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Hydrogen fuel cells vs lithium-ion batteries

The quest to find a clean, renewable alternative to diesel is fuelling a boom in electric vehicles and lithium-ion batteries. However, many manufacturers and developers are continuing to research hydrogen fuel cells due to its huge potential.

Here is a guide to both technologies. What do they share, what makes them different, and what role does each have in the future development of transport?

How do they work?

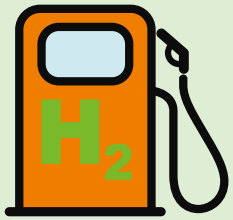
A lithium-ion battery stores electric energy that has been generated from an external source. It needs to be regularly charged and charging times can vary depending on the method used. An electric battery is produced with raw materials that come from a mine. There are various alternatives depending on the properties required by the user. One important component common in lithium-ion batteries is cobalt but alternative chemistries such as Lithium ion Iron Phosphate (LFP) are quickly emerging.

A hydrogen powered vehicle works by fuelling a fuel cell with high pressured hydrogen gas that will mix with oxygen. This mix starts an electrochemical reaction that produces electricity to power the electric motor. A hydrogen vehicle is in many ways similar to an electric vehicle as it has an electric motor but the method in which the electricity is delivered is different.

Emissions and noise
Both technologies are exceptionally clean when it comes to tank-to-wheel emissions. Neither emit CO_2 or NO_x, and in the case of fuel cells, the only by-products are water vapor and warm air. Both technologies are very quiet compared to combustion engines and can offer the same advantages when it comes to providing low-noise transport.

Climate Impact
When it comes to well-to-wheel emissions, the climate impact varies greatly depending on how the energy is sourced. If the electricity stored in a battery or the hydrogen used in the fuel cell, is generated from renewable sources, then the overall climate impact will be very low. This however is still a challenge today as most electricity grids around the world are still powered by coal, oil or gas despite the push for more renewables.

Hydrogen today is either extracted from fossil fuels or made using electrolytic processes powered by fossil fuels which increases hydrogen's overall climate impact. There are also many more steps in the energy life cycle process of hydrogen vehicles, compared with the direct use of electricity in battery electric vehicles. Only if renewable energy sources can be harnessed to provide the energy needed for these processes can hydrogen vehicles become truly clean.



