HYDROGEN: THE FUTURE OF FUEL?

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Hydrogen: The Future of Fuel?

When it comes to alternative power for cars, battery-powered, electric vehicles (BEVs) have seen a rise in interest and demand that hasn't been seen in the automotive industry since the invention of the internal combustion engine.

More and more of the market share, especially when it comes to passenger and personal vehicles, is being taken up by BEVs.

However, whilst they have gained a significant footing in the industry, another way of powering vehicles – one that has been coming in and out of the spotlight for decades now – might be here to stay.

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Hydrogen-Powered Vehicles

Image: Toyota Mirai

Vehicles using hydrogen fuel come in two forms: **fuel cell electric vehicles** (FCEVs), which use hydrogen to power fuel cells (making them completely electric), and **hydrogen combustion engines**, which are not so different from the ones found in most petrol and diesel cars today.

Some manufacturers have released hydrogen cars in the past, and we're likely to see more concept vehicles using the technology hit the market in the next few years.

Image: Toyota Mirai

Image: Hyundai Nexo

Currently, two brands in the UK have hydrogen cars on the market – Toyota with their Mirai model, and Hyundai with their Nexo model.

Both cars use hydrogen to power **an internal fuel cell**, making them emission-free (according to the EU's zero- and low-emission vehicles incentive mechanism), but the overall adoption of these passenger vehicles, especially when compared with BEVs, has been miniscule.

EU Standards for Zero-Emission
A vehicle is considered zero-emission if its tailpipe emissions are kept between
0 - 50g of CO_2 per KM

This doesn't mean that hydrogen hasn't been utilised in other vehicle markets though. In 2021, we saw **a fleet of hydrogen buses** launched in London to further support Transport for London's zero-emissions initiative and, in 2018, Germany launched **the hydrogen-powered Coradia iLint train.** Both of these used hydrogen fuel cells to power them. However, the industrial vehicle space has seen the adoption of the alternative, with JCB **having adapted their diesel combustion engine to run on hydrogen.**

With several examples across vehicle markets, why is wider adoption taking so long?

Hydrogen as an element is abundant, with far more availability than petrol or diesel, but transforming that element into a useable fuel for vehicles takes a serious amount of energy.

Currently, there exist two methods of generating hydrogen: **extraction from methane** (known as steam reforming) or by **electrolysis of water.**

Currently, **around 95% of all hydrogen** is produced from steam reforming of natural gas, which involves combining CH_4 (methane) and H_2O (water), using heat to create CO (carbon monoxide) and $3H_2$ (hydrogen).

$$CH_4 + H_2O \text{ (+ heat)} \rightarrow CO + 3H_2$$

The process doesn't end there, however. The carbon monoxide is made to react with the remaining steam, using a catalyst, to create carbon dioxide and more hydrogen. This is called the 'water-gas shift reaction'.

$$CO + H_2O \rightarrow CO_2 + H_2 \text{ (+heat)}$$

The CO_2 created in this process is captured and stored, but **the entire process requires a lot of energy to create large amounts of hydrogen.**

The second method is through electrolysis, using electricity to split water into its component atoms, hydrogen and oxygen.

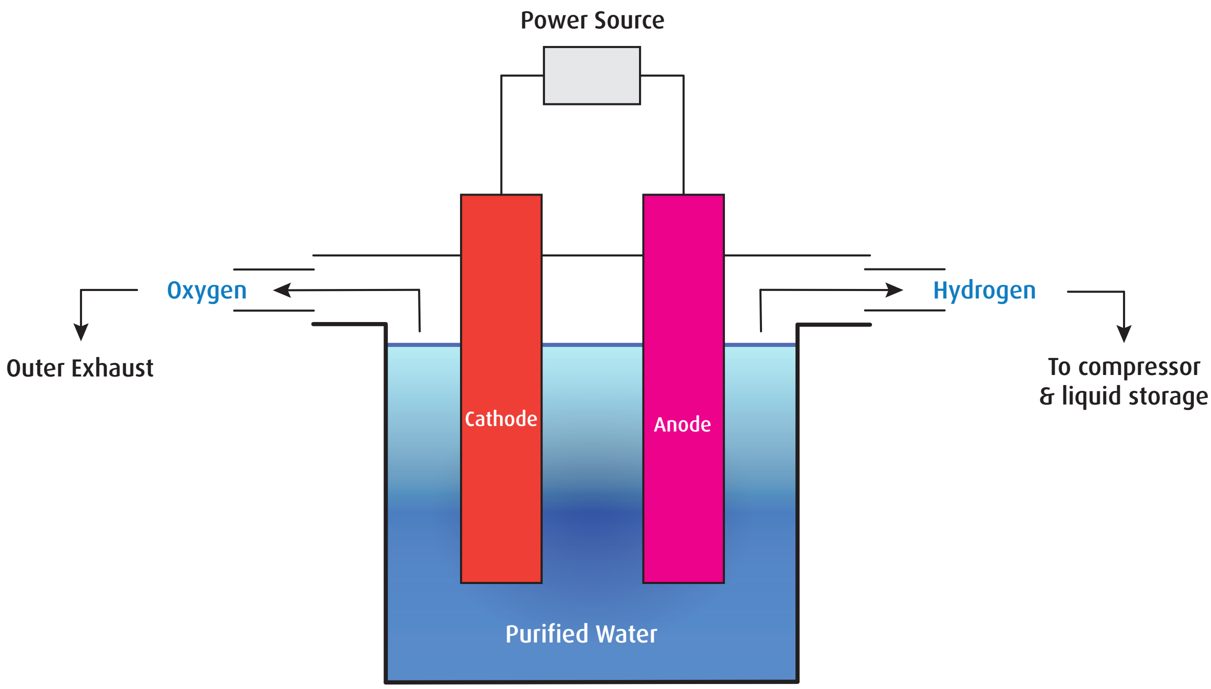


Diagram of Electrolysis

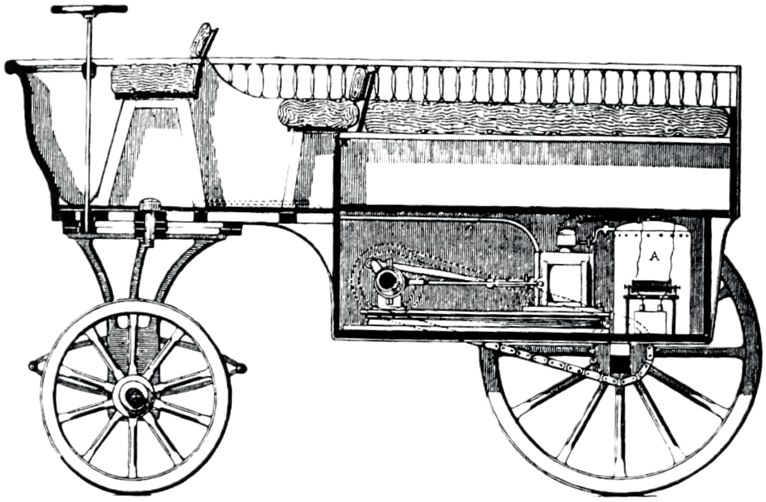
It might seem simple and, with renewable energy creating the electricity, be completely carbon neutral, but **the main reason only 5% of hydrogen is produced this way is because of the sheer amount of power required.** Without a renewable power source – solar, wind, nuclear or hydro-electric – it ends up generating more CO_2 in energy production than using hydrogen fuel would save.

