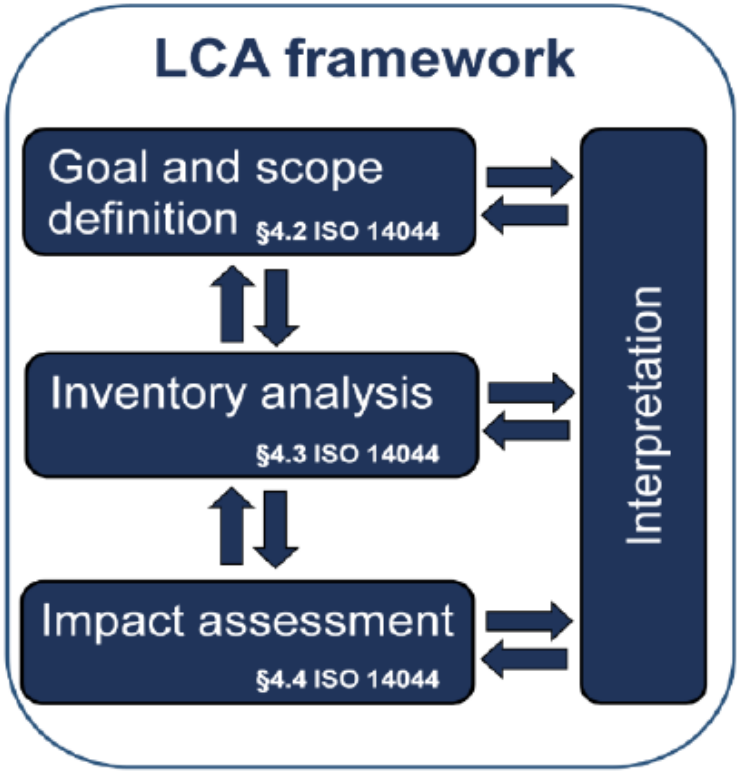
Given the amount of data, LCA analysis is usually done through an LCA software. Simapro 8 uses many databases including Ecoinvent ones.(Swiss Center for Life Cycle Inventories 2014)

- Functional unit: 1 Kg of Lithium battery cells
- LCIA method: CML 2000 baseline
- Geographical scope: Brazil compared to GLO
- Inventories database: Ecoinvent V 3.1
- Time Scope: 2009-2016

SimaPro

*Global inventory represents a global average




LCA framework
Goal and scope definition §4.2 ISO 14044
Inventory analysis §4.3 ISO 14044
Impact assessment §4.4 ISO 14044
Interpretation

Battery cell components

Component	Geographic region	Mass (Kg)
Graphite anode.	Brazil	0,3797
Lithium Hexafluorophosphate.	Brazil	0,0180
Cast aluminum alloy.	Brazil	0,0156
Low density polyethylene, in pellets.	Global	0,0693
LiMn2O4 Cathode.	Brazil	0,3094
Sheet rolled aluminum.	Brazil	0,0156
Liquid Nitrogen.	Europe w/o CH	0,0094
Chemical products factory. *	Global	3,79E-10
Ethylene Carbonate.	Brazil	0,1510
Extruded plastic film.	Brazil	0,0693
Battery separator.	Brazil	0,0508

How to regionalize an LCA

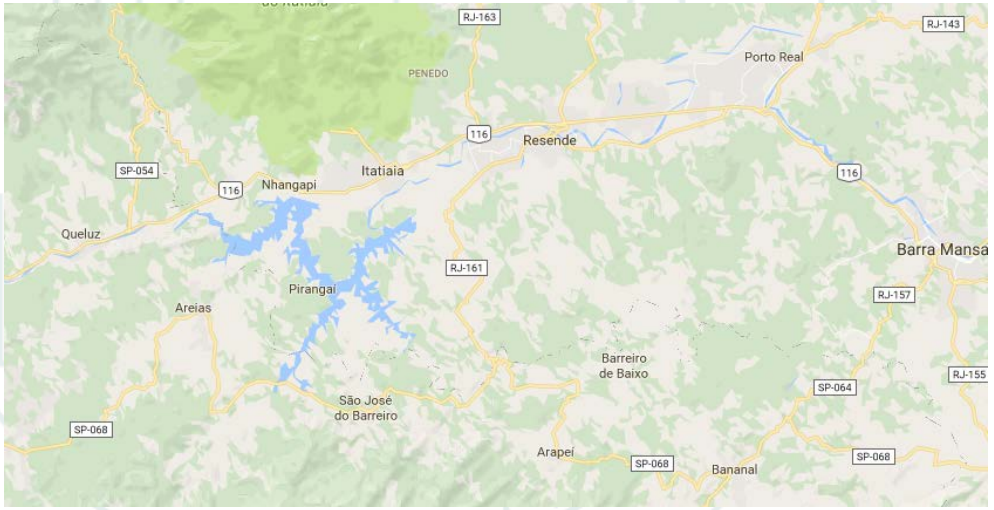
Although the choice for the plant construction site is not trivial at all and is strongly influenced by economic and legal parameters besides logistic, the decision-making was based mainly on three criteria:

