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Commentary

Commentary health risks from climate fix: The downside of energy storage batteries

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ABSTRACT

Energy storage is the key component to almost all technologies arising in response to climate change. Although most lead batteries are recycled, the process as employed in the majority of recycling plants around the world is highly polluting. Lithium ion batteries, considered the most advanced battery for climate solutions, are employed in electric vehicles, solar lanterns, and increasingly in other energy storage applications. These are generally not being recycled as there are no available technologies to economically extract metals in a form that can be used to make new batteries or other high-value products. As the energy storage market is projected to grow rapidly in coming years, we must consider the impacts of increased mining, milling, smelting and recycling of these metals. Much of these materials will be extracted and processed in low and middle-income countries and eventually be recycled in these same jurisdictions with few regulations to protect public health and the environment. Technological responses to climate change must take account of potential health risks inherent in such products.

1. Background

A recent initiative by the U.S. Department of Energy unmasks a little-known fact that lithium ion waste batteries employed in electric vehicles and increasingly for energy storage are not economical to recycle with present technology. In response, the Department announced a $20 million investment to boost the rate that these batteries are recycled (U.S. Department of Energy, 2019).

Climate change policies have accelerated the adoption of lithium-ion and lead storage batteries with serious consequences for environmental sustainability and human health. Although these efforts have reduced greenhouse gas emissions, they have sparked demand for batteries made with hazardous materials including cobalt, manganese, and lead. This material is increasingly being sourced from informal sector mining in low and middle-income countries where few regulations provide any protections.

Off-grid solar energy is providing power to 73 million households mostly in Asia and Africa and installations are expected to triple by 2022 (International Finance Corporation, 2018). These systems are largely dependent on lead batteries for storage. Millions of solar lanterns are also being distributed in the most remote regions and rely on lithium-ion batteries. It is estimated that 44 million such units have been sold and that future sales will grow by 34% annually. (Mills, 2016).

More than 3.7 million electric cars with lithium-ion batteries are already in use and sales are increasing by more than 50% annually (Trafigura, 2018). The arithmetic mean mass of the batteries used in current popular models in the U.S. is more than 350 kg (see Table 1). It is anticipated that there will be 50 million electric vehicles by 2030. In addition, more than 200 million electric bikes (ebikes) are registered in China (Zhecheng, 2018). In cities around the world, more than 70 companies have installed millions of ebikes and electric scooters for short-term rentals largely dependent on lithium-ion batteries. (Lin, 2017).

2. Lithium-ion batteries

Aside from the rare incidents where lithium-ion batteries have caught on fire, hazards come primarily during the production and disposal process (Finegan, 2016). There are few controls in place to address the health impacts of manufacturing and recycling of lithium-ion batteries in most countries. The hazards inherent in lithium-ion batteries include exposures to cobalt, manganese and nickel that come from mining, smelting, and recycling or disposing of these materials.

Exposures to cobalt can cause health effects such as asthma, pneumonia, skin rashes and it is a possible carcinogen. Liver and kidney effects have also been observed in animal studies (Leyssens, 2017). Exposures to manganese can result in lung irritation, impotence,

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Table 1
Mass of Lithium-ion batteries in common electric vehicle models.

Make/Model	Li-ion Battery Mass (kg)
Nissan Leaf	272
Tesla Model S	544
BMW i3	204
Volkswagen e-Golf	312
Chevrolet Bolt	436
Mean	**353.6**

respiratory problems, permanent brain injury, loss of motor skills, and neurological problems (ATSDR, 2012). Less is known about the combined effects from multiple metal exposures common in mining or, potentially in recycling these batteries.

Informal cobalt mining produces up to 40% of global cobalt supplies and is concentrated in the Democratic Republic of Congo (Trafigura, 2018). Evidence of health impacts on these communities is building (Nkulu et al., 2018).

Despite having been commercially available since the 1990s, there is only limited capacity for recycling these batteries and current processing plants are unable to recover metals with adequate purity for producing new batteries. Instead most of these batteries are being disposed in landfills where they potentially can contaminate drinking water sources. In the U.S. and European Union, it is estimated that only 3–5% of lithium-ion batteries are recycled despite having the most robust battery collection requirements (Vikström et al., 2013, and U.S. Department of Energy, 2019).

A major challenge in recovering raw materials from recycled lithium-ion batteries is that more than eight differing chemistries are being commercially produced without any uniform labeling system or color coding (Gaines, 2014). The recovery of high purity metals from such varied feedstock will remain difficult or impossible to achieve on a commercial scale. As the most lucrative by-product of processing these batteries is the recovery of cobalt (constituting up to 20% by weight), other metals and components are generally incinerated or discarded in the few facilities where these batteries are processed.

Yet the industry's only response to this looming waste crisis is to suggest that these batteries will be redeployed for energy storage applications after exhausting their potential from ten or more years of use in vehicles. Given the size and weight of these battery packs, this may be more of a public relations program than a realistic possibility. At best the idea of reuse will only prolong their life for a few years and slow down overall demand.

While legislation has been passed in some States in the U.S. (including California and New York) to collect batteries used in electronics, these laws do not yet extend to vehicle applications (Nash and Bosso, 2013). Even if the technological hurdles for recycling can be overcome, mandatory collection systems would be necessary to provide the necessary economy of scale.

3. Lead batteries

In contrast, lead batteries are the most recycled product but few countries have recycling plants with adequate emission controls and occupational protections. It is estimated that 99% of lead batteries in the U.S. and EU are recycled (Gaines, 2014). These plants generally operate with a pyro-metallurgical process, but in 2017 a startup had begun recycling lead batteries in Nevada with a hydrometallurgical process that still requires refining with high temperature kettles (Ballantyne, 2018). Lead contamination emitted from the lead battery recycling process is spread around facilities in Africa and Asia (Gottesfeld et al., 2018). Lead particulates and fumes from these facilities are inhaled and deposited on soil, dust and water. In Los Angeles, the State has allocated millions of dollars to clean up contamination from a lead battery recycling plant that was forced to close in 2015 that has impacted thousands of properties over a 1.7-mile radius (Johnston and Hricko, 2017).

Even at low levels, lead is associated with neurological deficits, high blood pressure and is responsible for 674,000 deaths annually (Lim et al., 2012). In children, moderate lead exposure is responsible for a significant decrease in school performance, lowering IQ scores, and is linked with hyperactive and violent behavior. The health effects of lead battery recycling on workers and surrounding communities are well described in a report by the World Health Organization (WHO, 2017).

Lead ore is also sourced from informal sector mining and used lead batteries in many low-income countries are melted down on the side of the road or in crude facilities to be sold for scrap (Gottesfeld and Pokhrel, 2011). Poorly processed lead is not useful to make new batteries and must first be smelted and refined before it is used. At each step, there are considerable losses to the environment in the form of air and water emissions. As the lead battery industry grows, we can expect to see ongoing expansion of these hazardous informal activities and growth in the volume processed in poorly designed smelters without adequate pollution controls.

4. Conclusions

If we are going to responsibly advocate for policies to encourage the adoption of electric vehicles, as well as wind and solar power reliant on hazardous energy storage batteries, we must also work to develop standards for these industries. Governments need to address mining practices and improve the manufacturing and recycling of lead and lithium-ion batteries in order to minimize health impacts. An obvious place to start is to require manufacturers and importers to take back used batteries. We must not turn a blind eye to the negative impacts of technology driven climate change solutions. It is time to shine a light on these shortcomings and greatly expand investment to reduce hazards and improve sustainability of storage batteries.

Declarations of interest

None.

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