

# HYTEC FUEL CELL ELECTRIC VEHICLE END-USER SURVEYS

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# Introduction

- HyTEC (Hydrogen Transport In European Cities), supported by the FCH JU, demonstrated the deployment of fuel cell electric vehicles (FCEVs) and hydrogen refuelling infrastructure in Copenhagen, London and Oslo between 2012-2015.
- One of the primary aims of HyTEC was to demonstrate the real-world use of FCEVs by urban fleets in order to understand how they would be viewed by end-users.
- This presentation summarises two end-user engagement workstreams carried out towards the end of the HyTEC vehicle trials:
  1. Two surveys of vehicle users in Copenhagen:
    - i. A first given to users of the vehicles (conventional, electric or fuel cell) in the City of Copenhagen municipal car pool which aimed to establish which vehicle (conventional/electric/fuel cell) the user had chosen to drive that day, and to understand why they had made that choice.
    - ii. A second which assessed the attitudes of ten regular FCEV users towards the vehicles and the refuelling infrastructure used in the trial.
  2. The outcomes of a series of surveys and interviews with the drivers of the prototype fuel cell hybrid TX4 taxi conversions which operated in London between 2012-2015.
- All the questionnaires allowed for additional comments from the users. These have been added to the presentation and have been fed back to the manufacturers of the vehicles and refuelling infrastructure used in the trial in order to help improve the technology in future.
- We would like to express our gratitude to Birte Busch Thomsen, Project Manager, Environmental Engineer of the City of Copenhagen for her invaluable assistance with carrying out the Copenhagen surveys and liaising with the users and fleet managers.
- This presentation, which concludes the end-user engagement workstream began with the *HyTEC Pre-Trial Surveys* report (deliverable 6.10) in 2013, forms HyTEC public deliverable 6.11.

# SURVEY OF COPENHAGEN MUNICIPAL CAR POOL DRIVERS



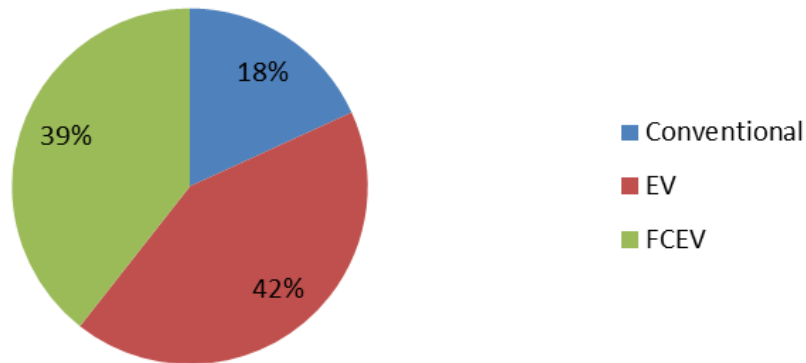
Level of dissemination: PU (public)



# Car pool drivers' vehicle preference

- 33 users\* of vehicle from the Copenhagen municipal car pool were asked which vehicle they had chosen to drive that day.
- The users had a choice of conventional (diesel/petrol), electric (EV) or fuel cell electric vehicles (FCEVs).

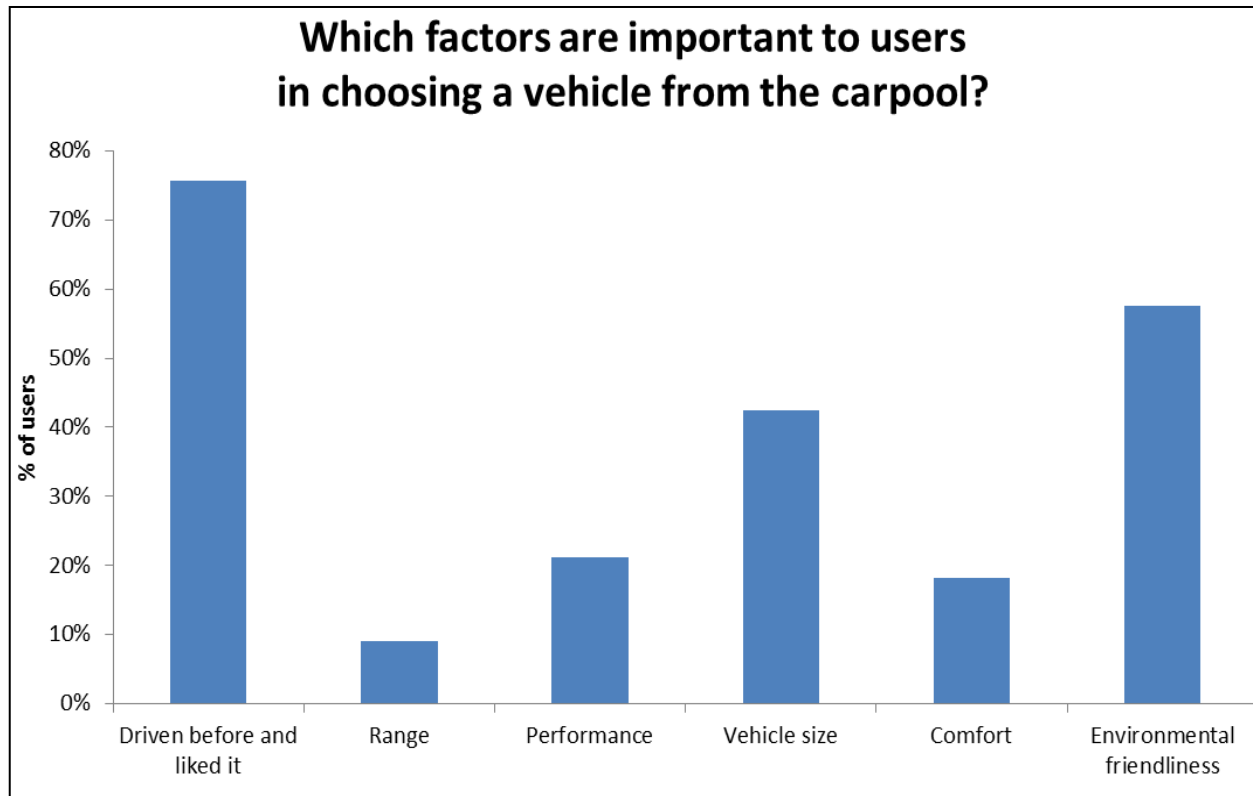
**Copenhagen municipal car pool  
vehicle choice**



- Over 80% of users chose electric drive vehicles.
- There was an approximately 50:50 split between those choosing pure electric and fuel cell electric vehicles.
- The reasons behind the choices are explored further in the following slides.

