The Power of 3
Driving the future further
ISSUE 26
October
2018

Hydrogen or lithium?

The quest for pollution-free consumer transport

Overview

As noted in the first edition of this newsletter, even in 2012 the number of modern, mass-produced, highway-capable electric vehicles (EVs) on the market was impressive. Five years on, more than three million EVs are on-road globally, a million of them since 2017.

Nevertheless, in years to come universal uptake of EVs will depend less on their looks, price and size and more on the efficiency and performance of what powers them, be that hydrogen or lithium-ion (Li-ion) batteries.

While both methods of propulsion can be produced using low- or zero-carbon sources, and both are cleaner and more efficient by far than internal-combustion engines running on fossil fuels, there's plenty of debate about which, ultimately, is better.

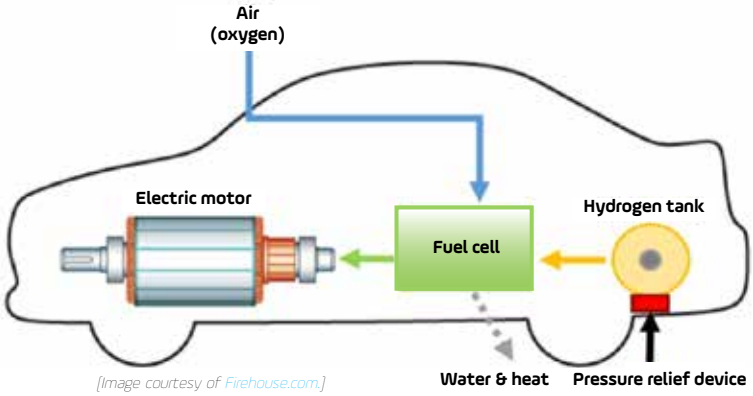
Toyota, for one, is banking on the success of its hydrogen-fuel-cell vehicle (FCV) technology, whereby hydrogen and oxygen react with each other to yield the electricity that powers the vehicle. Having first introduced its FCVs in 2014, it plans to mass-produce the Mirai FCV, as well as pick-ups, SUVs and trucks, in the near future. The company also plans to build 80 hydrogen-fuelling stations by 2022. Other automakers, including Nissan, Hyundai and Honda, are following suit.

Elon Musk, still the face of Tesla (but no longer its chairman), has on the other hand called the use of hydrogen 'incredibly dumb', the issue being, ultimately, efficiency.

> *Hydrogen is an energy storage mechanism ... not a source of energy. So you have to get that hydrogen from somewhere. If you get [it] from water, you're splitting H_2O, electrolysis is extremely inefficient as an energy process... if you [take] a solar panel and use the energy from that to just charge a battery pack directly, compared to trying to split water – take the hydrogen, dump the oxygen, compress the hydrogen to an extremely high pressure (or liquefy it) and then put it in a car and run a fuel-cell, it is about half the efficiency, it's terrible. Why would you do that? It makes no sense.*

FCV or EV?

An EV runs off an electric motor and a Li-ion battery pack. In an FCV, though, it's hydrogen – stored under pressure – that flows to the fuel-cell stack. There it chemically reacts with oxygen, ultimately generating the current that powers the electric drive motor. Hot water, a by-product of the reaction, is manually discharged at the rear of the vehicle.



[Image courtesy of Firehouse.com.]

Since both FCVs and EVs draw their enegy from renewables and are close to emission-free (ignoring the costs in energy required to build wind and solar farms, etc., as well as the energy sources involved in manufacturing the vehicles themselves), then technically FCVs *are* EVs.

A quick comparison of FCVs and EVS reveals the following.

- Build costs are similar.
- Operating costs for EVs are about a third of those for FCVs.
- Unlike FCVs, EVs are grid-compatible.
- Currently, infrastucture for hydrogen refuelling is limited.
- EVs have a relatively long charge time, whereas FCVs can be refuelled in three minutes.
- Unlike FCVs, EVs are already well-established, with a rapidly growing market, as is the charging infrastructure for them.

