Risk vs. Reward: do the dangers associated with electric vehicles outweigh the benefits?

Introduction: Sustainability, decarbonisation and climate change policies are at the forefront of the minds of both the public and governments. We are likely to experience a significant shift in personal transport policy from internal combustion engines (ICE) to electrical vehicles (EV). By 2030, the sale of internal combustion engine (ICE) propelled cars will be banned in the United Kingdom, with other countries following suit. Clearly EV's are not restricted to cars - the sales of electrically supported cycles and scooters are rising exponentially. Within the events industry, hybrid generators running on biofuel, which in turn charge an onboard battery are becoming ever more commonplace. But what are the risk associated with EV's – are they inherently more dangerous than ICE powered vehicles?

Fire: In normal operation, EVs might not seem to be more inherently dangerous than their ICE cousins. The world's firefighting services, however, are finding that may not be the case when one of these vehicles catches fire. The component materials of the batteries mean that the fires are very energetic and traditional firefighting techniques do not necessarily work. Fires in EV's is somewhat of a misnomer. Chemically, a thermal runaway is a chain reaction propagating within a battery cell that can be very difficult to stop once it has started. It occurs when the temperature inside a battery reaches the point that causes a spontaneous chemical reaction to occur.

Statistically, the estimated failure rate (and therefore risk of combustion) of an individual battery cell is one in ten million. However, when you consider that an average EV contains approximately 7000 cells, the risk increases significantly. Data from the London Fire Brigade suggests an incident rate of 0.04% for ICE car fires, but the rate for EVs is more than double that at 0.1%. Although it is not clear whether EVs are more likely than ICE vehicles to catch fire, it is commonly accepted that the consequences are potentially more disastrous and significantly more difficult to control.

Sporting applications for EV's in Formula E, Moto GP, Extreme E and E Touring cars are clearly increasing the speed of development of EV's, but can we compare the use of EV's in sport to the increase in sales of road going EV's? I suggest not. EV's in motorsport are managed by teams of highly qualified engineers monitoring the battery cells in real time during races. This clearly does not happen in a standard roadgoing EV's, therefore it is fair to conclude that real worlds risks of an EV used on the highway cannot be compared to a sporting application of EV technology.

There is, therefore, a distinction between ICE and EVs when considering the risk of fire. The component that carries the fire risk in an EV cannot be removed; the battery cannot be drained of electrolyte. An EV has chemical components that, in specific circumstances, can initiate and sustain a fire; often a very energetic fire. In addition, 'normal' firefighting techniques are less effective in fighting EV fires. Two common suggestions are either to let the vehicle burn out or submerse it in water. There is a further complication in that most of the firefighting water used will be contaminated during the firefighting process adding environmental pollution as a real and significant risk. Also, the smoke from a lithium-Ion battery can be equally as dangerous as the fire itself.

Studies by the Federation International Automobile (FIA) indicated that maintaining a state of charging of the battery significantly mitigates the risk and EV manufactures should consider a safe charging mode that ensures the battery is in the safest state possible (30%). It is likely early detection of increase cell-pack temperature will be key. Manufacturers can assist by developing a way of plugging the vehicles into a monitoring system utilising the batteries' internal sensors.

Lithium Ion vs. Solid-State batteries: The key difference is what the ions move through. In a traditional lithium-ion battery - a liquid electrolyte, while a solid-state battery would use a solid material. These are more technically more demanding to make, but they could be more efficient than normal lithium batteries. With an energy capacity at least two times greater than traditional lithium-ion batteries with flammable liquid electrolytes, solid-state batteries are safer, as well as more efficient.

What harm do lithium batteries do to the environment? Lithium mining destroys the soil structure and leads to unsustainable water-table reduction. Ultimately, mining lithium depletes water resources, leaving the land too dry and exposing ecosystems to the risk of extinction. In a recent report by Friends of the Earth, lithium extraction inevitably harms the soil and causes air contamination. In Argentina's Salar de Hombre Muerto, locals claim that lithium operations have contaminated streams used by humans and livestock, and for crop irrigation.

Alternatives? Sodium-sulphur battery potentially solves one of the biggest hurdles that has held back the technology as a commercially viable alternative to the now ubiquitous lithium-ion batteries that predominantly power electric vehicles. Graphene batteries are an emerging technology which allows for increased electrode density, faster cycle times, as well as possessing the ability to hold the charge longer thus improving the battery's lifespan. Graphite batteries are well-established and come in many forms but a commercially unviable for EV application at the moment.