These production methods might make it seem as if the move towards hydrogen fuel has only come as a response to the rising pressure of climate change, but hydrogen has been used as a fuel source a lot longer than you might think.

The History of Hydrogen Vehicles

Image: Toyota Mirai

It might surprise you to know that hydrogen-powered vehicles have actually been around since the 1860s, with an invention by Belgian-French engineer, Étienne Lenoir. Known for his work creating a commercialised combustion engine, he later adapted the engine to create **the Hippomobile**, a hydrogen-powered car that generated the hydrogen used to power it with electrolysis.



The Hippomobile, Étienne Lenoir

The Hippomobile **managed 11 miles**, travelling from Paris to Joinville-le-Pont and back in an hour and a half, a time that closely compared to other combustion engine vehicles of the period. Of course, the ready availability of petroleum meant the Hippomobile was not the trailblazer Lenoir might have expected it to be.

It was actually over a decade before then, in 1842, that Welsh physicist **William Grove** created a hydrogen fuel cell (though the term 'fuel cell' had yet to be used) using the method of reverse electrolysis to create electricity and water. However, the hydrogen fuel cell-powered vehicle wouldn't appear until 1966.

The swinging 60s were well underway when General Motors created **the Electrovan**. Fuelled by both a super-cooled liquid hydrogen tank and a liquid oxygen tank, it featured over 500-feet of piping within the rear of the vehicle. The sheer size of the fuelling system meant that fitting a similar design into a smaller vehicle would have been near-impossible.

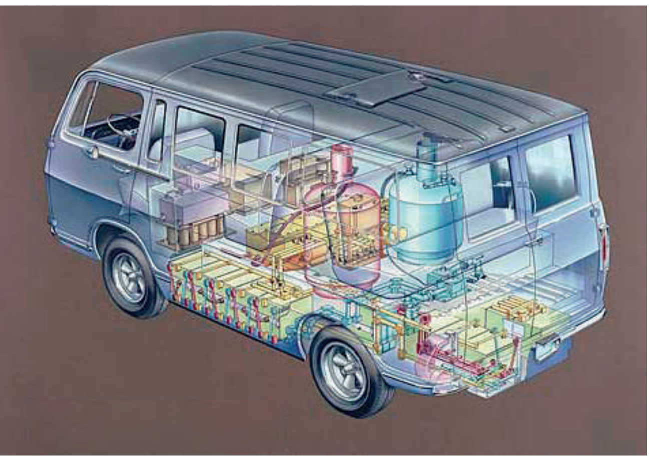


Image: Auto Concept Reviews

Image: Hydrogen Cars Now

The Electrovan did manage to reach a top speed of 70 mph with an impressive range of 120 miles, but due to safety concerns it never left company property. Further development of the Electrovan was scrapped by GM as the platinum required to manufacture just the prototype was enough to *"buy a whole fleet of vans"*.

Seeing GM's difficulty, very few manufacturers chose to invest in hydrogen vehicle technology, and **it was not until 2003 that General Motors would come back on the scene with the Hy-Wire**, a hydrogen-powered concept car that had no pedals, screens instead of interior or exterior mirrors, and an adjustable steering wheel – not so you can find the right position for your arms, but so you can switch from right-hand drive to left-hand drive in seconds.

Images: Car Magazine

In a piece the British TV programme ***Top Gear*** ran on the Hy-Wire, presenter James May called hydrogen the "***fuel of the future***", but in the two decades since, what updates have we seen?

Well, it was Hyundai who took the first step in creating a hydrogen-powered, commercially-produced vehicle with the ix35 FCEV in 2013. The SUV body served the space required for the hydrogen tanks well, and though it was awarded with the ***What Car?*** Tech Award in 2016, the model was replaced by the Hyundai Nexo in 2018.

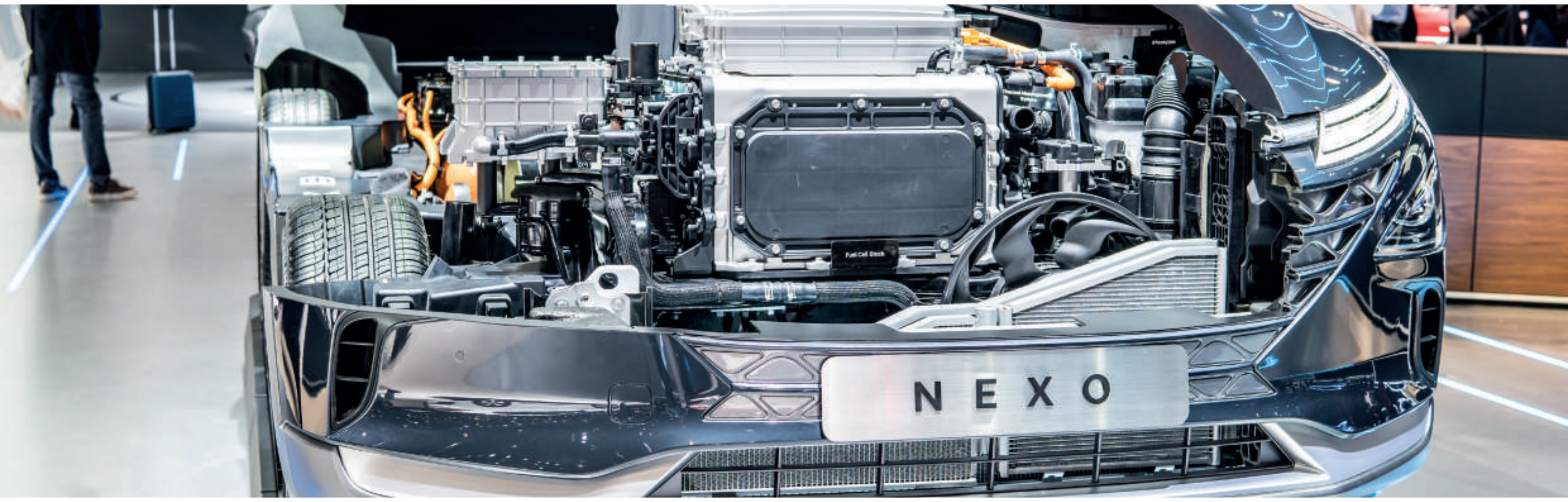
Toyota threw their hat into the ring in 2014 with the Toyota Mirai. Instead of the SUV-style body that Hyundai used, the Mirai had a saloon four-door body. Still in production to this day, both cars committed to zero emissions and although they're sold throughout the world, they certainly haven't come close to inspiring a market shift the same way BEVs have.