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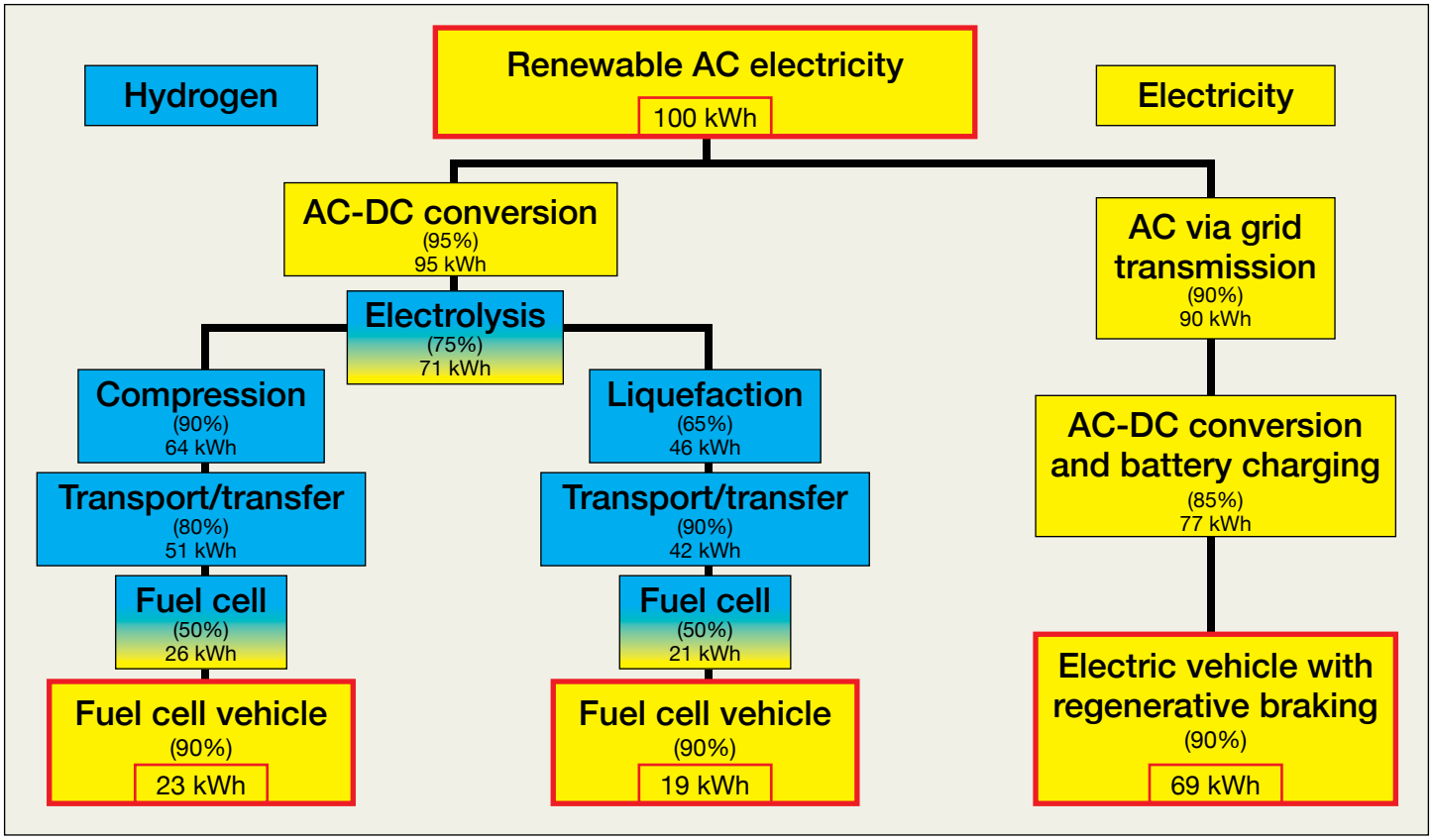
FCV or EV?



Energy efficiency of FCVs versus EVs

(source: http://phys.org/news85074285.html).

Confusingly, too, not all FCVs are created equal, in that they can use either compressed or liquefied hydrogen fuel cells to power the car.

Then there's the matter of range. The weight penalty incurred in increasing the range of an FCV is modest, making it a more pragmatic solution to range anxiety than the alternative – increasing range in an EV means more batteries, more weight and more superstructure to carry that weight. From a practical viewpoint, then, EVs must incorporate next-generation Li-ion batteries to circumvent those range and weight issues.

So, from an environmental point of view, comparisons appear to favour hydrogen as a fuel source. However, the production, compression, distribution and storage of hydrogen involve numerous challenges, consuming enormous amounts of energy and thus being inherently inefficient.

These considerations, though, are not deterring Japan, which aims to be the first hydrogen economy in the world. Why? Because the country is small in terms of area, with high population densities, and the hydrogen infrastructure can be concentrated in small areas to service the large population.

Elsewhere, however, product advances are more likely to favour established technologies. Given that it's taken 30 years to perfect Li-ion batteries to the point at which they are truly effective in EVs, much momentum would be required to shift to an alternative at this stage.

From that perspective, what would it take for Li-ion battery technology, and therefore EVs, to reign supreme well into the future? Certainly, the following will play a large part.

- Cost reductions as production volumes increase.
- Greater energy-storage capacity resulting from changes in cathode chemistry (for example, lithium sulphur).
- Battery anodes with higher capacity (such as lithium metal, graphite/silicon).

With Li-ion battery-powered EVs, then, there is significant potential for cost reductions and removal of range anxiety and, given the leading position of such vehicles today, they are likely to rule the roost for some time to come.

And finally ...

As *The Guardian* reports, this month Germany launched 'Combino' – the world's first autonomous tram – in Potsdam, west of Berlin. Articulated and powered by renewables, it's been developed by a team of 50 computer scientists, engineers, mathematicians and physicists at German engineering company Siemens. Although its makers acknowledge that Combino is still some way from being commercially viable, they consider it an important milestone on the way to autonomous driving. As one observer noted, " ... it's a bit like what it must have been to witness the transition from horse-drawn to steam trams, or gas to electric."

Which Perth-based company is currently engineering next-gen Li-ion battery precursors?

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