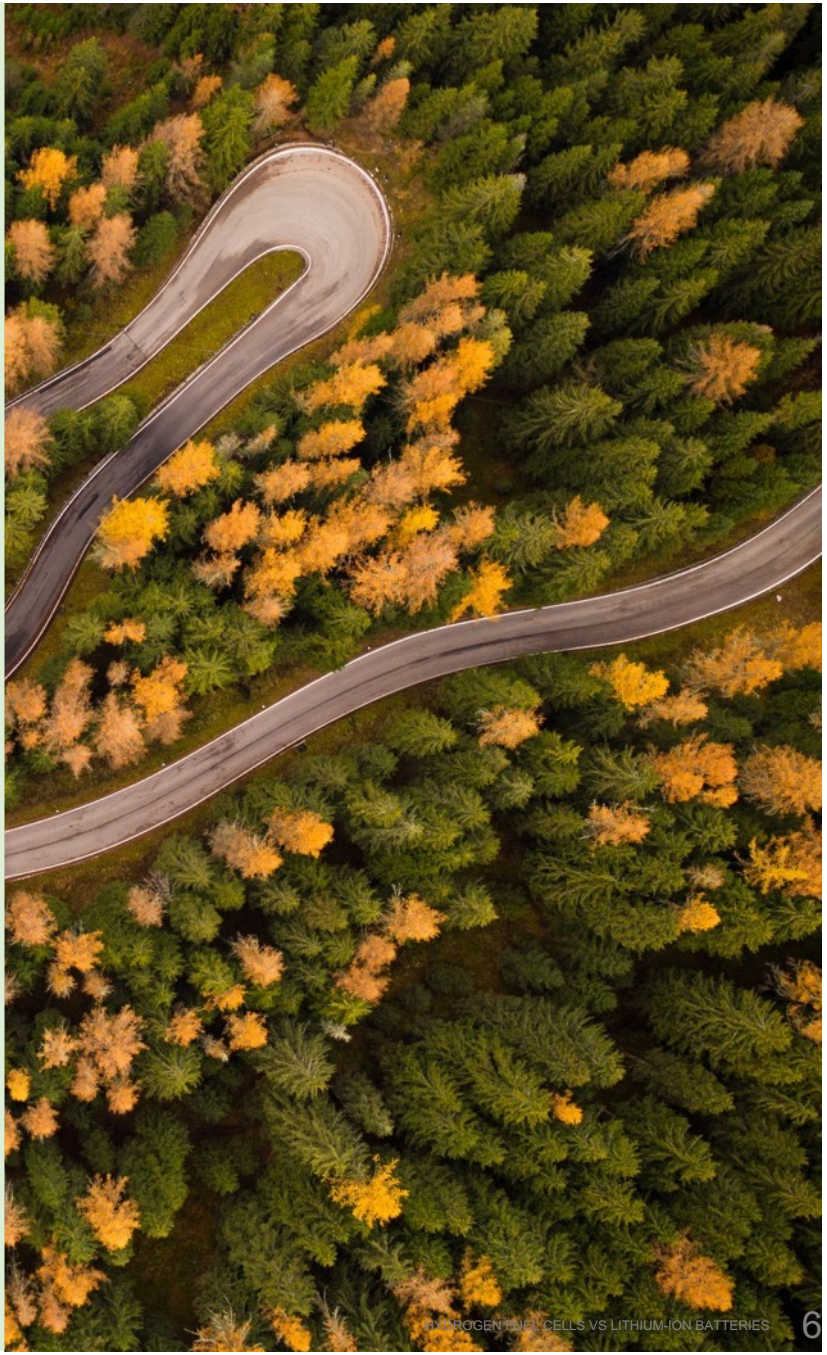
When it comes to lithium ion batteries, climate impact is also dependent on the potential to recycle and reuse. Today the recycling of batteries is not widespread but this doesn't mean that they end up in landfills. In fact, batteries can have a first, second and third life. Once the capacity of a battery in an electric truck reaches a certain threshold it can be operated on a route where a shorter range is sufficient or moved to a vehicle with lighter operations. When batteries are removed from electric vehicles, they are likely to retain around 70%–80% of their original capacity. They can therefore, play an important role in supporting the electric grid in hospitals and schools for instance.

Cost

Hydrogen fuel cells and lithium-ion batteries have similar disadvantages, namely the higher costs compared with diesel engines. The cost of lithium ion batteries however is coming down swiftly as energy density continues to improve. Bloomberg predicts that the crossover point — when electric vehicles become cheaper than their combustion-engine equivalents — could be as soon as 2022. Because the development and roll-out of hydrogen vehicles has been limited it has been difficult to measure similar gains.

Range

Hydrogen fuel cells offer greater energy density than batteries, and therefore can provide greater range to a vehicle. In fact the energy to weight ratio of a fuel cell is ten times higher than a battery. On the other hand electric trucks are extremely efficient; it's a fact that 75 % efficiency (WTW) is achieved by an electric truck engine while a comparable number for diesel trucks is 35% (WTW). Regenerative braking can also help improve the range of an electric truck.



Payload
Hydrogen fuel cells are lighter, almost weight neutral compared to a diesel truck, so the adverse effect on payload compared to an electric vehicle is less.

Infrastructure
The development of lithium-ion batteries has progressed far further than hydrogen fuel-cells. The technology is already being used and has proven to be commercially viable, particularly in urban transport operations.

There are large-scale manufacturers, like Volvo Trucks, and suppliers of all the necessary components, and scaling up production would be relatively simple compared to hydrogen vehicles. The infrastructure for electric vehicles is also growing steadily. In the United States there were 20,000 electric charging stations as of December 2018 compared to less than 45 hydrogen refilling stations.

Outlook for the future

There are still many unanswered questions about hydrogen fuel cells since we have far less knowledge and experience of the technology. While it offers a lot of potential benefits in the long-term, if we want to make a change to a clean fuel today, then lithium-ion batteries are the most viable solution.

However it should be stressed that these are not necessarily competing technologies. In fact, fuel cells can be used to compliment batteries by acting as range extenders and increasing the distance an electric truck can drive.

In the longer-term, by electrifying trucks, we can prepare vehicles for either technology. It is just a matter of changing the means of energy storage. So even if the trend towards electromobility and lithium-ion batteries continues, there is still the possibility of adopting hydrogen fuel cells if the technology becomes a commercially viable alternative

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