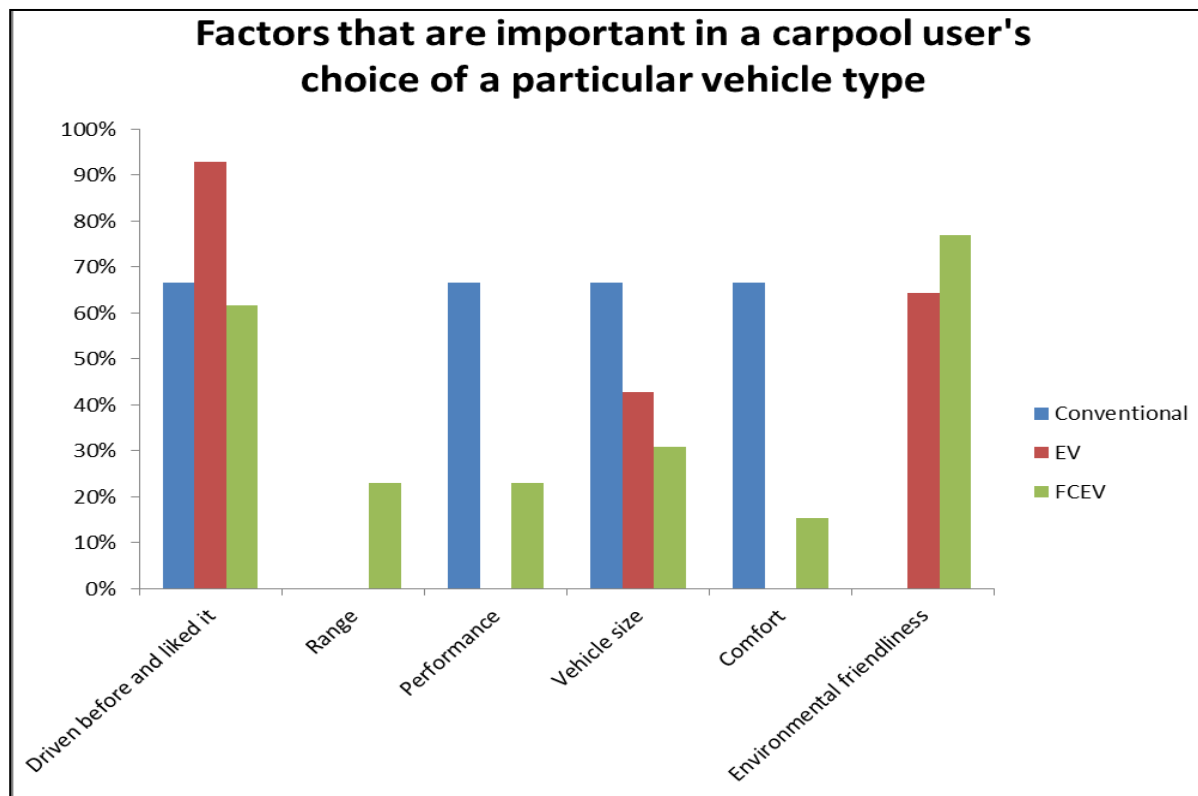
\* The sample size is not meant to convey statistical significance, but represents the users that completed the survey

# Factors that are important in car pool drivers' vehicle choice



- Familiarity with a given vehicle type dominates carpool vehicle choice.
- Other significant factors are environmental friendliness (58%) and vehicle size (42%).
- Vehicle range is not a significant factor for most Copenhagen municipal carpool users (see later discussion of this point).

# Factors that are important in car pool drivers' vehicle choice



- EV and FCEV carpool vehicle users in Copenhagen see electric driver vehicles as an environmentally-friendly selection; conventional vehicles are not seen as environmentally friendly by their users.
- EVs appear to have built a very loyal following in the Copenhagen municipal fleet.
- Users choosing conventional vehicles appear to value vehicle size, comfort and performance.

# Other points from the municipal carpool users' survey

- When asked in a separate question whether they preferred conventional, electric or fuel cell electric vehicles, almost all users selected the same vehicle that they had chosen to drive which demonstrates the importance of hands-on vehicle experience in user choice. In total, 85% of the users stated that they preferred electric drive vehicles to conventionally fuelled vehicles.
- Around 10% of the respondents indicated that they had had issues with the FCEVs. Three users added further details:
  - Two indicated that they had had refuelling issues.
  - One stated that the vehicle floor-mounted parking brake was in a non-intuitive position and that there should be a notice in the vehicle warning about it (the parking brake is in the same position in the diesel/petrol versions of the ix35).



# SURVEY OF REGULAR COPENHAGEN FCEV DRIVERS

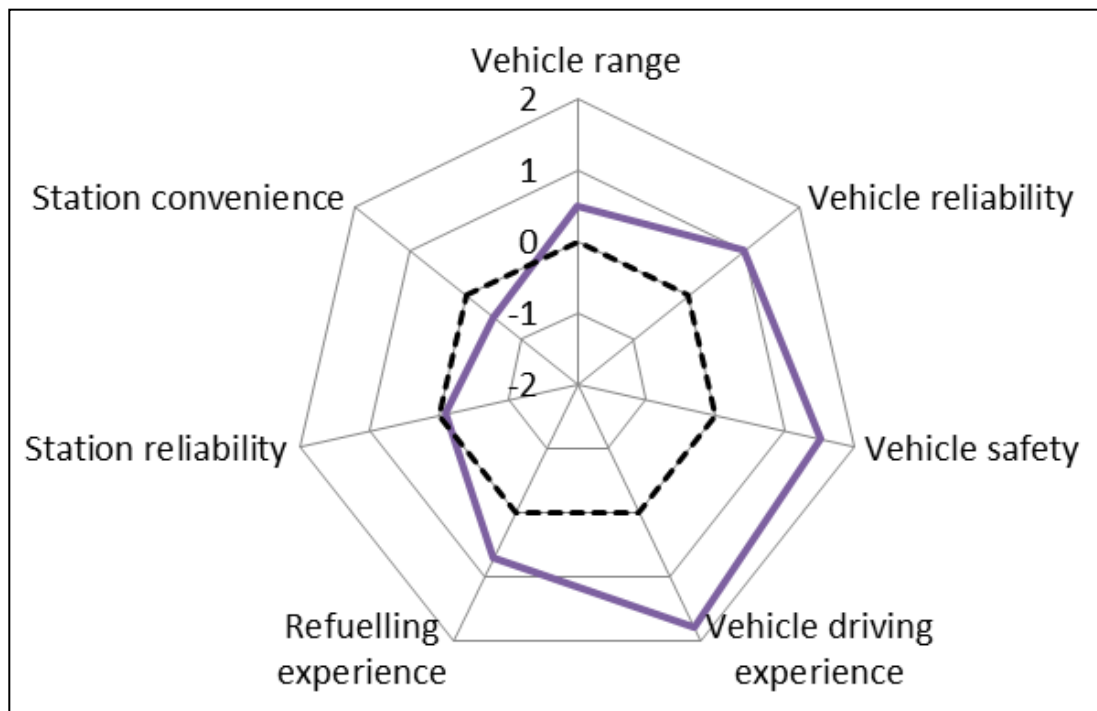


Level of dissemination: PU (public)



# Regular drivers' perception of the FCEVs and infrastructure

Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak



- Ten regular users were asked to rate aspects of the performance of the FCEVs and refuelling infrastructure at the end of the trial according to the scale shown above.
- The figure shows the average of the drivers' ratings of each aspect.
- The outcomes are discussed further in the next slides.

\* The sample size is not meant to convey statistical significance, but represents the users that completed the survey

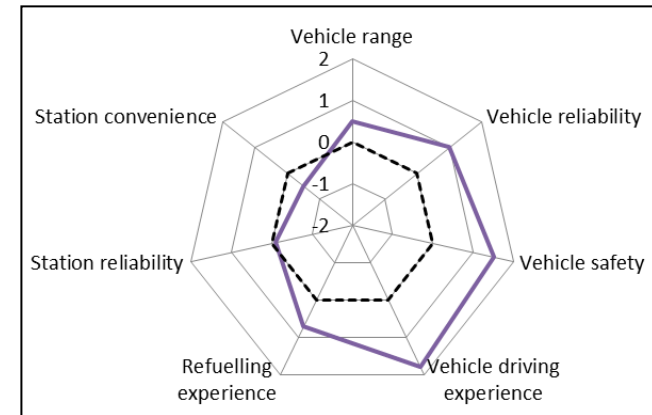
# Regular drivers' perception of the FCEVs (1)

The drivers viewed all aspects of the FCEV as either strong or very strong.

## Vehicle range

- This was seen as the least positive aspect of the FCEV; however only one driver of the ten saw it as a weakness, with most viewing it neutrally.
- The relative unimportance attached to vehicle range by the regular drivers should be considered against the generally relatively undemanding duty cycle of the FCEV vehicles in Copenhagen: the average daily distance travelled by the vehicles during the trial was around 40km, and typically they were used for short urban journeys, although some of vehicles assigned to the regular users travelled considerably further than this as part of their daily duties.

Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak



# Regular drivers' perception of the FCEVs (2)

## Vehicle safety

- All drivers viewed the FCEV vehicle safety either strongly or very strongly.
- There were no safety incidents reported with the vehicles during the two-year duration of the trial.

