4.3.13: Life Cycle Assessment of Cobalt & Lithium for Batteries & Electronics

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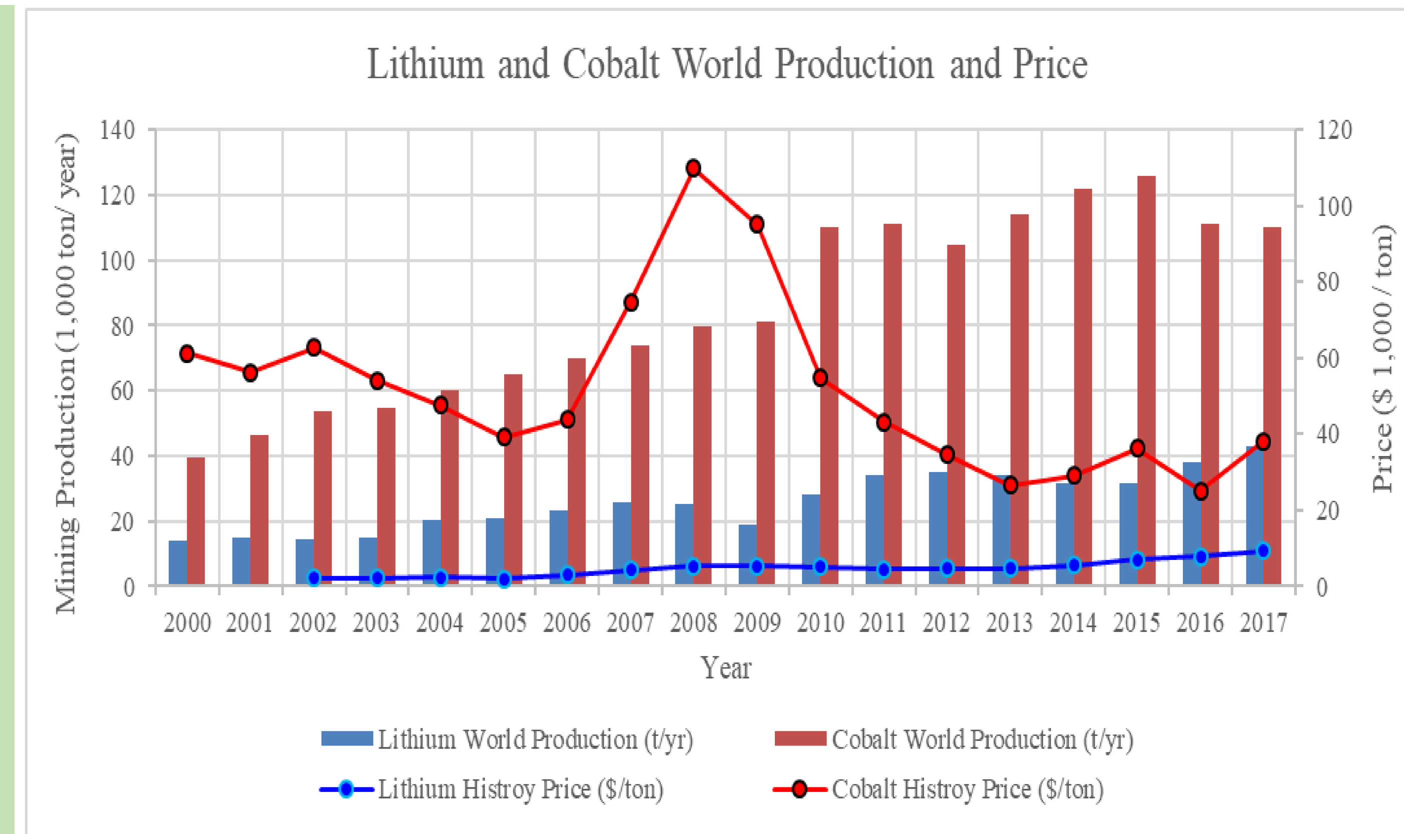
Introduction