Image: Hyundai Nexo

Image: Honda FCX

The few passenger car manufacturers to release hydrogen-powered vehicles have all used fuel cells to power their vehicles. Construction vehicle manufacturer **JCB, however, has taken strides** in the last few years to shift part of their ICE manufacturing so that their engines can be fuelled by hydrogen. CO_2 released by construction vehicles is the leading cause of emissions across the construction industry and one of the only other major industrial vehicle manufacturers we've seen advancing towards zero-emission vehicles is Volvo with their BEV range.

It will be interesting to see which side of the zero-emission vehicle market wins out in the industrial vehicle space.



Hyundai Nexo, Fuel Cell

Where are we now?

With the EU setting a deadline of 2035 on the sale of new petrol and diesel cars and the UK Government delaying their initial 2030 deadline to match it, car manufacturers have had to push forward their own alternatives. But the drive for net-zero in vehicles reaches beyond just cars. Every industry is looking to do what they can to minimise their carbon footprint so vehicle manufacturers across the world are looking for any alternatives to fossil fuels.

Currently, several governments have mentioned hydrogen in their drive for green, low-carbon energy but the key priority for them is less so about creating infrastructure for storage, or incentivising businesses to use hydrogen. Instead, any mention of hydrogen fuel has been pushing towards low-carbon hydrogen generation. This will have a huge factor on making hydrogen more accessible to fuel suppliers but without further infrastructure for its transportation and storage, combined with a consumer apathy towards hydrogen-powered vehicles, there will be continued difficulty in getting hydrogen fuel to consumers.

One of the larger issues with hydrogen's wider adoption is a perception of danger that comes with the fuel. Of course, the hydrogen-powered Hindenburg has entered the cultural lexicon as a colossal, outright failure and the hydrogen bomb does little to encourage the idea of safety.

The truth is that hydrogen is actually safer than the petrol and diesel we've been filling our cars with for a century. Hydrogen's light weight means that its gas moves directly up, unlike petrol where its fumes spill out around where it is poured. This means a lit match – that would pose huge risk to anything using petrol/diesel – becomes redundant next to hydrogen unless positioned directly above it.

Unlike petrol, hydrogen also dissipates incredibly quickly when released from storage, and because of its single electron structure, leaks can be quickly dealt with and are largely safe. Similarly to the initial fears around BEVs, it is likely that hydrogen will become more accepted as it becomes more mainstream.

The science is in its favour and public perception will likely shift over time as hydrogen-powered vehicles are seen on the road more often.

The Technology

Image: Toyota Mirai

As discussed in the introduction, hydrogen-powered vehicles come in two main forms: vehicles powered by fuel cell and vehicles powered by an internal combustion engine. Both produce zero emissions but where they differ lies in their strengths.

Fuel Cells

A fuel cell functions similarly to a battery, but instead of running down and requiring a recharge, they produce electricity and heat from a fuel source to the fuel cell.

A fuel cell is made up of two electrodes: a negative one (the anode) and a positive (the cathode) – and in between them is an electrolyte. In a hydrogen FCEV, the hydrogen is fed directly into the anode and air is fed into the cathode. The catalyst at the anode separates the hydrogen molecules into protons and electrons, and the electrons are then channelled through an external circuit, generating electricity. The protons travel through the electrolyte directly to the cathode where they unite with the oxygen, producing water and heat.

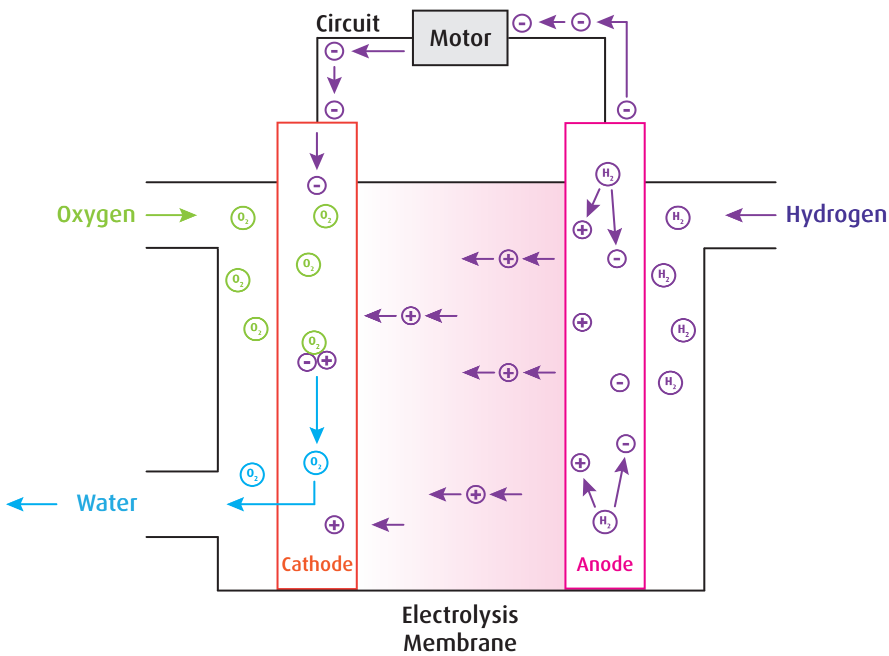


Diagram of Fuel Cells

But an FCEV does not just rely on its fuel cell for power. FCEVs require time to begin powering the electric motor within them. Hydrogen cannot instantly begin generating power within a vehicle, so FCEVs require a battery to act as a buffer between turning the car on and the fuel cell powering the motor.

This buffer doesn't just exist for starting an engine – fuel cells use the least amount of hydrogen when they are run at a consistent rate and various factors mean vehicles aren't able to run at constant speeds. The additional battery means power can be given when the car is moving faster, and recharged when the car is moving slower.

Having a battery also allows vehicles to use regenerative braking which is not dissimilar to a hybrid electric vehicle, using two power sources and having one – in part – recharge the other.

Images: JCB - Building a Greener Future

Hydrogen Combustion Engines

Hydrogen-powered combustion engines function almost identically to their fossil fuel counterparts. It's why **JCB and other manufacturers** have been able to so easily adapt their current manufacturing to incorporate hydrogen as a viable fuel source.

Within the engine, hydrogen is mixed with air and compressed in its cylinders. A spark plug then ignites the air and hydrogen causing combustion that generates power. Similarly to how a fossil fuel combustion engine works, that then drives the pistons and powers the vehicle.

Where the two differ most significantly, however, is on energy density. **Diesel has an energy density of 45.5 megajoules per kilogram**, a little less than petrol (45.8 MJ/kg), but **hydrogen has an energy density of around 120 MJ/kg**, making it nearly three times more powerful than petrol or diesel.

This means that to get the same amount of power that you might have with diesel or petrol, you only need a third of the amount of hydrogen.

Of course, with combustion engines much of that energy is transferred to heat, where with fuel cells only 10% of the energy generated becomes heat. But hydrogen combustion engines, do still have a place in the market, not just because their similarity to existing combustion engines makes manufacturing easier, but because of a process called hydrogen injection.

Hydrogen Injection

This process involves hydrogen being injected into diesel fuel and could allow for diesel-powered vehicles to move towards lowering emissions through hydrogen without the need for a completely new engine.

