FUTURE HIGHWAY: **HOW ALTERNATIVE DRIVETRAINS WILL SHAPE AN INDUSTRY**

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INTRODUCTION

In a world driven by innovation, the industrial vehicle market is gearing itself up for change. A change on a scale that has never been seen before. The internal combustion engine has been the workhorse of every truck, bus and coach since its invention in 1872. Yet within the next decade, the entire market will experience a seis mic shift to a new way of powering commercial vehicles with alternative power trains. The changes, driven by innovation and global legislation, will drastically reduce the carbon emissions vehicles emit.

Crucially, however, the industry still has a choice. Electric drivetrains have already proven their worth in the passenger vehicle market, with powerhouse brands driving change. Yet a relatively unknown technology, hydrogen, is making slow but significant progress.

Whilst there's no right or wrong answer, unlike previous technology battles, the likely outcome for the new 'engine' will be a split decision dependent on application, functionality, and availability of fuel.

However, manufacturers aren't the only parties taking part in the rapid advancement of technology. The rest of the supply chain is investing millions of dollars annually to service new technologies.
The components market is gearing up for the shift with as much energy as the rest, from more sustainable components to new materials to cope with supercooled hydrogen.

Alongside the Euro 7 regulations coming into force in 2025 and again in 2030, designed to reduce emissions by 55%, the EU has committed to reducing CO2 emissions by 100% by 2050, making it almost impossible to manufacture an internal combustion engine (Reuters,2021). These regulations, coupled with targets for waste reduction and renewable materials, require manufacturers to focus their efforts on new technologies.

In real-world scenarios, the actual value of these new technologies will come down to what's inside. Regardless of functionality, application or even what powertrain is used. The end goal is to reduce global carbon emissions with an effort to make every industry globally net-zero by 2050. Those components and powertrains inside future vehicles will make it count.

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TODAYS MARKET: **WHERE ARE WE NOW?**

The vehicle market has been transformed significantly in the past two decades. The Millennium started with with high capacity, high emission diesel engines. Since then, innovation has helped the market reach key milestones quicker than originally anticipated in. These innovations include lower capacity, more efficient turbocharged engines, developed through active competition between OEMs to achieve the highest mile per gallon (MPG) ratings.

Trucks, buses and coaches have also advanced in their use of technology. From safety-focused lane assist technology, to more driver friendly infotainment systems. Modern on-highway vehicles have become smarter, creating platforms that can be built upon to make future vehicles more advanced and efficient.

One innovation that radically increased the efficiency and, in turn, MPG more than anything else in the early 2000's was hybrid power. Driven at first by the passenger vehicle market, by the mid 2000's hybrid buses had become commonplace in city centres.

High capacity, high emission diesel engines

Low capacity, more efficient turbocharged engines

Hybrid power

TODAYS MARKET: HYBRID POWER

Whilst it comes in many forms, hybrid drivetrains are typically defined as a combination of traditional combustion and electric drive. Pioneered by companies like Toyota with the Prius, hybrid power has significantly reduced emissions through its 'dual fuel' model.

This technology has, with great success, found its way into the commercial market, most notably in inner-city public transport. Hybrid single and double-decker buses are commonplace in densely populated urban areas like Belgium and Luxembourg. Both countries are leading the charge in hybrid drive vehicles with a focus on decreasing combustion engine usage and in turn emissions. **In fact, 1.4% or 9,785 of buses operating across the EU in 2020 used a hybrid drive system. Luxembourg designated 5.9% of its fleets as hybrid, Belgium 7.2% and Germany 3% (European Automobile Manufacturers Association, 2022).**

This technology, whilst impressive, has been considered a stopgap for the on-highway market, due to ongoing range challenges and underpowered batteries. Currently, hybrid trucks and buses can only travel between 40km and 100km on full electric power, depending the load weight. Compared with an average daily mileage of 720km for current combustion vehicles, hybrid won't satisfy a net-zero goal without continuing to create CO2 and other pollutants.

In 2019 the Council of the EU declared that as of 2025, new commercial trucks across Europe must cut emissions by 15%. They must also cut emissions by a further 30% by 2030. The importance of this stopgap technology is therefore becoming more obvious. Hybrid drive will provide OEMs with a lifeline to reduce truck emissions in the interim whilst alternative drive trains like battery and hydrogen development continues ahead of the 2035 regulation changes. Additionally, the efficiency of hybrid drives can be seen in the cost. **Volvo for, example, suggests that hybrid drive trains can save operators between 5% and 10% depending on vehicle type and specification. This would allow truck operators to save thousands per year on diesel, which currently sits at its highest price ever.**

Hybrid Bus Pioneers Across Europe

Percentage of Buses using Hybrid Technology

TODAYS MARKET: CURRENT SUSTAINABILITY AND INVESTMENT INITIATIVES

From the outset, the goal of the European Council, the Paris Agreement and individual city Governments has been to reduce the impact of industry on the climate. Through reducing carbon dioxide, nitrous oxide and soot, policy and lawmakers worldwide aim to make the world a healthier place.

To achieve this, they've been working hand in hand with manufacturers, producers and designers to create new initiatives, products, and policies to achieve these goals. Most manufacturers have their own internal sustainability goals. Daimler, for example, has set the target of 2039 to be CO2 neutral throughout its own business production. This includes its supply chain made up of component manufacturers like Gates (Daimler Truck, n.d.). Alongside its supply chain, Daimler is also continuing to refine hybrid drivetrains as well in parallel to zero-emission drivetrains, to ensure they meet Euro 7 regulations.

Partnerships have also become important. Volkswagen is investing in acquiring or merging with other brands to combine the capabilities of each including Scania and MAN (Traton Group, 2020). Driven by the high cost of research, Volvo, Daimler and Volkswagen's Traton Group have formed a joint venture to research fuel cell and infrastructure technology (Volvo, Daimler, Traton Group, 2021),

Overall, the industry expects to spend between 50 and 100 billion euros to develop new technologies according to Scania's CEO Henrik Henriksson. (Financial Times, 2020). By spreading this investment through joint ventures and knowledge-sharing programmes, net-zero targets can be achieved sooner.

INTERNAL COMBUSTION: WHAT'S NEXT

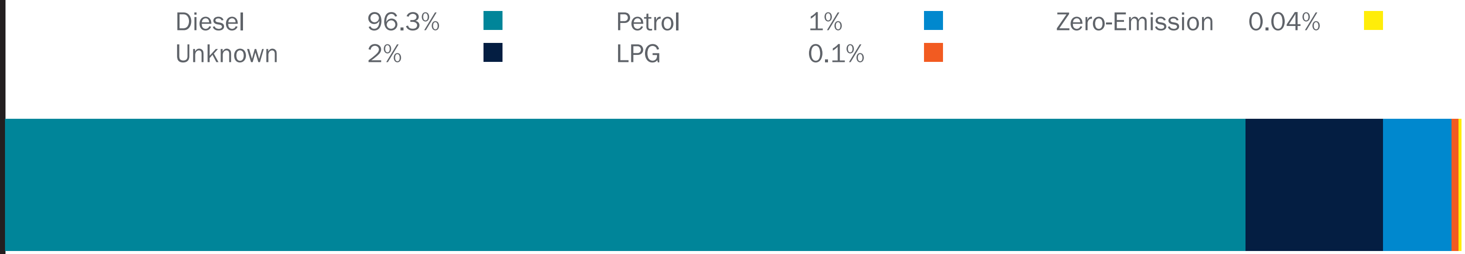
As the EU and other national and regional Governments continue to create and impose new sustainability regulations on the commercial truck market, the industry is considering what's next for the internal combustion engine.

