Northern Ireland Assembly

Research and Information Service Briefing Paper

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Electric-Vehicle Waste

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1 Introduction

At the Committee for Infrastructure meeting on 7 October 2020, RaISe briefed the committee on Transport Decarbonisation. At this meeting, the Committee requested information on issues relating to potential implications of waste arising from the disposal of used electric-vehicle (EV) batteries.

This briefing sets out the issues relating to EV waste and outlines current mitigation measures.

2 Context

Electric car deployment has been growing rapidly over the past ten years, with the global stock of electric passenger cars passing 5 million in 2018, an increase of 63% from the previous year.

- Around 45% of electric cars on the road in 2018 were in China – a total of 2.3 million – compared to 39% in 2017.
- In comparison, Europe accounted for 24% of the global fleet, and the United States 22%.[1]

[1] International Energy Agency, Global EV outlook 2019, accessed 20 October 2020

Carbon Brief has reported that in the UK *"EV sales increased by 664% between 2016 and September 2020 while diesel sales have plummeted 75 per cent over the same period"*.[2] However, EVs still account for less than 1% of licensed vehicles in the UK.[3]

The Paris Agreement (PA) will be a major driver of EV uptake. RaISe publication 289-20 sets out the UK Government's plans to decarbonise road transport by 2040, as part of its commitment to the PA, which is based largely on the promotion of zero emission vehicles, including EV. The International Energy Agency estimates there will be 140m electric cars globally by 2030 if countries meet PA targets.[4]

2.1 The issue

The growth in EV deployment has given rise to concerns over waste created by batteries which have reached the end-of-life.[5] Engel, et al. point out that lithium ion batteries (LIB) in EV degrade considerably over the first five years of operation and are designed for approximately a decade of useful life in most cases.[6]

Harper, et al. have calculated one million EVs, of an average battery pack weight of 250 kg and volume of half a cubic metre, would comprise around 250,000 tonnes and half a million cubic metres of unprocessed pack waste, when these vehicles reach the end of their lives.[7] Professor Andrew Abbott, of the University of Leicester and co-author on the paper cited, has commented:

> *"Electrification of just 2 per cent of the current global car fleet would represent a line of cars that could stretch around the circumference of the Earth – some 140 million vehicles.*
>
> *Landfill is clearly not an option for this amount of waste. Finding ways to recycle EV batteries will not only avoid a huge burden on landfill, it will also help us secure the supply of critical materials, such as cobalt and lithium, that surely hold the key to a sustainable automotive industry."*

3 Effective waste management

According to the International Energy Agency, effective battery end-of-life management polices – including second-life applications, standards for battery waste management and environmental requirements on battery design – will be critical to ensure the sustainability of EV.[8]

[2] Toby Hill, UK electric car sales surge despite bleak period for car market, figures show, Business Green, 6 October 2020
[3] ONS, Road transport and air emissions, September 2019
[4] International Energy Agency, Global EV outlook 2019, accessed 20 October 2020
[5] Gavin Harper, et al. Recycling lithium-ion batteries from electric vehicles, *Nature* **volume 575**, pages75–86(2019)
[6] Hauke Engel, et al. Second-life EV batteries: The newest value pool in energy storage, McKinsey and Company April 30, 2019
[7] Gavin Harper, et al. Recycling lithium-ion batteries from electric vehicles, *Nature* **volume 575**, pages75–86(2019)
[8] International Energy Agency, Global EV outlook 2019, accessed 20 October 2020

3.1 Current policy

In the UK electric vehicle battery recycling is covered by the Waste Batteries and Accumulators Regulations 2009 (NI has an equivalent Statutory Rule), which ban the disposal of automotive and industrial batteries to landfill and incineration. This also establishes take-back and recycling obligations for industrial battery producers. [9]

In the European Union, the Strategic Action Plan for Batteries in Europe was adopted in May 2018. It brings together a set of measures to support national, regional and industrial efforts to build a battery value chain in Europe, embracing raw material extraction, sourcing and processing, battery materials, cell production, battery systems, as well as reuse and recycling.[10]

3.1.1 *R&D*

The UK Government is funding a number of programmes to promote the reuse and recycling of battery components. This includes several industry led collaborative Research and Development (R&D) projects such as the 'ReLib' research project. ReLib is developing the technological, economic and legal infrastructure to allow high percentages of the materials in lithium ion batteries at the end of their first life to be reused or recycled. The Faraday Institution also participate in the Global Battery Alliance – a World Economic Forum initiative which aims to accelerate action towards a socially responsible, environmentally sustainable and innovative battery supply chain.[11]