Using deionised water, hydrogen injection uses a tank piped into the engine alongside the air intake to 'inject' hydrogen into the diesel engine whilst the car is driving. This lowers the amount of fuel consumed and can reportedly reduce emissions from diesel combustion engines by up to 70%.

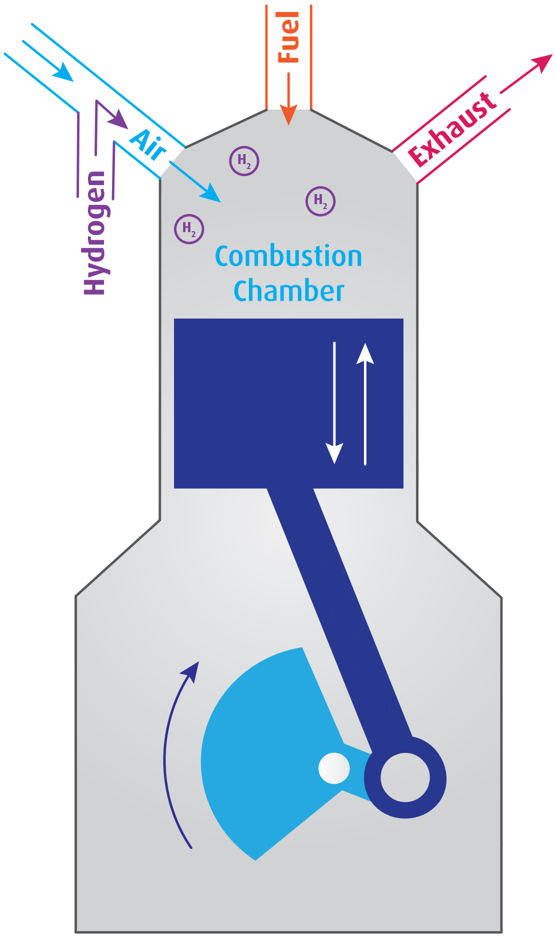


Diagram of Hydrogen Injection

It might seem that hydrogen can surpass diesel and petrol in many ways, but there's a lot more going on outside of the engine or fuel cell that makes it a harder for hydrogen to spark a market shift.

Infrastructure

Currently, there are only 5 hydrogen car refuelling stations available to the public in the UK, with 3 more on the way, and 4 for refuelling buses. Even factoring in the whole of Europe, there are only 161 hydrogen refuelling stations open, most of which are in and around Germany. You might think that battery-powered vehicles had a long way to come, but as of 2014, London alone had just under 1,400 public charging stations for BEVs and in 10 years it has increased almost 10-fold with 13,455 now available.

Electric charge points have an advantage over hydrogen refuelling in that anywhere that connects to power lines can become a charging point. Though we have gas lines that likely will begin to take in more hydrogen as time goes on, piping that hydrogen in the large quantities needed to replace diesel and petrol will be next to impossible.

It's more likely that, as is the case for petrol and diesel, tankers will be used to transport hydrogen to refuelling stations. But that adds a different problem: Hydrogen storage.

What is so difficult about Hydrogen Storage?

Hydrogen can be stored in one of two ways, either as a gas or as a liquid. Storing hydrogen gas requires high pressure tanks with 700 bar pressure. Because of hydrogen's atomic structure, it also means that tanks must be lined with Polytetrafluoroethylene (PTFE) to make sure that the molecules surrounding the hydrogen are smaller than the molecules of hydrogen itself, preventing any seepage.

Storing hydrogen as a liquid isn't any easier. To turn hydrogen into a liquid, you have to keep it at cryogenic temperature. The boiling point of hydrogen is -252.9°C which is only 20 degrees from absolute zero. Getting to these temperatures also requires a huge amount of energy.

Although the technology is in place, there are still great strides needed to make it available in petrol stations across the world, especially when factoring in the space and energy requirements.

Is on-site electrolysis the answer?

With electrolysis you can create hydrogen with just water and electricity, so could petrol stations just generate their own hydrogen fuel through electrolysis machines on-site?

To create 1 kg of hydrogen, with no inefficiencies in production, it would require 39 kWh of electricity. To put that into perspective, the average household in the UK consumes 242 kWh of electricity a month, and the Toyota Mirai has a 122-litre tank that can hold 8.6 kg of hydrogen. That means that to fill up just one Toyota Mirai with hydrogen generated from electrolysis, it will take as much energy as it would to power an average house in the UK for nearly a month and a half.

To generate hydrogen without using so much electricity requires the electrolysis of ammonia in wastewater. This uses only 1.55 kWh of electricity to create 1 kg of hydrogen, but this would require a complete rethink of how we structure sewerage systems to support this method of generating hydrogen and would still need hydrogen to be transported from water treatment plants to petrol stations.

The solution to the issue of hydrogen infrastructure is not going to have an easy or cheap answer. A lot of effort and money is going to be required to make it a viable fuel, but it is by no means impossible. There are opportunities across the UK and beyond for investors to help countries become one of hydrogen's early adopters, but until there is more demand it's likely we won't see much advancement in infrastructure technologies.

So where will the demand come from?

Advancements in hydrogen technology are happening across the vehicle industry. We've seen everything from motorcycles to rocket ships use hydrogen fuel to generate their energy, some much more successfully than others. So, where does hydrogen excel? And where might it eclipse BEVs and fossil fuel vehicles in becoming the main fuel source for vehicles?

Since the Electrovan in 1966, hydrogen-powered passenger vehicles have always had a strange position in the market. The technology, whilst certainly impressive, hasn't found a strong consumer base in the same way hybrid and BEV vehicles have. Car manufacturers have been working on hydrogen vehicles for decades now, but it's only in the last 10 years that we've seen real moves to produce consumer-friendly vehicles that are powered by hydrogen. There was the aforementioned Hyundai Nexo and Toyota Mirai but even BMW, Honda and JLR have thrown their hat into the ring with cars set to come out in the next few months.

Even though significant space requirement is considered a necessity in hydrogen-powered vehicles, Hyundai have created a sporty, 670-horsepower supercar with the N Vision 74; American supercar manufacturer Hyperion Motors recently unveiled the XP-1 with a top speed of 220 mph; and Riversimple, a Welsh manufacturer, revealed their tiny concept car the Rasa capable of going 300 miles on just 1.5 kg of hydrogen.

For hydrogen-powered FCEVs, there is still a lot of room for the technology to continue evolving, just as there is with BEVs. On the next page, you'll find a rundown of how hydrogen-powered cars compare to BEVs and fossil fuel-powered cars. We've not included hydrogen combustion engine cars as there aren't currently any available on the market.

