

Hydrogen cars won't overtake electric vehicles because they're hampered by the laws of science

June 3 2020, by Tom Baxter



Hydrogen may bomb. Credit: Eillen

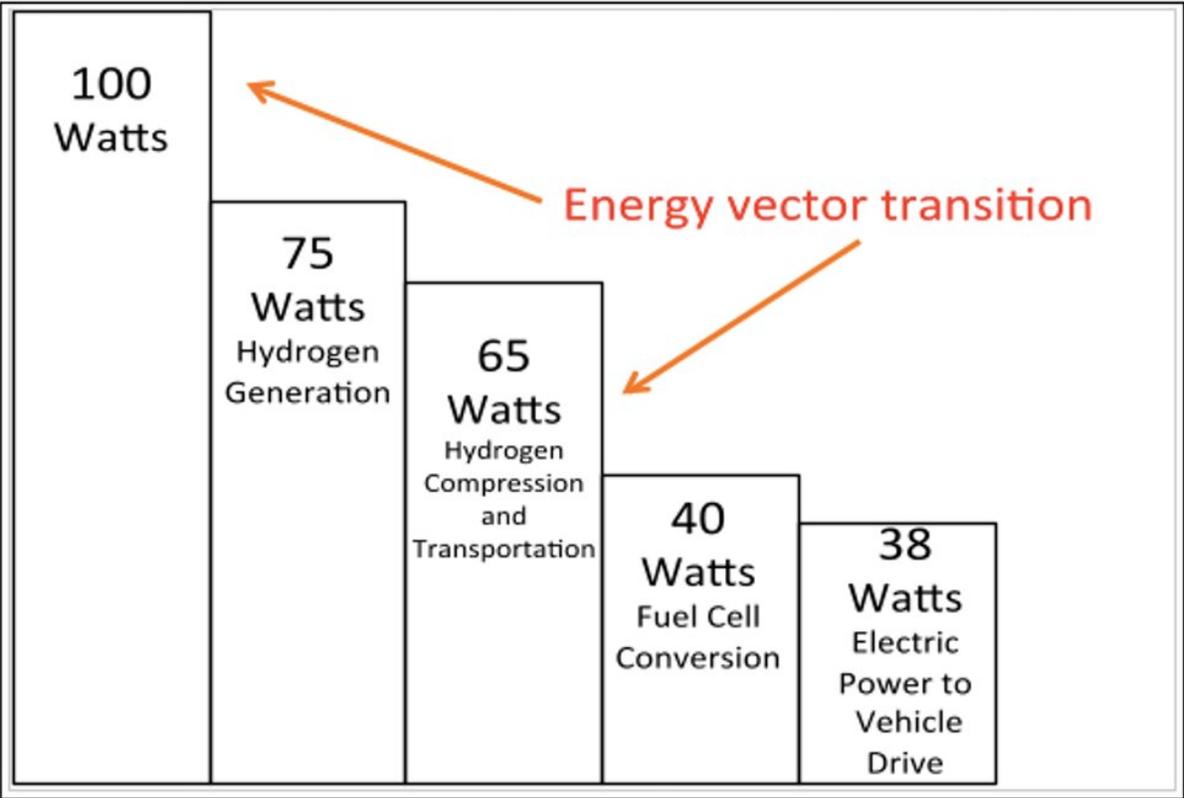
Hydrogen has long been touted as the future for passenger cars. The [hydrogen fuel cell electric vehicle \(FCEV\)](#), which simply runs on pressurised hydrogen from a fuelling station, produces zero carbon emissions from its exhaust. It can be filled as quickly as a fossil-fuel equivalent and offers a similar driving distance to petrol. It has some heavyweight backing, with Toyota for instance [launching](#) the [second-generation Mirai](#) later in 2020.

The [Canadian Hydrogen and Fuel Cell Association](#) recently produced a report extolling [hydrogen vehicles](#). Among other points, it said that the carbon footprint is an order of magnitude better than electric vehicles: 2.7g of carbon dioxide per kilometre compared to 20.9g.

