

Whitepaper

The need for hydrogen trucking

A whitepaper setting out the underlying arguments in favour of the use of hydrogen to decarbonise long-haul trucks. This paper discusses the role of hydrogen in facilitating rapid and enhanced renewable energy deployment, and the need for hydrogen as the only zero-carbon zero-emission fuel in the heavy-duty trucking sector which can provide a combination of fast refuelling and very long range between refuels.

This paper was published by the H2Accelerate Collaboration in July 2021 as the first in a series of whitepapers in support of the use of hydrogen in long-haul trucking.

The H2Accelerate collaboration

The H2Accelerate collaboration has been formed between Daimler Truck AG, IVECO, OMV, Shell, TotalEnergies, and Volvo Group to work collaboratively to develop the evidence base and public funding programs which can help move Europe towards a commercially viable hydrogen trucking system. Each of these major industrial players, from both the fuel supply and trucking sectors, have made their own organisational commitments to achieving net zero carbon in line with Europe's ambitious decarbonisation targets under the Paris climate agreements.

The H2Accelerate companies are agreed that achieving the decarbonisation of the heavy-duty trucking sector will require the use of hydrogen as a fuel for many of the vehicles used by the continent's vehicle operators.

This paper will set out the basis for this conclusion. Two aspects of the case for hydrogen are considered:

- The role of hydrogen in enabling overall energy system decarbonisation (providing long-term energy storage to balance the energy system and allowing the transport of low carbon energy across the globe).
- The need for hydrogen as the only zero-carbon zero-emission fuel in the heavy-duty trucking sector which can provide a combination of fast refuelling and long ranges between refuels.

These two arguments lead to the conclusion that hydrogen as a fuel for trucking is essential for the decarbonisation of the trucking sector which causes 6%¹ of the total European CO₂ emissions. This conclusion supports the case for public sector support of the early roll-out and industrialisation of the hydrogen trucking sector in Europe in the period from now to 2030. The H2Accelerate collaboration aims to orchestrate the roll-out by leveraging the expertise and commitments of key truck manufacturing and hydrogen infrastructure players.

¹ European Commission (2019) *Reducing CO₂ emissions from heavy-duty vehicles*

The role of hydrogen in sustainable energy systems

Achieving the European Green Deal target of becoming the world’s first climate-neutral continent by 2050 will require deep cuts to emissions across all aspects of the economy. Europe has so far achieved the majority of its emissions reductions by decarbonising electricity generation, principally through reducing coal fired generation and increased deployment of hydro, wind, and solar projects, which generated 28% of gross electricity consumption in the EU-27 in 2019².

Further cuts will require a massive expansion in the deployment of renewable energy generation, to provide the primary energy for the electricity sector, as well as much of the energy needs for heat, industry and transport. This alongside different combinations of other technologies such as carbon capture and storage, and substantial increases in overall energy efficiency, are required in all the recognised scenarios for achieving a net zero emissions continent.

The challenge faced in using renewable power sources to further decarbonise the energy sector is that renewable sources such as wind and solar are inherently intermittent, and the quantity of renewable energy generation can be expected to fluctuate on both a short-term, and seasonal timeframe. Resolving the imbalances created by this massive penetration of renewables will require storage of energy on timescales of weeks and months to avoid wasting large quantities of energy every year. While many renewable energy storage options will be available, only hydrogen-based options can be deployed at the scale required to achieve this seasonal energy balancing, as shown in the diagram below.