3.2 Waste Management Hierarchy

When an EV battery reaches the end of its useful first life, manufacturers have three options: they can dispose of it, recycle the valuable metals, or reuse it. In the waste management hierarchy, re-use is considered preferable to recycling, "…in order to extract maximum economic value and minimize environmental impacts."[12] Disposal most frequently occurs if packs are damaged or if they are in regions that lack necessary market structure. In most regions, including the UK (see above) regulation prevents mass disposal.[13]

3.2.1. Recycling

A review of lithium ion battery (LIB) recycling has indicated that recycling technologies for end-of-life LIBs are not keeping pace with the rapid rise of EV, storing up a potentially huge waste management problem for the future:

[9] Question for Department for Transport, UIN 14812, tabled on 10 February 2020
[10] European Economic and Social Committee, Strategic Action Plan on Batteries, March 2019
[11] The Faraday Institution, Recycling and Reuse, accessed 20 October 2020
[12] Gavin Harper, et al. Recycling lithium-ion batteries from electric vehicles, *Nature* **volume 575**, pages75–86(2019)
[13] Hauke Engel, et al. Second-life EV batteries: The newest value pool in energy storage, McKinsey and Company April 30, 2019

> *"The recycling challenge is not straightforward: there is enormous variety in the chemistries, shapes and designs of lithium ion batteries used in EVs. Individual cells are formed into modules, which are then assembled into battery packs. To recycle these efficiently, they must be disassembled and the resulting waste streams separated. As well as lithium, these batteries contain a number of other valuable metals, such as cobalt, nickel and manganese, and there is the potential to improve the processes which are currently used to recover these for reuse."*[14]

According to the European Economic and Social Committee, while there is considerable potential for processing/recovery of materials from these batteries, development of appropriate processes is still in the early stages. "Even now, only some 10% of the material from batteries is recovered."[15]

The recycling review identifies a number of key challenges that engineers and policy-makers will need to address, including:

- Identifying second use applications for end of life batteries;
- Developing rapid repair and recycling methods, particularly given that large-scale storage of electric batteries is potentially unsafe;
- Improving diagnostics of batteries, battery packs and battery cells, so the state of health of batteries can be accurately assessed prior to repurposing;
- Optimising battery designs for recycling to enable automated battery disassembly, safer than the current manual handling techniques;
- Designing new stabilisation processes that enable end-of-life batteries to be opened and separated, and developing techniques or processes to ensure that components are not contaminated during recycling.[16]

3.2.2 *Reuse*

Many companies in various parts of the world are already piloting the second use of electric-vehicle LIBs for a range of energy storage applications. For example, LIBs are increasingly reused in stationary energy storage systems.[17]

> *Compared to use in EVs, stationary applications demand lower current density from the battery pack. Hence, batteries retaining between 80-85% of their original capacity are collected. Battery modules found to have similar power and life are sorted out and re-assembled in new "repurposed" battery packs, ready for stationary usage, such as utility-scale grid, building and telecommunication tower storage.*

[14] University of Birmingham, UK needs to act to prevent electric vehicle battery waste mountain – new study,
[15] European Economic and Social Committee, Strategic Action Plan on Batteries, March 2019
[16] Ibid.
[17] Mario Pagliaroa and Francesco Meneguzzo, Lithium battery reusing and recycling: A circular economy insight, Heliyon, volume 5, Issue 6, June 2019

Pagliaro, et al. point out that energy storage systems using second-life EV battery modules have a range of residential, commercial and industrial applications. They provide the example of Amsterdam's "Johan Cruyff Arena". It had a 3 MW (nominal power)/2.8 MWh (nominal capacity) energy storage system installed in 2018.[18]

- The system comprises 590 battery packs (340 new and 250 second-life batteries)
- These were supplied by the EV manufacturer and the second-life batteries are certified to last 10 years;
- The new energy storage system enables optimal use of both solar photovoltaic (PV) and grid electricity retrieved at low cost from the grid during the night hours.
- PV energy generated during the day, rather than being fed into the grid and sold to the grid operator at low price, meets the enhanced energy demand when the stadium is in use. [19]

Pagliaro et al note that by 2025 about 75 per cent spent EV batteries will be reused in second-life solutions for several years after retirement from vehicles, after which they will be sent to recycling to recover all the valued components[20] However, it must be noted that while re-use and current recycling processes can divert some of these wastes from landfill, current limitations mean a significant amount of waste will still be directed to landfill.

[18] Mario Pagliaroa and Francesco Meneguzzo, Lithium battery reusing and recycling: A circular economy insight, Heliyon, volume 5, Issue 6, June 2019
[19] ibid
[20] ibid