All the same, I think [hydrogen](#) fuel cells are a flawed concept. I do think hydrogen will play a significant role in achieving net zero carbon emissions [by replacing](#) natural gas in industrial and domestic heating. But I struggle to see how hydrogen can compete with electric vehicles, and this view has been reinforced by two recent pronouncements

A report by BloombergNEF [concluded](#): "The bulk of the car, bus and light-truck market looks set to adopt [battery electric technology], which are a cheaper solution than fuel cells."

[Volkswagen](#), meanwhile, made a statement comparing the energy efficiency of the technologies. "The conclusion is clear" said the company. "In the case of the passenger car, everything speaks in favour of the battery and practically nothing speaks in favour of hydrogen."



Hydrogen's efficiency problem

The reason why hydrogen is inefficient is because the energy must move from wire to gas to wire in order to power a car. This is sometimes called the energy vector transition.

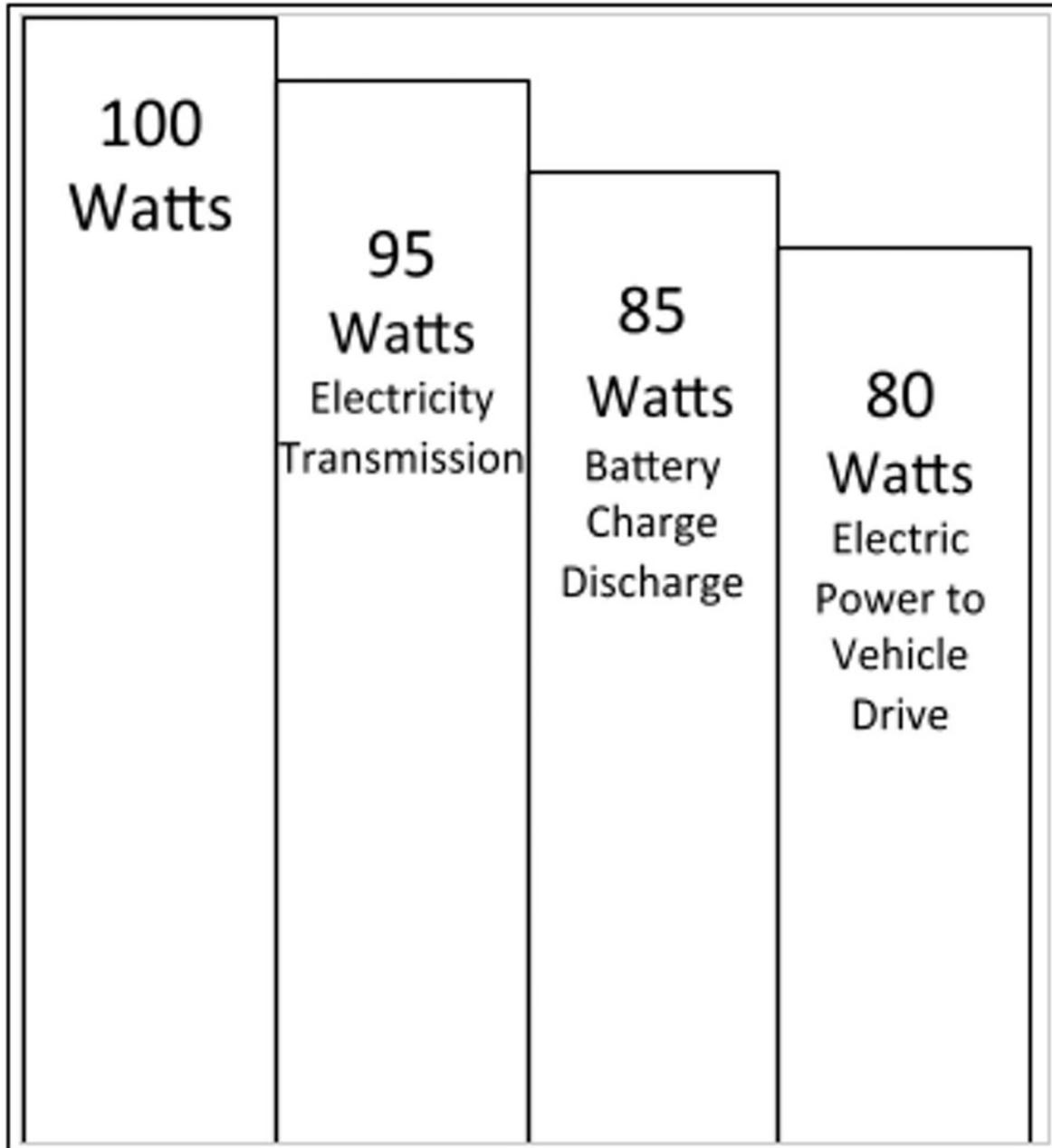
Let's take 100 watts of [electricity](#) produced by a renewable source such as a wind turbine. To power an FCEV, that energy has to be converted into hydrogen, possibly by passing it through water (the [electrolysis](#) process). This is around 75% energy-efficient, so around one-quarter of the electricity is automatically lost.