Currently, diesel-powered commercial trucks, coaches and buses dominate roads across the EU with 96.3% of commercial trucks running on diesel and less than 1% running on petrol. **The remainder run on either natural gas (0.5%), LPG (0.1%) or unknown fuel types (2%). However, a small percentage (0.04%) are already running on zero-emission power trains, including battery-electric (European Automobile Manufacturers Association, 2022).** For coaches and buses, it's a similar story.

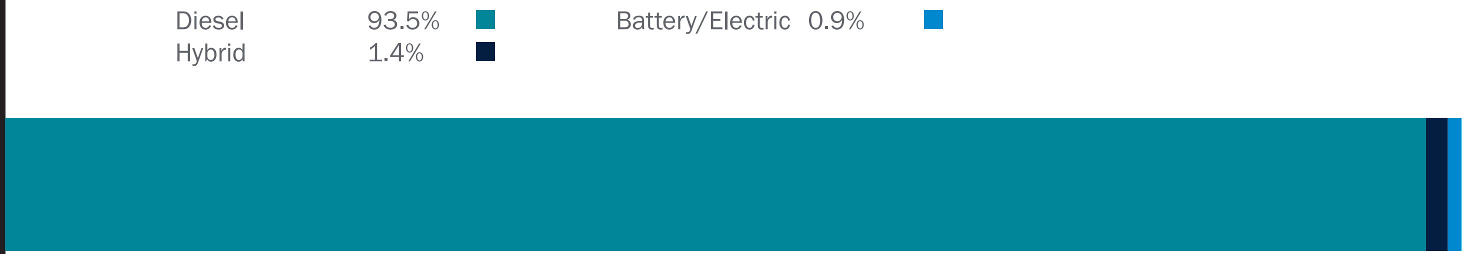
Diesel is the primary fuel choice for 93.5% of buses across the EU with 0.9% being battery-electric and 1.4% being hybrid (European Automobile Manufacturers Association, 2022).

These numbers pose a significant question for the on-highway market in terms of what happens next.

Commercial Truck Fuel Usage

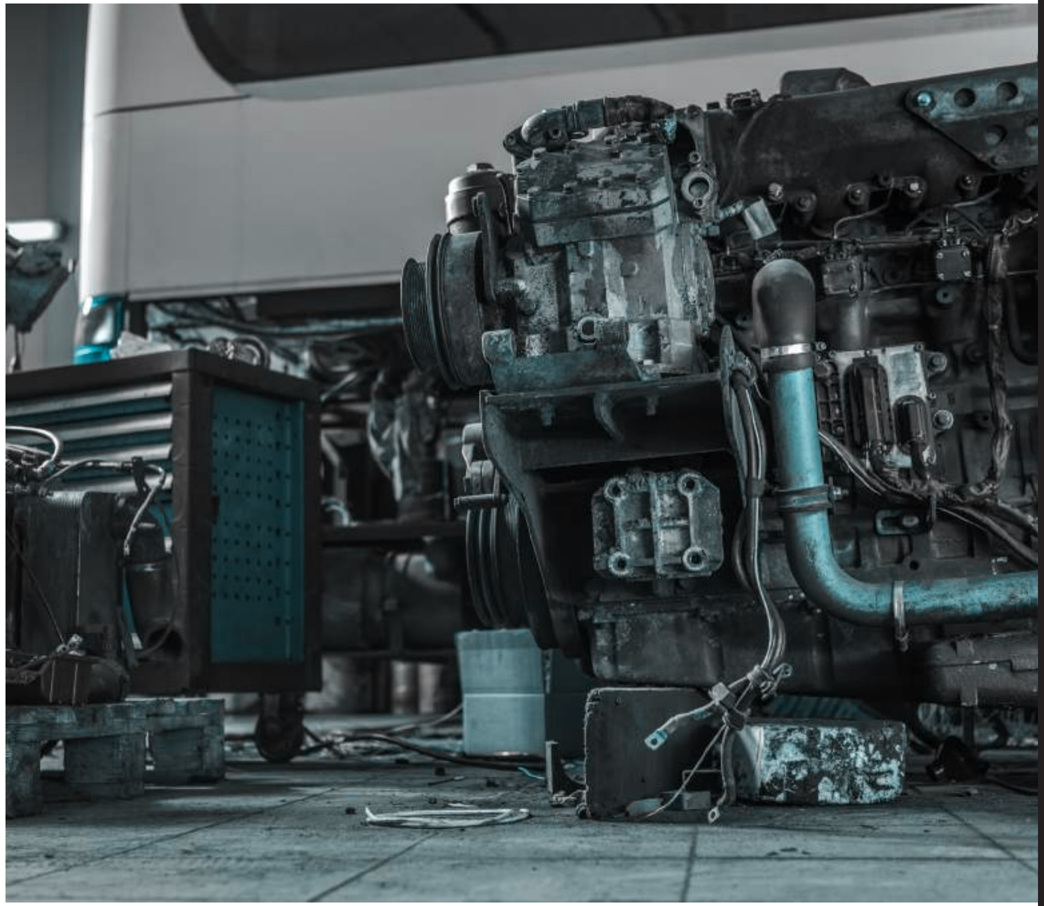


Commercial Buses and Coaches Fuel Usage



INTERNAL COMBUSTION: NEXT ITERATIONS OF ICE ENGINES

Internal combustion engines (ICE) will be entirely phased out within the next 30 years. With the 2035 laws set to effectively cease production of ICEs, the market expects one final ICE iteration to be launched, designed to last until 2034.



These new engines, won't, unfortunately, revolutionise the ICE's carbon footprint. They will simply be an evolution of existing products with elements of hybrid drive. Manufacturers are spending their development budgets on future power trains not those being phased out in the next decade.

But that doesn't mean that manufacturers won't ensure these engines meet the 2025 Euro 7 regulation. Active or continued development of Euro 7 compliant ICEs is expected to continue until 2025, in parallel to alternative drive trains. However, the number of vehicles using ICE powertrains globally has already begun to decrease. **New diesel truck registrations dropped 1% between 2019 and 2020 from 97.5% to 96.5% (ACEA, 2021).** The reason for this final iteration is the age of current vehicles. According to 2020 figures, the average age of a European truck was 13.9 years, with a bus being 12.8 years. **With an estimated annual mileage of 125,000 miles and an average age of 9.8 years most UK trucks have covered 1,225,000 miles in their lifetime. With 1,000,000km (621,371 miles) being recognised as the point at which a truck has generated a positive return on investment (often when vehicles are scrapped or sold) the majority of trucks in the UK are due to be replaced (European Automobile Manufacturers Association, 2022).**

Because of range deficiencies, however, full electric trucks are not yet able to directly replace existing fleets, neither is hydrogen. So, hybrid ICE technology is the next logical step to meet the 2025 Euro 7 regulations and extend a new truck's compliance to 2034. That's where the new iteration of internal combustion comes in.