## Vehicle reliability

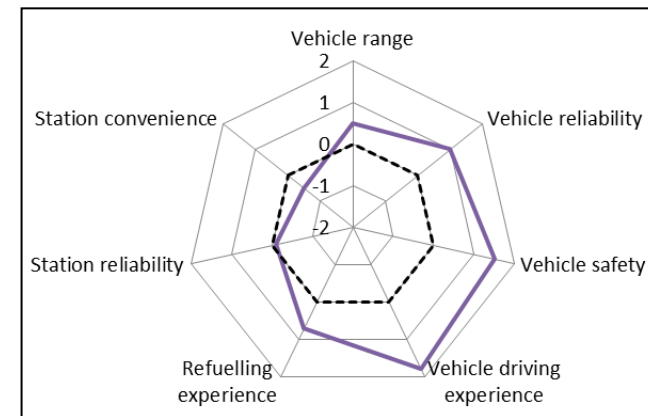
- Views on vehicle reliability split evenly between very strong, strong and neutral.
- Since the vehicle availability during the trial was practically 100%, and no adverse comments were received, it maybe that the overall rating reflects a relative lack of concern over reliability.

## Vehicle driving experience

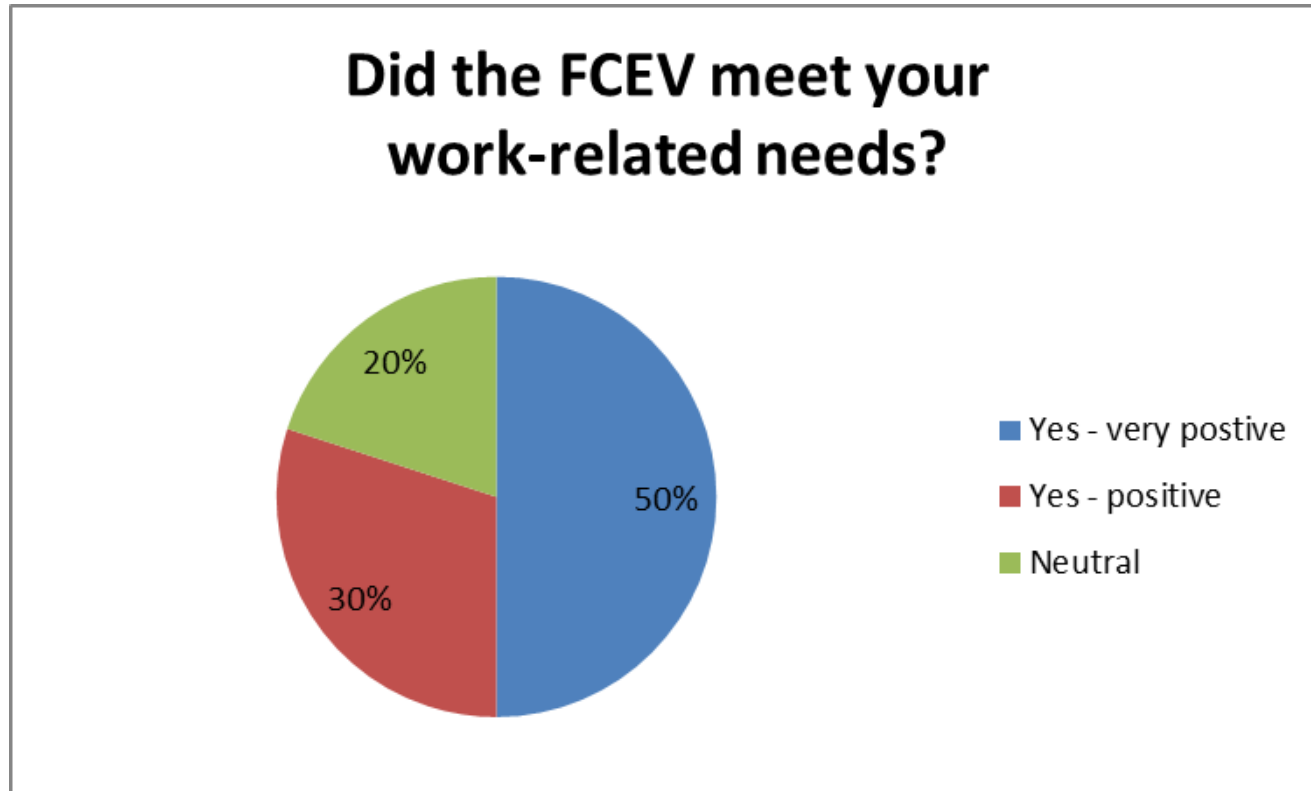
- This is clearly a very positive feature of the FCEV.
- Seven of the ten drivers rated the vehicle drivability very strongly.

Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak

*"Many of our department use the hydrogen car and we are very pleased with it"*



# Regular drivers' perception of the FCEVs (3)



Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak

- Eight of the ten drivers were positive that the FCEV was able to meet their work needs.
- No negative responses were received to the question.

# Regular drivers' perception of the FCEVs (4)

**Torben Saxtorff, City of Copenhagen Engineering and Environmental Unit :**

*“We are probably the single most consistent users of the hydrogen car.*

*It has been used by supervisors at any time of the day, especially on the city's Metro construction sites, but also in other major projects in the city.*

*The vehicle attracts a lot of attention and many citizens have asked about the car and how it works.*

*It is a very pleasant car to drive. What I enjoy most is the silence”.*

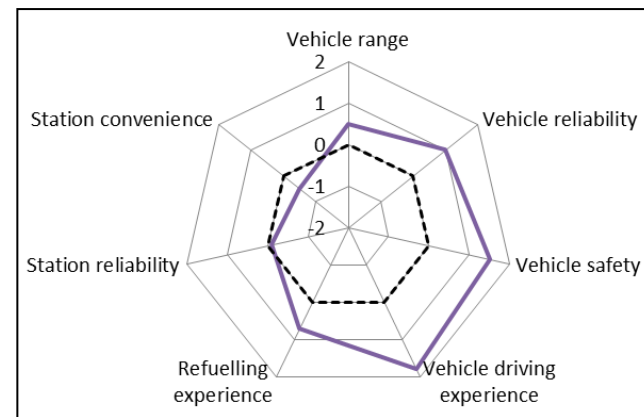
**Jane Källberg Hansen, Head of Section for Cleaning Unit in the Children and Youth Administration:**

*“Many of us in my section use the fuel cell vehicle and every one is very pleased with it”.*

**Lotte Engelund Jensen, Copenhagen Fire Brigade:**

*“The Brigade is very pleased with the fuel cell vehicles; as matter of fact I have been asked if one of them could be used as on-site commander vehicle fitted with blue lights and siren (sadly I had to decline) which shows we are pleased to drive them”.*

Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak



# Regular drivers' perception of the refuelling infrastructure

The drivers' views of the refuelling infrastructure during the trial were generally less positive than those expressed towards the vehicles.

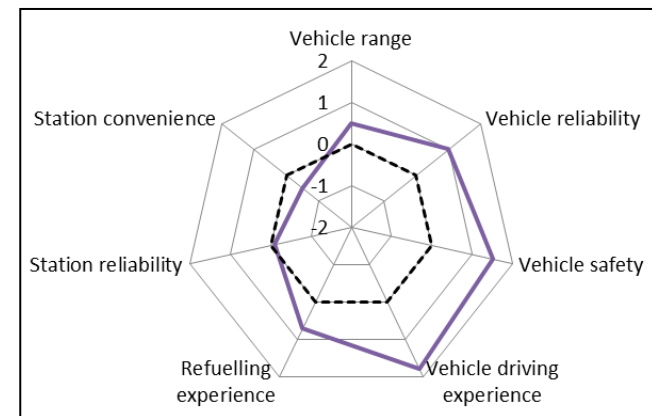
## Refuelling experience

- This was seen as the most positive aspect of refuelling. Most rated this very strongly or strongly.

## Station reliability and convenience

- Most users rated this either as neutral or weak.
- The relatively poor ratings of these aspects are likely to be due to two factors:
  - At the time of the survey there were only two stations operating in Copenhagen. A third station opened in August 2015 in Køge to the south west of the city which will help improve coverage.
  - There were two relatively long (up to three week) planned outage periods to upgrade the two existing stations in January and May 2015. Outside of upgrades and planned maintenance periods, the stations were available for more than 99% of the trial.

Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak



## Moving the technology forward: issues with the refuelling network and actions for improvement

- The users' comments on the refuelling network were fed back to the station manufacturers (H2 Logic) and operators (Copenhagen Hydrogen Network). Their responses are below.

<b>Driver feedback</b>	<b>Response from hydrogen infrastructure provider (H2 Logic) and station operator (Copenhagen Hydrogen Network)</b>
We need larger capacity stations and more stable operation.	The HRS network in Copenhagen has more capacity than needed by the present fleet. However the hourly capacity has from time to time been fully utilised as the City of Copenhagen conducts fleet fuelling, where several vehicles are filled consecutively (similar to a rush hour). In those situations, the last customer may experience an incomplete fuelling.
An expanded SMS service that gives information about the amount of hydrogen in the station would be valuable. Otherwise you fear that you will only be able to half fill your tank.	During the course of the HyTEC project the SMS service was upgraded to state when the station has limited capacity.
Need some hydrogen stations on Funen (Fyn).	Refuelling outside Copenhagen and in the other parts of Denmark is being addressed. A new HRS is planned in Korsør, which is on the main way to the western part of the country, just before Fyn – this will close the gap between HRSs in the west part of the country and Copenhagen.



# Conclusions of the Copenhagen surveys

- When faced with a choice of conventional (petrol/diesel), electric (EV) and fuel cell electric vehicles (FCEVs), over 80% of a sample of 33 Copenhagen municipality car pool users chose electric drive vehicles, with an approximately equal split of EVs and FCEVs.
- The main reason for the choice of a particular vehicle type was past experience with the vehicle. EVs in particular have built a very loyal following amongst users.
- EVs and FCEVs are seen as environmentally-friendly vehicles by the Copenhagen car pool users.
- Conventional vehicles are not seen as environmentally-friendly choices by their users in the Copenhagen car pool; instead these users value vehicle size, comfort and performance.
- Regular Copenhagen FCEV users particularly value the vehicles' driving experience, but also view its safety and reliability relatively favourably.
- Vehicle range was deemed relatively unimportant by these urban fleet users.
- All regular users thought that the FCEV met their work-related needs.
- In general, the regular users generally rated the hydrogen refuelling stations less highly than the FCEVs.
- The users were relatively positive about the vehicle refuelling experience, but were less impressed by the reliability and convenience of the current refuelling network.
- The user feedback has been noted by the station manufacturers and operators and a number of actions have already been taken to improve the refuelling network for future users.

# SURVEYS OF LONDON FCEV TAXI DRIVERS



Level of dissemination: PU (public)



# Introduction

- This presentation summarises the outcomes of surveys and interviews with the drivers of the prototype fuel cell hybrid TX4 taxi conversions which operated in London between 2012-2014 as part of the FCH JU-supported HyTEC project.
- Pre-trial (2012), mid-trial(2013) and end of trial (2014) questionnaires were produced in order to understand the perception of the drivers before and after they had driven the taxis and utilised the refuelling station.
- The questionnaires addressed issues such as:
  - Drivers' knowledge of and attitude towards hydrogen vehicles
  - The users' driving and refuelling experience compared to their previous work vehicle
  - Whether they believe the FCEV taxi and refuelling infrastructure could replace their work vehicle
  - Willingness to pay for hydrogen vehicles
- The drivers also participated in an end of trial discussion session on 17<sup>th</sup> December 2014 where they provided further details on their answers. These comments have been added to the presentation.

# Background

- The taxi vehicle conversion involved the development of bespoke hybrid drive and fuel cell system.
- A key part of the project was to gain feedback from real-world users to highlight the areas for development required for productionisation of the vehicle and to inform the development of future vehicle refuelling solutions.
- The taxis were driven by a pool of four drivers during each year of the trial (2012-2014).
- The drivers were male and in their 50s and 60s.
- All were highly experienced taxi drivers with 20 years+ of driving.
- A number had previously worked with LTI (now LTC) on vehicle testing.
- Two of the drivers completed all three (pre/mid/post) trial surveys.
- Four of the drivers completed two (mid/post) trial surveys.

# Pre-trial information

## Why did you get involved?

- “I was approached by LTI to work on the taxis during the 2012 Olympics as they wanted experienced drivers”.
- “I’ve driven all LTI’s vehicle variants over the last 30+ years and so I’m interested in new technology”.
- “I’m interested in helping to create a better future vehicle for drivers and passengers”.

*“The iconic London taxi shape is instantly recognised worldwide”.*

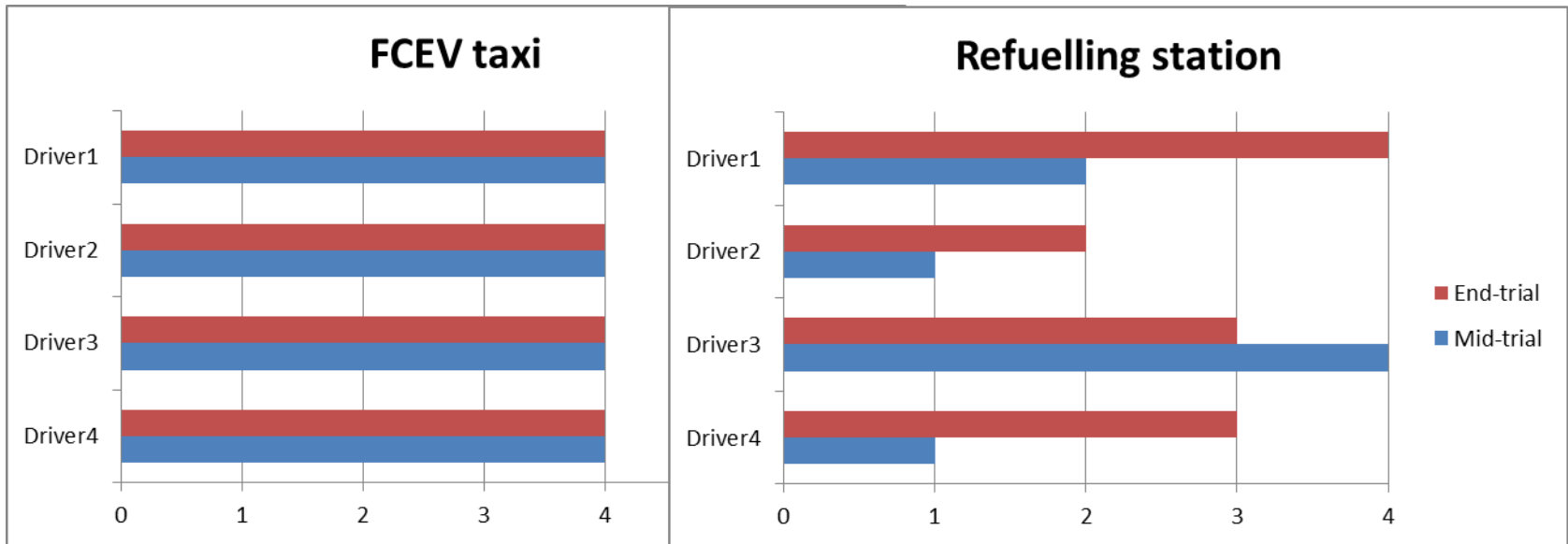
## Previous knowledge of hydrogen vehicles?

- Two of the drivers said they already knew a lot about hydrogen vehicles; two others said they had heard of hydrogen vehicles, but didn’t know a lot about them.

# Sentiments towards the FCEV taxi and refuelling station

- The drivers rated their feelings towards the FCEV taxi and London refuelling station compared to diesel equivalents at mid-trial (2013) and end of trial (2014) based on the key below.

