ZERO EMISSION FLEET FOR EUROPEAN ROLLOUT

D4.7 – Summary of customer value proposition of FCEV/HRS in the ZEFER project

Iteration: June 2022 (3 of 4)

Confidential level: Public

Status: Final

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Contents

Stakeholders identified FCEVs as a solution for decarbonising high mileage applications in transport sector

- Since the advent of personal cars, petrol and particularly diesel vehicles have been viewed as the only option for high-mileage fleet applications such as taxis, private hire and emergency service vehicles. This is a result of the high demands of the use case, requiring **long range vehicles with quick and convenient refuelling processes**.
- However, with growing concerns about the environmental and health damage associated with internal combustion engine (ICE) there is a global consensus, including amongst stakeholders directly impacted such as fleet operators and policy makers, that a **transition is required to cleaner, less polluting vehicles.**
- The transition towards **hybrids and plug-in hybrid fleets began in the late 2000s** with recent trends showing similar evolution for **zero-emission vehicles** including battery-electric or fuel cell electric vehicles. This is illustrated by the ban on sales of new internal combustion cars from 2035 announced by the European Commission[1].
- Generally, this transition has been driven by 2 key factors:
    - **Policy support** for low and zero emission technologies;
    - **Cost effectiveness** of technologies in high-mileage applications.
- In recent years **fuel cell electric vehicles (FCEVs), using hydrogen as a transport fuel, have been identified as a sensible alternative for heavy duty and high mileage use cases with hydrogen** clearly identified as part of the EC Net-Zero strategy[2]. This is because FCEVs can provide **similar operational flexibility and experiences** as ICE vehicles with long ranges (over 600km) and fast refuelling times (3-5 minutes refuels).
- Despite trials evidencing the performance of the vehicles, **high-cost premiums for purchasing the technology and a lack of sufficient national refuelling infrastructure to support individual drivers has limited uptake of FCEVs** in recent years. This, in turn, has hindered the business case for hydrogen refuelling station (HRS) operators as stations have suffered from low utilization and poor hydrogen sales. A positive trend with increased utilization level and a decrease in the price of hydrogen at the pump has been observed in areas where stakeholders have developed local hydrogen ecosystems.

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[1] *Announcement of July 2021*, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3541

[2] *Detailed EC proposal*, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52021PC0559

ZEFER aims to demonstrate that FCEVs can be a viable and competitive alternative to ICE in fleet applications where their value can be monetised

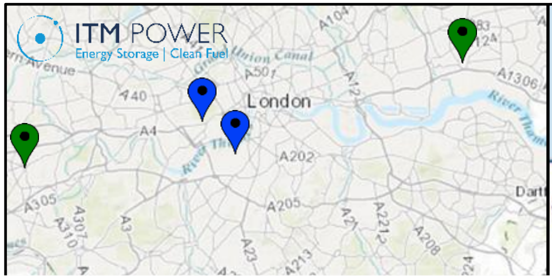
- The ZEFER project aims to demonstrate **viable business cases** for the utilisation of fuel cell electric vehicles (FCEVs) in **fleet applications** by combining two approaches:
  - **An early business case** – **180 FCEVs are deployed in London, Paris and Copenhagen** in applications that require long ranges (where battery vehicles are not viable) and where the value of zero emissions can be monetised.
  - **Captive fleets** – **Large fleets are linked to specific hydrogen refuelling stations (HRS)** to provide a meaningful increase in the utilisation levels of the station and provide a sizeable guaranteed demand, and revenue, for the HRS operator.

To date, **all 180 vehicles have been deployed** into taxi, private hire and emergency response services across London, Paris and Copenhagen. The vehicles are operated by:

- **Green Tomato Cars (GTC)** – operates 50 Toyota Mirai in private hire services in London.
- **Metropolitan Police Service (MPS) –** operates 10 Toyota Mirai as General Purpose vehicles in London.
- **STEP –** operates 60 Toyota Mirai in Paris in professional taxi services.
- **DRIVR –** operates 60 Toyota Mirai (23 Mirai I and 37 Mirai II) in Copenhagen in professional taxi services.

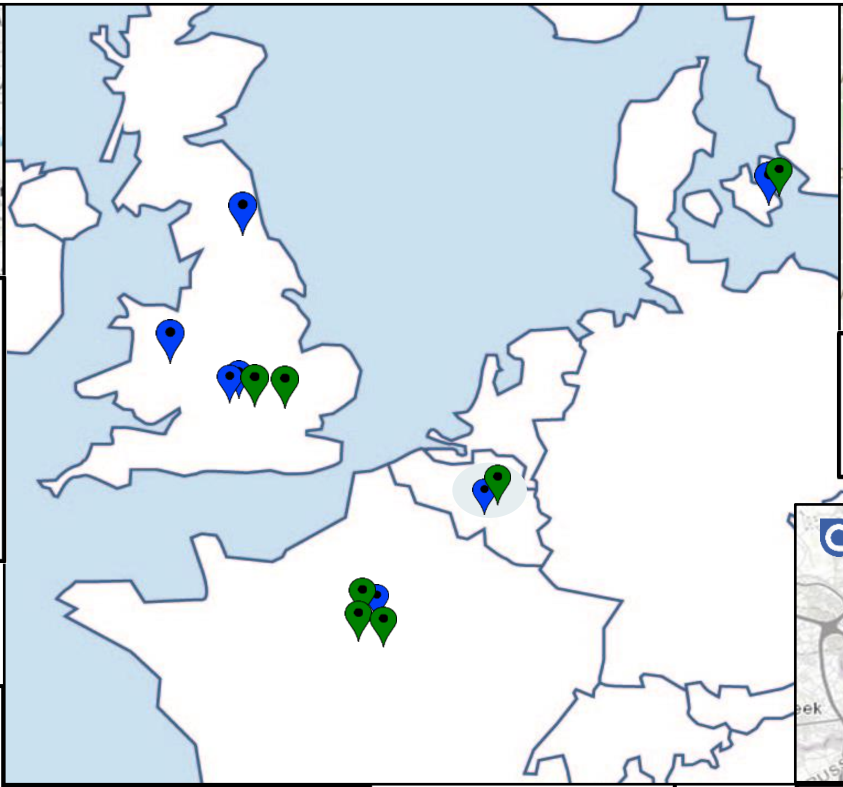
__HRS__: Hydrogen refuelling Station | __FCEV__: Fuel Cell Electric Vehicle

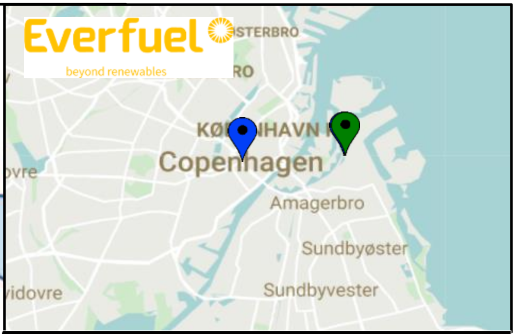
ZEFER activities reinforce H_2 activities in Europe by upgrading and using stations from ITM Power (London), Air Liquide (Paris) and Everfuel (Copenhagen)



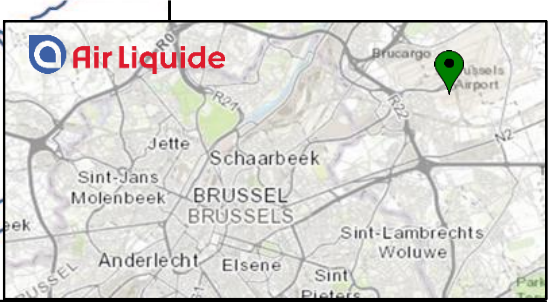
Teddington
- >700 kg/day dispensing capacity
- Commissioned Q2 2016

Rainham
- >700 kg/day dispensing capacity
- Commissioned Q4 2016





Copenhagen – Prags Boulevard
- 700 kg/day capacity
- Commissioned Q3 2021



Zaventem
- 200 kg/day capacity
- Commissioned Q1 2016

Paris Sud
- 200 kg/day capacity
- Commissioning Q1 2018

Versailles
- 200 kg/day capacity
- Commissioning Q1 2018

Paris Ouest
- 200 kg/day capacity
- Commissioning Q1 2019

🟢	ZEFER stations
🔵	Other stations

This report aims to analyse the customer value proposition of FCEVs/HRS in fleet operations

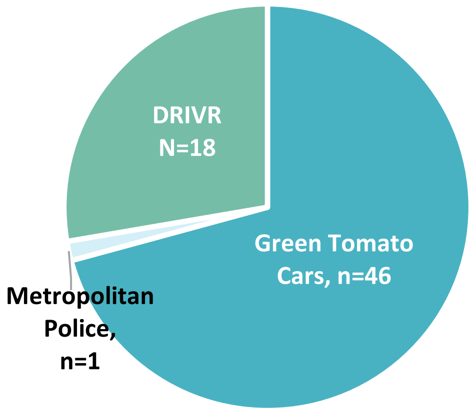
- This report aims to analyse the customer value proposition of FCEVs and HRS to investigate whether the hydrogen mobility is feasible, and sustainable, within high mileage fleet applications.
- The report will use a variety of data including:
  - ✓ **Insights from fleet and HRS operators derived from interviews and ad/hoc discussion** – 4 rounds of interview with all FCEV and HRS operators to understand current issues/challenges of operating FCEVs in fleet applications
  - ✓ **Surveys of FCEV users and fleet operators** – drivers and fleet managers are requested to answer project surveys both before, and after, operating the vehicles to understand attitudes towards FCEVs and HRS and end-user experiences of the technology.
  - ✓ **Workshops with the project consortium** – throughout the ZEFER project a series of workshops have been hosted to discuss the customer value proposition of FCEVs with partners and observers members.
  - ✓ **Performance data collected from the FCEVs and HRS** – data on FCEV and HRS performance is collected and analysed by the project and can be used to corroborate sentiments of fleet drivers/operators.

- The report will first analyse **motivations for FCEV uptake and the experiences of the technology** to understand whether the 'value' of FCEVs is being seen in operations**.** The **business case** will then be assessed along with the improvements required to integrate FCEVs into commercial operations. To conclude, the report will draw upon the findings to form **recommendations to improve future experiences.**
- The report represents the **third iteration (of four)** of the customer value proposition. A final iteration is expected to be published at the end of the ZEFER project.

