ZEFER

Zero Emission Fleet vehicles for European Rollout

Hydrogen for Private Hire and Taxi Vehicles in Europe

October 2022

Foreword

ZEFER is a real-world flagship project in hydrogen mobility demonstrating the business case for captive fleets of hydrogen vehicles across Europe.

These vehicles can contribute to achieving the necessary carbon neutrality in the mobility sector by 2050, in line with the European green deal and governments' Net Zero targets.

The project has deployed large fleets of hydrogen taxis and private hire vehicles for operation in three European capital cities (Copenhagen, London, Paris) to enable early adopters to use this zero-emission technology and encourage the replication of this business case in other cities.

The vast dataset accumulated in the project has confirmed the expectation that the vehicles can support the transition towards green mobility, providing the same operational convenience and flexible mobility as conventional vehicles, without harmful emissions.

This is all a result of the innovative vision and excellent work of ZEFER's partners: fleet operators (Hype, Green Tomato Cars, the Metropolitan Police, DRIVR), HRS operators (Air Liquide and ITM Power), data analyst (Cenex), engineering consultancy (Element Energy) and city regulator (Mairie de Paris) as well as its observer partners (BMW and Linde).

As coordinator, we are very proud to see how far the project has come since it started in 2017. This would not have been possible without the support of the European Commission and its funding agency, the Clean Hydrogen Joint Undertaking.

Lisa Ruf, Consulting Director at Element Energy, an ERM group company, and Coordinator of the ZEFER project.

About Hydrogen Fuel Cell Vehicles

Fuel cell electric vehicles (FCEVs) use hydrogen to produce electricity. FCEVs offer efficient and quiet transport with no exhaust emissions other than water.

If fuelled by hydrogen produced from renewable sources, they are a true zero emission solution. However, they are a relatively new technology, and as such, there are very few models available and are relatively expensive to buy and operate.

The workings of a fuel cell electric vehicle are summarised below:

> Hydrogen gas from the tank is supplied to the fuel cell stack with air
> The oxygen and hydrogen combine in the fuel cell stack to generate electricity and water.
> The motor provides power to the wheels and the water is emitted via the exhaust

Electricity generated through the reaction is supplied to the electric motor and/or battery. The battery acts as an energy store, providing additional energy for acceleration, and can also capture regenerative energy from braking to improve vehicle efficiency.

Fuel cells are inherently more efficient than an ICE because they do not burn the fuel. They are also much quieter than ICE vehicles. Crucially, their only emission is water, which offers a compelling advantage over ICE vehicles.

Hydrogen therefore offers a route to true zero emission transport, providing that green (zero emission) hydrogen from renewable energy is used.

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About Hydrogen Refuelling Stations

The zero emission credentials of FCEVs are reliant on hydrogen produced from renewable sources.

Traditionally, hydrogen has been extracted using fossil fuels, although this is not necessarily the case for hydrogen used in transport applications.

Electrolysed hydrogen, a process of using electricity to split water molecules into hydrogen and oxygen, (referred to as ‘green hydrogen’ when using renewable energy), offers a true net zero solution that can integrate wind and solar sources of energy.

Filling a fuel cell electric vehicle with hydrogen gas is a broadly similar experience to filling a conventional ICE vehicle with diesel or petrol as they have a nozzle and a trigger to release the hydroge n, and this takes place at a hydrogen refuelling station (HRS).

At a HRS, hydrogen is stored at 200 bar, then compressed to 900 bar and cooled to -40˚C for high pressure dispensing, filling a passenger vehicle’s 5 kg tank in as little as 5 minutes – a useful perk for saving drivers time.

The processes involved, from hydrogen production, compression, storage, cooling, and dispensing, is complex and energy intensive, and is currently one of the main drawbacks of hydrogen fuel for transport. HRS are relatively new and expensive, and therefore are few in number and can be susceptible to breakdowns.

There are around 150 HRS across Europe, the majority of those in Germany.

Hydrogen for Taxis and Private Hire applications

Taxis and private hire vehicles present one of the most promising types of fleet applications for early hydrogen markets, for two main reasons:

> Taxis fleets are one of the first sectors to be impacted by increasing pressure to reduce air pollution in city centres. Many cities in Europe are facing air quality issues and are increasingly taking action to discourage or ban the most polluting vehicles through Clean Air or Low Emission Zones.

> Taxi fleets have duty cycles and high daily mileage (e.g. >220 km per day for the STEP taxis in Paris) which may not be suited to other leading zero-tailpipe emission vehicles, such battery electric vehicles, due to range and recharge times.

Therefore, the taxi sector is likely to be one of the first in which a commercial case for FCEVs can be made, as regulations and charges aimed at reducing air pollution hit conventional vehicles, and other drivetrains may not offer the performance required.

There are a large number of taxis registered in major cities (e.g. 67,000 vehicles registered in London in 2020), and many of these will be hit by regulations to ban internal combustion engine vehicles and limit tailpipe emissionse.

As taxi and other fleet operators search for alternatives to diesel vehicles, FCEVs will have advantages over other types of low and zero-emission vehicles.

With similar refuelling times and process to petrol and diesel, hydrogen could reduce downtime for recharging and keep vehicles available for passengers.

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About ZEFER

Zero Emission Fleet vehicles for European Rollout (ZEFER) is a five year, pan-European project comprising 12 partners, funded by Europe's Clean Hydrogen Partnership.

The project has deployed 170 Toyota Mirais, a flagship FCEV model, across London (50 for Green Tomato Cars), Paris (60 for Hype) and Copenhagen (60 for DRIVR) for private hire and taxi operations, with an additional 10 Mirais for London Metropolitan Police.