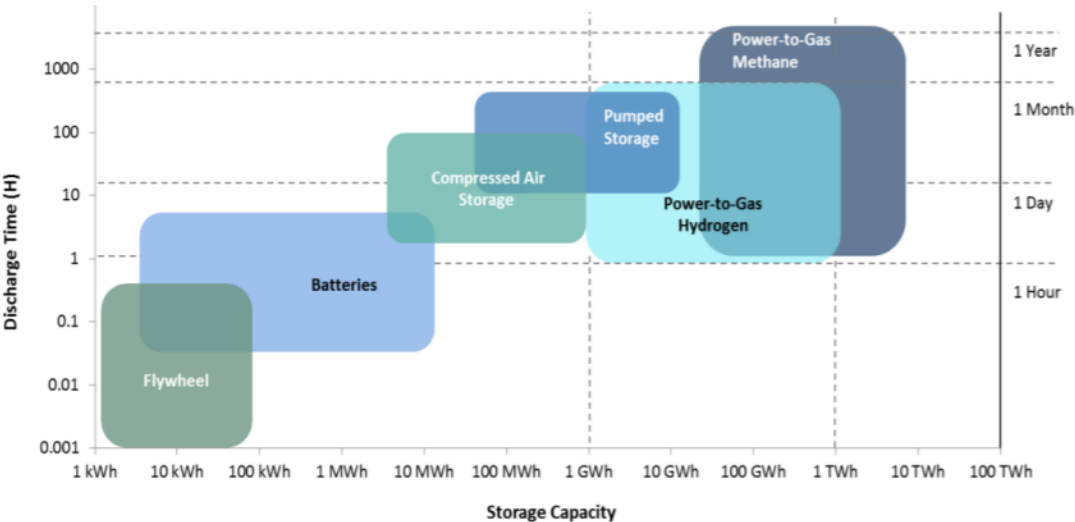


Figure 1: Storage capacity and discharge time of different energy storage mechanisms³

² Eurostat (2021) Wind and water provide most renewable electricity

³ European Commission (2018) A clean planet for all: A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy

To meet the challenge of intermittency, hydrogen can be produced using electrolysis powered by excess renewable electricity and used in many different sectors as a clean energy vector. Unlike other storage options, hydrogen can be stored over long periods of time and scales compatible with seasonal energy storage, making it a leading candidate to enable the seasonal balancing of renewable power sources.

At a large scale, it becomes cost-effective to store hydrogen in salt caverns. This solution is compatible with European geography, and a number of potential hydrogen storage sites have been identified across Europe, including in Germany, the Netherlands, Norway, Denmark, and Poland. It is estimated that Europe has the technical potential to store 84.8 PWh⁴ of hydrogen in bedded salt deposits and salt domes and is therefore well equipped to implement the seasonal storage of green hydrogen in large-scale geological formations, in order to provide grid-balancing functions. An additional advantage of hydrogen is that once generated, it can be moved by ship (as compressed or liquid hydrogen, or in carriers such as ammonia and liquid organic hydrogen carriers) or pipeline around the world at a reasonable cost. This means countries with a large land mass and good renewable resources (deserts coastal regions, large windy plains etc.) can become exporters of large quantities of low-cost hydrogen. A recent analysis by the Hydrogen Council suggested that this international bulk movement of the fuel will only add between 10-30% to the delivered cost of the fuel⁵. This means that hydrogen can become the storable, transportable fuel of the future progressively displacing the role that fossil fuels play in today's energy system.

Given that hydrogen appears to be the most promising long-term energy store and a means for transporting bulk quantities of renewable energy around the world, the next question is where the hydrogen should be used. Here, the value of hydrogen in displacing different energy sources is relevant. The transport sector, particularly hydrogen trucks, is an application where hydrogen becomes cost effective at displacing fossil fuels at a relatively high cost of hydrogen production compared with other applications, and hence is an obvious first target for the fuel.

Within the transport sector, the only other fully zero emission option is the use of battery electric vehicles charged using renewable electricity. Whilst battery electric vehicles are clearly emerging as promising options for certain applications, particularly for smaller cars, vans, and short and medium haul trucks, the section below will demonstrate that for larger, longer-range trucks, where flexibility and high productivity is required, hydrogen is a very attractive solution compared to battery alternatives.

⁴ Caglayan et al (2020) *Technical potential of salt caverns for hydrogen storage in Europe*

⁵ Hydrogen Council (2020) Path to hydrogen competitiveness: A cost perspective

The use of hydrogen in trucking

The decarbonisation of long-range and heavy-duty trucking is one of the most difficult challenges in reaching net zero carbon emissions from the road transport sector. Emissions from lorries, buses and coaches are estimated to account for 6%⁶ of total EU emissions, of which the vast majority comes from the trucking sector.