With hybrid relying on an ICE unit to assist in delivering power, battery recharging or supplementary drivetrains, the need for a final ICE is clear. However, investments aren't going to be significant; most major manufacturers have already declared an end to ICE production and subsequent investments.

The Chief Executives of several of Europe's biggest truck manufacturers including, MAN, Daimler, Scania, Volvo, DAF and IVECO signed a decree in 2021 alongside the ACEA to phase internal combustion engines out globally by 2040. Well ahead of global net-zero targets of 2050 (ACEA, 2020).
This is expected to result in Internal combustion usage declining at a steady pace rather than overnight.

INTERNAL COMBUSTION: MAKING ICE MORE SUSTAINABLE

When you consider the next generation of ICE will be designed to run until 2034, engines produced in these final years could continue their service with hydrocarbon fuels well into 2048. In fact, in countries like Greece where the average truck is 21.4 years old, it could be even longer (European Automobile Manufacturers Association, 2022).

So, what about future maintenance and availability of parts?

In the case of component manufacturers like Gates, there are ongoing commitments to produce and maintain spare parts for 10 years past the final manufacture date. This could force many operators to replace trucks before they reach the end of service. This is where a more sustainable approach to production comes into play. Hybrid drive trains will play a considerable role in reducing the carbon footprints of future internal combustion engines. The rest of the supply chain, however, also needs to play its part.

Utilising sustainable materials like recycled rubber in power transmission belts and reducing waste through redesigned manufacturing processes will help reduce the overall carbon footprint of future ICEs. In turn, this will support operators with their own sustainability goals.

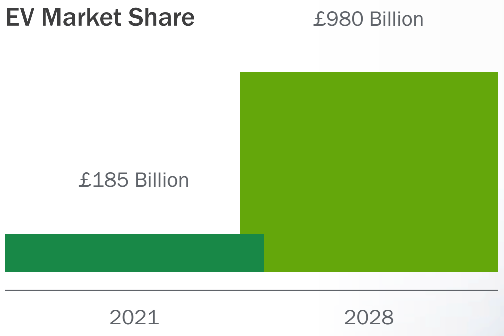
Such initiatives are accelerating. China for example produced 4.6 million tonnes of recycled rubber in 2019 and saw its virgin natural production decrease by 24,000 tonnes as a result (PW Consulting, 2020). Additionally, the increase in biodiesel use, which emits 11% less carbon monoxide and reduces net CO2 emissions by 78%, is expected to increase to 182 million litres from 2023 to 2025. An increase of 13 million litres in comparison to 2019 (International Energy Agency, 2020).

In reality, the sustainability of the ICE won't be improved through new development, because manufacturers are focussed on zero-emission powertrains. However, by using a combination of hybrid drive trains, more sustainable materials and alternative fuels, the carbon footprint of engines produced in 2034 will be negligible by the time they reach their end of life.

ELECTRIC:
IS BATTERY POWER THE FUTURE?

Battery-powered vehicles are proving to be extremely popular within the global transport market. Over the past five years, electric vehicle (EV) market share had jumped to £185 billion by 2021 and is expected to surpass £980 billion by 2028 (FNF Research, 2021). It is so valuable that Tesla recently achieved a trillion-dollar valuation on Wall Street, the only automotive brand to do so.

Thanks to lightweight chassis, lower load capacities and an average annual range of just 11,300km it is much easier to produce consumer EVs. However, the technology itself does hold potential, and commercial truck and bus manufacturers are investing in its future.



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ELECTRIC: WHERE IS BATTERY POWER NOW AND IS IT VIABLE?

Battery power is proving to be a real contender for the future of powertrains within the commercial truck sector, but there are challenges, not least charging time and range.

With current lithium-ION batteries, commercial trucks using battery technology have an effective range of anywhere between 300km and 380km. Whilst this is a big improvement on previous battery technology, it is still not enough for long-haul journeys, especially with cargo weight further reducing maximum range.

In tandem with range, current charging times on an AC (43kW) charger of roughly 9.5 hours means a truck could be off the road for a full day after it's covered its expected range.

Even with access to high-speed DC (250kW) chargers, charging times could still take up to 2.5 hours on average, and this time needs to be accommodated.

It means that within a 9-hour driving / working day with two hours of charging an electric truck can only cover 520km (based on 80kph average speed) as opposed to 720km with a diesel truck. Temperature is also a major issue for battery-powered vehicles. Current batteries must be kept within a range 20°c and 50°c to maintain efficiency without degrading. This means operators in colder regions like Alaska, Finland or Sweden will be at a disadvantage for almost half of the year unless manufacturers can find effective ways to heat and cool the battery cells.

However, electric trucks are creating their own market when it comes to application. Volvo, for example, has developed a range of trucks specifically for construction applications that have access to on-site charging, making range insignificant. Equally, its range of regional trucks for city-to-city transport and urban deliveries will have access to inner-city charging points with high-speed connections.

ELECTRIC: WHERE IS BATTERY POWER NOW AND IS IT VIABLE?

Similarly, inner-city buses, covering short-haul routes of no more than 300km a day are proving effective in urban environments. However, it's the lack of range and high-speed charging facilities that make long haul a challenge.