Passenger Vehicles			
	Hydrogen Fuel Cell	**Electric**	**Fossil Fuel**
Refuelling/ recharging	Fully refuelled in under 5 minutes	Takes between 4-8 hours to fully recharge, can recharge at home	Can be fully refuelled in minutes
Infrastructure	Only 4 public charging stations across the UK and less than 200 in the whole of Europe	Over 40,000 charge points across the UK and installation of charge points available at home or work	Over 8,000 petrol stations in operation across the UK
Acceleration	Currently 0-60 averages around 9 seconds for non-concept consumer vehicles	High torque levels mean even standard consumer cars can get from 0-60 in as little as 2-3 seconds	Varies depending on engine size but is similar to Hydrogen for average consumer car
Range	Fully fuelled can average over 400 miles	Varies on battery but average between 150-300 miles	Varies depending on tank and engine but some can go upwards of 600 miles
Tail pipe Emissions	Zero Emissions	Zero Emissions	On average 4 tonnes of CO_2 every year

With passenger vehicles, we'll likely see a rise in hydrogen fuel usage as the technology continues to grow. There are plenty of manufacturers who are likely waiting for their contemporaries to test the waters before diving into the technology themselves. But from a consumer perspective, it isn't just cars that they'll have on offer.

Several BEV motorcycles have entered the market over the last few years, but in terms of hydrogen vehicles, in 2009 we saw the ENV hydrogen-powered fuel cell motorcycle capable of top speeds of 50 mph and a range of 100 miles.

Though the lightweight design certainly drew the attention of consumers, the lack of infrastructure left it to remain an early foray into hydrogen motorcycles and very few manufacturers followed suit. Recently, however, motorcycle manufacturer Kawasaki announced a hydrogen-powered bike, the H2 Hydrogen. The bike is still in development stages but with **Japan's Ministry of Economy, Trade and Industry** helping Kawasaki, Honda, Yamaha and Suzuki with the development of hydrogen engines for motorcycles, we'll likely see more from Japanese motorcycle manufacturers in the near future.

Retrofit market

One of the significant opportunities compared to BEVs, is that there is room for hydrogen to replace diesel in fuelling existing ICE cars. There are currently **11.6 million** diesel cars in the UK and 1.6 million electric cars using alternative fuels. If hydrogen becomes a widely available fuel source, it is much cheaper to adapt a diesel car to allow it to accept hydrogen than to buy an entirely new car. There have already been attempts to equip existing cars with batteries transforming them into BEVs, but with hydrogen this would be much cheaper and require considerably less effort in converting the car.

Once we see an increase in hydrogen fuel's availability across the UK, we will likely see a market rise in retrofits of older cars, just as we have seen with BEVs, only cheaper and easier.

Commercial Vehicles

Image: Volta Trucks

The push for governments to hit net-zero targets have meant that public transportation has made fairly significant leaps towards hydrogen power. As previously mentioned, even London's iconic red double-decker bus has gained a fleet of hydrogen versions within the city and Germany has already adopted a hydrogen-powered train. The EU has supported research towards clean urban transport since 2001 and there's no doubt that hydrogen will play a key part in moving towards zero-emission transportation and vehicles in cities.

Though we've seen electric-powered buses, trains and trams across Europe and hydrogen-powered vehicles are slowly joining them, a challenge arises in electric trucks and HGVs.

Due to their multiple large batteries, electric cars are some of the heaviest available on the market today. The Tesla Model X weighs **nearly 2,500 kg** – not far off the heaviest car ever made, **the 1960 Lincoln Continental**. A standard heavy goods vehicle needs to carry nearly 20 times that without factoring in the weight of a heavy battery in a BEV's tractor. Smaller trucks have taken further steps towards battery power, with several companies, including Volta Trucks, focusing on urban distribution with smaller ranges, but in America and less concentrated countries, trucks need to be able to go much larger ranges without needing to refuel.

Image: Volta Trucks

Tesla have created the Tesla Semi, capable of going an estimated **500 miles**, and Nikola have developed the **TRE BEV**, a fully-electric, battery-powered truck with a 330-mile range and a charge time of 90 minutes. But even Nikola are taking steps to create a hydrogen alternative to their battery electric HGV knowing that hydrogen FCEVs beat BEVs on range consistently.

The logistics industry is looking to become greener, with the industry responsible for around **a quarter of global** CO_2 emissions and, according to the European Environment Agency, that could be set to rise to 40% by 2050 unless significant action is taken.

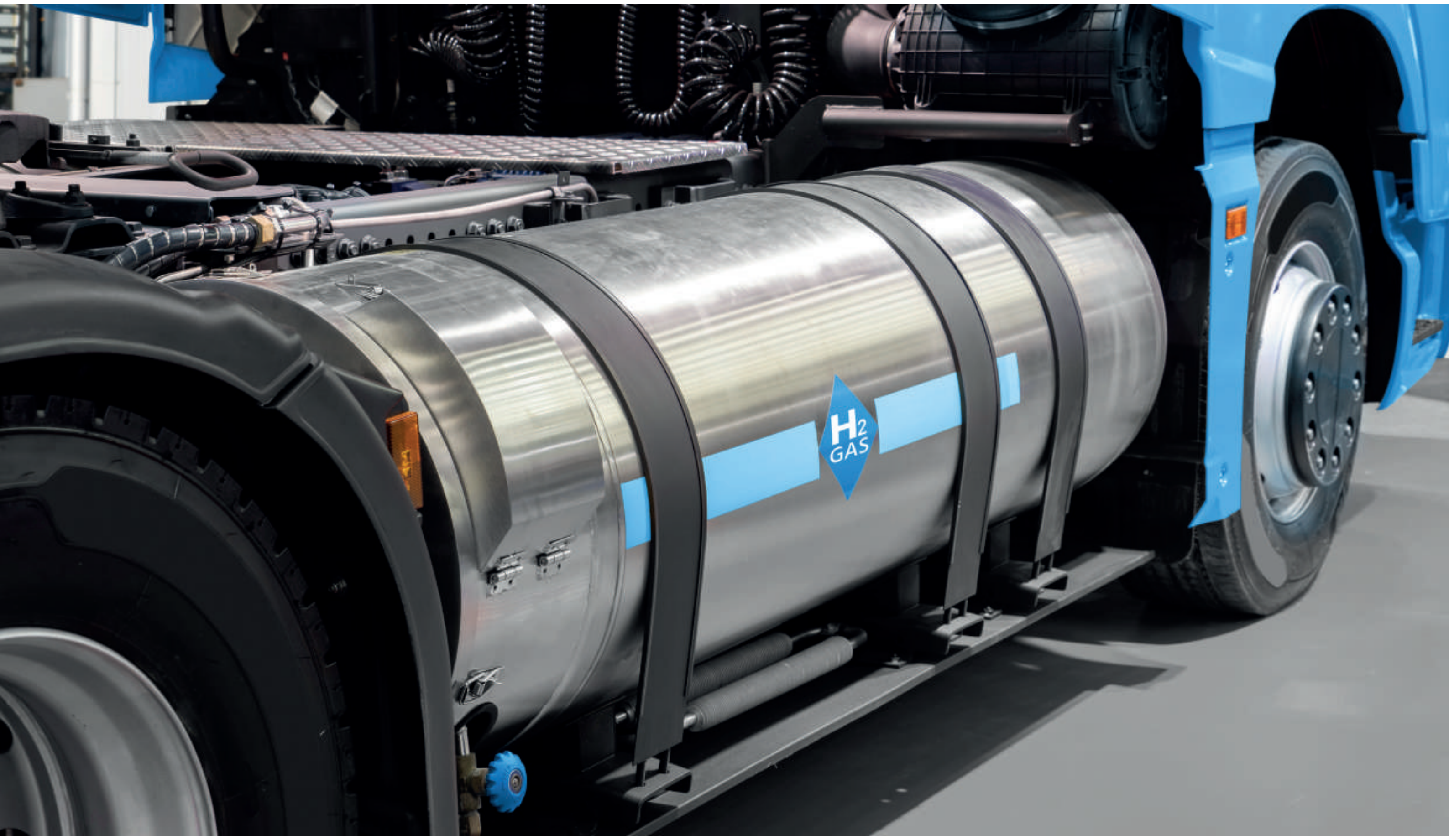
The expense of replacing diesel trucks with hydrogen and electric trucks likely puts off many in the industry to make the shift, but this could be where hydrogen injection systems thrive, not only by lowering emissions but by saving fuel, making the case that even diesel-powered HGVs could begin to benefit from hydrogen.