Truck transport can be divided into four categories, based on the utilisation and range of the vehicles.

1. Short haul transport that largely returns to a depot location overnight.
2. Medium haul transport within a restricted geographic region, that largely returns to a depot location overnight.
3. Long-haul transport in line traffic with repeated, predictable routes between set destinations.
4. Long-haul transport, travelling by motorway for the majority of the journey, often internationally over multi-day trips. These trucks seldom stay at the same location overnight.

While heavy-duty long-haul trucks comprise only 12% of the European fleet, they are responsible for 41% of road freight emissions due to their high payload, weight and distances travelled⁷. For these trucks, shorter ranges and slow refuelling has a significant impact on both the cost of transport and logistics operations. This leads to a need for a zero-emission alternative to current diesel vehicles that can achieve a high vehicle range, with fast refuelling/recharging, high payload, and an extensive supporting infrastructure network that is harmonised across Europe.

There are three potential solutions to achieve zero emission long-haul trucks, which result in zero CO₂ tailpipe emissions:

1. Hydrogen fuel cell trucks
2. Battery trucks with stationary charging
3. Battery trucks with catenary charging

While biofuels, power-to-X type fuels, or hydrogen internal combustion engines may be able to reduce CO₂ emissions from trucking in the short term, these solutions do not mitigate the NO_x and particulate emissions associated with internal combustion engines. Hydrogen fuel cell or battery-based solutions will therefore be required in the long term.

Currently, battery trucks are not able to compete with hydrogen fuel cell alternatives on either a range or refuelling time basis. While fast charging for battery alternatives is technically feasible, this solution adds significant operating cost due to the cost of fast charging, resulting in a higher total cost of ownership when compared with hydrogen solutions in certain applications.

⁶ European Commission (2019) Reducing CO₂ emissions from heavy-duty vehicles

⁷ Shell International B.V. (2021) *Decarbonising road freight: Getting into gear*

Conversely, hydrogen trucks will be able to operate in a similar way to diesel vehicles, through fast refuelling (under 15 minutes) and similar range (ranges in excess of 800km even for the heaviest loads, depending on the specific technology used), offering operational simplicity and reduced total cost of ownership compared with battery alternatives with fast charging. Unlike battery-based alternatives, hydrogen solutions are expected to meet customer needs within the long-haul trucking space, and the companies driving H2Accelerate are prepared to bring them to market in the near-future.

An additional challenge of the range of battery trucks operating in certain long-haul trucking use cases, is the need for an increased number of charging points compared to hydrogen refuelling stations. This further presents operational challenges in long haulage due to the comparatively low maximum radius that can be travelled by a truck from a charging point.

Some argue that the challenges of range for battery trucks could be resolved through the installation of a network of catenary lines allowing vehicles to charge whilst driving on major road networks throughout Europe. However, this requires European governments to commit to a large-scale long-term pan-European infrastructure project, at significant technical and financial risk, and delaying the emissions reductions achieved by decarbonising heavy transport while infrastructure is developed. There are also questions over the cost of upgrading electricity networks to provide the power which will be required by these catenary networks to ensure a sufficiently rapid charging rate for the batteries (without requiring charging along the entire length of the road network), and whether sufficient network utilisation will be achieved to repay infrastructure investments. Finally, in practice (as with railways), there will always be areas of the road network which are not covered by the catenary system meaning that many users will require an alternative that is able to operate in areas that are not covered by the catenary system.

By contrast, the hydrogen providers involved in H2Accelerate plan to roll out hydrogen refuelling infrastructure across key strategic routes and expand from these routes to provide sufficient coverage to support continent-wide hydrogen trucking for Europe. These stations will have a high capacity to refuel fleets of hydrogen trucks using renewable hydrogen in under 15 minutes and will be modular so that they can easily expand with increasing penetration of hydrogen trucks. Hydrogen has the additional advantage here that the long range of the hydrogen truck reduces the number of refuelling stations needed compared with battery charging stations to cover the same overall length of road.