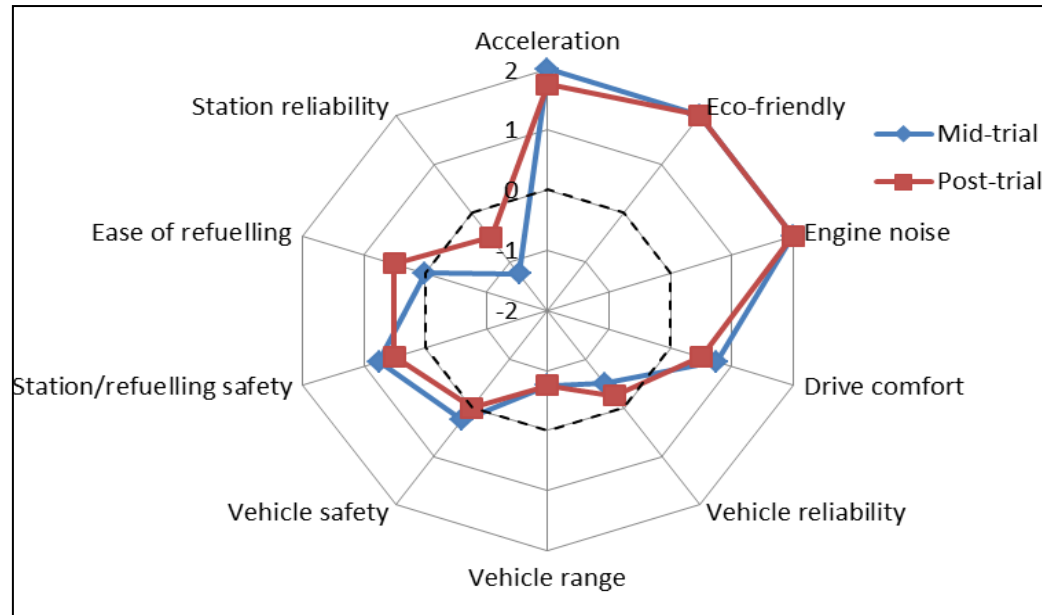
Score	1	2	3	4	5
Description	Very negative	Negative; don't perform well	Neutral	Positive; performs well	Very positive; prefer them



- The drivers' feelings towards the FCEV taxis remained positive through the trial.
- Feelings towards the refuelling station were less positive, but tended to improve as the trial progressed.
- This feedback is explored in further detail in the next slides.

# Perception of the taxis and refuelling infrastructure

- The four drivers were asked to rate aspects of the performance of the FCEV taxis and refuelling infrastructure at mid-trial (2013) and post-trial (2014) according to the scale shown on the right.
- The figure shows the average of the drivers' ratings of each aspect.



Key	
+2	Very Strong
+1	Strong
0	Neutral
-1	Weak
-2	Very Weak

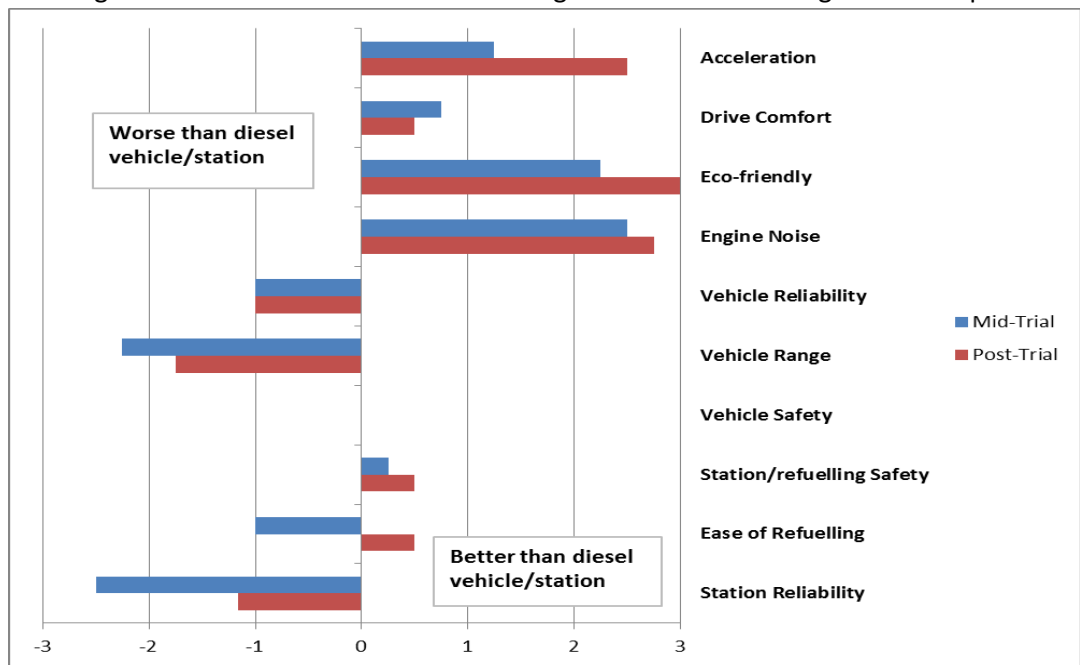
*“Intermittent station reliability, although most problems were resolved shortly after contacting Air Products”.*

*“Obviously these taxis are prototypes and have their own foibles”.*

- The drivers' ratings at mid- and post-trial were broadly similar.
- Vehicle performance:**
  - The drivers viewed the FCEV taxi's acceleration performance, eco-credentials and lack of engine noise very favourably
  - The vehicles were viewed as relatively safe. There were some issues with unexpected loss of hybrid drive (not related to the fuel cell) which resulted in a neutral rather than a positive rating for this aspect
  - The drivers were less impressed by the vehicle's range and reliability
- Refuelling station performance:**
  - The station was viewed as safe and relatively easy to use
  - There were concerns about the station's reliability

# Relative performance of taxis and refuelling infrastructure compared to their diesel equivalents

- The four drivers were asked to rate aspects of the performance of the FCEV taxis and refuelling infrastructure at mid-trial (2013) and end of trial (2014) relative to diesel equivalents according to the scale shown.
- The figure shows the difference of the average of the drivers' ratings of each aspect.



Key	
+3	Very much stronger
+2	Much stronger
+1	Stronger
0	Neutral
-1	Weaker
-2	Much weaker
-3	Very much weaker

*“This is the quietest and most responsive vehicle I’ve driven since I stated driving a taxi nearly 40 years ago. After a day’s driving you do not feel fatigued by the constant drone that you normally get from a diesel taxi”.*

- Vehicle performance:**
  - The fuel cell taxis are viewed considerably more positively than diesel equivalents in terms of acceleration performance, eco-credentials and lack of engine noise
  - The vehicles were viewed as being as safe as diesel vehicles
  - Weak points relative to diesel in this prototype vehicle were range and reliability. Future actions to address these concerns (increased tank volumes and pressure and improved drivetrain robustness) are discussed in the next slide
- Refuelling station performance:**
  - The station was viewed as at least as safe and easy to use as diesel equivalents
  - There were concerns about the station’s reliability, although there is evidence that this improved following the installation of the upgraded refuelling station in May 2014



## Moving the technology forward: vehicle and station issues and actions for improvement

- All of the drivers said they had experienced issues with the vehicles and refuelling station.
- The vehicle issues were fed back to the manufacturers to highlight the areas for development required for productionisation of the vehicle and to provide learning for future vehicle platform developments.
- The refuelling station issues were also fed back to the manufacturers to enhance the refuelling experience for future users.
- The issues highlighted, and the manufacturers' responses, are summarised in the following three slides.

## Moving the technology forward: issues with the prototype FCEV taxis and actions for improvement (1)

<b>Driver feedback</b>	<b>Vehicle manufacturer's (Intelligent Energy) response</b>
The vehicle has frequent electrical and/or software issues. In the main, the drivers understand what is happening and are able to clear them themselves.	Reliability concerns were predominantly caused by the hybridisation of the vehicle and these would be eliminated by the use of a vehicle with a validated hybrid base architecture.
Need to expand the range capability.	The lower range of the taxis shows that additional work must be done to increase storage pressures and integrate larger tanks into future vehicles.
The remaining range feedback in the vehicle is not sufficiently accurate.	