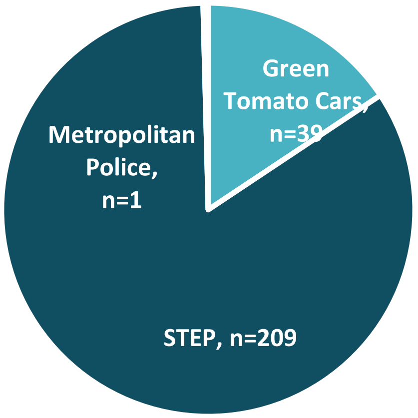
This iteration benefits from inputs from the third deployment site and updated TCO figures

- To date, two iterations of the report have been prepared. Following the delivery of the final 60 vehicles in Denmark, the project has been able to benefit from information and data from an additional European market.
- For this report, Element Energy **used driver survey answers collected at the beginning of the trial[1]**, and incorporated information from the Danish market such as **total cost of ownership figures**, **users' perceptions** or **policy incentives** in Copenhagen based on discussions with DRIVR.
- **Vehicles with new features** have been incorporated into the project following the deployment of the 60 vehicles in Denmark which includes **37 of the newer Mirai II among the vehicles deployed** the main advantages of which are a larger tank, one additional seat and a lower catalogue price.[2]
- Compared to last iteration, the business case has also been updated using latest figures for the counterfactual vehicles (BEV, PHV and petrol hybrid) particularly on the fuel price.
- In particular, recent increases in the energy price have been reflected in the business case. This is mainly relevant for ICE and hybrid vehicles.

Pre-operation
N = 65*



During operation
N = 249*



**Some respondents did not submit complete answers, that is why the numbers can vary depending on the questions.*

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[1] *The answers have been collected as part of D4.1 – Results from vehicle driver surveys*

[2] *See annex 3 for a comparison between Mirai I and Mirai II*

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Policy and regulations within cities are key drivers to the transition of transport to zero-emission technologies

- Since the Paris Agreement and COP 21, **improving reducing CO_2 emissions has become a priority for national and local authorities in Europe. Air pollution is responsible for over 300,000 premature deaths per year** in Europe.[1]
- Transport has been identified as a key initial target for policy makers to tackle both policy areas. This has resulted in a **variety of zero-emission targets and legislations which aim to reduce the number of polluting vehicles** operating in city centres. The table below outlines key policies introduced across the ZEFER cities.
- As restrictions in city centres mount, **increasing value can be attributed to zero-emission vehicles** which allow licensed operation and avoids financial penalties for using vehicles in central areas.

London	Paris	Copenhagen
Congestion Charge Zone (CCZ) – financial fee of up to £15 per day for any petrol/diesel vehicle entering the defined zone between 7am and 10pm[1]. The Cleaner Vehicle Discount, introduced in October 2021 is limited to full electric vehicles only and will be valid until 2025. Hybrid vehicles are excluded from any kind of discount.	**Low Emission Zone (LEZ) and Crit'Air –** limits the vehicles that can enter the city at certain times of the day based on the emission standards of the technology[5]. From June 2021, Crit'Air 4 & 5 (equivalent to Euro 3 or lower diesel vehicles) are not allowed in the LEZ.	**Low Emission Zone** – covers the geographic area of the center of Copenhagen and the municipality of Frederiksberg. The LEZ is applied every day of the week, 24 hours a day. Passenger cars are not yet affected by LEZ, which currently only affects diesel-powered trucks, vans and buses.
Ultra Low Emission Zone (ULEZ) – covers the same area as the CCZ and introduces an additional fee of £12.50[2] per day for vehicles which do not meet the ULEZ emission standards[3]. The ULEZ was expanded to the North and South Circular roads in October 2021.	**Taxi licensing** – operating zero-emission vehicles in Paris provides access to a particular category of taxi license (medallions) which allows the operators to conduct multiple shifts per day with one vehicle and one license. This can reduce the effective cost of the vehicle.	**Green parking spaces** – Since 2020, a political incentive allows zero-emission taxi (BEV and FCEV) to have a priority access to some public parking spaces (e.g closer to the entrances of buildings) in hospitals, airports, train stations...
Taxi and private hire licensing – Transport for London (TfL) have defined licensing for taxi and private hire vehicles operating within London. Today, legislation states all newly licensed vehicles must be 'capable of producing zero emissions'[4] to receive official London licenses.		**Reduction of registration taxes for ZE vehicles -** On registration in 2022, zero-emission private cars are subject to a basic deduction of DKK 167,500 from the vehicle registration tax.

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[1] *Figures from European Energy Agency for 2019,* https://www.eea.europa.eu/publications/air-quality-in-europe-2021

For high-mileage applications, FCEVs can provide a positive customer value proposition due to their operational advantages over BEVs

- In the face of increasing regulations on operations in city centres, fleet operators are being driven to find low-emission and now zero-emission alternatives for their operations. As of today, there are two market options: battery-electric vehicles (BEV) or fuel cell electric vehicles (FCEV).
- For high mileage fleet applications, FCEVs are increasingly being recognized as an appropriate zero-emission alternative as their **long range (up to 650 kms) and quick refuelling times (3-5 minutes)** in comparison to BEVs[2] allows them to provide a more like-for-like comparison with petrol and mainly diesel incumbents in operation today. The value ascribed to FCEVs differs between operators in the ZEFER project, largely divided into their use case.
  - **Taxi/private hire operations** – the long ranges and fast refuelling times of FCEVs are critical to the taxi/private hire business model as profits rely on the ability of vehicles to drive for many hours with little downtime and to make journeys at short notice.
  - **Emergency services** – motivations for FCEV uptake in the Metropolitan Police Service fleet focused on the availability of FCEVs and their capacity for 24/7 usage. The focus of attention was therefore their quick refuelling times, with longer ranges viewed as an additional (but non-essential) extra.
- By combining the regulations for zero-emission technology and the operational advantages for FCEVs in fleet applications a **positive value proposition can be made for FCEVs** in fleet applications today. The following slides will explore the extent to which FCEVs are meeting the demands of fleet operators and where the technology provides specific advantages in comparison to its zero-emission alternative.

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[1] *The recent unveil of Toyota Mirai 2 whose 37 are in operation with DRIVR in Copenhagen have a catalogue range of 650 km, see [Annex 3]*

[2] *With rapid chargers 20-30 mn can provide between 60-200 miles of range. [https://pod-point.com/guides/driver/how-long-to-charge-an-electric-car]*

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In order to understand the customer value proposition it is important to assess whether FCEVs are meeting the needs of end-users

☐ The following section will use data from performance assessments, interviews and questionnaires to understand how well real world FCEVs, and their supporting HRS, are suited to end user demand in fleet applications.

☐ The data from the questionnaires included in this report are based on responses to the “during operation" questionnaire. Only STEP, GTC and MPS drivers have completed this version of the questionnaires. DRIVR drivers who have just started to use FCEVs will complete the questionnaire following a year of operation. Therefore, their answers are not included in the following graphs.

☐ The analysis will be broken down into the following sections:

1 **Overall experience**

2 **FCEV experience**

3 **HRS experience**

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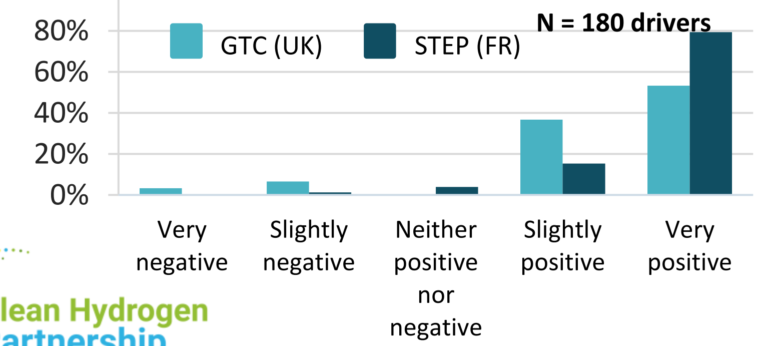
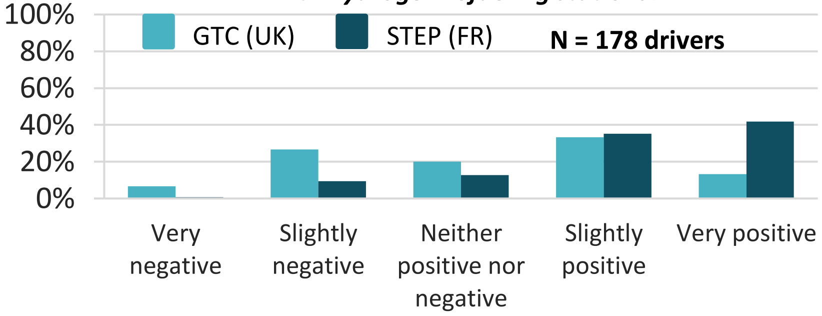
Overall, drivers have noted a positive experience of operating FCEVs in fleet applications but infrastructure has been noted as a key challenge

- ❑ **All operators within the ZEFER project have noted a very positive experience** with FCEVs in their fleet, with the technology meeting or exceeding their expectations in terms of reliability and performance. Positive sentiments towards the performance of the vehicles have also been supported by survey results from drivers, with more than **90% of drivers noting a 'positive' or 'very positive' experience with the technology (see Graph 1 below)*.**
- ❑ For the refuelling infrastructure, a large portion of UK drivers (34% of GTC respondents) reported a bad or very bad experience, linked with **challenges with the hydrogen refuelling infrastructure having preventing the full operational advantages of the vehicles**. This is mainly due to:
  - ▪ Limited number of stations across cities mean that the FCEVs are not used to their maximum capacity as they are either **restricted to operations close to an HRS or have to lose time and mileage making dedicated trips to the stations**.
  - ▪ The lower reliability of the HRS (in comparison to petrol/diesel stations) has meant that some drivers have been unable to refuel upon arriving at the station. This leads to the driver either having to **commute to another station (often a significant distance away) or in the worst case be recovered by breakdown services**.
- ❑ Compared to the previous responses provided for the survey, an improvement on the satisfaction of the HRS network in Paris is worth noting with 9% of the STEP respondents reporting a bad experience compared to 13% previously.

Graph 1: Overall, how would you describe your experience with FCEVs?



Graph 2: Overall, how would you describe your experience with hydrogen refueling stations?