Commercial Vehicles			
	Hydrogen	**Electric**	**ICE**
Refuelling/ recharging	Similar to ICE	The larger batteries require 6–8-hour charging	2-3 minutes
Infrastructure	Currently there are 2 hydrogen refuelling stations in the UK for HGVs and buses but there are several in the EU (mostly Germany)	Most distribution centres that use electric HGVs have installed their own charging points, but adapting current charge points to fit HGVs would not be too difficult	Thousands of stations available across the UK
Range	Depending on model, around 450 miles but some have been reported to manage over 900 miles	Varies from model to model but largely manages between 200-300 miles	On a 120-gallon tank, range can reach 600 miles
Emissions	Zero Emissions	Zero Emissions	ICE HGVs accounted for 21 million tonnes of CO_2 last year

With the wider adoption of emission-free public transport vehicles, we will likely see hydrogen's positives win out over electric, once the infrastructure becomes available.

When it comes to logistics transport though, last mile battery-powered goods vehicles are increasing in popularity, and while long-haul battery electric HGVs do exist, we've yet to see much growth in the market. The largest reasons for this are the cost of replacing diesel fleets with BEVs and the lack of infrastructure to support the lower ranges of battery-operated goods vehicles.

As hydrogen fuel shares some similarities with fossil fuel vehicles in terms of use in ICEs, it allows for retrofitted hydrogen combustion engines at a lower cost, or hydrogen injection into diesel engines. This means it could be very likely that hydrogen-powered HGVs surpass heavy good BEVs in the next few years. But similarly to BEVs, without the infrastructure there's little incentive for logistics businesses to push for this change.



Industrial Vehicles

It might not be the first point of call when considering hydrogen power in vehicles, but as already stated, diesel-powered construction equipment is the primary source of greenhouse gas emissions in the construction industry. The push towards clean-air cities has meant that without an alternative, diesel-powered industrial vehicles might be the last bastion of fossil fuel usage within cities adopting clean-air policies.

Battery-powered industrial vehicles do exist and some companies, including Volvo and Hitachi, have made moves towards zero-emission vehicles with Hitachi creating vehicles designed to plug directly into mains wires to keep fully charged at all times. Of course, diesel goes a lot further on a construction site than just powering the vehicles. From generators, to cement mixers, and a variety of tools, diesel supplies a lot more power than you might think and it's this that has encouraged JCB to move towards hydrogen power.

Images: JCB - Building a Greener Future

Hydrogen's similarity to diesel means adapting current combustion engines in both vehicles and equipment to use hydrogen is much easier than requiring mains access to recharge vehicles, batteries, and equipment.

Where construction vehicles differ from passenger and commercial vehicles is that they won't require refuelling stations across the country to supply them with hydrogen as the fuel can be brought directly to them and stored in tanks on-site in the same way as happens with diesel.

This isn't without its issues, however. Storing hydrogen as a liquid requires significant energy to keep it cool, and storing hydrogen as a gas means that you need a lot more space than you would with diesel or petrol. On some build sites, it might be completely impossible to fit storage large enough for hydrogen gas and factoring in delivery time might make it more difficult than just using BEVs.

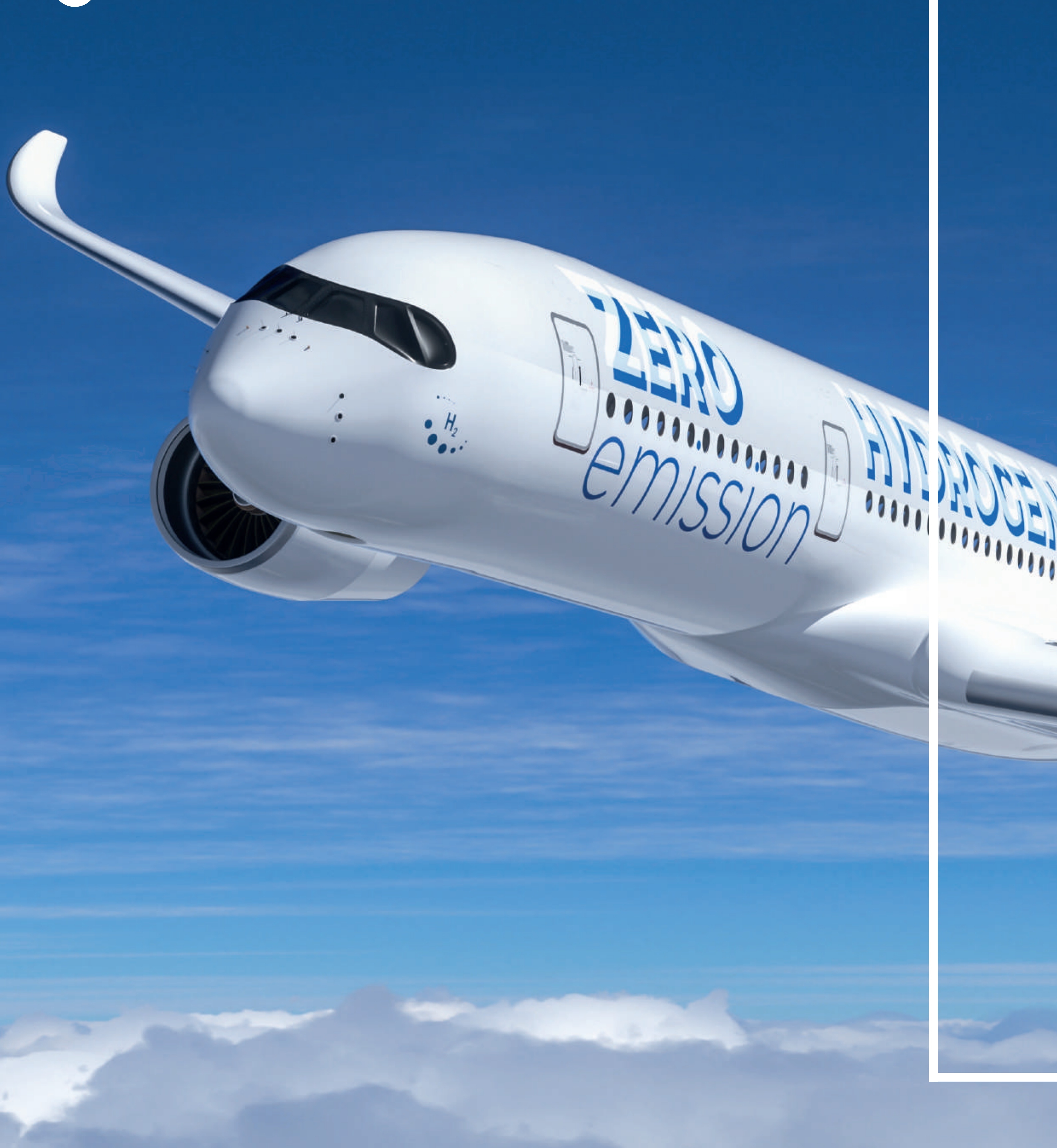
This also helps in agriculture, where fossil fuels are one of agriculture's leading causes of CO_2 emissions. Though it only makes up 1.7% of the UK's overall carbon emissions, hydrogen could all but eliminate that should it become more easily available to your average farmer.