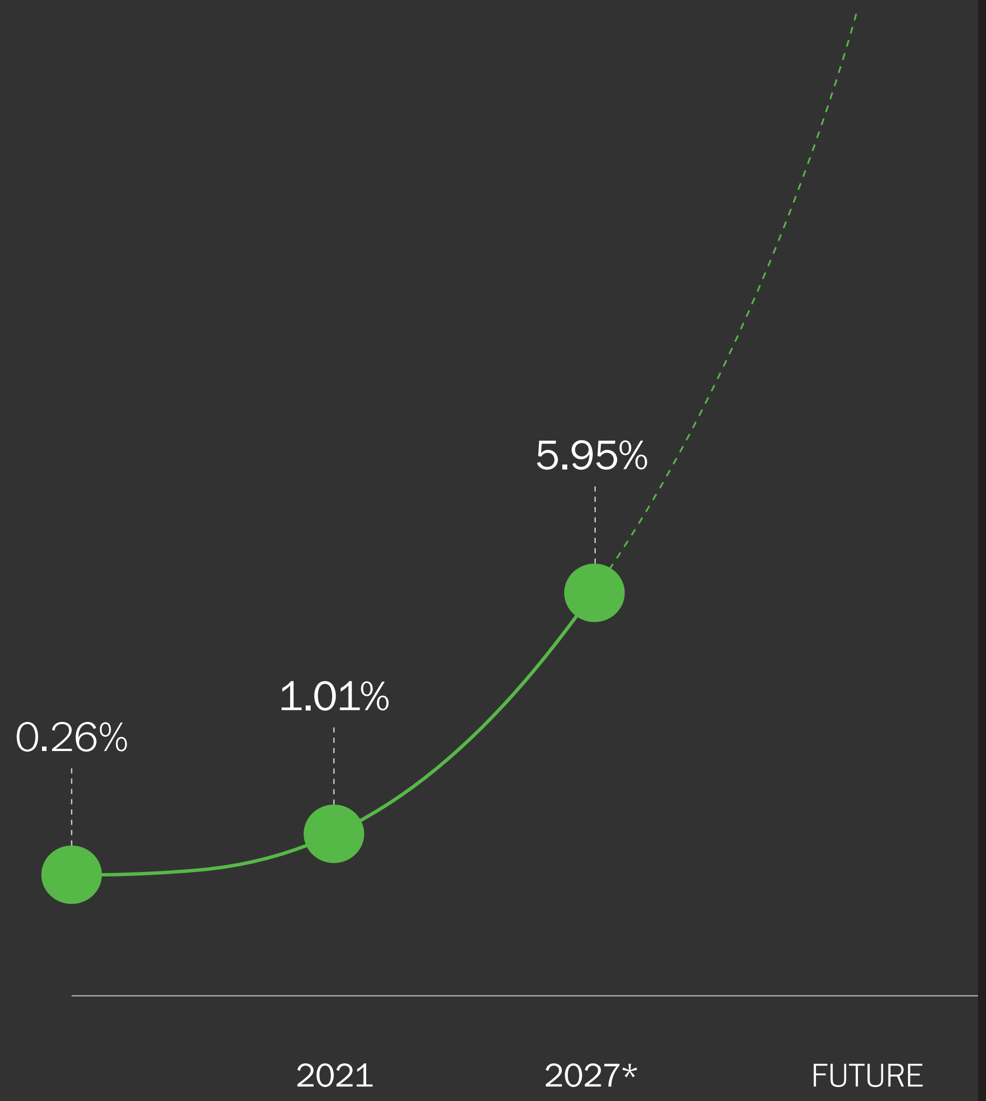
Put simply, current electric trucks do not have the range to compare with diesel or hybrids, but they are making inroads in markets where the range issue is less important. In addition, with the increasing concern for air quality amidst inner-city Governments, electric trucks and coaches could unseat diesel in urban areas very soon. This will be focused with clean air zones and pedestrianised areas like London's Oxford Street and Paris' Low Emission Zones become more popular.

At present electric trucks account for 0.26% of trucks on the road across Europe with Buses adding 0.9% to the total (European Automobile Manufacturers Association, 2022). However early predictions for electric vehicle productions rates expect battery electric vehicles to make up 1.01% of production in 2021 and up to 5.95% by 2027 (Power Systems Research, 2021).

The remaining question yet to be answered is how these new battery-electric trucks will be maintained? Many on the road currently are still within warranty periods and therefore maintained by highly trained technicians under license by the manufacturer. With the life of these vehicles expected to match that of current diesel vehicles, third party maintenance will be essential for the future. These future mechanics, however, will need specialist training to be able to handle high voltage batteries which will come at a cost. In addition swapping supplementary parts like cooling pumps or hoses won't be as easy as it is with traditional combustion engines.

The sector, therefore, needs to invest not only in the charging infrastructure but the upskilling of workers globally to ensure an efficient maintenance infrastructure.

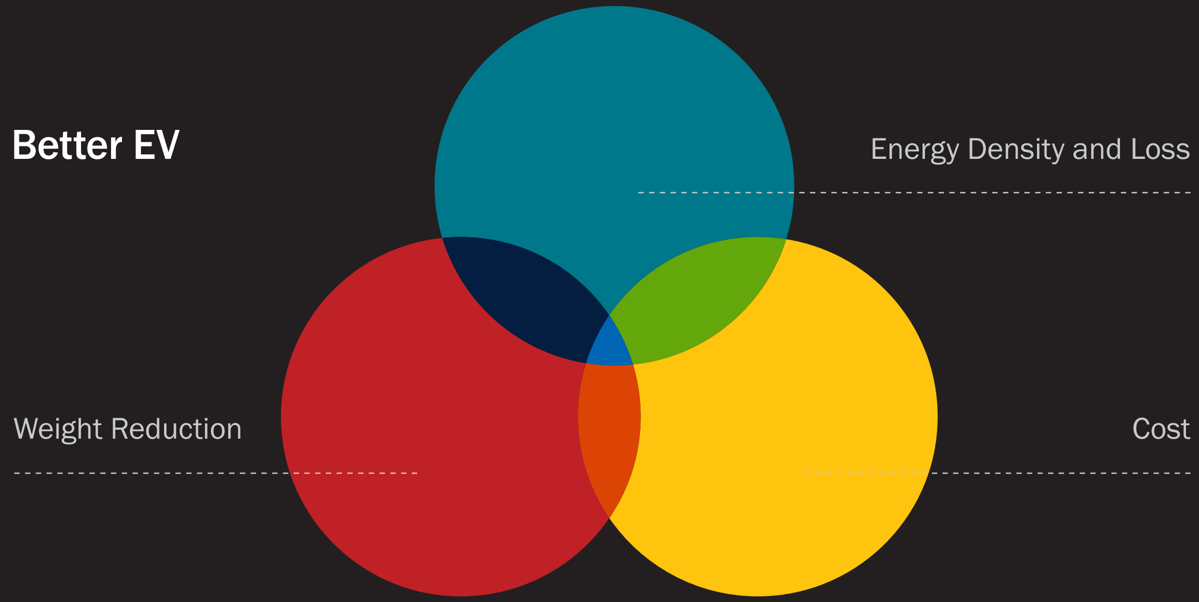
Percentage of Electric Trucks in use across Europe



ELECTRIC:
FUTURE INNOVATIONS

With current battery technology being hindered by the energy density of lithium-ION batteries, innovations need to be found to make it feasible for long haul. Most of these innovations will focus on three key areas: energy density and loss; weight reduction; and cost. According to recent pricing, an electric truck will cost 75% more than a diesel counterpart upon initial investment. If current ranges can be improved to meet industry standards, they could, however, cost 13% less per mile to run than internal combustion trucks (Forbes, 2021).

Similarly, if the weight and energy density of batteries can be improved, the overall range can be increased. Haulage capability will also increase and running costs will come down to such a level that electric trucks could return the investment within three years.



ELECTRIC:
SOLID-STATE BATTERIES

The key focus for increasing energy density within batteries is the development of solid-state batteries. Unlike lithium-ION batteries that require a liquid lithium electrolyte to store energy, solid state uses a solid electrolyte, also made from lithium. However, the main difference comes in the form of capacity and readiness. Solid-state batteries are said to be lighter and more energy-dense (due to a denser molecular structure), increasing range and decreasing recharging times. Solid-state batteries are also more compact and more stable.

However, despite the many benefits, the development of solid states batteries is proving to be slow. Predictions suggest solid states batteries will hit the market way beyond the 2030 deadline (Forbes, 2020), with the consumer market being the primary focus above commercial. **Additionally, current global lithium supply isn't sufficient enough to maintain the level of electric vehicle battery production needed to meet the 2030 targets. Shortfall predictions vary between 5,000 and 400,000 tons annually (Financial Times, 2022).**

Heavy investment would help. Manufacturers like Ford and BMW have invested £130 million in a solid-state start-up (Just-Auto, 2021) and Daimler has already delivered a small number of solid-state electric buses to cities within Germany (Electrive, 2021).