* *See appendix for survey methodology and statistics*

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Critical to the value of FCEVs in fleet applications is their range – operator experience to date rates FCEVs highly on this parameter

- All ZEFER vehicles have been deployed into regular services by fleet operators, acting as **direct replacements to petrol/diesel equivalents**. As a result, the vehicles have been highly utilised amassing over 7 million kilometres since April 2018[1].
- Operators have noted that **distances driven meet their expectations in terms of ranges** for their services. In fact, for GTC the average annual distance driven by FCEVs (~45,500km) compares favorably with equivalent petrol/diesel hybrids and plug-in hybrids (~39,000km). This indicates that GTC see **value in operating the FCEVs more than their incumbent vehicles**, likely due to the ability of FCEVs to avoid financial charges for operating in London's city center.
- Value was also noted in the daily range of FCEVs. Data from the project has shown that **GTC vehicles operate an average 169km per day[1]** (~3,800km per month) and **STEP fleets an average of 142km per day[1]** (~3,260km per month) with some ad hoc occurrences of vehicles driving 500km a day.
- Whilst the average daily utilization for the GTC, STEP and DRIVR fleets falls within the range of most modern BEVs, **operators noted that BEVs would likely struggle to cope with the frequency of events (days) where drivers go well beyond this average**.
- To provide an example **operators stressed 'extreme cases'** in taxi services which have led some vehicles in ZEFER to double their average daily and monthly mileage. In one case, a GTC FCEV was driven 542km in a day and 12,646 km in a single month, over 3 times the usual average for vehicles in the fleet.
- This demonstrates the **need for taxi fleet operators to have vehicles with the ability to deliver high mileages in a single day and to quickly refuel** to maximise operating time. The added value of FCEVs in comparison to BEVs is further explored on the following slide.

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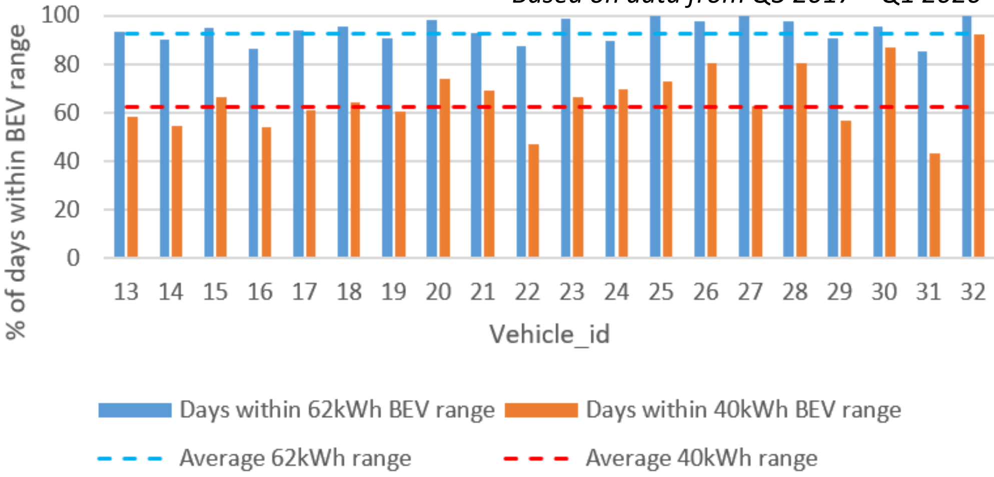
[1] Between April 2018 and November 2021. Source: ZEFER Deliverable 3.2 – Quarterly technical performance monitoring reports for HRS and FCEVs

Based on a case study of STEP vehicles, no BEV is capable of meeting the range services of FCEVs although large battery BEVs come close

- The graph on the right shows the number of days on a given representative period* that STEP's taxi operations falls within the range of:
  - ✓ A 62 kWh BEV: **93% overall**, assuming 312 km real-world range on a single charge (based on BEV operational data).
  - ✓ A 40 kWh BEV: **62% overall**, assuming 200 km real-world range.
- ~ 93% of daily operations could, in theory, be covered by a modern large-battery BEV without recharging. This would increase to 99% for a BEV with an 85kWh battery. Longer journeys would require a recharge.

Graph 3: Hype/STEP taxis operation days within range of BEV comparator

Based on data from Q3 2017 – Q1 2020



- However, at present, taxi business models rely on minimal refuelling during operational hours, and when refuelling is necessary, for quick refuelling times. Further, evidence from the project shows that drivers are not willing to run vehicle energy stores down to near its minimum, so it is expected that the practical BEV range would be less.
- As such, **FCEVs offer an operational advantage against other zero-emission mobility solutions in high mileage and high availability applications, offering an interesting customer value proposition for fleet operators.**

** The period selected is before the Covid-19 pandemic to provide a representative context*

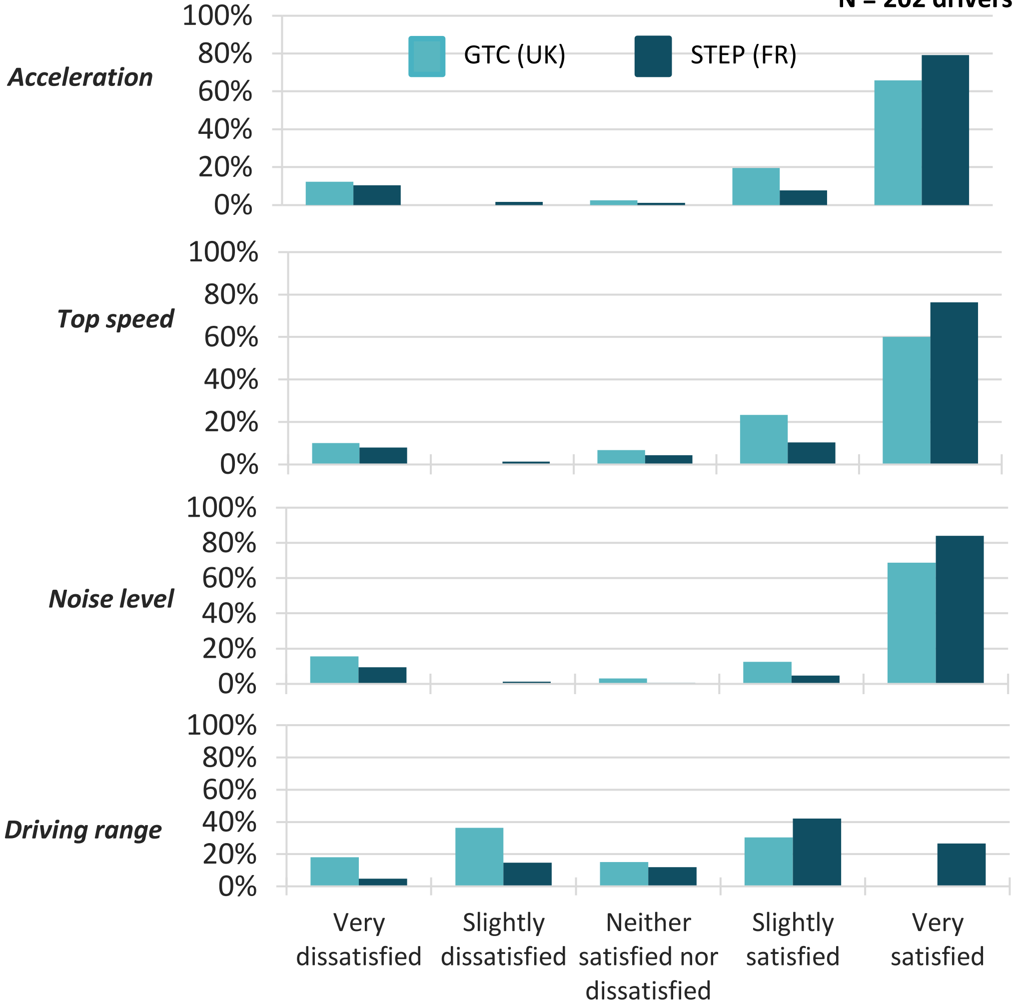
Ref: H2ME D4.14 Technical Performance Report, Cenex, 2020

Driver experience of FCEVs have also been positive with the majority noting that they were 'very satisfied' with various aspects of performance

- Findings from driver surveys largely **support fleet operator views on the performance of the technology** (acceleration, top speed and noise level).
- This indicates that the technology can be deemed a **suitable alternative** to current petrol/diesel incumbents in fleet applications.
- Perceptions are more mixed with regard the driving range. This is possibly partly due to a slightly skewed perception due to issues with HRS availability[1] in the UK. As a result, the vehicles are often not used to their full potential. The catalogue range indicated to drivers are also very difficult to meet in daily application, which can be a source of frustration for drivers.
- The reasons behind the small portion of the negative perceptions on the other topics will be investigated as part of the last iteration of the interview with fleet operators. This will also be included in the 4th iteration of this deliverable.

Graph 4: How satisfied or dissatisfied are you with the following aspect of your FCEV?

N = 202 drivers



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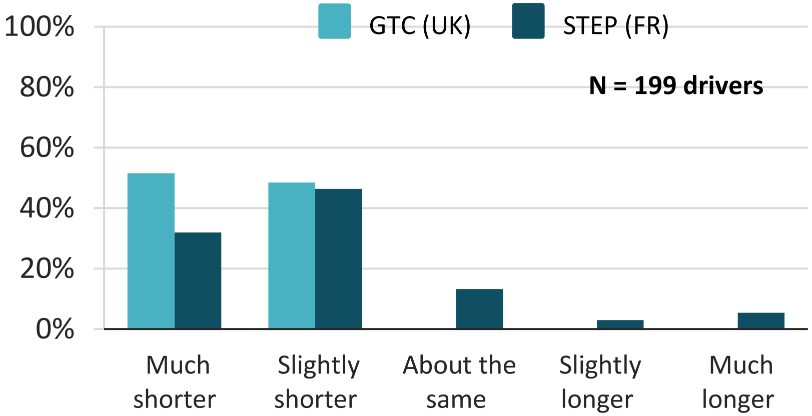
[1] See slide 22 for details on drivers HRS perception

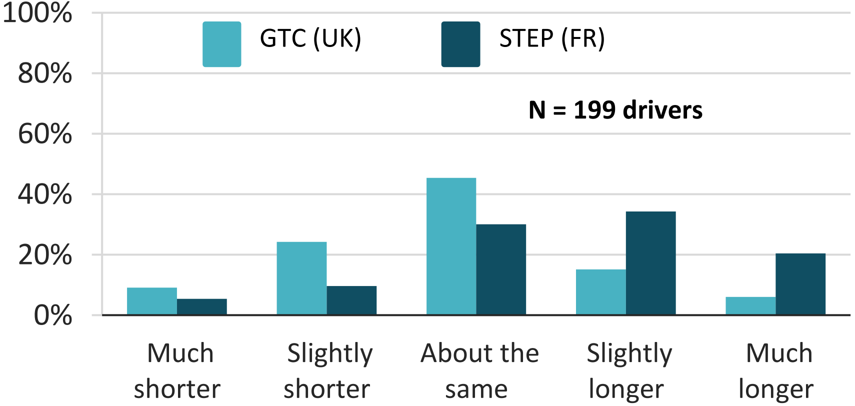
Although FCEVs are not perceived to match the range of conventional petrol/diesel vehicles, the majority of drivers see them as a longer range option than BEVs

- While the **majority of drivers were satisfied with FCEV driving range**, there were a number who requested improvements in performance to match incumbent vehicles in fleet applications.
- When comparing the range of FCEVs with other petrol/diesel incumbents **89% of drivers felt that the driving range is lower (see graph 5).** This is likely due to the vehicles drivers usually operate, with the Toyota Prius commonly used for taxi services throughout Europe (especially within the GTC fleet). This is a hybrid vehicle and has a significantly higher range than current FCEVs models (~1,000km[1]).
- The **perception of FCEVs in comparison to battery-electric equivalents was however more positive,** with the majority of drivers surveyed viewing FCEVs to provide superior ranges than their BEV equivalents (see graph 6)[2]. This **reinforces the operational value of FCEVs in fleet applications.**
- However, **perceptions of the technology varied significantly between organisations** with the majority (54%) of STEP drivers believing that that driving range of FCEVs is greater than BEVs. In comparison, most GTC drivers (45%) viewed the range of vehicles as being the same as BEVs, with 24% considering that they were shorter. This will be analysed in the following slide.