Energy source	(%)
Hydroelectricity	65,2
“Small” Hydro	-
Solar	-
Wind	2,3
Nuclear	2,9
Biomass	8,0
Natural gas	13,0
Coal	3,2
Fuel oil	3,2
Diesel oil	2,2

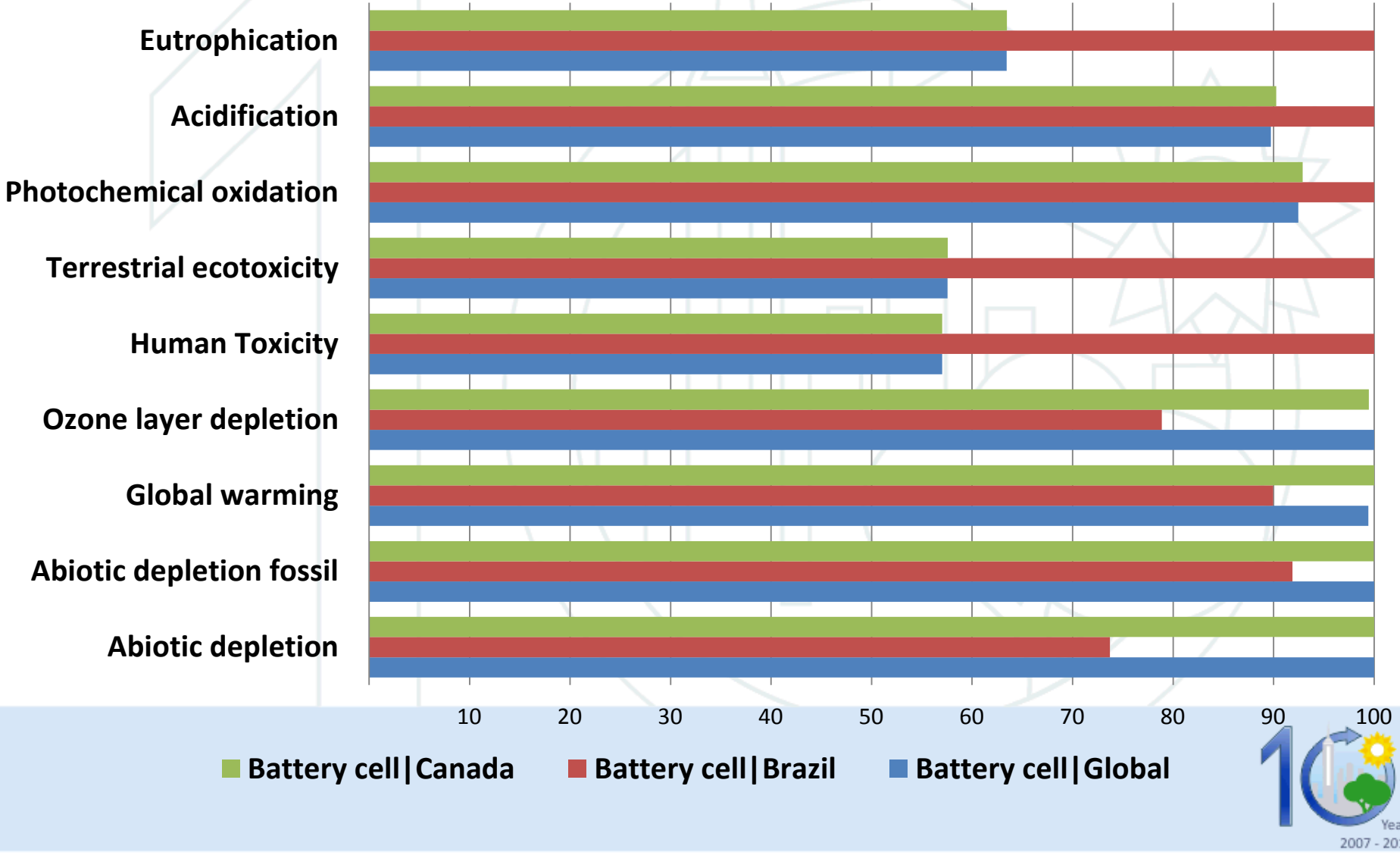
→ **Transportation-Logistics**

- The manufacturing plant must be granted an easy access to Brazilian highway system and, if possible, ports.
- Building the plant in locations too far away from potential suppliers (or customers) will probably mean higher costs / environmental impact.