While EV cars sales are growing exponentially and are widely seen as the future of emissions free motoring, hydrogen cars are still somewhat overlooked. While there are hydrogen-powered cars available for sale in the UK, very few people are currently buying or even considering them. So, could hydrogen fuel cell vehicles really have a future?

Hydrogen and fuel-cell technology: Car makers have been experimenting with hydrogen fuel cell technology for a number of years, trying to crack the formula for using the most abundant resource in the universe to power cars. While progress has been made, it has been very slow compared to that of EV's, principally due to R&D costs. There are currently only two mainstream hydrogen-powered cars on sale: the Toyota Mirai and Hyundai Nexo. There are more hydrogen-powered cars and vans confirmed to be on the way, though, with brands such as BMW, Land Rover and Vauxhall all planning new models within the next five years. However, JCB have fully committed to producing hydrogen powered excavator models from 2023, confirming they will refocus towards hydrogen away from EV research.

Because refilling a hydrogen car is very similar to filling up with petrol or diesel, it is also almost as quick - it takes around 5 minutes to fill a tank. This is undoubtedly an advantage over the long waiting times when charging an electric car. However, one of the biggest reasons for the slow uptake of hydrogen vehicles is the existing infrastructure. According to UK Hydrogen Mobility, there are currently 11 hydrogen stations open in the UK. This is obviously far less than the amount of petrol stations and public EV charge points, but more hydrogen filling stations are planned. For now, though, not having a filling station nearby is clearly impractical for many people who may consider moving to hydrogen powered vehicles.

How do hydrogen cars work? One of the arguments that's sometimes made against hydrogen vehicles is that they're less efficient than EVs. Because hydrogen doesn't occur naturally, it has to be extracted, then compressed in fuel tanks. It is then combined with oxygen in a fuel cell stack to create electricity to power the vehicles motors. Sceptics point to the efficiency loss in this process when compared with an EV in which the electricity comes directly from a battery pack charged from a domestic power supply or charging point.

That's true to an extent, but hydrogen-powered cars are not really expected to replace EVs. Instead, hydrogen is intended to complement pure electric power, and there's a good reason for this: it is arguably the cleanest fuel possible. Lithium-ion battery production for EV's is very energy-intensive, with Lithium mining emitting several tonnes of CO2. If you take this into account along with charging the battery from anything other than a zero-emission source throughout its lifetime, an EV still contributes towards a certain amount of CO2 emission - even if this does not originate from an exhaust.

Conventional wisdom holds that battery-powered cars are the future of motoring. But Hyundai, the South Korean vehicle-maker, is developing and alternate solution. Over the last year, it has been running a worldwide public-relations campaign extolling the virtues of an alternative source of electrical power - fuel cells. Hyundai are working closely with an off-road racing championship, Extreme H to develop the technology. Instead of storing and then releasing electricity gathered from a domestic supply or charging point in the way that a battery does, a fuel cell generates current from a chemical reaction between hydrogen and oxygen. The oxygen comes from atmospheric air. The hydrogen, suitably compressed, is stored in a tank on board the vehicle, and is replenished at a filling station, like petrol. Unlike a battery, a fuel cell does create exhaust. But that exhaust is simply the reaction product of hydrogen and oxygen - water.

Conclusion: While it is clear that ICE vehicles will be phased out before the end of this decade, the alternative vehicle power sources are less clear. A combination of ICE, EV's and HV's will be compete for primacy in the personal transportation market for the foreseeable future. The best solution is likely a combination of HV and EV where a hydrogen cell powers a solid-state battery. Will we be driving cars in 20 years' time? There is certainly an argument that current levels of personal vehicle ownership is unsustainable. A future where we hire an EV or HV short-term when needed, supplemented by better public transport seems the most likely solution. This of course subject to a paradigm shift in our approach to personal vehicle ownership and acceptance of public transportation.

## Notes & Research:


- *The Faraday Institute*
- *OFGEM Gov UK – Dec 2022*
- *Europe Auto News – 11th, Nov 2021*
- *London Fire Service Research Dept.*
- *Friends of the Earth publications UK*
- *Autocar Weekly – June 15th, 2022*
- *Retained Update Oct 21 - Hydrogen Fuel / X Venture Global Risk Solutions*
- *Retained Update Nov - Battery Tech / X Venture Global Risk Solutions*