Graph 5: Based on experience, how would you compare the driving range of FCEVs to petrol/diesel vehicles?



Graph 6: Based on experience, how would you compare the driving range of FCEVs to BEVs?



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[1] *Driving ranges are derived from WLTC test cycle fuel consumption figures, note that driving ranges are often shorter under real-world conditions*

[2] *It is not known how many of the drivers surveyed have had previous experience of driving a battery-electric vehicle.*

Negative perceptions are likely to be the result of misconceptions about the maturity of FCEVs and their supporting infrastructure

- As the range of FCEVs are known to be a key benefit and reason, for choosing FCEVs it is important to understand why some GTC drivers (and to a lesser extent some STEP drivers) did not view them as being competitive with performance standards of BEVs. This trend could be explained by a number of factors, including:
  - **Problems with HRS infrastructure create anxiety over the range of the vehicles** – drivers in ZEFER vehicles refuel more frequently than required as there are concerns about the limited number of stations and the reliability of the refuelling technology. This ‘range anxiety’ will likely have a negative impact on driver’s perceptions of the vehicles.
  - **Limited infrastructure reduces the perceived range of vehicles as significant mileage to access station is taken into account** – many drivers are required to travel significant distances to refuel their vehicles due to the limited number of stations in each city. In some cases, the additional mileage may be taken into account by drivers to produce a ‘serviceable range’ for FCEVs which accounts only for the range of vehicle when they are in service or transporting paying customers (in the case of GTC and STEP).
  - **FCEVs have historically been advertised as being operationally identical to petrol/diesel vehicles** - This can lead drivers to have higher expectations of the maturity and performance of the technology which cannot be met in real-world applications at this stage.
  - **Advertised FCEV ranges are not always achieved in the real world** – many factors impact the range of an FCEV including seasonal variations and driver patterns (e.g. demanding quick acceleration and high speed journeys etc.). This can reduce the range of vehicles in comparison to the figures advertised which are largely based on factory test cycles. An efficiency of 1 kg / 100 km is often presented for FCEVs whereas fleet operators have reported averages around 1,1 to 1.2kg / 100 km in real world operation. **However, it is important to note that this phenomenon applies to all vehicles (including conventional vehicles and BEVs).**

When considering further uptake of the technology, two major issues emerge, with a series of more minor requests

- ☐ **Two major issues can be identified as preventing further uptake of FCEVs:**
  1. **Business case** – Operator's main concerns focussed on improving the business case for FCEVs in fleet applications, noting that cost parity with current hybrid/plug-in hybrid vehicles is required to facilitate commercial uptake. To date, operators are heavily reliant on public funding to cover the cost premium of FCEV purchase/lease and fuel costs in comparison to incumbent technologies. It is expected that public funding will need to continue in the short-term whilst FCEV deployments remain small, but there is confidence that with scale and the introduction of new generation technologies that parity can be reached.
  2. **Number and reliability of HRS to support FCEV fleets -** All operators noted that inefficiencies were encountered in their operating models due to the time taken to travel to HRS and problems encountered with the reliability of the stations. Increasing the number of stations in each city is therefore vital to reduce wasted time/mileage and to provide some redundancy to the network. However, operators recommended a focus on larger scale, more reliable stations in strategic areas to allow easy access for fleet users and other high demand transport cases (e.g. heavy-duty trucks and buses).
- ☐ Operators also suggested some **enhancements would be required to improve the suitability of FCEVs for fleet services**.
  - **More FCEV OEMs and models on the market** – there are a limited number of FCEVs on the market today with operators largely limited to 2 major OEMs (Toyota and Hyundai). In order for FCEVs to be applicable to all fleet services, operators believed that a wider variety of OEMs and vehicle models (e.g. multi-passenger vehicles) need to be introduced. Different 'standards' of car should also be introduced to allow for a less expensive 'basic' model, and high-end 'luxury' models for executive customers.
  - Following the delivery of the second-generation Toyota Mirai (Mirai 2) in Copenhagen, 37 of the project vehicles now have 5 seats capacity (as opposed to 4 in the first generation Mirai), this allows drivers to service the same trips as their competitors. This was one of the reason given by drivers for not switching to a FCEV previously, as it could lead them to refuse journeys with more than 3 passengers (though 85% of the taxi rides are individual rides).

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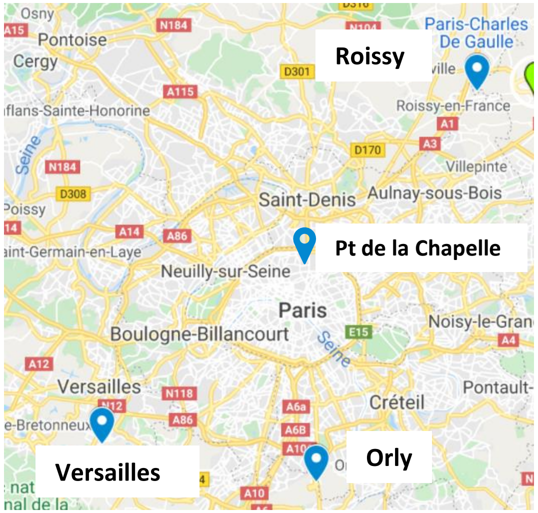
Existing HRS have provided a good foundation for initial FCEV deployments in London, Paris and Copenhagen

- Before analysing the HRS experience and in order to understand operators' perspectives, it is important to describe the number of HRS in each deployment location differs, as well as the operators of the stations:
  - In London, six HRS have been commissioned (see the map below). As of the date of this report, 5 are available Teddington, Rainham, Cobham, Gatwick and Heathrow. ITM Motive operates the majority of the stations (excluding Heathrow). The London metropolitan area is spread over 1,583 sq km (Greater London).
  - In Paris, the four HRS are available. All of these are now operated by HysetCo (except Versailles) - see slide 29. The Paris metropolitan area is spread over 814 sq km (Grand Paris).
  - In Copenhagen, Everfuel is the operator of the two HRS currently in operation. One of the HRS is a dual station (with two dispensers). The Copenhagen metropolitan area is spread over 1,767 sq km (but the urban area of Copenhagen is spread over 292 sq km).

Map illustrating the location of HRS in London

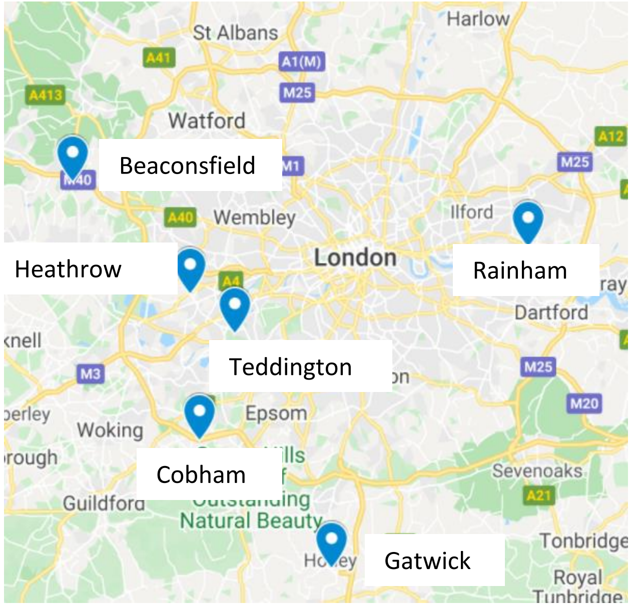


Map illustrating the location of HRS in Paris

Map illustrating the location of HRS in Copenhagen

In London, operator’s have utilised a network of 6 stations but key concerns focussed on the reliability of technology

- In London, operators have noted concerns about how the **limited infrastructure in the city is impacting the availability and efficiency of their operations** as drivers amass a lot of dead mileage and time making dedicated trips to HRS during their shifts.
- However, operators stressed that the main problem they were facing related to the **reliability of HRS in the London network** as there have been several instances where one, or more, stations have been out of operation for prolonged periods. This has led to periods where the FCEVs have been taken off the road until the station(s) are fixed and vehicles can refuel again.
- Concerns about the infrastructure supporting the FCEVs has also led to **operators encountering driver inefficiencies**, with many drivers refuelling more frequently than is required due to concerns that they will not reach the next station or that the next station will be closed. GTC have also noted that they have struggled to keep drivers in the vehicles when periods of low reliability are encountered.
- This highlights that **improvements in the HRS network in London are required in order to maximise the value of FCEVs in fleet services** and elevate their benefits above BEV equivalents.
- **Increases in the number of stations could decrease the distance (and time) drivers have to travel to refuel.** Fleet operators suggested that only a **small number of reliable stations would be required in strategic locations** to facilitate a more positive user experience and to allow for the expansion of their activities.