- Manufacturing Plants outside large urban centers can bring tax advantages and lesser local environmental impacts to already polluted cities

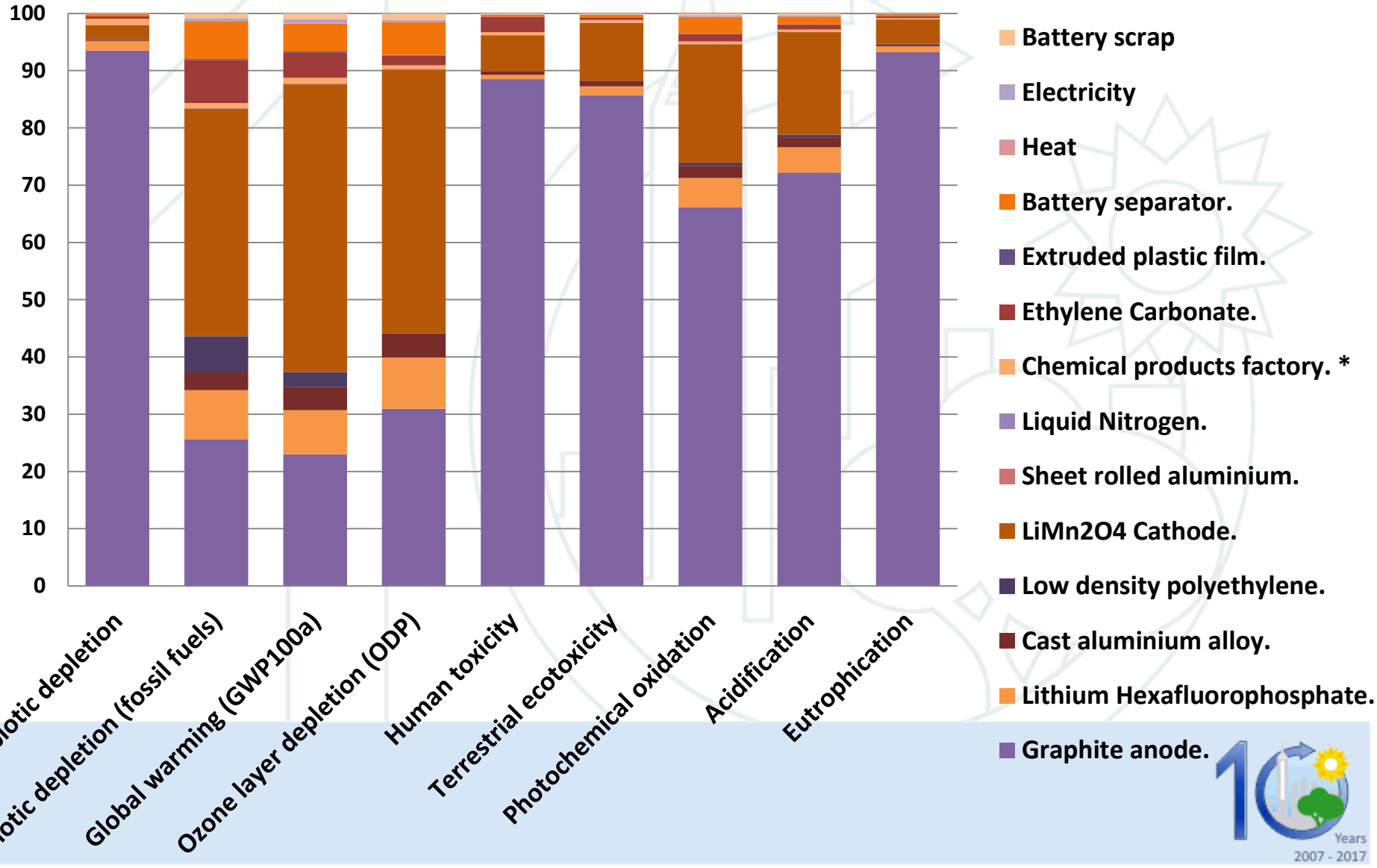
Resende (RJ), (Lat: -22.46 S, Long: -44.44 W), known as the "Fluminense Capital of Entrepreneurship". Its proximity to Dutra Highway and its strategic position between São Paulo and Rio de Janeiro, in addition to having almost equidistant access to the ports of Santos (SP) and Rio de Janeiro (RJ) made it an outstanding option