This doesn't even mention refuelling times for hydrogen vs. recharging times for BEVs. With hydrogen, you can refuel a vehicle in minutes, while with BEVs they need to be plugged in for hours to return to full charge. If a vehicle is in usage for a full day, with BEVs you are likely required to recharge it overnight after a few hours of use, while with hydrogen worksites won't have to factor in refuelling.

With JCB leading the market shift, and other companies following suit, it's difficult to say where hydrogen will be in the industrial vehicle space. But a push towards clean air in cities means that diesel will likely begin to see an ever-decreasing usage. If it's cheaper to adapt existing vehicles than to buy new ones, we'll likely see construction vehicle suppliers adapting their existing fleets rather than outright replacing them, even if hydrogen fuel is more expensive than recharging a BEV.

As the dependency on fossil fuels lowers, it is likely that rural construction and agriculture will not be able to adopt electric vehicles as an alternative so will have to rely on a clean energy source to replace their vehicles' current power, but the challenge of transportation will remain a key issue halting great adoption.

Other Vehicle Applications
Planes and Boats



Other vehicle applications – planes and boats

Fossil fuel powers a lot more vehicles than just those on wheels, and there are some applications that other zero-emission would struggle with. Hydrogen has actually been used to power planes since 1988, with the Tu-155. Built in the Soviet Union as a prototype, the plane used hydrogen to make its first flight, using cryogenics to store the hydrogen as a liquid. There had been plans to create a successor, but these were scrapped after the fall of the Berlin Wall.

For planes, one of the fundamental issues to the wide adoption of hydrogen is the size of the fuel tanks. This is why the Tu-155 used Cryogenic fuel tanks, meaning that unlike the usual 'wet wing' design planes use – where the wings are sealed and filled with fuel – space has to be specifically dedicated to the storage of the hydrogen fuel. Hydrogen might have a greater energy density in terms of weight, but in terms of volume hydrogen loses out to petrol or diesel.

Image: TU-155

With aviation making up 11.6% of CO_2 emissions from vehicles (and over 2.4% of global emissions), there is certainly a large push to find zero-emission options for aviation vehicles. Several concept vehicles have emerged in the last three and a half decades since the Tu-155, but no major company has made a push towards creating a plane that uses hydrogen fuel. Until we see wider usage in other vehicles, and hydrogen becomes globally available, we will likely still be waiting for this shift.

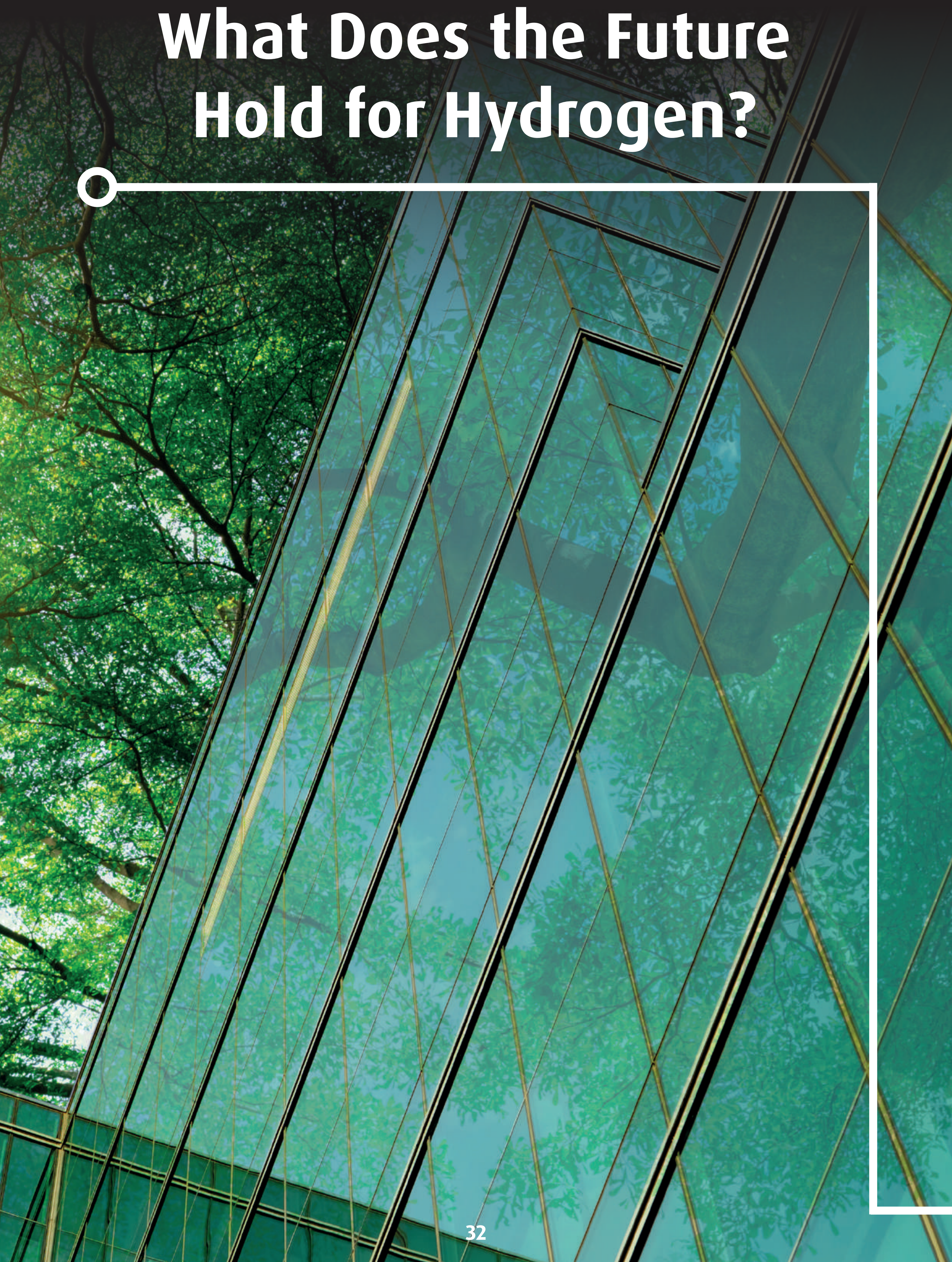
Unlike planes, however, boats are much more forgiving on what their fuel source is. Shipping makes up 10.6% of vehicle emissions, and the push for cleaner seas and greener shipping is starting to make a real difference to how ships operate.