## Moving the technology forward: issues with the prototype FCEV taxis and actions for improvement (2)

Driver feedback	Manufacturer's (Intelligent Energy) response
The lack of vehicle noise means you learn to drive the cab differently to a normal taxi with respect to cyclists and pedestrians.	In 2014 the European Commission issued a regulation requiring electric drive vehicles to emit minimum noise levels by 2019.
The lack of driver feedback on the instrumentation panel and the lack of regenerative braking means there's no incentive to try to drive more economically.	This point is noted and regenerative braking and improved driver visual feedback will be incorporated into future vehicles.
A heater would be nice! The diesel TX4 has a really good heater.	This point is noted and improved heating will be incorporated into all future vehicles.

## Moving the technology forward: issues with the London refuelling stations and actions for improvement (1)

<b>Driver feedback</b>	<b>Response from hydrogen infrastructure provider (Air Products)</b>
There aren't enough stations.	The number of fuelling stations is expected to increase over time. E.g. Since the start of the HyTEC project, when there was only one public hydrogen fuelling station in operation in London, a second public hydrogen fuelling station has become operational in the north of city.
Hydrogen deliveries can be erratic and the station is sometimes out of fuel.	The upgrade to the Heathrow fuelling station has improved its on-stream availability. The fuelling station has experienced one run out since its start of operation in 2012.

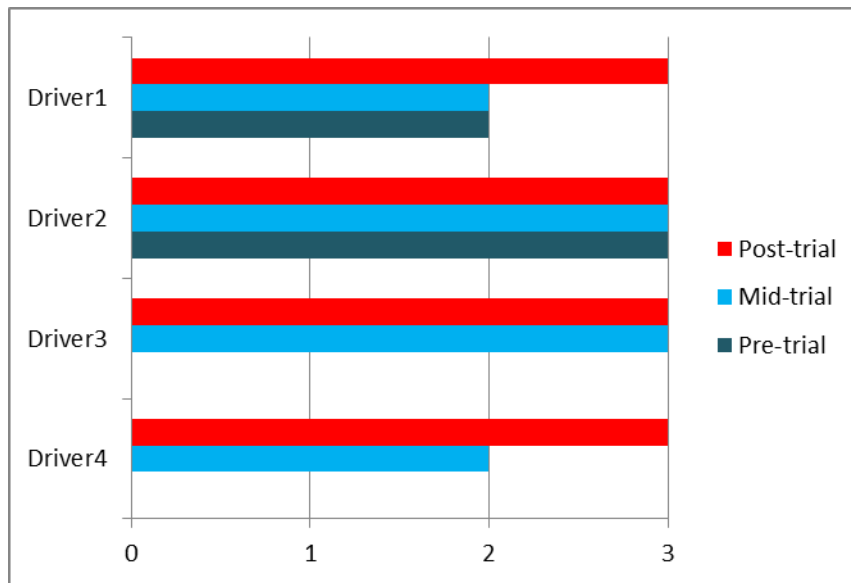
## Moving the technology forward: issues with the London refuelling stations and actions for improvement (2)

<b>Driver feedback</b>	<b>Response from hydrogen infrastructure provider (Air Products)</b>
<p>A remote monitoring system would be valuable so that problems can be detected and therefore fixed quicker.</p>	<p>The upgraded fuelling station has improved remote monitoring capability that will be further improved in the coming months.</p>
<p>The new station is better, but still needs improvement:</p> <ul style="list-style-type: none"><li>- You still can't see the keypad when it's sunny</li><li>- The station has no canopy so you get wet when it's raining</li></ul>	<p>Upcoming improvements to the fuelling station include the provision of a canopy that will improve the user experience.</p>

# Will the FCEV taxis be able to meet your work-related needs?

- The four drivers were asked at pre-trial (2012), mid-trial (2013) and post-trial (2014) whether they believed hydrogen vehicles could meet their work-related needs.
- The drivers answered according to the following key:

Score	1	2	3
Description	No	Maybe	Yes



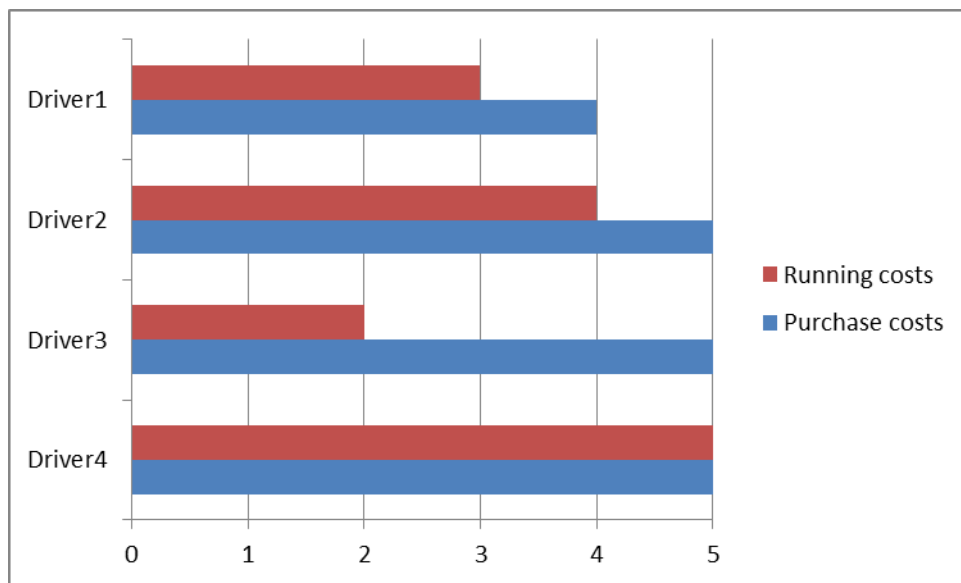
*“It would be an ideal vehicle for the London Ultra Low Emission Zone”*

At the end of the trial all of the drivers believed that the taxis would be able to meet their work related needs.

# Cost of hydrogen vehicles

At the end of the trial drivers were asked their views on what they expect the future purchase and running costs of hydrogen vehicles to be compared to conventional vehicles based on the key below.

Score	1	2	3	4	5
Description	A lot less (> 25%)	A bit less (10-25%)	The same	A bit more (10-25%)	A lot more (>25%)



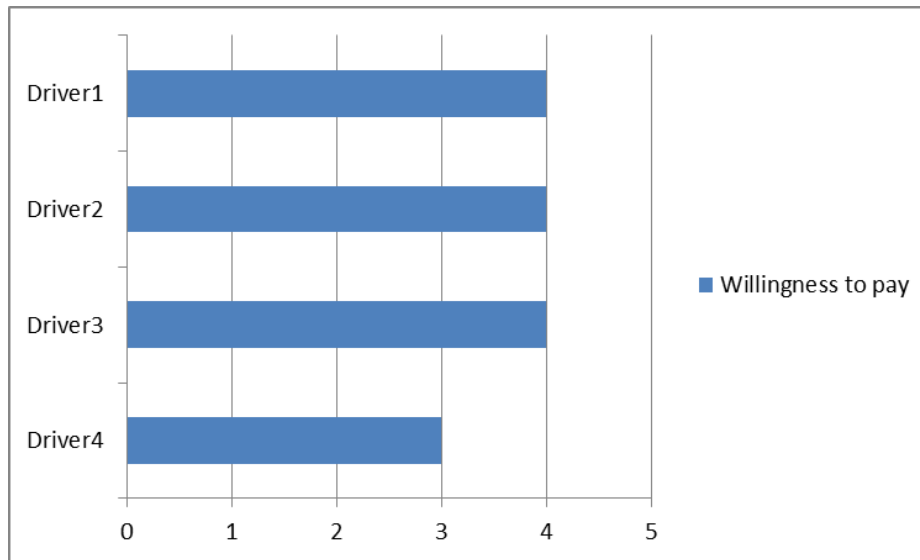
*“If this or a similar vehicle reached production line numbers and was competitively priced I’m sure quite a few drivers would be prepared to move with the times”*

- The drivers expect hydrogen vehicles to attract premium purchase pricing when they are deployed.
- They have divergent views on the expected running costs of hydrogen vehicles.

# Willingness to pay for hydrogen vehicles

At the end of the trial (2014) drivers were asked whether they would be prepared to pay a premium to purchase a hydrogen vehicle based on the key below.