Relative environmental impact



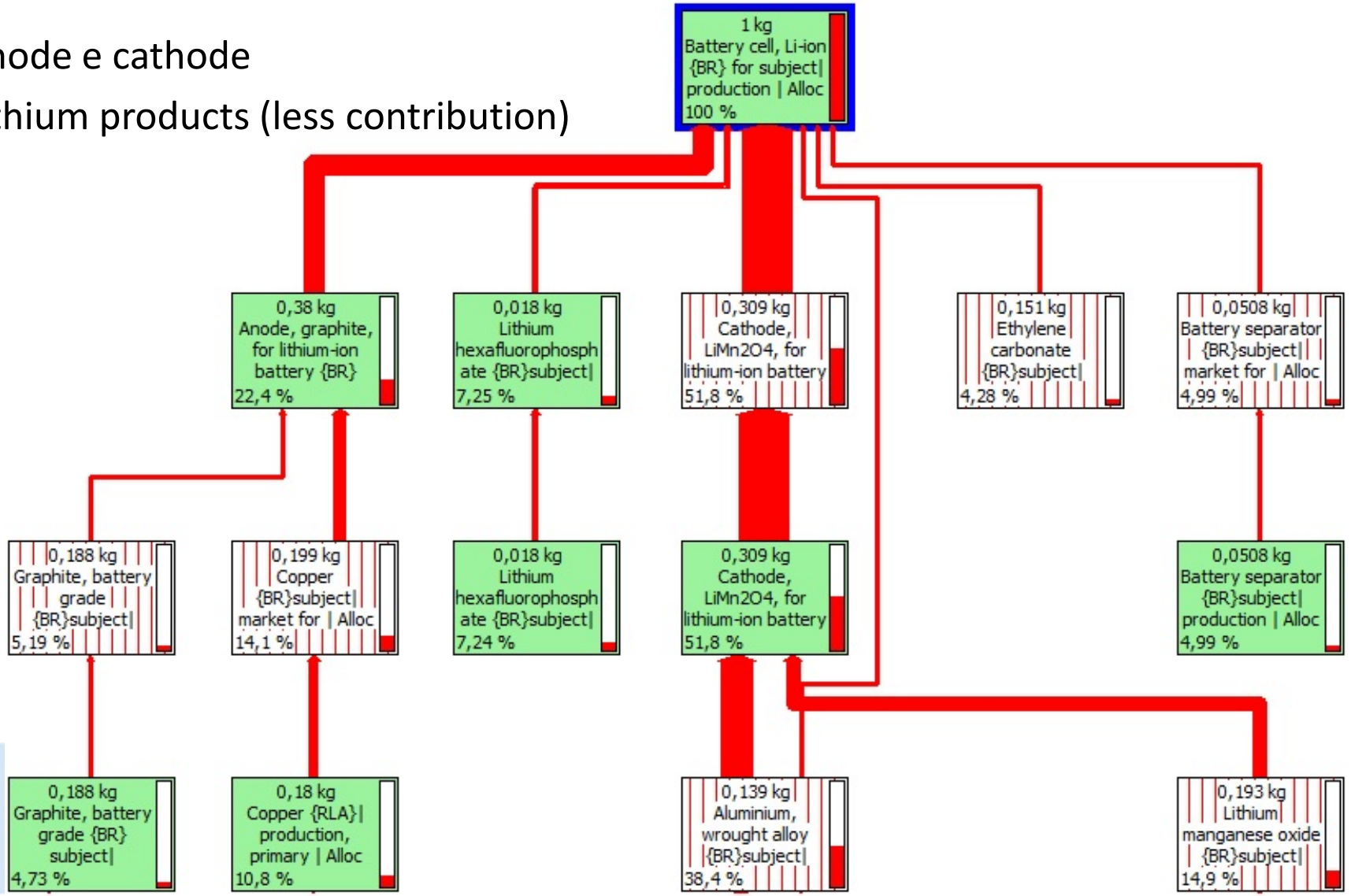
Contribution of each component to each category



