

Electric Transport Future

Gareth Allen

Over 99.4% of transport fuel in Ireland is derived from oil. Due to dwindling oil supplies, strong climate change concerns and ever increasing oil prices, this situation is clearly not sustainable. In order to correct this problem, the transport sector's energy source must become more adaptable and sustainable. This means that the most promising future vehicles must have the ability to run on a mixture of power sources, for example wind, coal, natural gas and nuclear.

Obviously, a vehicle with the ability to use all of the above directly would not be feasible. However our electricity grid has the capability to integrate all of these. Thus a way to diversify our transport fuel sources is to run vehicles off electricity or hydrogen produced from electricity.

The advantage of both hydrogen electric vehicles (HEV) and battery electric vehicles (BEV) is that at the point of use they have no harmful emissions, which can help improve urban air quality. HEVs merely emit water. BEVs have no emissions at all. However, the electricity used to fuel both vehicles will come mainly from fossil fuels in the short to medium term. This means that these vehicles' emissions are at a power plant rather than on our streets. Over time, the proportion of renewable sources used to create Ireland's electricity will increase. These vehicles will become greener in line with the electricity used to power them.

What are hydrogen electric vehicles?

The possibility of a hydrogen economy, an economy powered by hydrogen as opposed to oil, has been discussed for many years. It is true that hydrogen is the most abundant element in the universe. In contrast to fossil fuels, we cannot extract hydrogen from the ground as a useable fuel. On earth, hydrogen only occurs joined to something else, like oxygen in water (H₂O) and pure hydrogen is needed for fuel purposes. This means that hydrogen must be artificially produced, usually by breaking up water into oxygen and hydrogen. This process requires energy, typically electricity. Hydrogen can also be made from natural gas but it is more beneficial to burn the gas directly.

Hydrogen can be thought of as a battery. Hydrogen stores the energy used to separate it from the oxygen in water. It

then releases this energy when it is used. HEVs won't have an engine, they will instead have a fuel cell. This uses oxygen and hydrogen and releases electrical energy. The by-product of this process is water. The electrical energy is used to drive a motor, which turns a hydrogen car's wheels.

What are battery electric vehicles?

BEVs are powered by stored energy in a battery, much like a mobile phone or a laptop. The batteries are charged at night time or whenever suits the user, though it is likely that day time charging will be more expensive. The stored electrical energy is used to drive a motor, which drives the BEV.

What are the differences?

The hydrogen economy would operate similarly to today's transport model. Refuelling a HEV would be similar to refuelling a petrol or diesel vehicle, with a different pump. Hydrogen stations could operate two ways. Hydrogen could be produced onsite using electricity and water. Alternatively, large quantities of hydrogen could be produced in one location and transported to the station, like the model we have for petrol and diesel. Both models incur large capital costs to set up. Hydrogen is a gas at room temperature, which means its energy per volume is extremely small. Thus, to transport large amounts of energy it must be heavily compressed. This means existing tankers and storage containers could not be used to store or transport hydrogen.

The BEV scenario is significantly different. The majority of users would charge overnight, eliminating the need to refuel during the day. There is work being carried out by ESB Networks to bring charging stations to street parking spaces. This would facilitate recharging for those who required it. The capital cost of the BEV infrastructure is substantially lower than hydrogen infrastructure. However, some upgrades to the electricity grid would be required.

On an energy basis, hydrogen, as a fuel, is inefficient to produce and transport. Electricity transmission and batteries are not without their inefficiencies. However, in comparison the losses incurred during the transport and storage of electricity are substantially less than that of hydrogen.

A way of visualising the losses associated with both HEVs and BEVs is in terms of power plants. If four equal power plants were used to power these vehicles, three of the plants would supply energy for the losses incurred in the hydrogen energy cycle. One would effectively power the hydrogen cars.

In contrast, in the battery electric option only one of the plants is used to power the losses, with three effectively powering the BEVs. Thus, it is likely that the running costs and emissions of a BEV will be substantially lower.

Where are we now?

Battery limitations are the aspect of BEVs that will slow their adoption. Current batteries are expensive, heavy and require replacing after a certain amount of cycles. The range (distance without recharge) of BEVs is smaller than that of petrol/diesel models and HEV prototype equivalents. The typical range of near-to-market electric vehicles is 100- 200 kilometres.

HEVs are further behind in relation to commercialisation. They cannot yet be mass-produced at reasonable cost. This is due, in part, to the platinum used in the fuel cell which is a material more expensive than gold. Work is being done to replace platinum with cheaper materials and thus to reduce the cost. However, without significant breakthroughs in this area, it seems that HEVs cannot become commercially viable. Hydrogen, therefore may play a part in the long-term rather than in the short or medium term.

The only BEVs currently on the market are either odd-looking cars with niche uses or expensive sport cars. However, in the near future we will see the emergence of BEVs that can meet the needs of a typical family at more competitive prices.

What will we see in the future?

The primary area where we will see the use of BEVs is for urban travel in the near future. This is the area where electric vehicles perform best for a variety of reasons. They can help reduce air pollution, meet the short journey demands and reduce running costs for the user.

Rural users will probably not see their needs met by BEVs in the medium term (5-10 yrs). This is due to greater distances travelled by these users. Plug-in hybrid electric vehicles (PHEVs) and highly efficient diesel vehicles or hybrids will probably meet these requirements. PHEVs, once recharged, can drive 10-65 km on their battery alone. They then become a regular hybrid, utilising a diesel engine and battery combination to improve efficiency and extend range.

HEVs are more suited to applications where batteries are not a viable solution in the long-term (over 10 yrs). This may include heavy machinery or trucks. A proportion of this may also be met by bio-fuels, fuels extracted from plants, as discussed in the previous section.

Conclusion

One thing is certain, oil prices will increase in the future. We must seek more sustainable solutions that can meet our transport needs. No single technology will be able to meet our numerous needs. We will see a diverse set of solutions to this complex problem.

Gareth Allen is a 2nd year Electronic and Electrical Engineering student at University College Dublin and a member of ENI 2009, an undergraduate summer research project team. <http://eni.ucd.ie>

