EVIRONMENTAL IMPACT ANALYSIS OF SODIUM-ION BATTERY MANUFACTURING IN THE UK AND CHINA

Life Cycle Assessment of the Manufacturing Process of Sodium-ion Batteries

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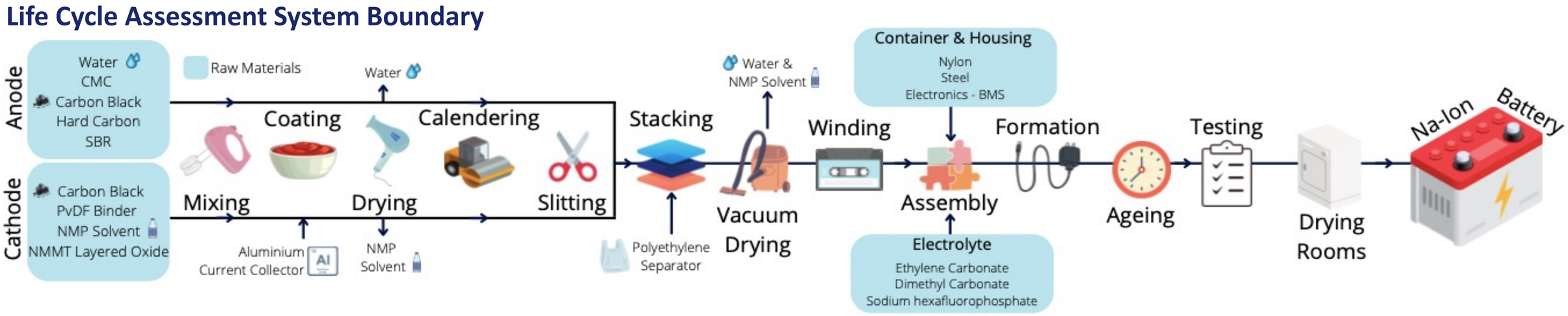
Abstract

Sodium-ion (Na-ion) batteries are becoming apparent as potential alternatives to Lithium-ion (Li-ion) batteries as they use cheaper and more abundant materials. Current Na-ion battery technologies don't require copper electrodes and the abundance of sodium around the world helps to overcome geopolitical issues around sourcing. [1] One way that environmental impacts of manufacturing Na-ion batteries can be mitigated is by choosing the location of the manufacturing site wisely. This study found that manufacturing Na-ion batteries in the UK instead of China resulted in a lower environmental impact.

Study Details

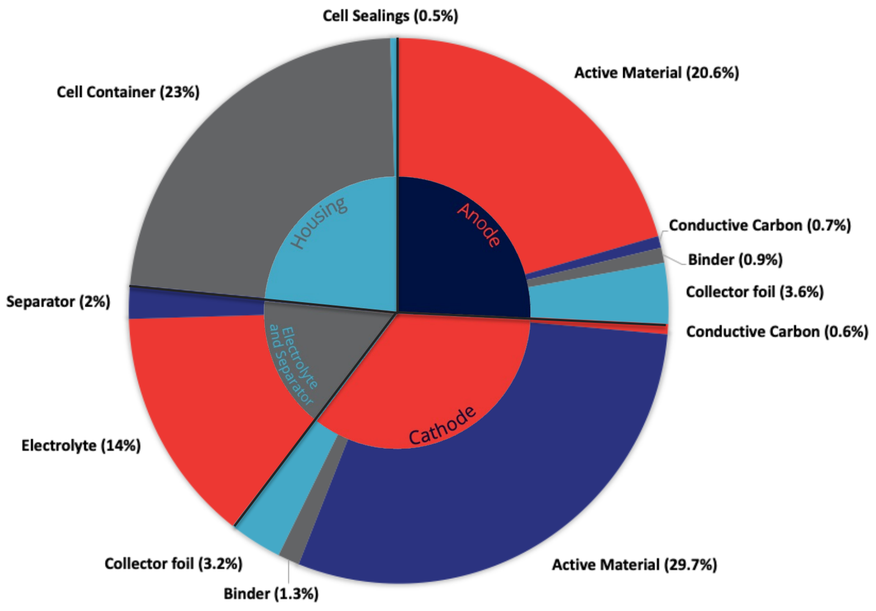
- In this study, it was intended to employ a cradle-to-gate life cycle assessment focusing solely on the environmental impacts of the Na- ion battery manufacturing process and the source of the raw materials.
- The system boundary of the study is shown in the schematic below, which highlights the inputs and outputs of each manufacturing step.[2] Note that energy, infrastructure and transportation requirements are not shown but were taken into account in this study.