It will demonstrate the viable business cases for captive fleets of FCEVs in operations which can realise value from hydrogen vehicles, and thereby drive sales of FCEVs and improve the business case for HRS serving captive fleets in other cities.

To date, ZEFER has delivered a rich dataset from the 180 vehicles that gives an insight into the operation of FCEV drivers; since the first 25 Mirais were deployed to Green Tomato Cars in April 2018, over 9 million kilometres have been driven, using 88,000 kg of hydrogen.

The project partners are working together to prove the business case for deploying HRS and for owning FCEVs, and to produce and share the evidence underpinning these business models in order to encourage more widespread uptake.

Case Study: Green Tomato Cars London

London's self-proclaimed "green and ethical car service" received 25 Toyota Mirais as part of ZEFER in 2018, with an additional 25 joining the fleet a year later.

The vehicles primarily use two HRS in the capital, Teddington and Rainham. The latest data shows there has been 42,475 kg of hydrogen dispensed in 20,600 refuelling events, averaging 2.1 kg per refuel (equivalent to 210 km, 41% of the 5 kg hydrogen tank capacity).

The Mirais used by Green Tomato Cars averaged 180 km and 14 journeys per day, and 31 km/h.

Peter Joseph was one of the first drivers to sign up for Green Tomato Cars when they received their Toyota Mirais.

"We all have to do our bit for the environment and the Mirai is at the forefront of that technology," he said.

"The proposition was extremely attractive, the chance to trial this new car and the employment package with Green Tomato Cars allows me to use it for my own personal use too.

"It's a lovely car to drive. Driving it feels like you're almost floating on air as you take off as it's so smooth and quiet – it's really comfortable and ticks all the boxes, not just for my passengers but even my family enjoy it when I take them out.

"I get a number of passengers who specifically request to be driven in a zero emission car because they want to do their bit for the environment and the Mirai meets that need."

Case Study: STEP/Hype Paris

Hype has operated hydrogen vehicles in Paris since 2015 and deployed their first 36 Toyota Mirais for ZEFER in 2018.

The ZEFER Hype FCEVs have reported a total of 3,590,000 km driven, at an average of 3,063 km per month (141 km per day and 36,800 km/year)

The most popular HRS are the ones located at the airports (Orly and Charles de Gaulle/Roissy), as the taxis refuel there when they leave and pick up passengers so do not need to detour to refuel.

Nabil has been a Hype taxi driver for 3 years: "I take full advantage of this hydrogen electric car: the lack of noise and vibration and the increased comfort for me and passengers," he said.

"As a taxi driver I cover 200 to 220 km a day on average and the Toyota Mirai has a range of 500 km which more than covers my needs in a day's work.

"The refuelling stations are strategically located so that you can't fail to pass one during the day.

"Refuelling a hydrogen car is easier and cleaner than filling up a traditional car with petrol or diesel - just plug in the gun and refuelling is automatic. It only takes about 3 minutes.

"The benefits offered by this type of vehicle improve the daily life of the driver."

Future of Hydrogen

Victor Lejona is a senior technical specialist at Cenex, a low emission transport consultancy and research organisation involved in real-world hydrogen transport trials across the UK and Europe, including ZEFER.

“Hydrogen will suit sizeable cities with large taxi demand and where enough refuelling infrastructure is available,” he said.

“If the HRS are located in the right places, they can be very convenient for both the taxi fleet and the hydrogen provider.

“For example, the Hype fleet in Paris are operating 160 hydrogen taxis, and often refuel at the two main city airports which is extremely convenient for taxi drivers, as they can use their trips to pick up or drop off passengers at the airport without any ‘stem’ or ‘dead’ mileage,

“Over the next ten years both vehicles and infrastructure will still need to be heavily incentivised by national or EU governments, and joining forces with other local fleets, such as heavy vehicles or commercial vehicles, will allow the business case to flourish as prices will decrease from the high volumes of hydrogen dispensed.

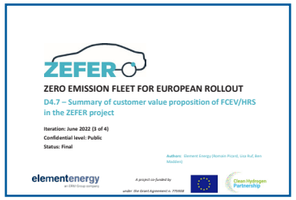
“If we build the hydrogen refuelling infrastructure and get serious about air quality and climate change, hydrogen-powered commercial transport could become a significant part of the world economy.

“The results from hydrogen vehicle trials across Europe highlight the benefits and impacts, and tackle the barriers, and only by growing confidence in the technology can it integrate into our transport network in the future”.

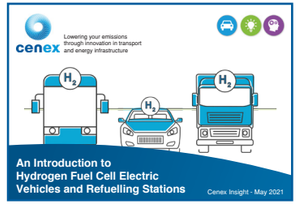
Further Reading

Zero Emission Fleet vehicles for European Rollout
www.zefer.eu

ZEFER Bi-Annual Report June 2022
zefer.eu/reports/zefer-d3-4-bi-annual-public-technical-report-on-fcev-and-hrs-operation-june-2022/

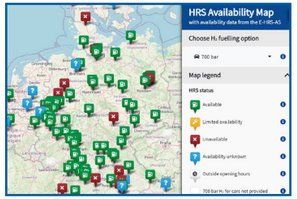


ZEFER Customer Value Propositions June 2022
zefer.eu/reports/d4-7-summary-of-customer-value-proposition-of-fcev-hrs-in-the-zefer-project-june-2022/



An Introduction to Hydrogen Fuel Cell Vehicles and Refuelling Infrastructure
www.cenex.co.uk/app/uploads/2021/05/Intro-to-hydrogen-1.pdf

ZEFER Information Leaflet
zefer.eu/uncategorised/zefer-project-brochure-june-2022/



HRS Availability Map
www.h2-map.eu

H2ME Project Presentation
h2me.eu/wp-content/uploads/2021/01/H2ME_project_presentation2020.pdf

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