Life Cycle Analysis of Electric Vehicles

It is important to focus on whole life-cycle of electric vehicles in order to give the strongest argument for adoption over the next 10 years. Dr Stuart Coles, Associate Prof of Sustainable Materials and Manufacturing at WMG explains the three phases of emissions.

Manufacturing

It is evident that manufacturing a battery creates more carbon emissions than manufacturing internal combustion engines (ICE), as there are more materials and more complexities in assembly. However, there is a huge variance in calculating these emissions due to a lack of consistency in how batteries are made. A standard model would enable much easier calculations of emissions. There are also gaps in our knowledge of emissions in relation to the supply-chain - particularly in the technology metals used and our understanding of where they come from and how they are mined.

Usage

The biggest benefit of batteries is that they are zero emissions at the point of use, which improves air quality in the local environment. Any electricity generated to charge vehicles has to have some kind of carbon emission related to it (unless generated from entirely renewable energy). However, when you compare emissions generated by electricity in comparison to emissions generated by ICE, particularly with the UK grid mix, it is actually very favourable.

By 2030 (when the UK grid is going to be much improved), full life cycle emissions from electric vehicles are predicted to be very low compared to ICE. There will still be a cross-over point due to the manufacturing emissions created at the start of the electric vehicle life-span, but overall emissions are much lower unless the vehicle is very low mileage.

End of Life

Batteries are difficult to disassemble and therefore recycle, because of how they are put together, the closeness of materials, thinness of separators, contained electrolyte (anodes/cathodes) etc. It is much easier to recycle ICE vehicles compared to electric vehicles at this point in time.

Recycling is the missing part of the puzzle for electric vehicles, if we can solve it then we can really understand the true benefits of electrification moving forward. Additionally, if more recycled material is fed back into the system, rather than sourcing mined virgin materials from overseas, we improve manufacturing emissions. In order to effectively move forward, legislation to meet material recycling targets for electric vehicles is imperative.

Opportunities in Recycling and Reuse of E-Machines and Power Electronics

Dr Anwar Sattar a lead engineer at WMG released a well-received report detailing Automotive Lithium ion Battery Recycling in the UK in September 2020.

Anwar expands on his knowledge further by explaining the additional recycling opportunities, in the vehicle e-machines and power electronics.
Electric Motors

It is estimated that 2 million electric motors will reach end of life in the UK each year. This presents a huge opportunity as it is likely that at the point the vehicle is no longer in use, the motors will still have a lot of life left. There are three options for reuse of electric motors: use in another vehicle, use in other application or use a component of the motor in another application. It is important that motors are designed for easy disassembly to aid this process.

The electric motor is made up of components including steel, copper and magnets. Each motor contains 1.5-2kg of magnets made up of very rare, valuable materials not native to the UK. The cost breakdown of the motor shows that the magnets account for 50% of the value. A process for separating the magnets and re-introducing them to the supply-chain is a great opportunity.

Prof Allan Walton, Magnetic Materials Group University of Birmingham, adds that we currently import far more magnets than we manufacture in the EU (8-12,000 tonnes of material), if recycling can be achieved the economics would be favourable and the environmental impact very small. There are lots of challenges: it is hard to identify magnets in waste streams as coatings need to be removed, magnets are hard to shred and hard to disassemble. If you shred an electric motor you will never recover the rare earth magnetic material, it oxidises and sticks in the system (similar to other critical materials). Prof Walton’s group at The University of Birmingham have been developing techniques to extract magnets from waste streams through processing the components in hydrogen, this process has proven successful and is now being scaled up. Furthermore the technology has been patented by a new company Hypromag, with the hope of providing a sustainable solution for the future supply of magnets and alloy powders.

Electric Powertrain Components

Electric powertrains are made up of circuit boards which contain valuable precious metals, most of which can be recovered. Circuit boards found in electric vehicles are of medium quality with a scrap value of £5-£10 per kg. Gold is primary driver of the value as the table below demonstrates.

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition</th>
<th>Value/kg</th>
<th>Value/ tonne boards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>33%</td>
<td>£5.8</td>
<td>£1,900</td>
</tr>
<tr>
<td>Gold</td>
<td>313ppm</td>
<td>£43,500</td>
<td>£13,615</td>
</tr>
<tr>
<td>Silver</td>
<td>625ppm</td>
<td>£700</td>
<td>£438</td>
</tr>
<tr>
<td>Palladium</td>
<td>31ppm</td>
<td>£52,300</td>
<td>£1,621</td>
</tr>
<tr>
<td>Tantalum</td>
<td>0.29%</td>
<td>~£100</td>
<td>£290</td>
</tr>
<tr>
<td>Antimony</td>
<td>157ppm</td>
<td>£4.5</td>
<td>£0.7</td>
</tr>
<tr>
<td>Tin</td>
<td>0.93%</td>
<td>£17</td>
<td>£158</td>
</tr>
</tbody>
</table>

Composition source: Recycling 2015, 1

The likely method for recycling these electronics going forward is the hydrometallurgical method (leaching in acid). A tonne of circuit boards from an electric vehicle has a value exceeding £15k per tonne. At the moment this value is being exported outside of the UK for recycling, which is a missed opportunity for the UK.

Giving Reused Batteries a Second life

CEO Matthew Lumsdon, explains how Connected Energy has, over the last 5 years, been repurposing EV batteries for Energy Storage applications. The business has put in place a set of
technical and commercial uses ready for when 2nd life batteries start to come out of electric vehicles in volume. Energy storage is fairly new and a whole business model needs to be considered including services, feasibility support, grid network approval and financing. The business began as a start-up with a single 10ft container 60kW system, they are now creating cluster container 12MW systems which can be remotely monitored to optimise value.

Connected Energy are integrators and their core IP is around control systems, there were many questions to be considered when setting up the business:

- How to control a thousand batteries that are all different to maximise the value?
- How to collect data that allows you to respond to different aspects of the market, incl. control system efficiency, degradation, heat etc.?
- How to create a low cost, efficient logistics process to bring all of the batteries together from different locations?
- How to sell energy storage units into different sectors?
- How to reduce the risk for early adopters?

The USP for Connect Energy is that low cost 2nd life batteries for systems that have long duration (more batteries to power electronics) become more and more cost effective. Also the cycle cost and cost of degradation is much lower relative to using new batteries in systems.

GET IN TOUCH WITH US:

If you would like to find out more about the opportunities in life cycle, recycle and reuse of electric vehicle components please contact wmgbusiness@warwick.ac.uk