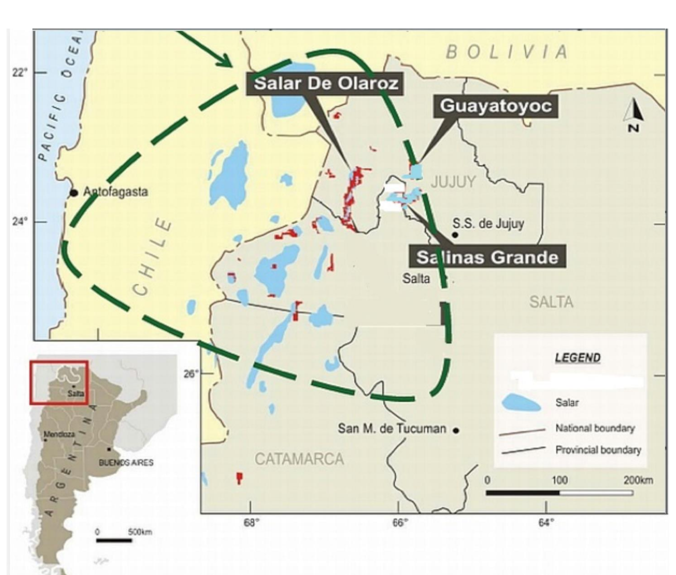
The battery and electronics include critical materials such as cobalt and lithium. As the demand of electric vehicles and electronics is increasing, there are increasing concerns on resource depletion and environmental impact of these critical materials. Current environmental life cycle assessment studies have issues such as:

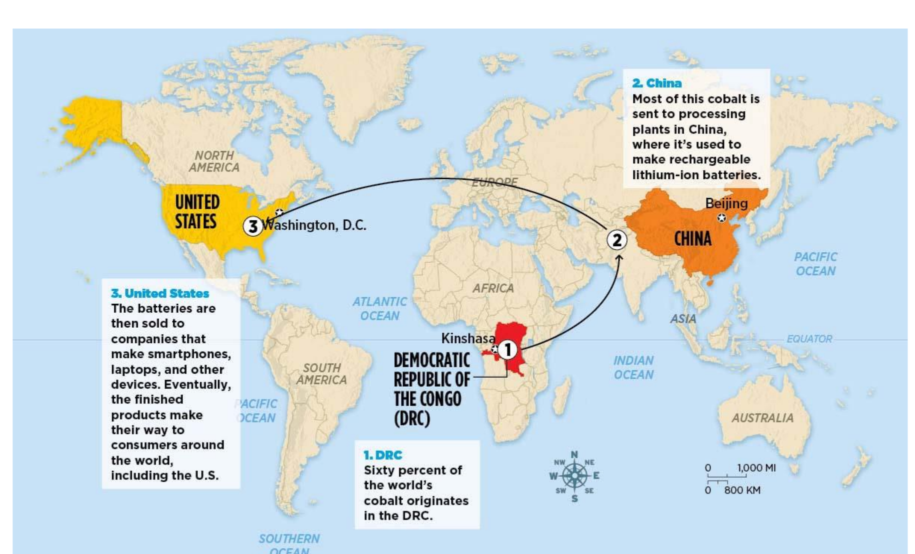
- No standard functional unit definition and boundary setting
- Lack of specific Life Cycle Inventory for critical materials
- Unrealistic characterization of some impact categories, e.g. resource depletion



Background

- **Lithium** is mainly extracted from **salt brines** (50%), **minerals** (40%), and others (10%), e.g. clay deposits.
- **Cobalt** is mined from the Democratic Republic of the Congo (DNC) (58%), then mainly refines in China (60%).