Map illustrating the location of HRS in London

A case study on GTC's operations highlights some of the operational inefficiencies associated with using a limited infrastructure network

- The 50 FCEVs operated by GTC utilise 6 HRS which are located on the outskirts of London.
- Although GTC tried to locate drivers in West London around the cluster of HRS in Teddington, Beaconsfield and Cobham, the vehicles operate across the city of London with many jobs in, or around, central London.
- Due to the limited number of stations, drivers face significant disruption when they refuel during the day, often requiring dedicated trips away from the center and off their designated routes.
- Through an analysis of 5 GTC taxis fitted with telemetry devices, it was estimated that drivers **travel on average 24km to refuel their vehicles and take nearly 30 minutes out of their shift to reach the HRS*.** This poses a large obstacle to GTC's business case as a significant period of driver's shifts are spent refuelling rather than completing paid passenger services. The 'dead mileage' and wasted fuel to the HRS also adds an additional operational cost for the driver/operator to consider in their business case.
- This indicates that the **number of HRS needs to be increased in London and that stations need to be more strategically placed** (i.e. closer to the city center or easy motorway access) to reduce downtime and dead mileage.
- Concerns about the reliability of the infrastructure have also led drivers to **refuel their vehicles more frequently than required, with the average refuel across the fleet amounting to ~44% of the tank capacity** on the Mirai. This leads to inefficiencies in GTC's operation as drivers take additional time out of their shifts to top up their vehicles. To avoid this in the future, the **HRS network needs to be improved in terms of reliability** and drivers need to be reassured that they will (in most cases) be able to refuel.

**calculation is based on evidence from 5 GTC vehicles and is based on the assumption that trips ending at an HRS represent dedicated trips. Source: ZEFER Deliverable 3.4 – Bi-annual Technical Report on Vehicle and Refuelling Station Operation*

In Paris, the HRS network has been operating well with STEP noting limited concerns about the performance of the stations

- STEP’s **overall perception of hydrogen refuelling infrastructure is positive**, with few concerns noted about the reliability of the stations in operation.
- Although the number of stations was flagged as a concern, the **limited infrastructure has not been viewed as a major barrier** to operations to date. This is due to the **strategic location of stations**, close to major airports (Orly and Charles de Gaulle) or close to the center (Porte de la Chapelle), at a site owned by the operator where vehicles park between shifts. The construction of several additional HRS (see slide 29) will contribute to increasing the density of the network.
- In Paris, the majority of refuels have been undertaken at the Orly station at the airport. This represents a key area of business for STEP, with airport transfers starting/ending in this location accounting for a large proportion of STEP’s daily business. The **Pont de l’Alma** HRS being currently not in operation, the newly built **Porte de la Chapelle** HRS is highly utilised as it is the closest one to the Paris city center.
- Since the start of the project, 96,444 kg of hydrogen has been dispensed in the Parisian network, of which 25,000kg were delivered to ZEFER cars.[1]
- The positive outlook on the stations could also reflect:
  - **Important hydrogen demand from STEP fleet –** The current STEP fleet includes around 200 vehicles which refuel regularly. This allows the stations to have a good level of utilisation. Moreover and despite the change of ownership for Roissy and Orly, Air Liquide, the station manufacturer, still remain involved in the maintenance of the HRS.
  - **The HRS archetype -** Air Liquide produce hydrogen off-site via steam-methane reforming (with carbon capture and storage) and deliver it to stations via high-pressure gas tube trailers. As a result, the stations are less complicated and therefore have less opportunity for technical failure compared to sites with on-site production. Additionally, Air Liquide can provide back-up hydrogen supply should one production site close, improving the reliability of hydrogen supply to the station.

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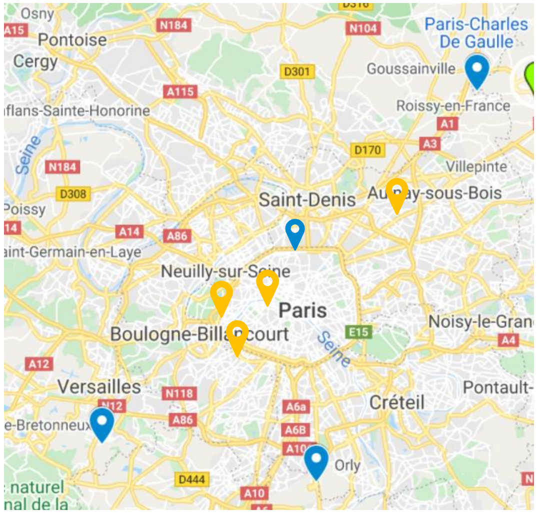
[1] *Source: ZEFER Deliverable 3.4 – Bi-annual Technical Report on Vehicle and Refuelling Station Operation*

Change in ownership and plans for new HRS are expected to lead to increased redundancy with a dense network of HRS from 2024 in Paris

- Major changes have happened in the Paris HRS network over the course of the project.
  1. **Change of HRS ownership structure**
  2. **Commissioning of additional HRSs**
- **STEP acquired the taxi company SLOTA,** taking over taxi licences and parking sites. **One semi-temporary HRS was built in Porte de la Chapelle (north of Paris)** in the premises of SLOTA. The HRS, owned by HysetCo, is situated close to the city center, at a site owned by the SLOTA where vehicles park between shifts, increasing the convenience of refuelling for drivers.
- **HysetCo** took over the **ownership and operation of the Paris North (Roissy) and Paris South (Orly) HRS and operate the HRS at SLOTA (Porte de la Chapelle).** In terms of maintenance, both Air Liquide and HysetCo’s technicians intervene on the station depending on the type of operation to be performed. o’s historical shareholders are STEP, Air Liquide, Toyota and Kouros. **An additional HRS in Porte de St Cloud (west of Paris)** close to the city center is also planned for Q2 2022 **by HysetCo.** This is expected to be the ‘largest HRS in Europe’[1]. This HRS, manufactured by NEL, will be equipped with an electrolyser producing 1000 kg/H_2 per day which could allow up to 400 cars fill-ups per day. The HRS will have 4 dispensers with 1 dual dispenser 700-350LF, 1 twin dispenser 700-700 (2 simultaneous refuelling possible) and 1 dual dispenser 700-350HF.
- Beyond this, **HysetCo has announced 6 new HRS to be built in ‘Ile de France’ region** after being granted 13,5 million by l’ADEME (French agency in charge of the energy transition). **By 2024, HysetCo plans to operate 15 HRS in the Paris region.**
- In parallel, pure player **Hype Asset (created by STEP) also announced its ambition to commission 20 HRS in Ile-de-France region capable of producing 1,000kg/day by 2024** via partnerships with the company HRS, a European leader in the design and construction of hydrogen refueling stations, and McPhy for the supply of respectively 8 HRS and 6 HRS.[2]

HRS network in Paris by 2025



Legend:
- HRS in currently in operation 🔵
- HRS under commissioning (to be opened by Q1 2023) 🟡
- Number of HRS in operation by 2024/2025 >35

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[1] https://www.francebleu.fr/infos/transports/voitures-a-hydrogene-passer-la-seconde-pour-installer-des-stations-en-ile-de-france-1642783250

[2] https://zefer.eu/uncategorised/hype-raises-e20-million-in-strategic-industrial-partnerships-with-hrs-and-mcphy/

In Copenhagen, a partnership between DRIVR, Toyota and Everfuel aim for the joint development of HRS and taxis

- **DRIVR, Toyota and Everfuel established a partnership** in January 2022 aiming for a **symbiotic development of the market for fuel cell vehicles in Copenhagen** by the vehicle manufacturer Toyota, the taxi operator DRIVR and the hydrogen provider Everfuel.
- The collaboration was initiated with the **deployment of an initial 100 taxis and one HRS in Copenhagen in Q3 2021.** The three companies have announced a **joint ambition to reach more than 200 by the end of 2022 and 500 Mirais in Copenhagen by the end of 2025.** [1]
- **Previous deployments have shown that access to a reliable hydrogen refuelling station is vital** for a new site with relatively limited refuelling options to ensure it can cater for the need of FCEVs in fleet applications.
- Drivers surveyed in the ZEFER project have reported **concerns about the limited number of stations available and the reliability of the infrastructure network** to provide consistent, and 'full' refuels to vehicles.
- To address this concern, two HRS were planned and commissioned in the centre of Copenhagen. A larger dual HRS commissioned in November 2021 in Prags Boulevard and a smaller HRS in Ernergieporten. They provide full redundancy for the vehicles in operation:
  - At the site of the larger HRS - which has built in redundancy for all equipment to ensure drivers can still refuel at the site in the event of a technical failure on one of the unit.
  - At the network level – via the second smaller HRS.
- This initial network will be complimented by additional HRS 'to support the rapidly growing taxi fleet' as announced by Everfuel.[2]

DRIVR taxis in front of the HRS in Prags Boulevard - © Everfuel

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[1] *See https://news.cision.com/everfuel-a-s/r/toyota--everfuel-and-drivr-signs-agreement-on-scaling-up-hydrogen-taxis,c3482371*

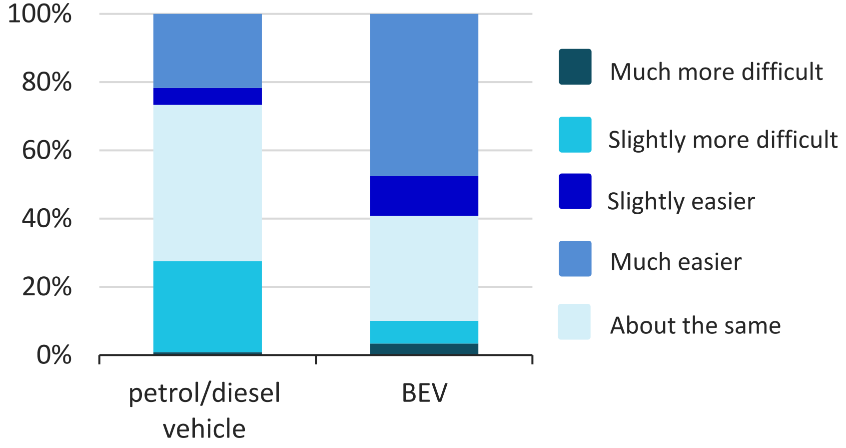
[2] *See slide 3 of this presentation: https://www.everfuel.com/app/uploads/2022/01/Everfuel_DKRollOUtPlan.pdf*

The majority of drivers note a positive experience with HRS, with many agreeing that refuelling an FCEV was easier than a BEV

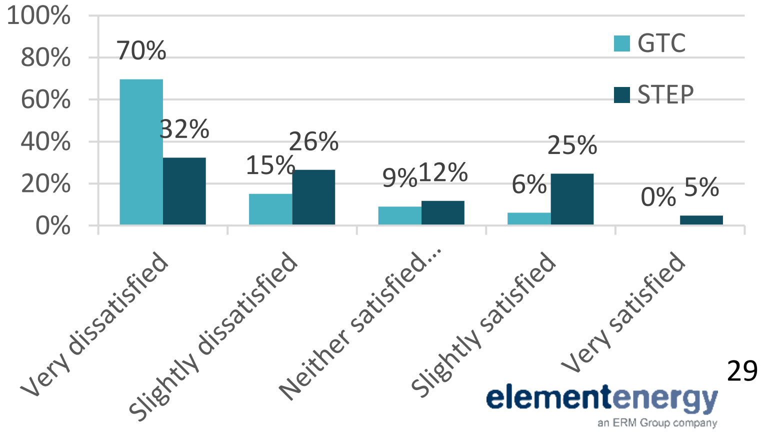
ZEFER

- As noted in the overall experience slides, **most drivers (69%) surveyed have had a positive experience with the HRSs** in their respective cities.
- Survey results from drivers using the stations have illustrated that drivers across London and Paris are **satisfied with the performance of the station** on aspects such as time required to recharge/refuel.
- Overall, the FCEV refueling process seems to be quite intuitive for STEP and GTC drivers with only **28% of respondents suggesting that refueling an FCEV is harder** than a petrol/diesel vehicle (see graph 7). Thus, the refueling process should not be a major obstacle to the deployment of future FCEV fleets.
- Most of STEP and GTC drivers (about 59%) consider that **refueling an FCEV is to some extent easier than recharging a BEV*.** This highlights the value FCEVs can add to fleet operations, avoiding long periods of downtime required to refuel.
- However, many noted a **severe dissatisfaction with the number of places to refuel FCEVs** in their respective cities (see Figure 8). Driver experience in London (GTC) appears to be worse with over 85% of respondents noting a dissatisfaction with the number of HRS, in comparison to ~58% for STEP.
- Feedback from drivers in Copenhagen will be included in a future iteration of this report.