Most large cargo ships use diesel engines, which could much more easily be retrofitted to take hydrogen, and the colossal size of the ships mean there would be plenty of space to store the hydrogen fuel. We've seen the French project, Energy Observer, reveal a concept design for a multi-purpose cargo ship fuelled by liquid hydrogen and on a smaller scale, Norwegian ferry operator Norled run a fully hydrogen-powered ferry.

Of course, just as is the case with the rest of the vehicle world, there is still a lack of infrastructure for boats, but it's likely that with large cargo ships and ferries, it would only take a few docks to adopt the infrastructure for them to become fully viable. We've seen talk of hydro-electric dams being used to generate clean hydrogen directly from the water that flows through them, and coastal hydro-electric systems could make getting hydrogen to ships and boats much easier than getting them to refuelling stations further in land. It could be that boats and ships lead the way before the wider adoption from cars or HGVs, but this could still be decades away.

There are certainly negatives to using hydrogen to fuel planes, but concepts have shown that it is possible. Whether we'll see any wider adoption remains to be seen though, but once better infrastructure is in place hydrogen planes will surely take off.

What Does the Future Hold for Hydrogen?



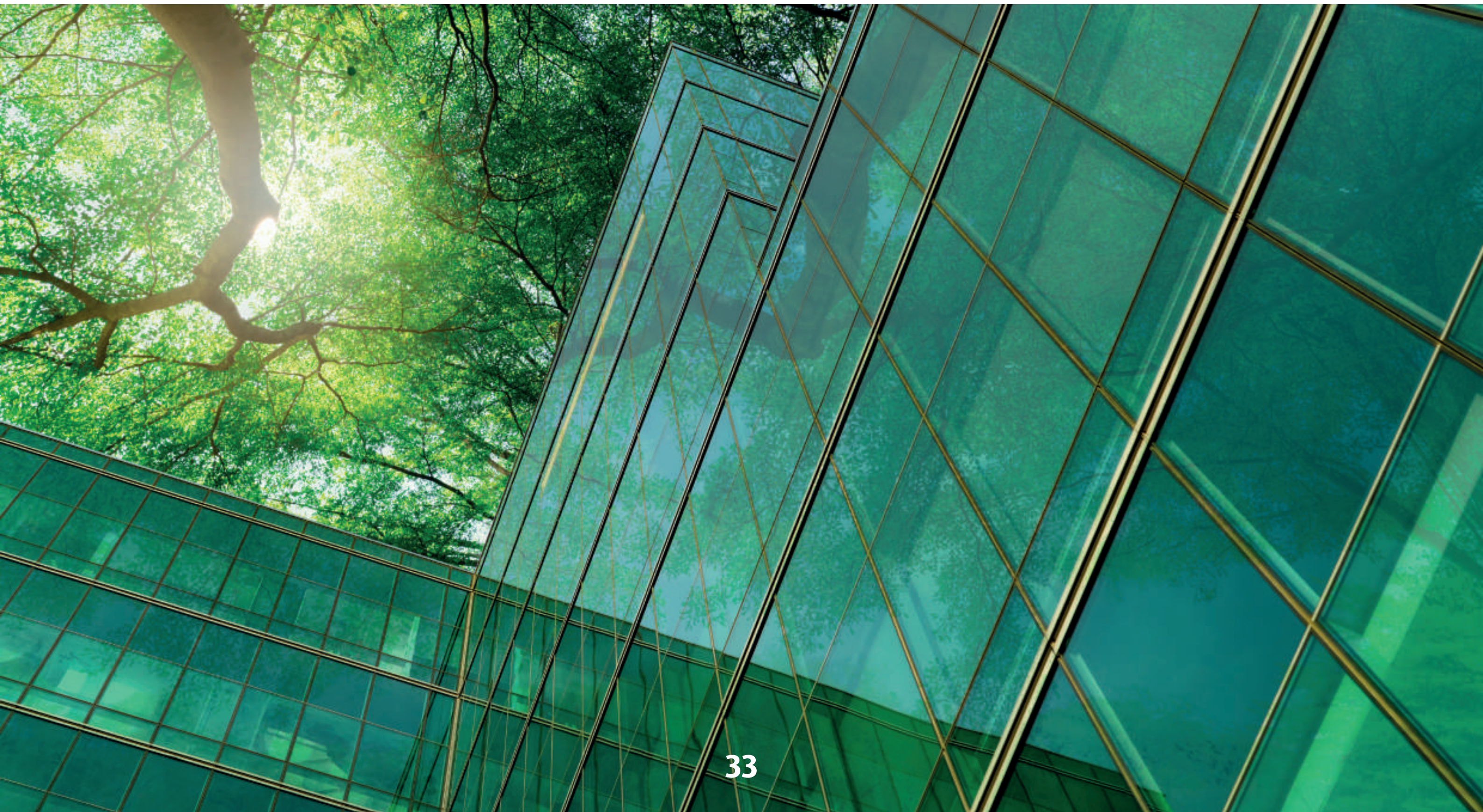
There is clearly a future for hydrogen vehicles, but it's difficult to say when wider adoption will truly begin to pick up speed. BEVs have existed for decades, but it wasn't until 2021 that we saw a real rise in mass adoption across the automobile space. And with the increased demand, we saw a direct response in infrastructure advancements and further adoption across other sectors within the automotive space.

Battery electric vehicles have big downsides that have made adoption in some industries difficult, but hydrogen can look to fill those gaps and match or even surpass both electric and fossil fuels in many regards.

With a push towards net-zero across Europe and the wider world, it could be that hydrogen becomes an industry leader by default, being the only fuel source that can replace fossil fuels in nearly every regard. Without policy and support, it will be very difficult for businesses to adopt a technology that, while not in its infancy, still has a lot of room to grow

With more brands and businesses moving towards hydrogen fuel technology, it's likely that in the next decade we'll see a boom in hydrogen power, with infrastructure increasing alongside the push towards net-zero. To get to that net-zero target, hydrogen requires cleaner energy sources, whether through renewable energy or nuclear power and if clean energy can't supply the demand that replacing fossil fuels with hydrogen will create, then clean tail-pipe emissions won't help fight climate change.

Hydrogen-powered vehicles might have been around for decades, but the recent push towards net-zero will be the necessary boost to push it from one-offs and prototypes into the mainstream. Here at FutureMotiv, we look forward to seeing what the next decade has in store for the technology.



Who are we?

FutureMotiv work with Automotive OEMs and startups to assist in the drive towards a low-carbon future. Our expertise range from high-voltage system integration prototyping to production designs.

We provide technical support towards the production of hybrid, electric, and fuel cell technologies giving the automotive industry the knowledge to pave the way towards net zero. If you'd like to know more about what we're capable of, get in touch with us today.

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