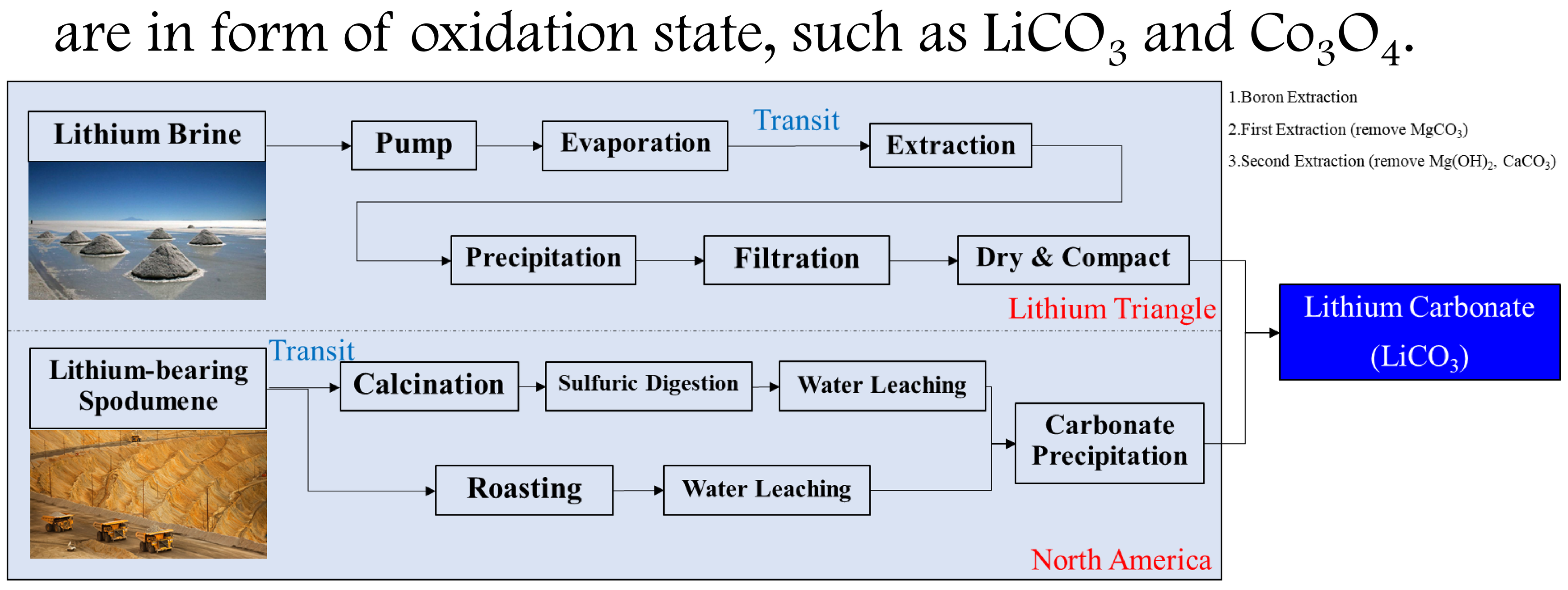
Source: 1. Lithium Triangle, https://ultralithium.com/projects/overview-of-projects/
2. Cobalt, https://junior.scholastic.com/issues/2016-17/051517/the-real-cost-of-batteries.html

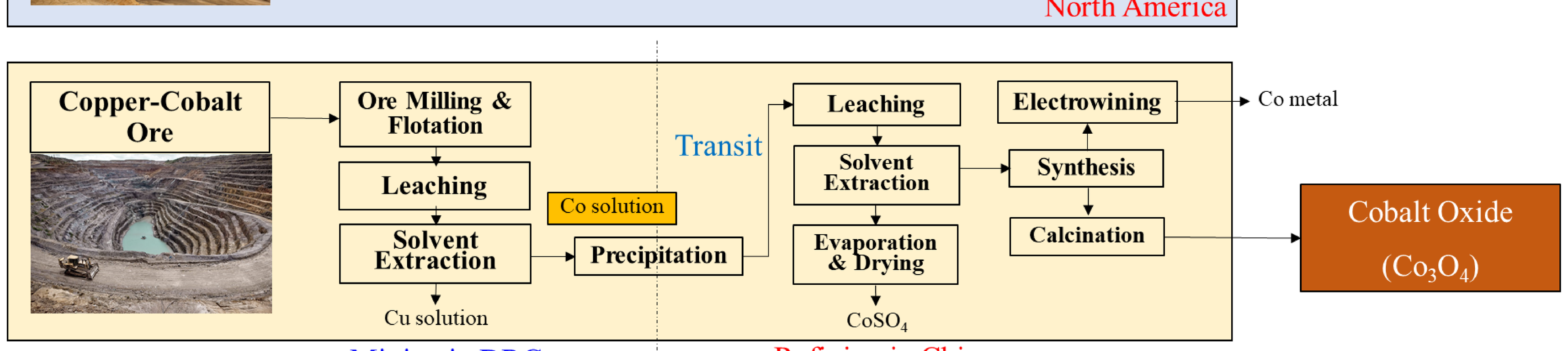
Objects

- Evaluate Li and Co manufacturing processes
- Quantify the environmental impact associated with Li and Co production processes
- Identify issues for LCA of critical materials