For battery truck options, it is highly unlikely that there will be sufficient charging network coverage and/or range to meet the needs of all truck users to deliver on climate targets within the agreed upon timescales. As a result, the view of the H2Accelerate truck OEMs is that the future mix of technologies used in the trucking sector will be as shown in the graphic below, with the hydrogen fuelled truck providing the longer-haul, heaviest-duty routes.

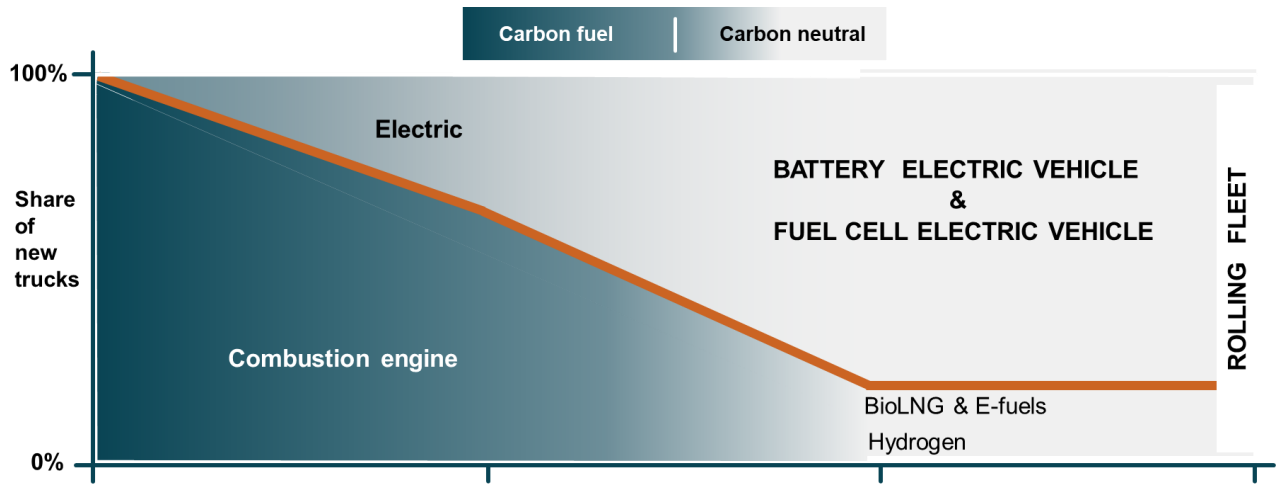


Figure 2: Transition of trucking to zero emission alternatives between 2020 and 2050

In the long term, the hydrogen-based solution has the additional benefit of being much more compatible with autonomous vehicles. In this future scenario, where self-driving trucks are able to operate autonomously on a 24/7 basis, charging time for battery vehicles will have an untenable impact on the business case.

Conclusions

The member companies of the H2Accelerate collaboration: Daimler Truck AG, IVECO, OMV, Shell, TotalEnergies, and Volvo Group, are fully aligned in their view that:

- Hydrogen is required to manage imbalances in energy generation and consumption in the renewable-dominant energy system of the future. It is also one of the very few options for bulk transport of renewable energy around the world.
- Hydrogen can solve the challenge of decarbonising the heavy-duty long-haul sector, for which there are essentially no other viable options which can work for all users.

As a result, it is reasonable to consider hydrogen a required fuel for the trucking sector of the future and to start accelerating the industrialisation of hydrogen fuel cell truck technology and the associated refuelling network and field support mechanisms. The H2Accelerate collaboration is committed to act now to facilitate the rapid deployment of hydrogen trucks and the required supporting infrastructure at scale, to achieve an acceptable ownership cost proposition and easy operation for end users. This will help facilitate the penetration of renewable energy generation. By 2030, the infrastructure deployed will allow hydrogen to become a key solution for long-haul road transport across Europe, allowing the sector to achieve climate goals.