Score	1	2	3	4	5
Description	A lot less (> 25%)	A bit less (10-25%)	The same	A bit more (10-25%)	A lot more (>25%)



*“It’s a difficult question to answer as many owner-driven cabs are acquired through three-year Personal Contract Purchase or similar schemes to private cars”*

*“Currently if you drive 150 miles a day it costs around £25 in diesel. Hydrogen needs to be able to compete with that or drivers need an incentive to change”*

- Most of the drivers would be prepared to pay a small (10-25%) premium to purchase a hydrogen vehicle.
- Fuel costs were noted as being at least of equal importance to many taxi drivers.



# Conclusions of the London surveys (1)

- The drivers of the HyTEC FCEV taxis were surveyed at the start of the trial in 2012, mid-trial (2013) and at the end of the trial in 2014. The drivers also participated in a post-trial discussion session on 17<sup>th</sup> December 2014 where they provided further details on their answers.
- All were highly experienced (20+ years) taxi drivers. They got involved in the trial due to a wish to improve the taxis and interest in new technologies.
- All the drivers viewed the FCEV taxi positively throughout the trial. Feeling towards the refuelling station were more negative, but improved as the trial progressed.
- The main assets valued in the FCEV taxi compared to its diesel equivalent were acceleration, lack of noise and eco-friendliness. The vehicle's range and reliability were viewed less favourably.
- The drivers gave a number of suggestions for improving the FCEV taxi, including better driver feedback on range and the addition of a heater.
- The trial outcomes and drivers' feedback have been noted by the vehicle manufacturer and fed back into its future vehicle development process. Reliability concerns were predominantly caused by the hybridisation of the vehicle and these would be eliminated by the use of a vehicle with a validated hybrid base architecture; range concerns will be addressed by larger tank sizes and pressures in future platforms.

# Conclusions of the London surveys (2)

- The refuelling station was viewed as safe and relatively easy to use. Its reliability was viewed relatively poorly, but was seen to improve after a new upgraded station was installed.
- The drivers requested a rain canopy and a keypad that was more easily visible in bright sunlight to improve the refuelling station, plus remote monitoring for earlier problem detection.
- The trial findings and driver feedback were noted by the station manufacturer and will be addressed in station upgrades planned to take place by 2016.
- All drivers believed that the FCEV taxi could be used as their work vehicle.
- At the end of the trial the drivers said they would be willing to pay a small (10-25%) premium for a hydrogen vehicle, but also noted the need to provide incentives for uptake if the running costs are not comparable to those of a diesel taxi.

# CONCLUSIONS



Level of dissemination: CO (confidential)



# Conclusions: introduction

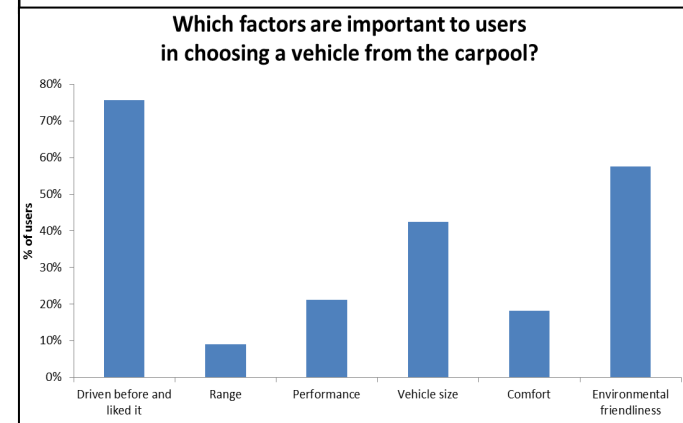
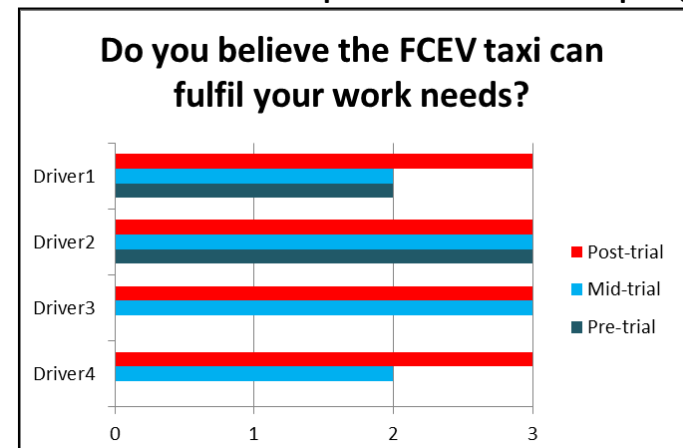
- A number of previous studies<sup>1</sup> have assessed user attitudes to hydrogen vehicles. These studies have generally been carried out:
  - With the general public, not working fleet users.
  - Without offering hands-on experience of hydrogen vehicles to those being surveyed.
- The end-user engagement work carried out during HyTEC is amongst the first<sup>2</sup> where fuel cell electric vehicles (FCEVs) were deployed with working fleets, and their users surveyed about their attitudes to the FCEVs and associated refuelling infrastructure.
- Due to time and budgetary limitations, the HyTEC surveys have not been conducted with the full rigour of some studies (e.g., there was no the use of a control group who were not given access to an FCEV), and the number of responses was limited by the number of people taking part in the trial.
- However, a number of broad conclusions can be proposed from the information presented in this report and the previous report *HyTEC Pre-Trial Surveys* (deliverable 6.10). These are presented in the following slides.

<sup>1</sup> For examples, see: Martin et. al., *Behavioural response to hydrogen fuel cell vehicles and refueling: Results of California drive clinics* and Truett et. al, *Compendium: Surveys Evaluating Knowledge and Opinions of Hydrogen and Fuel Cell Technologies*.

<sup>2</sup> For a recent fleet end-user survey, see Lipman et al, *Hydrogen Fuel Cell Bus Driver Response in a Real World Setting: Study of a Northern California Transit Bus Fleet*.

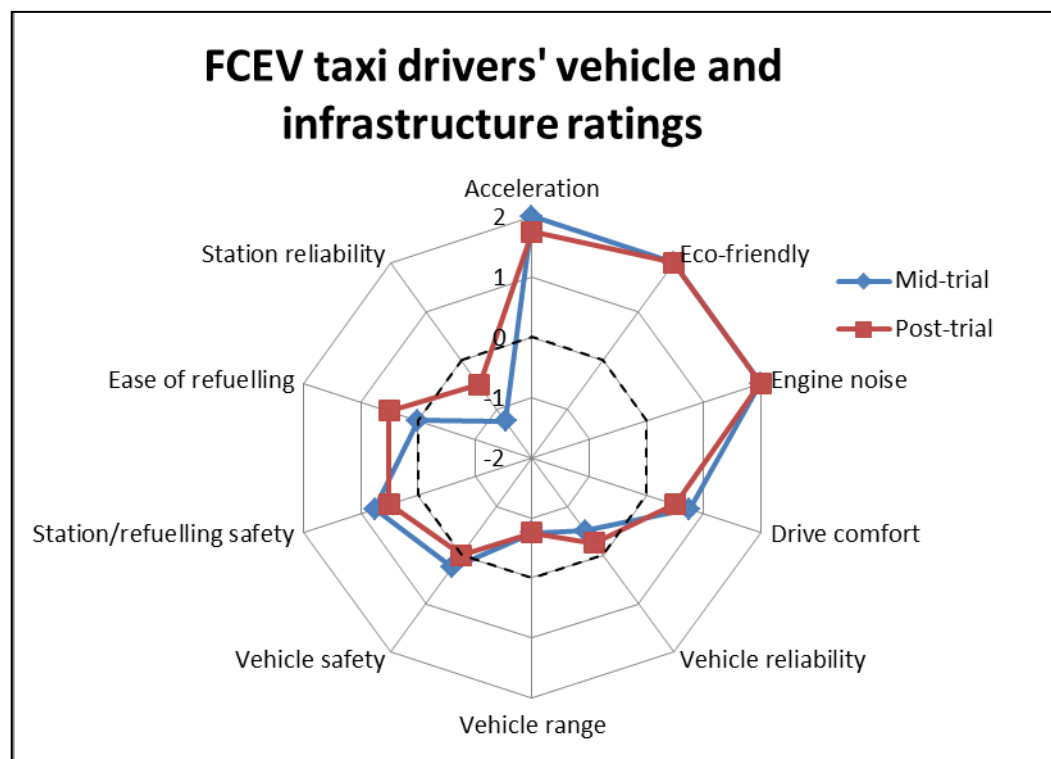
# Conclusions: 1. hands-on experience of vehicles is important

- Previous reports on hydrogen technologies have noted the importance of allowing end-users to get hand-on experience of the technology to allow them to gain an informed opinion of the vehicles.
- This work has confirmed the importance of hands-on vehicle experience in shaping user opinion and choice:
  - For the London FCEV taxi drivers, ongoing driving experience meant that by the three-year trial period all believed that the FCEV taxi could substitute for their work vehicles.
  - In Copenhagen, prior vehicle experience was shown to be the most important reason for a user's choice of a particular vehicle.