Graph 7: Based on your experience, do you think that FCEVs are more difficult or easier to refuel than a ...?



Graph 8: How satisfied or dissatisfied are you with the number of places to recharge or refuel?



Clean Hydrogen Partnership

**It is not known how many of the drivers surveyed have had previous experience of driving a battery-electric vehicle.*

elementenergy
an ERM Group company

Contents

Approach taken for the business case analysis

- A critical aspect of the customer value proposition is whether the technology **meets expectations in terms of purchase and operational costs.** This allows an assessment into whether a sustainable business case can be devised for fleet applications.
- To analyse this, the project has collated indicative figures from partners to model the **total cost of ownership (TCO)** for leasing and operating FCEVs in high-mileage applications. In order to anonymise figures, an average for the leasing cost of the vehicles has been calculated using data from partners and internal databases at Element Energy. A generalized case is shown in the following slides using assumptions outlined below.
- Assumptions for hybrid, plug-in hybrids and battery-electric vehicles are based upon a number of references: fleet operator feedback, discussions and quotes received from OEMs and technical brochures for products.
- In this report, it has been decided to **take into account the global rise in oil prices**. Although it was caused by specific events, it is difficul to predict a return to normality. Experts suggest the oil prices could be volatile through 2022. This leads to an increase of the diesle price in this iteration from €1.29/litre in the preious iteration to €1.9/litre.
- For the comparison with BEV, it was decided **to include the price for using a rapid charger instead of home charging** (see slide 44 for the justifications), the price of which has been estimated at €0.4/KWh today (vs. €0.3/KWh in previous version). Again, it is difficult to estimate the energy cap price as the price of electricity is currently very volatile.
- Other updates compared to previous iterations include:
  - Hydrogen price at the pump has decreased in average over the 3 sites from €12/kg to €11/kg.
  - Fuel prices included for BEV is based on electricity price for rapid chargers which is expected to play a large role in high-mileage fleet applications as drivers try to minimise the downtime of vehicles during their shift.
  - The tyre costs have been removed to simplify the model as they don’t vary significantly with the car technology.

Business case analysis calculated from ZEFER figures and Element Energy's internal databases. This is presented for a 4-year leasing period

Assumption	Note	Petrol hybrid	Plug-in hybrid (PHEV)	Tesla model 3	Current FC vehicle	ZEFER FC vehicle[2]	FC vehicle 2025
Annual mileage (km)		45,000	45,000	45,000	45,000	45,000	45,000
Lease cost (€/vehicle/yr)	Excluding VAT	5,207	5,909	8,000[1]	13,239	8,239	5,207
Car maintenance costs (€/yr)		1,123	1,404	1,404	-	-	1,123
Insurance costs (€/yr)		2,500	2,500	3,000	3,000	3,000	2,500
Fuel consumption (l, kWh or kg per 100 km)		4.71 litres (60 mpg[4])	3.14 litres (90 mpg[4])	21.45 kWh	1.00kg [5]	1.00kg [5]	0.75kg
Fuel prices (€ per l, kWh or km)	Excluding VAT	€1.9/litre	€1.9/litre	€0.40/kWh[5]	€11/kg	€11/kg	€7.5/kg

[1] This figure does not take into account grants which can be significant in some EU markets.

[2] This column includes current public subsidies (from CH JU in this case).

[3] For FC vehicles (current and ZEFER) maintenance costs are included in the lease costs.

[4] Consumption figures derived from WLTC test cycle figures.

[5] This figure was determined by taking into account WLTP figures and feedback from partners.

[6] For BEV price for rapid chargers have been included.

The FCEV TCO model is broken down into three key scenarios for FCEV leasing

The graphs displayed in the following slides will show up to three TCOs for FCEVs:

- ☐ **Current FC vehicle[1] –** shows the current cost of FCEVs without any subsidy from European or National sources.
- ☐ **ZEFER FC vehicle[2] –** illustrates indicative costs for fleet operators in the ZEFER project, accounting for ~€20,000 funding per vehicle over its lifetime. Compared toe
- ☐ **FC vehicle 2025** – accounts for a reduction in many key costs, including:
  - **Capital cost of FCEVs** – cost of FCEVs are expected to reach parity with current petrol hybrids. This is based on OEM targets and assumptions that increased demand will allow access to economies of scale for production and manufacturing.
  - **Maintenance cost of FCEVs** – assumes a conservative reduction in maintenance costs to parity with current petrol hybrids. Certain OEMs are already more aggressive in their assumed maintenance costs with some quotes indicating yearly costs lower than petrol vehicles.
  - **Fuel costs** – Fuel costs are expected to reduce due to improved consumption figures (up to 25% improvement) and a reduction in fuel costs to ~€7.5/kg as a result of increased demand at stations. It is estimated that public funding will still be needed to reach this target.
  - **Insurance costs** - forecast to reduce to parity with current vehicles as the capital costs of the vehicle reduces and insurance companies become more familiar with the technology and its safety.

Summary of assumptions for FC vehicles

Assumption	Current FC vehicle	ZEFER FC vehicle	FC vehicle 2025
Annual mileage (km)	45,000	45,000	45,000
Lease cost (€/vehicle/yr)	13,239	8,239	5,207
Car maintenance costs (€/yr)	-	-	1,123
Insurance costs (€/yr)	3,000	3,000	2,500
Fuel consumption (l, kWh or kg per 100 km)	1.0kg	1.0kg	0.75kg
Fuel prices (€ per l, kWh or km)	€11/kg	€11/kg	€7.5/kg

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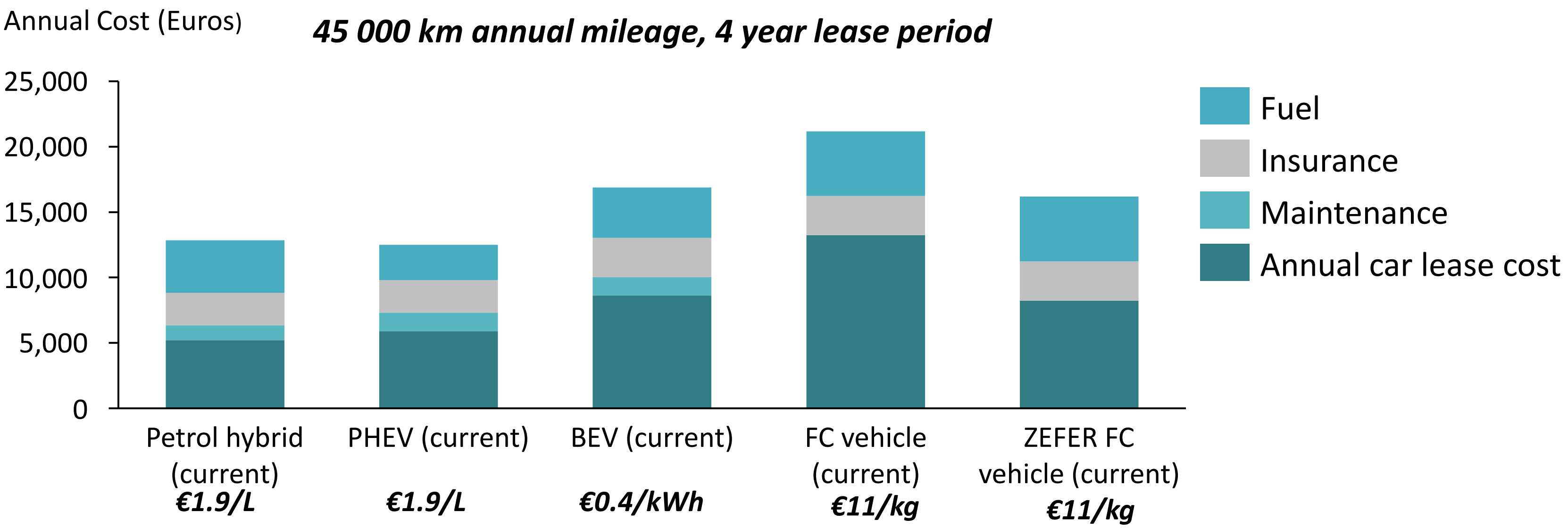
[1] Based on data provided by ZEFER partners and information gathered in internal databases at Element Energy

[2] Anonymized data calculated based an average between real estimates given by fleet operators