The hydrogen produced has to be compressed, chilled and transported to the hydrogen station, a process that is around 90% efficient. Once inside the vehicle, the hydrogen needs converted into electricity, which is 60% efficient. Finally the electricity used in the motor to move the vehicle is is around 95% efficient. [Put together](#), only 38% of the original electricity—38 watts out of 100 – [are used](#).

With electric vehicles, the energy runs on wires all the way from the source to the car. The same 100 watts of power from the same turbine loses about 5% of efficiency in this journey through the grid (in the case of hydrogen, I'm assuming the conversion takes place onsite at the wind farm).

You lose a further 10% of energy from charging and discharging the [lithium-ion battery](#), plus another 5% from using the electricity to make the vehicle move. So you are down to 80 watts—as shown in the figure opposite.

In other words, the [hydrogen fuel cell](#) requires double the amount of energy. To [quote BMW](#): "The overall efficiency in the power-to-vehicle-drive energy chain is therefore only half the level of [an electric vehicle]."



Energy efficiency in electric vehicles.

Swap shops

There [are](#) around 5 million electric vehicles on the roads, and sales have been rising strongly. This is at best only around 0.5% of the global total, though still in a different league to hydrogen, which had [achieved](#) around 7,500 car sales worldwide by the end of 2019.

Hydrogen still has very few refuelling stations and building them is hardly going to be a priority during the coronavirus pandemic, yet enthusiasts for the longer term point to several benefits over electric vehicles: drivers can refuel much more quickly and drive much further per "tank". Like me, many people remain reluctant to buy an electric car for these reasons.

China, with electric [vehicle](#) sales of [more than](#) one million a year, is demonstrating how these issues can be addressed. The infrastructure is being built for owners to be able to drive into forecourts and swap batteries quickly. NIO, the Shanghai-based car manufacturer, [claims a](#) three-minute swap time at these stations.

China is planning to build a large number of them. BJEV, the electric-car subsidiary of motor manufacturer BAIC, [is investing](#) €1.3 billion (£1.2 billion) to build 3,000 battery charging stations across the country in the next couple of years.

Not only is this an answer to the "range anxiety" of prospective electric car owners, it also addresses their high cost. Batteries [make up](#) about 25% of the average sale price of electric vehicles, which is still [some way higher](#) than petrol or diesel equivalents.

By using the swap concept, the battery could be rented, with part of the swap cost being a fee for rental. That would reduce the purchase cost and incentivise public uptake. The swap batteries could also be charged using [surplus renewable electricity](#) – a huge environmental positive.

Admittedly, this concept would require a degree of standardisation in battery technology that may not be to the liking of European car manufacturers. [The fact that](#) battery technology could soon make it possible to power cars for a million miles might make the business model more attractive.

It may not be workable with heavier vehicles such as vans or trucks, since they need very big batteries. Here, [hydrogen may](#) indeed come out on top—as BloombergNEF [predicted in](#) its recent report.

Finally a word on the claims on carbon emissions from that Canadian Hydrogen and Fuel Cell Association report I mentioned earlier. I checked [the source](#) of the statistics, which revealed they were comparing hydrogen made from purely renewable electricity with [electric vehicles](#) powered by electricity from fossil fuels.

If both were charged using renewable electricity, the carbon footprint would be similar. The original report was funded by industry consortium H2 Mobility, so it's a good example of the need to be careful with information in this area.

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