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E-Waste and the Circular Economy: Applying the Concept Of Circular Economy To E-Waste, Focusing On Lithium-Ion Batteries

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ABSTRACT

E-waste continues to be a global menace as millions of used electronic appliances are thrown away after use each year and a tiny proportion of them are recycled properly. To reduce the harm caused by E-waste, it is important to adhere to the concept of circular economy. A circular economy aims to make production a cycle, rather than the current linear model. This paper reviews the current literature on e-waste and circular economy. It sheds light on global efforts to boost the circular economy. The European Commission's action plan for the circular economy model in 2020 aims to reduce e-waste by promoting ideas of sustainable design and recycling. The action plan includes solutions for designs including the requirement for USB-C to be the common charger for most electronic devices and encouraging recycling through a reward system. The paper then focuses on challenges related to lithium battery recycling and discusses innovative efforts by Ascend Elements and the Faraday Institution project at the University of Leicester and Birmingham.

Introduction

A circular economy is an economic concept that aims to make production a cycle, rather than the linear style as it is today. Currently, products are manufactured, used, and discarded and new resources are acquired to start the same process again. Production and waste disposal methods themselves may not be efficient and might result in wastage of resources. Hence, the main focus of a circular economy is to use resources efficiently, by making sustainable designs that allow products to last longer, using recycling methods that allow materials from used products to be repurposed, and creating production methods that are less harmful to the environment (Alhawari et al., 2021; Arruda et al., 2021). One industry where the circular economy has a huge potential to bring about meaningful change is the electronics industry, which produces millions of tonnes of e-waste a year (Madkhali et al., 2023).

The Growing Problem of E-Waste

E-waste is a growing problem across the globe as millions of used electronic appliances are thrown away after use each year although some of them are recycled (Madkhali et al., 2023). In the European Union, 10.3 kilos of electrical and electronic equipment waste per inhabitant were collected in 2020. Out of the 44.7 million metric tonnes of e-waste produced globally in 2017, only 20% were recycled properly. The rest was likely dumped in landfills, traded, or improperly recycled (European Commission,2020). In this case, they neither aid further production nor add value to the environment.

Efforts To Promote Circular Economy

Some solutions to reduce e-waste have been enacted around the world. The European Commission presented an action plan on the circular economy model in 2020. It aims to reduce e-waste by promoting the ideas of sustainable design and recycling. Solutions for designs include the requirement for USB-C to be the common charger for most electronic devices to reduce unnecessary usage of resources and that the sellers must repair products unless providing a replacement is cheaper. Recycling electronics will be encouraged through a rewards system which gives people incentives to recycle their electronics correctly (European Commission,2020).

Lithium-ion batteries are the most widely used rechargeable batteries used in mobile phones, cameras and even electric cars. Lithium is mostly mined in Australia and South America, but the extraction processes require billions of gallons of water a year and high amounts of electricity, making extraction an environmentally destructive process (Hirschlag,2022). Lithium is theoretically infinitely recyclable. However, the physical and chemical processes are expensive and arduous (Hirschlag,2022). Normal cell batteries are typically shredded and then melted or dissolved in acid. Lithium-ion batteries, however, consist of a vast range of components which might explode if they are not broken down properly. This is why a majority of lithium-ion batteries are currently recycled by hand (Noudeng et al., 2022; Gellerman, 2022). Only 5% of lithium batteries are currently being recycled in the US due to the difficulty of recycling (Hirschlag, 2022).

Many innovative solutions to recycling lithium-ion batteries have sprung up around the world. One idea comes from the Karlsruhe Institute of Technology in Germany. The method involves using the battery's cathode and aluminium foil, which are then grounded in a spinning cylinder containing balls, also called a 'ball mill'. It is observed that the mechanical force of the milling is enough to cause reactions between the aluminium and the cathode components, although researchers are not sure why. After adding hot water to the ground mixture lithium carbonate, which helps produce new batteries is formed. The limitation of this idea is that the process of separating cathode material from the battery cannot be avoided, so we cannot simply grind the batteries as a whole (German Energy Solutions, 2021).

Another idea comes from the company Ascend Elements. Its founders, while researching at Worcester Polytechnic Institute, came up with the idea of shredding the batteries and passing them through sieves, a process called 'Hydro-to-Cathode'. The resulting powder is called 'black mass' which contains the valuable metals from the batteries. The company also claims that the batteries produced from this powder have longer life cycles than the original batteries. The most significant outcome is that this process requires only half the cost of mining minerals and results in 93% lower carbon emissions (Ascendelements.com, 2024).

Another creative solution comes from the Faraday Institution project at the University of Leicester and Birmingham, which has created a method using ultrasonic waves to separate usable material from the electrodes of a lithium-ion battery. This method is 100 times faster, more environmentally friendly, and leads to a higher purity of recovered material compared to traditional methods which mostly require materials to be separated by hand (le.ac.uk,2022).

Many other untapped solutions can be implemented to make the recycling process of lithium-ion batteries easier. One possibility is using automation to dismantle the parts of the batteries gently, thereby reducing the time by avoiding manual work. Another solution could be organic batteries, replacing lithium-ion batteries entirely, which could decompose naturally so they do not even need to be recycled (Zanoletti et al., 2024). Innovative solutions to these problems must be focused on in the coming years, especially because technology is spreading fast across the globe and e-waste will grow with it. Such solutions are vital to improving not only the state of the economy but also the environment.

Conclusion

Even though significant efforts are being made to boost the circular economy, these are sporadic and by no means adequate in comparison to the ever-increasing amount of e-waste generated across the globe. Lithium batteries in particular require much more attention and innovative solutions to lessen the harm to the economy and to the environment.

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