ELECTRIC:
OVERHEAD CABLES

The United Kingdom announced a £2 million investment to electrify 20km of roadway with a further £18 million being earmarked for further development

Source: The Guardian, 2021

Similar to passenger trains around Europe, first-lane overhead charging cables (or 'e-highways') are being considered as a viable solution to the issue of long-distance range . The core idea of overhead cables is to give commercial vehicles travelling on carriageways the option to recharge batteries or run completely off the electrical grid. In theory, this would be mean that overhead enabled trucks, coaches, and buses would be able to reach or exceed the range of internal combustion engines. The technology has promise and has already been tested in Germany where diesel hybrid trucks would run on grid electricity when on major carriageways and return to diesel power when they leave the highway or the first lane.

For battery-powered trucks, 'e-highways' could be used to recharge the batteries, reducing the amount of charging time, and increasing range.

Both the UK and Germany have invested in the technology. The UK announced a £2 million investment to electrify 20km of roadway with a further £18 million being earmarked for further development (The Guardian, 2021). Germany has already completed multiple, successful, tests led by Siemens Mobility.

Siemens has suggested that if one-third of Germany's highways were electrified to supply grid electricity to road freight, 7,000,000 tons of CO2 could be saved each year. In addition, trucks and coaches could use regenerative braking to provide electricity back to the grid in exchange (Simens Mobility, 2021)

However, there are limitations to the technology. E-highways will not work for delivery vehicles covering the majority of their mileage in urban centres, nor would they work for hauling sea freight to regional or semi-urban depots.

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ELECTRIC:
SOLAR CELLS

Similar to 'e-highways', solar cells are being considered as a viable way to recoup lost energy whilst a truck is moving, reducingdowntime. When an electric truck or coach is stationary at a physical charging point, it is losing an operator money. By charging some or all the battery whilst moving, some of that money can be recovered.

Unlike conventional cars, trucks, buses, and coaches have considerable surface area on the roof to place a substantial number of solar cells. Whilst this technology is in its infancy, solar cells have come a long way in a very short space of time.

Volkswagen announced a project through its Scania brand in 2020 to develop truck trailers with solar panels to recharge the hybrid drive systems of a plugin hybrid tractor unit. **The initial test showed that fuel savings could reach as high as 10% in Sweden and twice that in sun-rich southern Spain (VolkswagenAG, 2020).**

Shell has also developed a concept truck called 'Starship'. Labelled as a hyper-efficient Class 8 truck, it uses a 5,000-watt solar panel array on the trailer unit to charge the main battery bank and reduce engine loading from an alternator unit, in tandem with a traditional combustion engine (Shell Lubricants, n.d.).