Results: Global warming

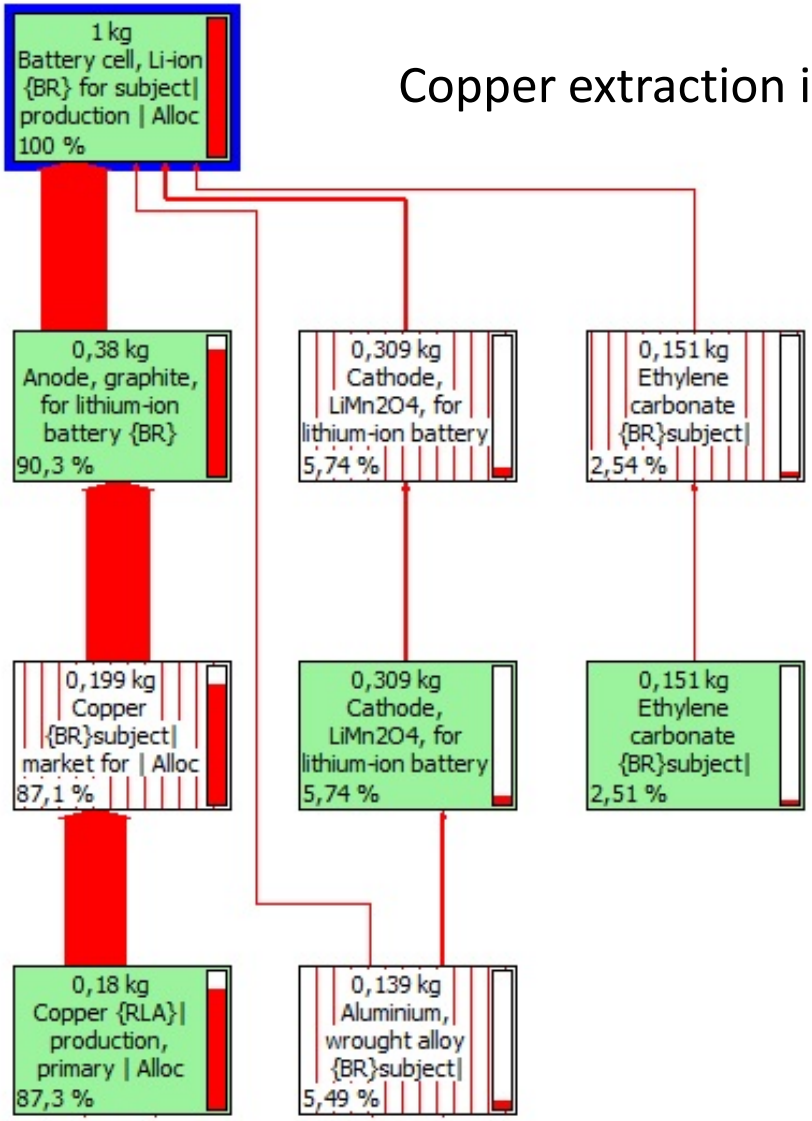
Anode e cathode

Lithium products (less contribution)