Mining Process Steps

1. **Lithium Brine from Lithium Triangle (South America):** 1,500 ppm lithium brine is pump from well. Then, use solar to evaporate brine to 60,000 ppm. After B, Ca, and Mg elements extraction, lithium chemicals are dried and make to $LiCO_3$.
2. **Lithium-bearing Spodumene from North America & Copper-Cobalt Ore from DRC:** For refining minerals, mainly utilize smelting, leaching, and refining processes. In order to be used in batteries, the minerals are in form of oxidation state, such as $LiCO_3$ and Co_3O_4.



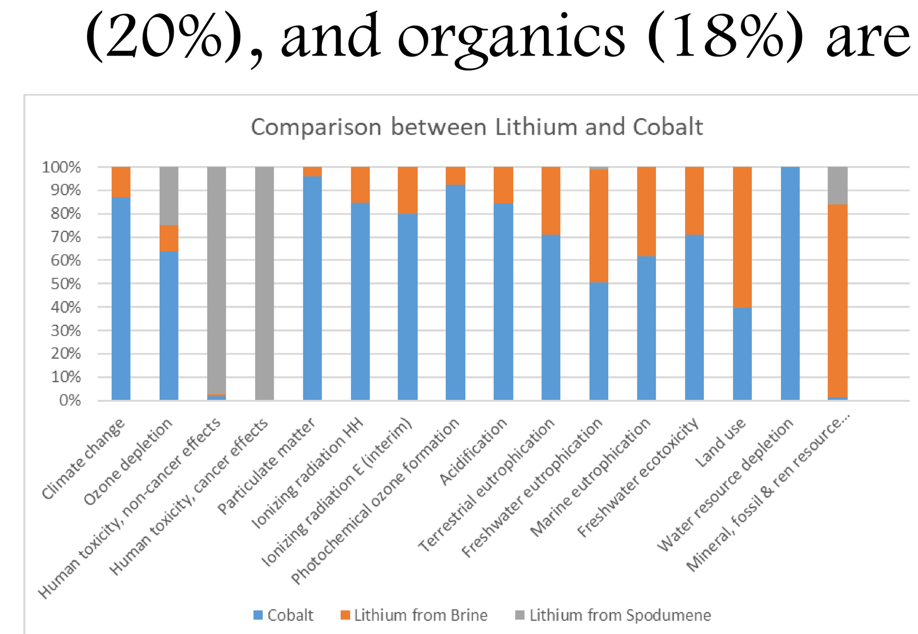


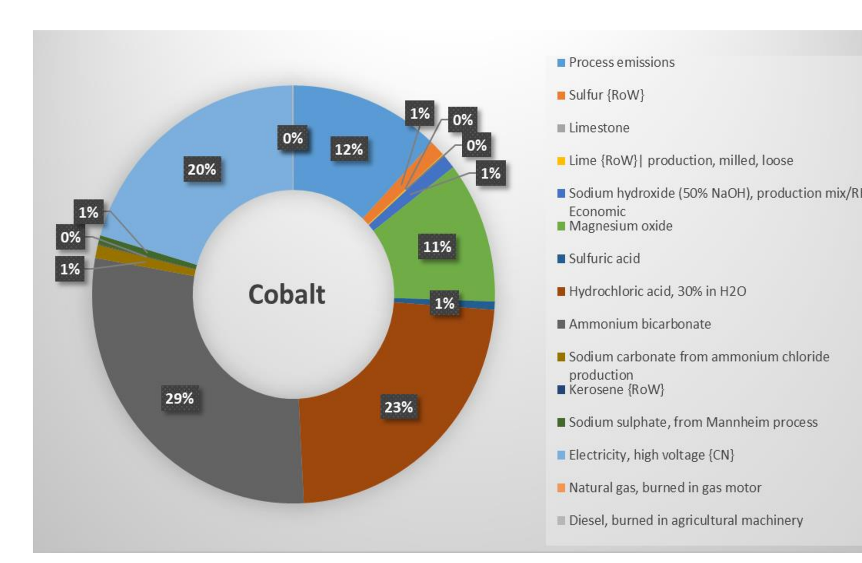
Methods

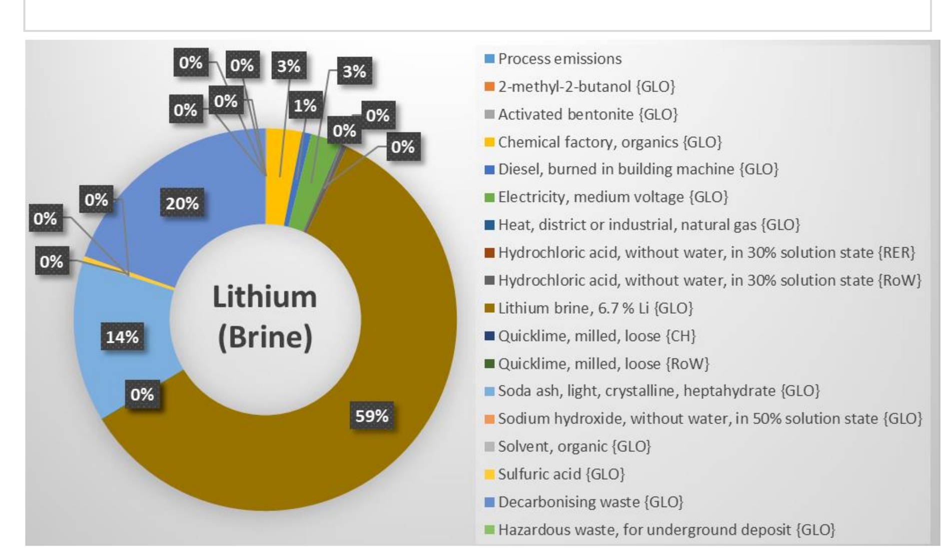
- Construct the Life Cycle Inventory by the secondary data
- Use CMLCA system to model the environmental impact of Co and Li processes
- Choose TRACI 2.1 and ILCD as the assessment methods

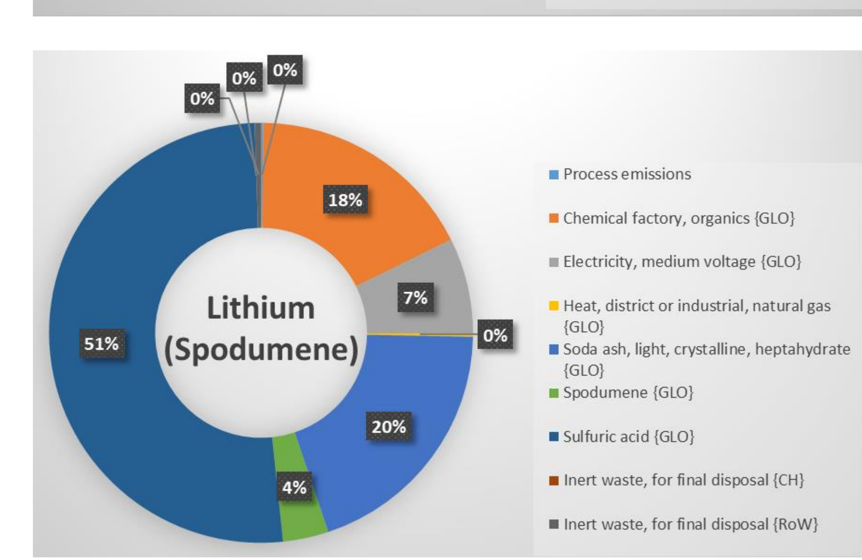
Life Cycle Assessment Results

- Environmental impact categories of Co exceeds it of Li, except Human Toxicity, Land Use, and Mineral, Fossil & Resource.
- **For Co**, usage of ammonium bicarbonate (29%), hydrochloric acid (23%), and electricity (20%) are the highest impact processes.
- **For Li from brine**, lithium brine extraction (59%), decarbonizing waste (20%), and usage of soda ash (14%) are the highest.
- **For Li from spodumene**, usage of sulfuric acid (51%), soda acid (20%), and organics (18%) are the highest.









Conclusions & Recommendation

- The hot spot processes identified suggest future research opportunities for making Co and Li production more sustainable
- Resource depletion method should be evaluated
- It is beneficial to integrated LCA with TEA in early process development stage.

Acknowledgements

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