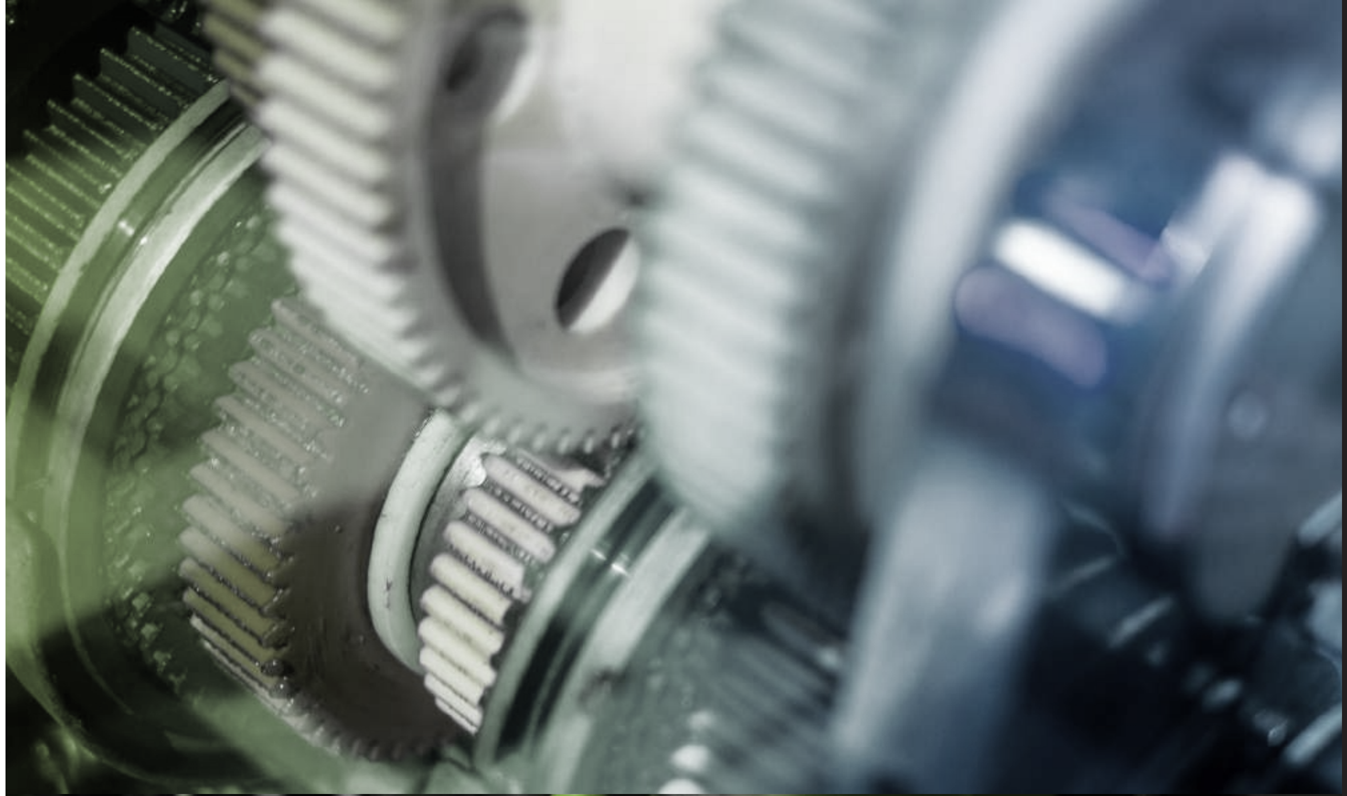
ELECTRIC: POWER TRANSMISSION AND FLUID POWER IN A BATTERY WORLD

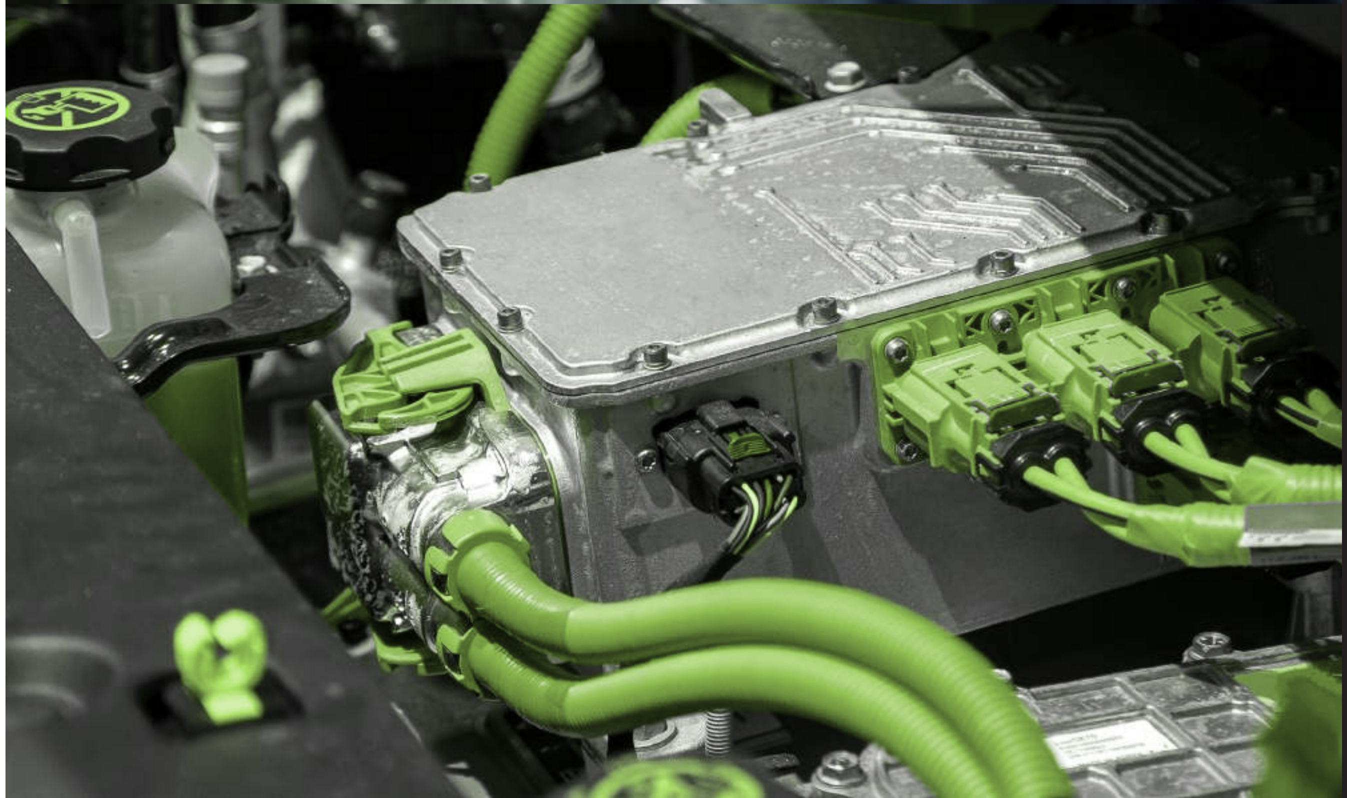
In a future dominated by battery power trains, the importance of power transmission products like v-belts, tensioners and bushings will decrease. Whilst this may seem damaging to a multibillion-dollar industry, it allows advancement and development of newer products for an ever-changing sector.

Outside of the products themselves, teams within the power transmission sector are already preparing for a shift to new categories and specialisms. Gates, along with other manufacturers, is already working on upskilling current engineering employees to ensure they are trained for the future.

The main focus for a battery-electric future will be cooling within the motor units and batteries. For the components market this means a major shift towards fluid power, which is already seeing a rise in demand from the consumer market.

Through the use of hoses, cooling pumps and couplers, the sector is working closely with vehicle manufacturers to develop new products to work alongside battery motors. **As part of these developments, sustainable materials are playing a big part. Companies like Gates are already experimenting with new rubber compounds to ensure that current EPDM rubber can be replaced with more sustainable, yet suitable materials.**





HYDROGEN: MAKING THE CASE FOR HYDROGEN

Hydrogen power was, for a long time, considered to be a concept rather than a mass-produced product. As technology has progressed so has the viability of hydrogen as a fuel for future drive trains. In fact, it has the potential to be more efficient and more sustainable for mass transportation. Unlike battery power, hydrogen is still viewed with relative scepticism, but this view is steadily shifting.

Hydrogen has two potential routes for a future within alternative drive trains: hydrogen internal combustion; and hydrogen fuel cell. The main difference between the two is the way in which these drive trains convert the hydrogen into energy and power the vehicle.

A hydrogen internal combustion engine (HICE) is very similar to the current internal combustion engines being used in buses, trucks, and coaches. A traditional power train burns hydrogen fuel to propel the vehicle through a drive shaft. Hydrogen fuel cell electric vehicles (FCEV), on the other hand, convert the hydrogen gas into energy. It uses a cathode and anode cell that splits an atom and draws electrons through a relay, to power electric motors.

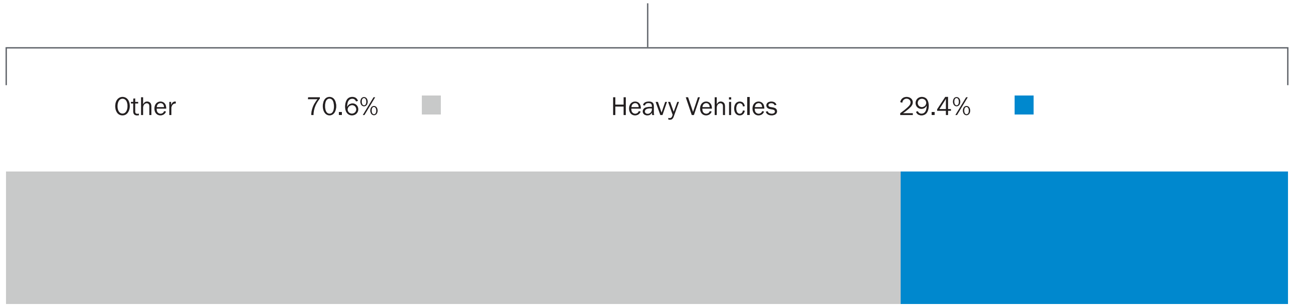
Whilst both technologies are viable, hydrogen fuel cell is favoured in the battle for many reasons. Firstly, fuel cell electric technology is much more efficient, and due to the lack of moving parts and stress in a hydrogen fuel cell, requires less maintenance. Secondly, and more importantly, hydrogen fuel cells are clean. The by-product of a fuel cell is pure water vapour. Hydrogen ICE, however, produces water vapour and NOx gases, which are heavily regulated under many of the world's clean air bills, and one of the most potent greenhouse gases other than CO2.

By using the right after treatments to reduce NOx emissions, hydrogen internal combustion could still be a plausible solution. Thanks in part to the reputable efficiency of combustion engines under heavy loads.

HYDROGEN:
THE CHALLENGES

Global C02 Emissions 2020

The global transport market accounts for 24% of globally Co2 emissions.



The biggest challenge hydrogen has to overcome is cost. This challenge doesn't relate to one particular part but the concept of a fuel cell vehicle. Firstly, the development of commercially viable fuel cells is extremely expensive. Secondly creating hydrogen as a fuel takes considerable amounts of energy, which in turn will need considerable investment.