Results: Human toxicity

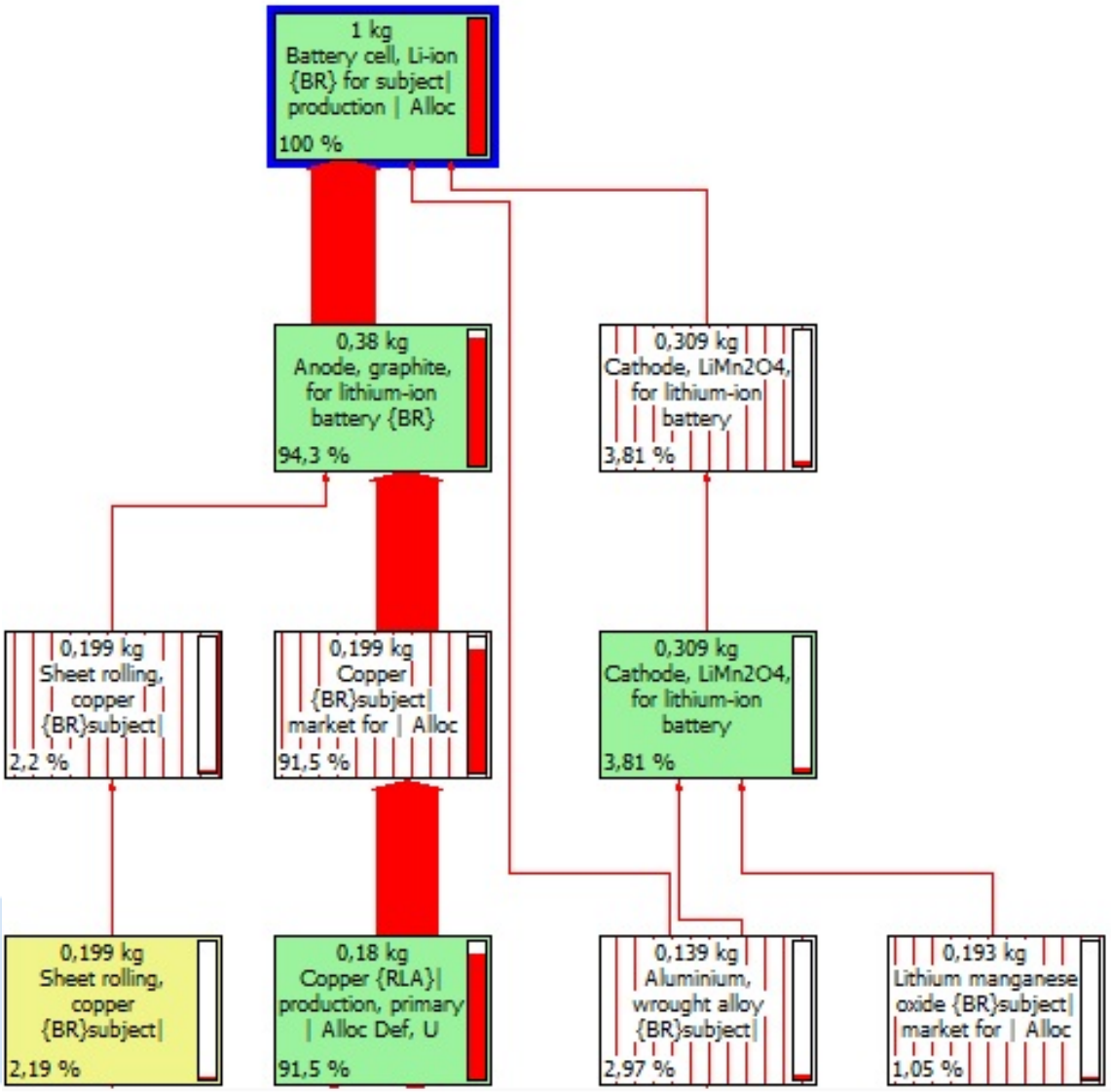
Copper extraction in Latin America



Results: Eutrophication

Copper !

Aluminum also



Conclusions

- In the case of global warming the production of aluminum plays an important role due to the fact of being so energy intensive. It is shown that aluminum intended for the cathode is the main contributor to this category.
- With regards to the anode, it is noticed that the main contributions are due to the extraction of copper and graphite.

Conclusions

- For Human Toxicity, copper extraction in Latin America ends up being the main contributor to an immense difference. This is a clear sign that any impact reduction in copper extraction stage could involve larger reduction of environmental impacts.

Thanks