Worksheet 3: Electric vehicle (EV) batteries

At present, EVs use almost exclusively lithium-ion (Li-ion) batteries, whilst some hybrid EVs use nickel metal hydride batteries. In this fact sheet, we will focus on lithium-ion batteries.

Lithium-ion batteries are also used in laptops and mobile phones and their high energy density (capacity in relation to physical size of the battery) and long life cycle are primary reasons in making them the leading battery type, in addition to the relative reliability of technology and the rapid developments and associated cost-savings in the manufacturing processes. Materials used in the chemistry of these batteries include nickel, copper and cobalt, as well as other materials such as lithium and sodium.

Environmental impact and ethics

There are some concerns about the environmental impact of mining these resources and the ethics surrounding this aspect of the EV supply chain, particularly in relation to the mining of cobalt in the Democratic Republic of Congo (DRC). As a result, manufacturers and national governments have taken steps to develop a more sustainable supply chain, with some manufacturers beginning to publish details of their supply chains. Others are making use of blockchain platforms, essentially digital decentralized ledgers, to trace each step in the production process of *all* minerals used in the production of these vehicles.

Another consideration is the carbon emissions related to EV manufacture. It is true that there are CO_2 emissions as a result of manufacture, related to the operation of manufacturing facilities and transportation of materials. Historically, due to the limited production facilities for them, it was transportation of batteries themselves that accounted for a significant portion of this. To tackle this, many manufacturers have developed localised battery assembly/manufacturing plants such as Jaguar Land-Rover in Hams Hall and the Envision battery plant in supplying the Nissan factory in Sunderland. Significant efforts have also been put in place to streamline the whole manufacturing process and maximise the use of recycled materials where possible.

Second life batteries

As EV batteries begin to reach their end-of-life, there is considerable potential for them to be used in other applications such as energy storage. Many manufacturers are making use of end-of-life batteries at their own sites and one of the most interesting applications of battery storage is at the Ajax Amsterdam arena which utilises a 3MW storage unit built from re-used batteries, the equivalent of 148 Nissan Leaf batteries. More information on the project is available here.

The E-STOR system from Connected Energy utilises second life batteries for energy storage systems in commercial and industrial settings and is also suitable for rapid EV charging functions. The system uses Renault second life batteries and are fully warrantied by the manufacturer.

Recycling

Lithium-ion batteries are not suitable for landfill as there is scope for toxic discharges as a result of reactions with water and also potential fire hazards as a result of chemical reactions. As we have also seen, the materials used in the batteries are valuable and due to the impacts both environmentally and socially of mining them then reuse and recycling is incredibly important.

Battery recycling is possible although it is very energy intensive. Germany are currently leading the way in this sector and have developed a facility with a significantly reduced level of energy use in the recycling process through evaporation and recovery of organic solvents as part of the process.

In the UK, the Farady Institution are enabling a three-pronged approach which looks at ensuring the UK is at the forefront of dealing with these batteries at the end-of-life: assessing the condition of battery packs, creating the systems for repair, reconditioning and reuse, as well as recovering components and materials when the unit is of no use in a car or other energy storage. The work will also look at current and future regulation, plus how to introduce robotics into waste and recycling. With the modern Li-ion battery having been invented in Oxford in 1980, it would be fitting for the UK to also lead on recycling it.

Calculating the carbon intensity of vehicles

Firstly, what does 'carbon intensity' actually mean?

The term refers to the number of grams of CO_2 required to deliver any process, such as manufacturing a product or generating power. In the case of electricity generation, coal fired power stations will have a high carbon intensity as there is a significant amount of CO_2 produced in the generation process.

It is important to understand that there are carbon emissions related to *all* vehicles, whether the vehicle is an Internal Combustion Engine (ICE), EV or otherwise. This is because we need to consider the whole lifecycle of the vehicle in question which includes the manufacturing process, as well as the actual emissions relating to the operation of the vehicle. There have been many questions asked about emissions relating to EV and battery production in particular, as well as the industrial processes of manufacturing them. In this section, we will compare the average CO_2 emissions of EV and equivalent ICE vehicles.

There are a huge variety of factors to consider, from where the battery was manufactured (and associated transport related emissions) to where the EV will actually be driven. A possible worst case scenario in terms of carbon emissions relating to EV life cycle would be a vehicle with a battery produced in China, which has well known high levels of pollution relating to industrial processes, that is then purchased and driven in Poland, a country that still uses a large amount of coal to produce electricity. Despite this, we still see an EV emitting 22% less CO_2 than a diesel car and 28% less than a petrol-powered vehicle over its whole lifecycle. Transport & Environment has produced an online tool to help compare lifecycle emissions of EV and fossil fuelled powered vehicles.

Battery warranties

All manufacturers offer similar warranties on the bodywork and drivetrain for EVs as their ICE vehicles, typically three years or 60000 miles, but some are far longer. They also offer battery warranties of around eight to nine years or 100,000 miles, which gives an indication of the confidence they have in the batteries powering these vehicles. There is a wealth of information available which has studied battery degradation and the key thing to consider is that there are five common factors which will impact the health of a lithium-ion battery:

- Time – how long the battery has been in use
- High temperature – very high operating temperatures do have an impact upon the discharge rate. The latest EV models include battery cooling systems
- Operating at high and low state of charge – manufacturers limit the minimum and maximum capacity that their vehicles will operate at or accept
- High electric current – very regular use of DC rapid charging, for example
- Usage – regular usage is better

EV batteries are made up of a series of modules rather than being one large battery unit. This means that in the rare case of a cell in a module failing, the module in question can be replaced.

In most cases, warranty issues relating to batteries are few and far between and at present will be dealt with directly by the manufacturer. In the case of the Nissan Leaf, the vehicle and battery are sent back to the factory to be checked in the case of any warranty claim.

For more information on battery warranties, visit Drive Green and Geotab.

If you are thinking of making the switch to a low emission vehicle, visit **www.energysavingtrust.org.uk/transport/electric-cars-and-vehicles** to see what support is available.