With the rising energy prices, gap between BEV and FCEVs is narrowing

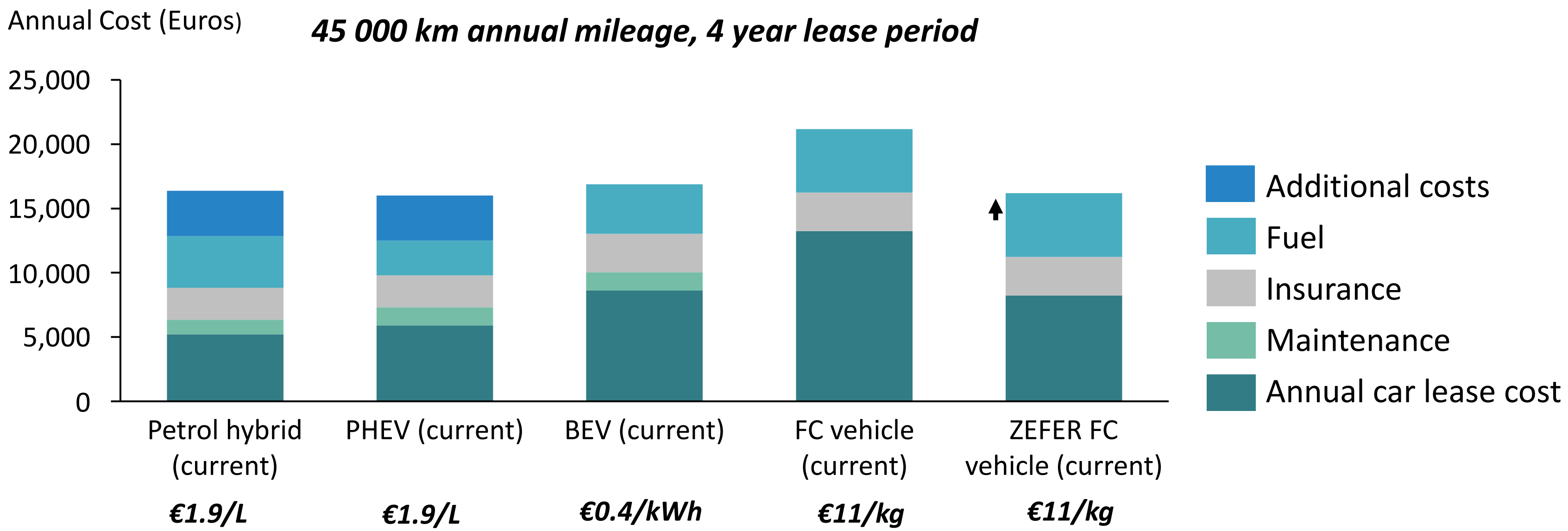
Taxi TCO compared to alternatives (€/year)



- ❑ FCEVs today comes at a **TCO premium of c. 65% above current petrol hybrids (compared to 80% in 2021)** such as a Toyota Prius without subsidy. With the funding support provided in ZEFER, the premium of FCEVs to petrol hybrids has been reduced to **c. 26% of a petrol hybrid and c. 30% of a petrol plug-in hybrid**.
- ❑ Higher costs of FCEVs can largely be attributed to **higher lease costs for the vehicles** (c. 150% premium).
- ❑ **Current FCEVs have reduced the costs premium to c. 26% over their alternative zero-emission technology. This becomes negative (-4.3%) when including the ZEFER grant funding**. This is based on the assumption that the battery electric vehicle uses rapid chargers which is expected to be the preference for taxi operation.
- ❑ **Grant funding is therefore currently vital in making the business case for FCEVs in operation today feasible.** This trend is expected to continue until FCEVs purchase/lease and operational costs can reach parity with PHEVs.

Adding the extension of the congestion charge (applicable in London), ZEFER vehicles are today (almost) as competitive as petrol hybrid or PHEV

Taxi TCO compared to alternatives (€/year)



- ☐ In London, the Congestion Charge Zone and Ultra Low Emission Zones have introduced financial penalties for drivers operating polluting vehicles in the city centre to decrease congestion and improve air quality. Since October 2021, **the Congestion Charge is applicable to all vehicles which are not fully zero-emission**.[1]
- ☐ Petrol/diesel hybrids in taxi and private hire operations have been exposed to these fees meaning that **operators have to pay up to £15 per day for operating in the centre. This makes the TCO of the ZEFER vehicles extremely competitive with a negative premium between FCEVs and petrol hybrids (-1.1%) and almost equal to PHEV (1.1%).**
- ☐ It is also important to note that, to date, the financial penalties for operating polluting vehicles are unique to London. Although many cities having increasingly ambitious plans to introduce similar incentives, this is not guaranteed. The impact of this cost saving is therefore limited across Europe.

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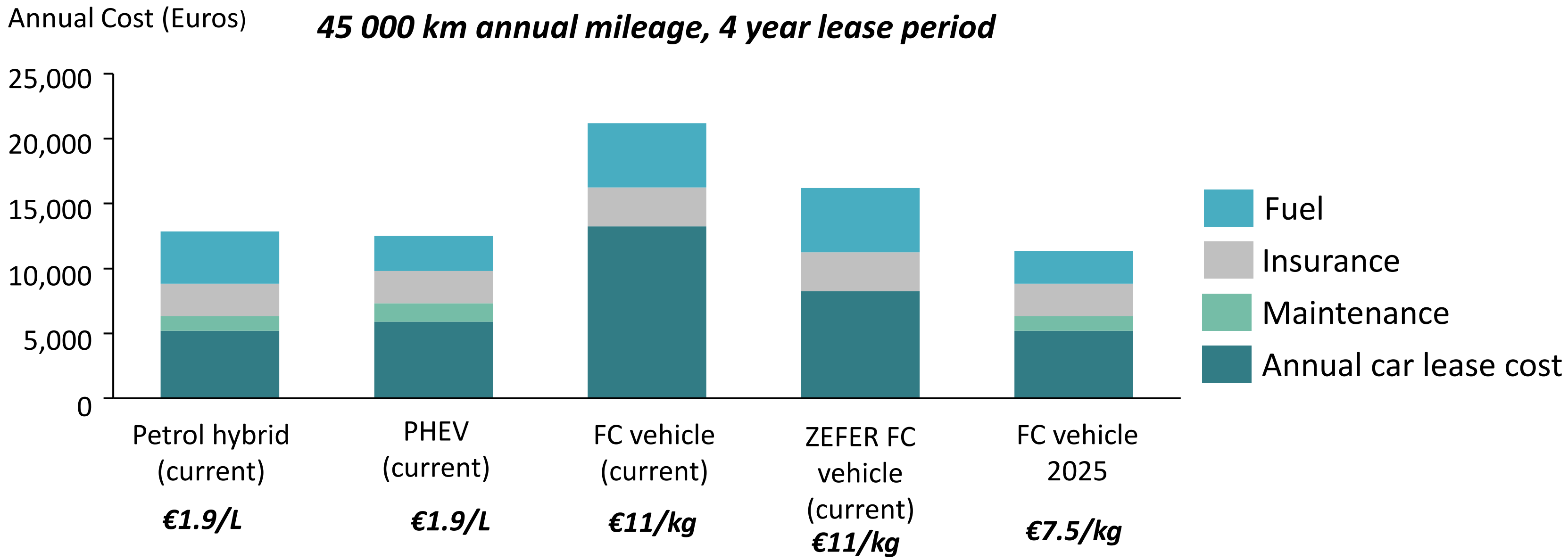
[1] Taxis (black cabs) will remain exempt from paying the Congestion Charge when actively licensed with London Taxi and Private Hire. It is nevertheless subject to debate and may change rapidly.

With projected cost reductions for vehicle and fuel, the FCEV can start to compete without subsidy by 2025

Taxi TCO compared to alternatives (€/year)

45 000 km annual mileage, 4 year lease period



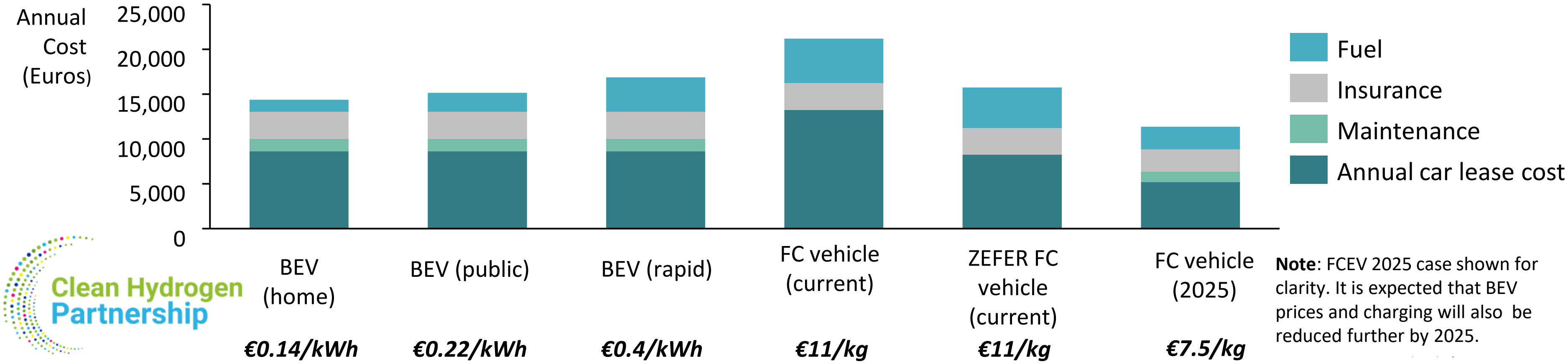
- ❑ Fuel costs are a significant component of the FCEVs overall business case and pose a key obstacle to commercialisation.
- ❑ Prices to date rest around €11/kg hydrogen which is expected to equate to ~100km/kg in real-world range of a vehicle. Accessing a lower price for hydrogen has a large impact on the TCO of vehicles, **reducing cost premiums by up to 10%.**
- ❑ It is **widely expected that FCEVs can reach capital cost parity with petrol/diesel hybrids by 2025**[1] **and that hydrogen costs can be reduced to €7.50/kg or below as a result of increased scale of demand**. This will bring the TCO of FCEVs below parity with petrol hybrids or plug-in hybrids and into competition with modern battery-electric equivalents.
- ❑ A **full and unsubsidised business case is therefore expected to be just one generation away.** However, scale of demand is critical in determining whether cost reductions can be achieved (this will enable the cut in vehicle and fuel costs).

1 – Price target in Toyota's roadmap

The comparison against BEVs is affected by the choice of charging strategy

Taxi TCO compared to alternatives (€/year)

- While Hydrogen costs tend to remain relatively stable today (between €10-€12 depending on the location of the HRS and scale of demand at the station), it is important to note that **charging costs for BEV can significantly vary in accordance with the type, and speed, of charging used** (e.g. home (slow) charging, public (slow) charging and rapid public charging).
- In previous slides, it is assumed taxi will use **rapid chargers when driving BEV** as many drivers will not be able to recharge vehicles at home due to a lack of off-street parking in many urban areas. It is therefore expected that **many drivers/fleet operators will need to pay some premium for using rapid charging points**.
- In cases where slow charging options are possible and suitable, the business case for **BEV would become more attractive**. In these configurations, the cost premium **of FCEVs over BEVs is increased because public charging and home charging are cheaper than rapid chargers**.
- This is an important consideration for fleet operators that may be able to relay on overnight charging. However, this will require significant capital investment and fleet operators to utilise a 'back-to-depot' strategy at the end of each day and might not be suitable for all type of operation. This is only expected to be an option for operators in a limited number of settings.
- **FCEVs currently have a c. 47% cost premium over the BEV in home charging mode (12% incl. grant funding), reduced to c. 39% for public charging (7% incl. grant funding) and 26% for rapid charger (-4.3% including grant funding).**



Note: FCEV 2025 case shown for clarity. It is expected that BEV prices and charging will also be reduced further by 2025.