According to the Energy Transition Commission, to become a hydrogen dependent society and decarbonise energy and industries like transport, a $15 trillion investment will be needed between now and 2050 (Energy Transitions Commission, 2021). Considering the global transport market accounts for 24% of globally Co2 emissions of which heavy vehicles create at least 29.4% of those, a substantial amount of that investment will be focused on decarbonising the on-highway sector (Our World in Data / IEA, 2020).

However, whilst it's expensive, the global consensus is that it's necessary in order to prevent further damage to the environment and that transition has started. As of 2020, estimates suggest the number of fuel cell electric vehicles reached almost 2,533 (Fuel Cells and Hydrogen Observatory, 2020) across Europe. Predictions now suggest that 0.29% (Power Systems Research, 2021) of new heavy commercial vehicles will be hydrogen-powered in 2027. Whilst many of these vehicles are inner-city buses with access to convenient refuelling stations, the truck market is developing.

Hyundai released the medium-duty Xcient Fuel Cell Electric Vehicle in 2020 to the mass market and has since seen positive results in range and refuelling times. At present the Xcient can travel 400km on a single tank of hydrogen, which is comparative to some electric counterparts, and refuelling only take anything a maximum of 20 minutes.

In parallel to Hyundai's development, most of Europe's biggest truck and bus manufacturers are working on or have released hydrogen fuel cell vehicles. Vanhool has an FCEV bus in public service across the UK, whilst DAF and Daimler have both made commitments to develop and trial technology. Daimler and BP recently announced a partnership to develop hydrogen infrastructure across the UK (BP, 2021).

Another major challenge the market must face is the perception of safety. Hydrogen has, unfairly, gained a reputation for its volatility, mainly due to very high-profile incidents. Rightly so, the safety of the drivers and the vehicles around them is paramount in the development of hydrogen vehicles and consumer perception of the dangers is understandable.

However, looking at the consumer market, which as of 2020 had 31,225 FCEV passenger vehicles on the road globally (International Energy Agency, 2020), both Toyota and Hyundai have achieved Euro NCAP 5 Star ratings with the Mirai and Nexo Models (NCAP, 2018). So, it's likely that commercial vehicles will achieve similar if not more impressive safety ratings.

Solaris Bus, one of Europe's leading producers helped dispel fears when it described the difference between hydrogen gas and conventional diesel. Thanks to its lighter than air properties, hydrogen escapes in the event of an incident, whereas liquid fuels have a tendency to pool at the site of impact and risk combustion (Solaris Bus eCity).

HYDROGEN:
FUEL COST REDUCTION

Most cost reduction innovations will focus on the technology within the vehicle itself maximising efficiency and limiting fuel wastage across long journeys. However, the most impactful innovation will be reducing the cost of the fuel itself.

Currently, hydrogen production utilises precious metals like platinum and iridium as catalysts within the production of the fuel. This means that fuel cost is often dictated by the metal commodities market. With precious metal prices only increasing as they become scarcer, it can be expensive to refuel. New techniques are being researched including the use of abundantly available iron and nickel, meaning prices will become more sustainable and ultimately, stable (Technology News, n.d.).

In the UK, hydrogen fuel costs, at present, are between £10 - £15 per kilogram. This means it would cost a minimum of £310 to fill the Hyundai Xcient's 31kg tank (Hyundai, 2020) for 400km range, a price of £0.75 per kilometre. Its diesel counterpart would, at today's diesel price (£1.77), cost £708 for an 1119km range based on an average of 7.9mpg, resulting in a price per kilometre of £0.63km.

This means that economically a current hydrogen truck won't return enough of an investment to warrant its purchase over a combustion truck. To make hydrogen work, therefore, the fuel itself is going to need to be more economical.

Fuel price per kilometer

HYDROGEN: INFRASTRUCTURE

Similar to battery-powered vehicles, a major stumbling block for hydrogen is the availability of an accessible refuelling network. Unlike battery power, hydrogen doesn't have the head start EVs do with both Government and private funding pushing for the construction, installation and development of charging points.

One area where hydrogen does seem the most practical solution is in the repurposing of facilities. **The EU has over 92,000 petrol stations (Fuels Europe, 2018). All of these have vast experience with storing and distributing volatile fuels to consumers and commercial vehicles. Therefore, hydrogen refuelling is much more compatible with the current infrastructure than battery-powered vehicles.** On top of that, hydrogen could potentially be produced onsite at larger forecourts through commercial electrolysis. The University of Birmingham previously released potential design plans for onsite hydrogen production to refuel its fleet of FCEV vehicles (University of Birmingham, 2012).

However, regardless of whether hydrogen is delivered, piped in, or manufactured onsite, the conversion of existing fuel stations or the building of new ones is going to require substantial investment. **The cost is estimated at roughly 32 million euros per station. Making these installations cheaper, in line with EV chargers, and securing Government funding is therefore essential to its success.**

> Hydrogen refuelling is much more compatible with the current infrastructure than battery-powered vehicles.

HYDROGEN: **POWER TRANSMISSION AND FLUID POWER IN A HYDROGEN FUTURE**

Unlike the introduction of battery power, power transmission as a market does have a role to play in future hydrogen power trains, but it will likely be smaller than the current market. Unlike hydrogen fuel cell electric vehicles which will rely heavily on fluid power products, hydrogen internal combustion will, like diesel vehicles, rely heavily on power transmission.

However, the question is how prominent hydrogen internal combustion will be in a future market. With NOx gas reduction being a high priority for environmental councils worldwide, the certainty of these engines is unclear. **With heavy reliance on exhaust after-treatments to reduce NOx emissions, most expect the priority to be focused on zero-emission fuel cell technology, which will utilise only a small number of power transmission parts for accessory drive elements.**

In truth, the biggest advancement in components will be seen in the fluid power sector with hoses, fuel lines and cooling systems. Similar to an EV, cooling pumps will be a necessity on hydrogen FCEV vehicles to ensure moving parts like the motors stay cool and within operating temperatures. Along with this, the fuel cell itself needs to be cooled to ensure it doesn't overheat and begin to lose efficiency.

New materials will also be crucial to the development of fluid power parts within both fuel cell and hydrogen ICE engines due to the nature and storage of hydrogen gas. Often stored at liquid temperatures, traditional materials like rubbers and plastics will, if exposed to -252 c liquid hydrogen, become brittle and vulnerable. Therefore new, more resistant materials will be essential.

Whilst hydrogen is in a liquid state when stored and when refuelling, Hydrogen FCEV vehicles are powered by hydrogen gas, which at 14 times lighter than air has a tendency to escape. In this instance, component manufacturers will need to stress-test products to the limit to ensure leakages and failures are kept to a minimum.

All of these innovations provide the industry with the opportunity to further develop product catalogues with a focus on more sustainable materials. This will ensure that once a vehicle is on the road, its carbon footprint doesn't increase dramatically through replacement parts during maintenance

FUTURE: FUTURE REALITY

With so many technologies being brought to the forefront of modern transport and new regulations set to disrupt the industry, it can be hard to predict where the market is going. With billions of euros being invested in new innovations, focussing investment in the right place will be key.

All of these ‘alternative’ technologies have the potential to fulfil the needs of the market, provided the challenges can be overcome. In truth, both electric power and hydrogen have a place in future markets, all be it in different applications.