Life Cycle Assessment System Boundary



Methodology

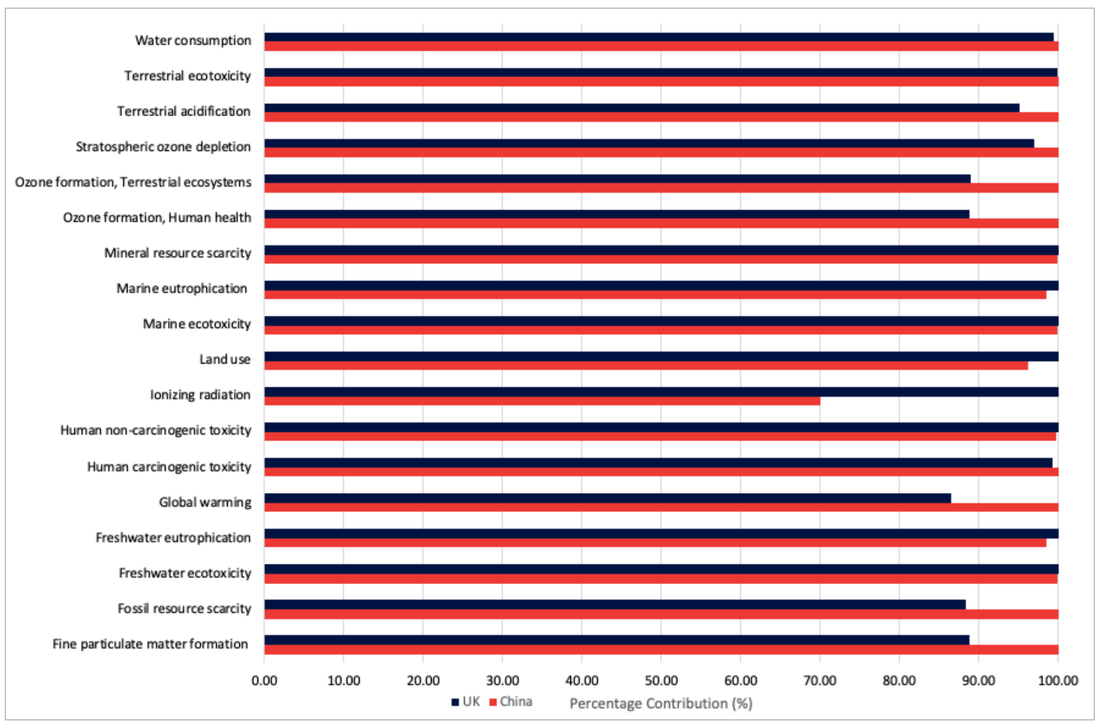
- The typical composition of a cylindrical Na-ion battery is summarised in the pie chart below.[1]



- A cradle-to-gate life cycle assessment was carried out using the Ecoinvent database on OpenLCA software to assess the environmental impacts of manufacturing these components.
- This study takes into account the energy, transportation, and infrastructure requirements of each step along with the extraction of raw materials.

Results

- The following results were obtained from the life cycle assessment conducted on OpenLCA.
- The percentage difference in all 18 environmental impact categories are summarised in the bar graph below.[3]



- From the bar chart above, the key results are:
- Ionizing radiation is reduced by 30% when manufacturing in China.
- Global Warming Potential is 13% less when manufacturing in the UK than in China.
- Fine Particulate Matter Formation and Fossil Resource Scarcity is 11% and 12% less respectively, when manufacturing in the UK.
- Ozone formation, Human Health and Terrestrial Ecosystems is 11% less when manufacturing in the UK.
- The other impact categories have small or negligible differences.

Conclusions

- Ionising radiation is the reduced by the greatest margin when Na-ion batteries are manufactured in China instead of the UK. It is linked to the emissions of radionuclides throughout a product life cycle and can damage human health and surrounding ecosystems.
- Global warming potential is reduced significantly when Na-ion batteries are manufactured in the UK. A 13% reduction corresponds to about 130,000 kg eq less CO_2 released into the atmosphere.
- Overall environmental impact is reduced slightly when Na-ion batteries are manufactured in the UK instead of China.

Impact / Next Steps

- Ultimately, to answer the question of how to reduce the environmental impacts, one must consider:
  - Transport to where the demand is. China has been the world's largest lithium battery consumer market for five consecutive years.
  - Rules and regulations. The EU, China and the UK all have specific guidelines with regards to battery transport and end-of-life processing.
- Additionally, Reka Keresztes has compared the impacts of Li-ion vs Na-ion batteries, to emphasise Na-ion batteries as a promising alternative.

References

- [1] Peters, J. *et al.,* 2016. *Energy & Environmental Science*, 9, 1744. DOI:10.1039/c6ee00640j
- [2] Degen, F. *et al.*, 2021. *Journal of Cleaner Production,* DOI:10.1016/j.jclepro.2021.129798
- [3] *Frischknecht, R. et al. 2007. Overview and Methodology. ecoinvent report No. 1.* Swiss Centre for Life Cycle Inventories, Dübendorf

Intern Bio

Nicholas is a second-year chemical engineering student at Imperial College London. Upon graduation, he aspires to be part of the global energy transition and help the UK achieve its net-zero targets by 2050. This will hopefully be achieved by pursuing a career in the energy sector or by focusing on research towards cleaner energy sources or cleaning energy sources.

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