Contents

Conclusions and recommendations –

FCEV experiences

- ☐ **FCEVs have met, or exceeded, operator's expectations in terms of performance and safety with the vast majority noting that they were satisfied with the specifications (range, acceleration, speed) of the technology and its ability to satisfy fleet application demands.**
  - Operators have been pleasantly surprised by the performance of FCEVs and no major requirements for improvements were suggested. Throughout interviews operators maintained that FCEVs provide fleet services with added value due to their unique operational characteristics in comparison to their zero-emission alternatives.
  - The vehicles have operated with >99% availability over the course of the project, matching or exceeding the average reliability of petrol/diesel hybrids or plug-in hybrids. The vehicles have also evidenced their operational characteristics with fleet operators being very satisfied with the long ranges of the technology and its ability to meet the needs of their services both safely and to a high standard.
  - Operators and drivers were also highly satisfied with the refuel time of the FCEVs, providing a similar experience to petrol/diesel vehicles. This was noted as a key differentiator of FCEVs, allowing higher availability of the vehicle for long and unpredictable service calls.
  - Satisfaction with the technology is evidenced by operators not requiring any technological improvements to expand their fleet. Main concerns related to the future of the business case for the vehicles but there is confidence that with scale and a new generation of technology that a sustainable business case can be created.
  - Other less critical recommendations, highlighted 'as desirable', included a wish for an increase number of OEMs and vehicle models for FCEVs on the market.
  - In terms of safety, no hydrogen safety related incidents have been recorded despite over 8 million km driven.

Conclusions and recommendations –
HRS experiences

☐ **Concerns regarding the number of HRS and their reliability are being addressed.**

- From our discussion with fleet managers, all operators in the project have been able to operate the FCEVs in similar patterns as their petrol/diesel vehicles using the stations in London, Paris and Copenhagen.
- However, fleet operators have faced a number of challenges with the refuelling infrastructure to during the deployments. The largest obstacles identified were related to the number of stations in each city as drivers often have to travel significant distances off-route to refuel and to the reliability of some HRS.
- The reliability of the stations has also posed a challenge for fleet operators in the ZEFER project with many noting that the limited infrastructure existing today would be sufficient should the technology have high reliability. To achieve this, it is recommended that HRS operators focus on building large scale stations equipped with redundancy to allow certain parts to fail without the full station being closed. Key areas of attention should be introducing multiple lines for dispensing to separate failures on the refuelling line. Additionally, HRS operators should pay attention to upstream issues in the hydrogen supply chain, either ensuring redundancy of sourcing and supply (for delivered hydrogen stations), or significant on-site storage. Finally, operational investment is required to ensure a readily available stock of spare parts and trained technicians ready to respond to incidents. All of these recommendations require a significant scale of demand to justify the investments.
- As described in the 'HRS experience' section, **these challenges are being addressed through local strategies.** This is notably the case in Paris where **important deployment plans** have been announced to deploy a significant number of HRS in the coming years (see slide 29) but also in London with Barking to be commissioned in 2022. In Copenhagen, the strategy relies on a highly reliable initial network of two HRS to be complemented by additional HRS when vehicles numbers growth in a symbiotic approach (see slide 30) .
- To support this development in the short-term, public funding (local, national or European) **is still expected to be required to initiate deployments**. However, as operators transition to larger scale stations with greater anchor demands from heavy duty users the need for external support will reduce as business cases become more robust.

Conclusions and recommendations

Business case

- ☐ **Today's ownership cost for FCEVs in fleet operations carries a premium to incumbent hybrid vehicles but with scale and new generation technology it is expected that FCEVs can be cost competitive by 2025.**
  - When considering fleet applications with heavy duty cycles, FCEV's operational advantages can lead to financial benefits. For example, in taxi services the ability of FCEVs to drive long distances means that they can be deployed on the same number of jobs as a petrol equivalent vehicle. Additionally, due to the fast refuelling of the technology, operators do not lose time (or money) associated with drivers refuelling/recharging on their shifts.
  - FCEVs are already competitive today with battery-electric equivalents when high daily ranges and rapid recharging are taken into account. This highlights the value of FCEVs in high-mileage fleet applications.
  - However, it is important to note that the business case for ZEFER vehicles today is sustained by local legislation and public funding which reduces the cost premium from c. 80% above a petrol hybrid, which is prohibitive to further uptake, to c. 40%.
- ☐ **Key elements required to improve this are:**

1) **Reduced capital cost and leasing of FCEVs** to a level at which it is competitive with petrol hybrids or plug-in hybrids. FCEVs could be available at a capital cost of ~€42,000[1] and then would make hydrogen taxis competitive with hybrid and BEV especially if it requires rapid public charging access which commands a higher price for electricity.

2) **Reduction in hydrogen price.** Hydrogen is a significant contributor to the cost premium of FCEVs in comparison to equivalent technologies. It is expected that costs need to reduce to below €8/kg to be competitive with petrol/diesel prices today.

3) **Continuation of funding and policy support.** Funding is required to support the business case going forward until vehicle prices can be reduced and low hydrogen costs can be sustained. It is essential that governments and local authorities continue to support FCEVs even when BEVs start to become competitive. Increased regulations on polluting vehicles can also help the business case for FCEVs as shown by the London case.

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1 – Based on OEM announcements for 2025 production *volumes* (expected to be 100,000 per year) - See annex 4

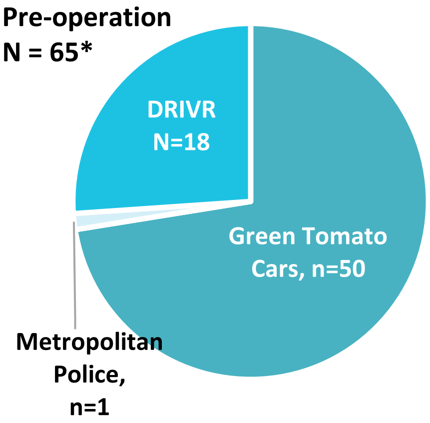
Toward the next and last iteration

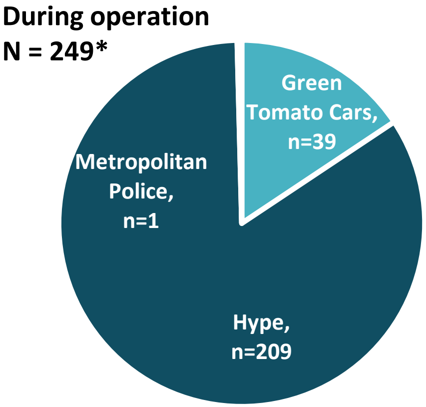
- The last and final iteration of this deliverable will provide a **complete synthetise of the customer value proposition for FCEVs in high mileage fleet.**
- It will benefit from:
  - Experience from DRIVR taxis drivers collected in the ‘during operation’ survey;
  - Insights from DRIVR fleet manager after several months of operation;
  - Insights from fleet operators (GTC, STEP, MPS) and HRS operator (Air Liquide, ITM Power and Everfuel) after returning to normal after the Covid-19 crisis.
  - Update on the hydrogen, electricity and oil prices.

Contents

Annex 1 - Overview of questionnaire approach - Data is collected from fleet drivers and managers across the ZEFER project

- Two questionnaires have been devised for the ZEFER fleet:
    - **Pre-operation questionnaire** – online questionnaire completed before deploying or operating FCEVs. This collects information on previous experiences, current and expected vehicle usage, and expectations around the technology capabilities and costs involved.
    - **During operation questionnaire** - online questionnaire completed by FCEV fleet operators and fleet drivers throughout their use of FCEVs. The survey collects information on attitudes towards various aspects of FCEV and HRS operation, expectations of the technology, vehicle usage, and opinions on the cost of hydrogen and vehicle purchase.
- In total, **69 responses** have been compiled on the **pre-operation questionnaire** and **249** responses on the **during operation questionnaire** (see Figures below)
    - To date, only DRIVR, GTC and MPS have provided responses to the pre-operation questionnaire as many STEP drivers had experience of operating FCEVs prior to the ZEFER deployment.
    - Responses to the during-operation questionnaire include one from each fleet manager (GTC, MPS and STEP). Fleet drivers make up the rest of the survey data. No responses have yet been received from DRIVR or MPS drivers.





**Some respondents did not submit complete answers, that is why the numbers can vary depending on the questions.*

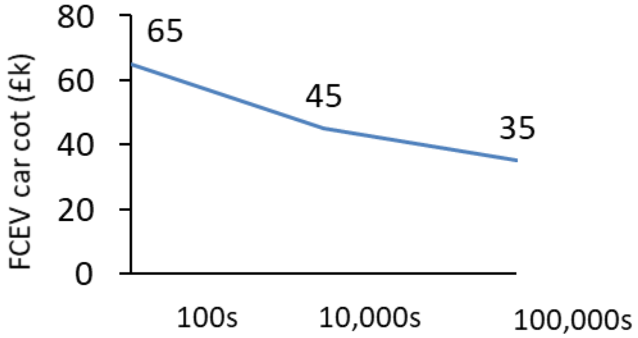
Annex 2 - ULEZ map after the October 2021 extension

Annex 3 - Toyota Mirai II vs Toyota Mirai I

	Toyota Mirai II	Toyota Mirai
Powertrain	Fuel-Cell Electric	Fuel-Cell Electric
Horsepower	182 hp	151 hp
Tank capacity	5,6 kg	5 kg
Standard Transmission	One-Speed Direct Drive	One-Speed Direct Drive
Standard Drivetrain	Rear-Wheel Drive	Front-Wheel Drive
Combined Fuel Economy (Estimated)	TBD	67 MPG
Driving Range (Estimated)	406 Miles / 650 km	312 Miles / 500 km
Refuel Time	5 Minutes	5 Minutes
Total Seating	5	4

Source: https://www.nashvilletoyotanorth.com/blog/2021-toyota-mirai-vs-2020-toyota-mirai/

Annex 4 - Projected cost of FCEV in proportion to the scale of production



Projected cost of FCEV in proportion to the scale of production based on Element Energy’s database

Acknowledgements

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