UFCFDS-15-1 CSA Report

# Topic: Sustainability of lithium-ion batteries

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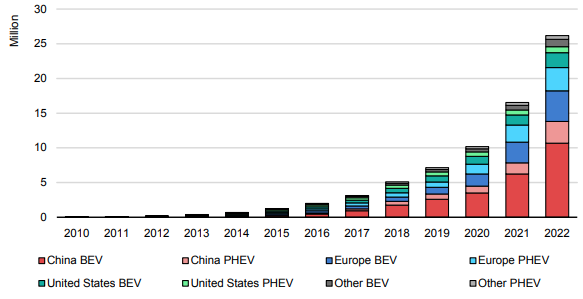
# Abstract

As the demand for rechargeable battery solutions increases, due to an increase in mobile technology and electric vehicles, the demand for lithium-ion batteries and the raw materials that are used in the production has also increased. This has also increased the need for battery recycling methods however economics of it is unclear currently. There have been life cycle assessments (LCA) on lithium-ion batteries focusing on the production however there has been a lack of conclusive LCAs on the disposable and recycling processes of lithium-ion batteries. This sector has been highly influenced by the governments of the world as in recent years they have been pushing policies for electric vehicles as a more environmentally friendly solution to transport however the lithium-ion batteries inside these vehicles can have a detrimental effect on the environment and can be a major contributor to climate change.

# Introduction

Factors including but not limited to population growth, economic development of the technology sector and technological research has increased the demand for energy storage solutions. Due to its high energy density and good energy cycling stability, the lithium-ion battery has become the most popular solution for rechargeable batteries [1][2] and are used in many areas such as personal electronics, medical equipment, [3] and electric vehicles [4]. As more governments push and enact policies for electric vehicles the market dominance of lithium-ion batteries is only going to increase [5][6]. This is most easily seen when viewing the amount of stored stock, in a two-year time period from 2020 to 2022 there was an increase by 15 million held by automotive companies and by 2022 over half, just under 15 million, of all vehicles are inside and produced by China (Figure 1) [7].

Figure 1



Chart, bar chart

Description automatically generatedThe growth of the lithium-ion battery industry has globally significantly increased the demand for lithium and therefor poses risks on the sustainability of the resource. Lithium mines in 2022 produced 130,000 metric tons of lithium which is the highest amount of lithium mined in a single year to date and is projected to only increase [8]. In only 10 years from 2012 to 2022 the yearly production of lithium has increased by almost 100,000 metric tons per year with 2012 having a peak production of 35,000 metric tons of lithium (Figure 2) [8].

Figure 2

# Technologies for lithium-ion battery recycling

Most techniques for recovering spent materials from lithium-ion batteries involve chemical treatment or a physical treatment which allows for the recovery of high value metals, active battery components or even the materials used to create active battery components.

## Pyrometallurgical recovery (PMR)

The process of pyrometallurgical recovery (smelting) can be used to recycle lithium-ion batteries into useful metals which can be reused either for battery production or for other products.

A commercialized process of PMR is currently used by companies across the globe, most notably JX Nippon Mining which is a Chinese based mining company and Glencore which is a multinational commodity trading company based in Switzerland [9]. As a result of PMRs being based on heating and smelting the batteries it allows it to be easily scalable for a commercial setting, however there are drawbacks to PMR most notably that the process produces toxic gas which is harmful to the environment. PMR processes also use significant amount energy to heat the batteries which can lower the efficiency of this method, coupled with the fact that the elevated temperatures of around 1723K can cause the loss of valuable metals such as lithium, aluminium and copper.

## Hydrometallurgical recovery (HMR)

Hydrometallurgical recover typically consists of three steps: pre-treatment, chemical leaching and separation [10]. HMR typically returns more returned resources that PMR however it is more expensive and less scalable making it less popular commercially.

Pre-treatment normally consists of discharging the battery then crushing it and removing the active materials. At this point they will recycle any aluminium foil and copper foil present in the battery [11]. However, the pre-treatment step also has a drawback as the disposal of electrolyte is currently environmentally unfriendly and upon decomposition can create harmful gasses.

Chemical leaching is the most crucial step for HMR as in this step the most metals can be extracted for recycling. The most common methods are acid leaching [12], ammonia leaching [13], electrochemical leaching [14] and bioleaching [15]. These methods are the most common due to them all having high extraction efficiencies.

The final process of separation is the final extraction of the metals from the leaching solution, this can be selective, by using certain solutions, and only specific metals can be extracted depending on what is required.

# Environmental impact of the production of lithium-ion batteries

Batteries are now one of the most common household items and due to improper disposal and the impactful production of lithium-ion batteries it has created environmental concerns.

Life cycle assessments (LCA) are used to determine the environmental impact of a item, the three types of LCA are cradle to gate, cradle to grave and grave to cradle [16] however lithium-ion batteries have managed to go under the radar for cradle to grave and grave to cradle LCAs which means the focus is on the production of the batteries which adds to the lack of knowledge when it comes to proper disposal practices.

LCA studies typically include multiple categories including global warming potential (GWP) and freshwater toxicity potential (FETP). The most assessed category in LCAs for lithium-ion batteries is GWP and this has found that the production of secondary materials that are used in construction of batteries generates more polluting greenhouse gas emissions than the production of the active cathode materials [17]. The level of greenhouse gas emissions ranges significantly depending on the manufacturer, this is due to the resource being used to generate the energy for production and some processes are less energy efficient than others. For example, most electricity production in China is coal-fired power plants whereas in the USA it is not.

# Conclusion

The long-term sustainability of lithium-ion batteries is dependent on the advancement of recycling methods becoming more energy efficient as the current methods require a lot of energy to perform and create hazardous materials in the form of electrolyte which if not disposed of correctly can generate toxic gasses.

The production of lithium-ion batteries will also have to become more efficient as currently both the production of secondary materials and lithium-ion cathodes create a toll on the environment in multiple ways. Firstly, the mining of lithium is increasing every year to keep up with the demand which is expected to continue increasing (Fig 2). Secondly, the production of lithium-ion batteries especially in countries where the main energy generation source is fossil fuels continues to release greenhouse gases.

Overall, the sustainability of lithium-ion batteries is at risk unless technological advances in both the areas of production and recycling are achieved.

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