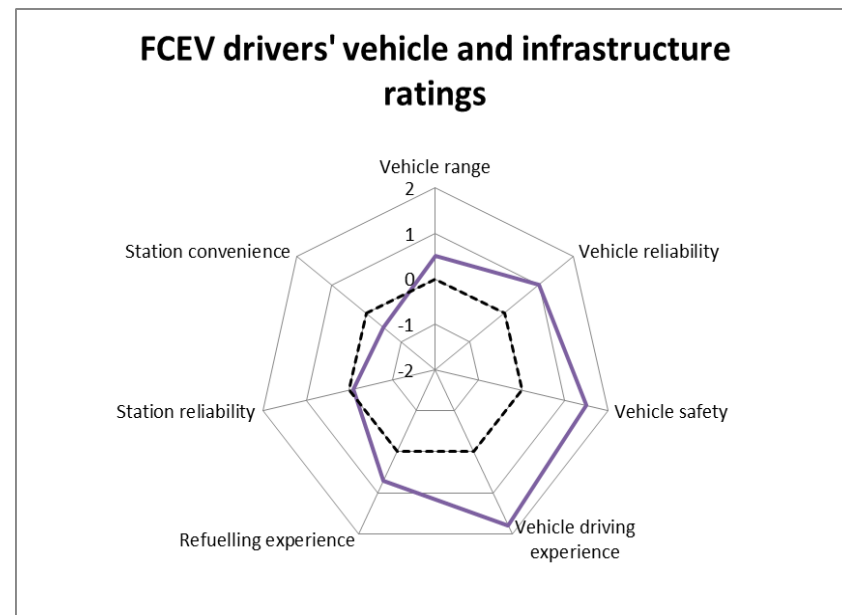
## Conclusions: 2. direct experience of FCEVs results in them being rated positively by end-users

- Direct experience of FCEVs has resulted in the end-users generally having very positive experience of the vehicles.
- End-users believe driving an FCEV is environmentally-friendly.
- Most aspects of the vehicles were rated positively, with users particularly highlighting:
  - Driving experience
  - Quietness



## Conclusions: 3. hydrogen refuelling stations tend to be judged more harshly by end-users

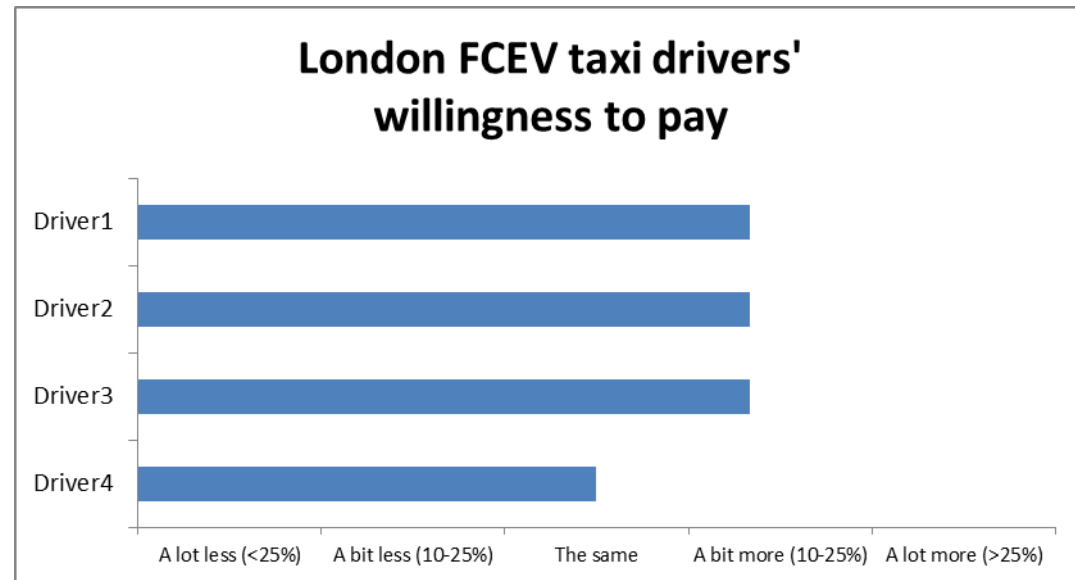
- In Copenhagen and London, hydrogen refuelling stations tended to be given lower ratings by users.
- For example, despite the fact that users generally found the HRS easy to use and there were no complaints from users about the refuelling process, the Copenhagen users on average rated the station refuelling experience at 0.75 compared to the vehicle driving experience rating of 1.8.
- There are a number of potential contributory factors to this, including:
  - Users complained about the inconvenience of refuelling due to current scarcity of the refuelling network. This may increase their general level of dissatisfaction with FCEV refuelling.
  - Using the language of Herzberg's motivation factors\*:
    - Refuelling can be considered a *hygiene factor*: if it works well, users will not particularly notice it (i.e., will tend to be relatively neutral about it) as it is considered to be the same as its petrol/diesel equivalent. It will only be when hydrogen refuelling showed a particular positive improvement over conventional refuelling (e.g., in terms of speed or cleanliness) that it will attract more positive ratings.
    - Driving an FCEV can be considered a *motivator*: as discussed previously, users see differentiating factors such as the lack of noise of the FCEV as *positive improvements* compared to petrol/diesel equivalents, and rate the FCEV driving experience accordingly.



\* Herzberg's two-factor motivation theory is used in discussing workplace satisfaction: *hygiene factors* serve only to cause dissatisfaction, whereas *motivators* can lead to positive satisfactory experiences.

## Conclusions: 4. positive feelings about FCEVs are not enough for fleet users – purchase and running costs must also be considered

- The London FCEV taxi drivers pay for their own vehicles, in contrast to the Copenhagen municipal fleet users.
- The London FCEV taxi users were enthusiastic about the vehicles, but in general only expressed a willingness to pay a small premium (10-25%), or no premium, for the vehicles.
- The London taxi drivers stressed the importance of running costs in making vehicle purchases, citing the cost of running an equivalent diesel taxi as the comparator they would use.





## Conclusions: 5. trials and user interaction provide valuable feedback to vehicle and station manufacturers to advance their technology

- For example, the London taxi vehicle conversion involved the development of bespoke hybrid drive and fuel cell system.
- The FCEV taxis were driven by a regular pool of drivers who, as well as participating in the user-engagement workstream described in this report, were constantly in touch with Intelligent Energy who developed the fuel system and managed the trial of the vehicles in London.
- In Copenhagen and London two-way interaction between the manufacturers and users during the project has provided valuable feedback for future vehicle and station development.

London FCEV taxi driver feedback	London FCEV taxi manufacturer's (Intelligent Energy) response
The lack of vehicle noise means you learn to drive the cab differently to a normal taxi with respect to cyclists and pedestrians.	In 2014 the European Commission issued a regulation requiring electric drive vehicles to emit minimum noise levels by 2019.
The lack of driver feedback on the instrumentation panel and the lack of regenerative braking means there's no incentive to try to drive more economically.	This point is noted and regenerative braking and improved driver visual feedback will be incorporated into future vehicles.
A heater would be nice! The diesel TX4 has a really good heater.	This point is noted and improved heating will be incorporated into all future vehicles.