Gates is investing heavily in both technologies with new battery and hydrogen innovations being developed, but there is a clear split regarding which technology will be used where.

Hydrogen fuel cells will most probably win the battle of the hydrogen power units due to the reduction of NOx gases, and with solid-state battery technology proving to be more than just a concept, electric power is likely to become the popular choice for urban market. Fuel cell on the other hand does hold greater potential for the long-range haulage and passenger industry, thanks in part to its ability to reduce the downtime of a vehicle through a faster refuelling process.

However, the infrastructure needed to fuel a hydrogen future will take significant investment, and battery power has a significant head start through Government and private funding. Studies suggest that the electrification of the critical routes could cost as much as hydrogenation.

This is in part due to the fact that hydrogen fuelling stations will need to be less abundant but cost more to install due to the complex storage of the fuel. Electricity on the other hand is cheaper to install but will need to be more populous globally.

The market is going to change significantly in the next 20 years as ICEs are phased out. Not only will vehicles need to be replaced but the entire network of businesses that depend on them will need to adapt. From components manufacturers like Gates to the maintenance garages and fuelling stations across Europe. Not only will this take time, but investment, and plenty of it.

Hybrid technology is going to provide manufacturers and operators with the level of technology advancements they need to bide their time until new power trains are readily available at affordable prices.

FUTURE:
HOW CAN YOU PREPARE

The changes the industry is set to undertake will alter the fundamental principles of many businesses and there is risk attached. But realistically, outside of hydrogen and electric power, there aren't any other viable routes.

Preparation and collaboration will be critical to ensuring success across the sector. As others in the market are already doing so, collaboration between manufacturers across the supply chain will reduce the cost and stress experienced by one manufacturer and result in a more well-round, successful product being developed.

Incorporating suppliers within the supply chain early will allow them to work more collaboratively to create products that maximise efficiency without losing time and money. Standardising the production of components across the industry will also help reduce maintenance costs later down the line through product ubiquity as we have come to expect within the current internal combustion market.

FUTURE: **WHAT IS GATES DOING TO PREPARE FOR THE FUTURE?**

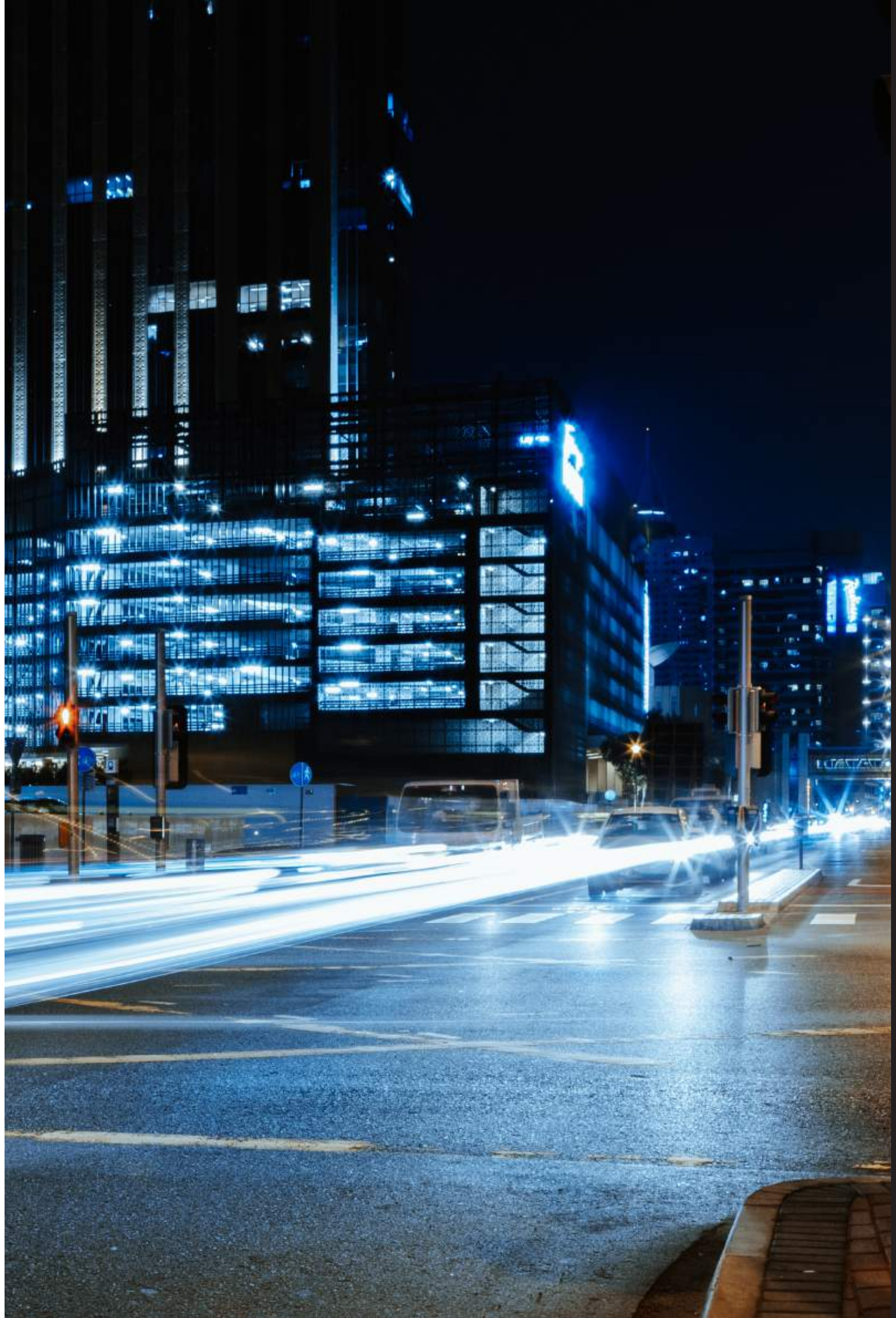
As part of our commitment to future power trains Gates is investing in both a hydrogen future and an electric one. With the benefits an electrified urban environment and a hydrogen fuel regional one, we're working with all of our customers to provide them with insight into new products, innovations and developments we're investing in.

Through these developments, we're also prioritising our own sustainability initiatives to ensure that our new future products will help not only us, but our clients decarbonise by 2050. As part of our plan to reduce our carbon footprints whilst becoming more sustainable, we're focussing on a three-pronged approach: People. Product. Planet.

Through a commitment to our people, the teams with our business previously trained and focussed on internal combustion products will be retrained and redeployed across our business. This is enabling us to increase our rate of development whilst also keeping our strongest assets within the business. To maximise opportunities across the future drive train markets, Gates will also be creating new teams to help customers prepare for the changes to come.

Within our product lines, we will utilise renewable materials where possible during both design and manufacturer. In addition we will be incorporating waste minimisation into design processes to maximise efficiency across our supply chain whilst improving environmental impact.

Whilst the future is still undecided, one thing remains true. It's what's inside that counts.



WITH GATES AS YOUR FOUNDATION, YOU AND YOUR CUSTOMERS CAN BUILD A SUCCESSFUL, SUSTAINABLE FUTURE.

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