Hydrogen For Innovative Vehicles

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Glossary

CEP *Clean Energy Partnership*

CHIC *Clean Hydrogen In European Cities*

E/F *Executive/Full-Size Luxury vehicle*

FCEV *Fuel Cell Electric Vehicle*

FCHJU *Fuel Cells and Hydrogen Joint Undertaking*

GLA *Greater London Authority*

H2ME *Hydrogen Mobility Europe*

HRS *Hydrogen Refuelling Station*

HyTEC *Hydrogen Transport in European Cities*

MAF *Monitoring Assessment Framework*

NOW *National Organisation Hydrogen and Fuel Cell Technology*

OEM *Original Equipment Manufacturer (car manufacturer)*

PHV *Private Hire Vehicle*

RCS *Regulations, Codes and Standards*

TCO *Total Cost of Ownership*

ULEV *Ultra Low Emission Vehicle*

WTW *Well-to-Wheel*

Contents

Executive Summary

The Hydrogen for Innovative Vehicles (HyFIVE) project has brought together the most innovative European hydrogen initiatives in the transport sector since its inception in 2014.

HyFIVE is an ambitious flagship project that has committed four years to demonstrating the commercial viability of hydrogen vehicles and stations in Bolzano, Copenhagen, Innsbruck, London, Munich and Stuttgart. HyFIVE has seen the delivery of six new refuelling stations, integrating an existing nine, with an initial plan to deliver 110 vehicles – this was revised to 185 in 2016.

BMW, Daimler, Honda, Hyundai and Toyota - HyFIVE's vehicle manufacturers - are leading the global movement in shifting the market from diesel and gasoline to greener, more sustainable fuels.

Over 100 vehicles have been operating within the project's Southern cluster (a region comprising Bolzano, Innsbruck, Munich and Stuttgart) for the duration of the project, utilising the existing hydrogen infrastructure network. It is through HyFIVE that the additional hydrogen refuelling station in Innsbruck was installed strengthening the connection between Germany and Austria. Additionally, two new stations in Aarhus and Korsør were installed in Denmark raising the country's HRS number to 10 and therefore giving Denmark the status of having the world's first national hydrogen station network. This development inspired the Danish government in 2017 to announce a 10 million DKK fund for FCEV and HRS growth. Lastly, London has seen three new refuelling stations and the UK government plans to phase out diesel and gasoline cars by 2040, and furthermore recognises that hydrogen is a practical solution for decarbonising our roads and reducing air pollution.

We have effected notable changes to policy across Europe, transforming the policy environments to commercialise the sector and prepare the market for high volumes of hydrogen vehicles and interoperable stations.

Notable regulatory developments led by HyFIVE include:

- the co-integration of conventional stations with hydrogen pumps, including a new relationship between ITM Power and Shell to expand and commercialise London's HRS network;
- tax exemption for FCEVs has been extended in Denmark to 2019[1];
- in 2017, the maximum supply pressure limit for hydrogen was raised from 350 bar to 700 bar in Italy – the value needed for modern cars[2].

Remaining challenges for FCEV commercialisation in Europe is primarily focussed on further development of HRS networks, and their financial viability, performance and utilisation.
In this report, the project partners share the objectives, conclusions and lessons learnt from HyFIVE.

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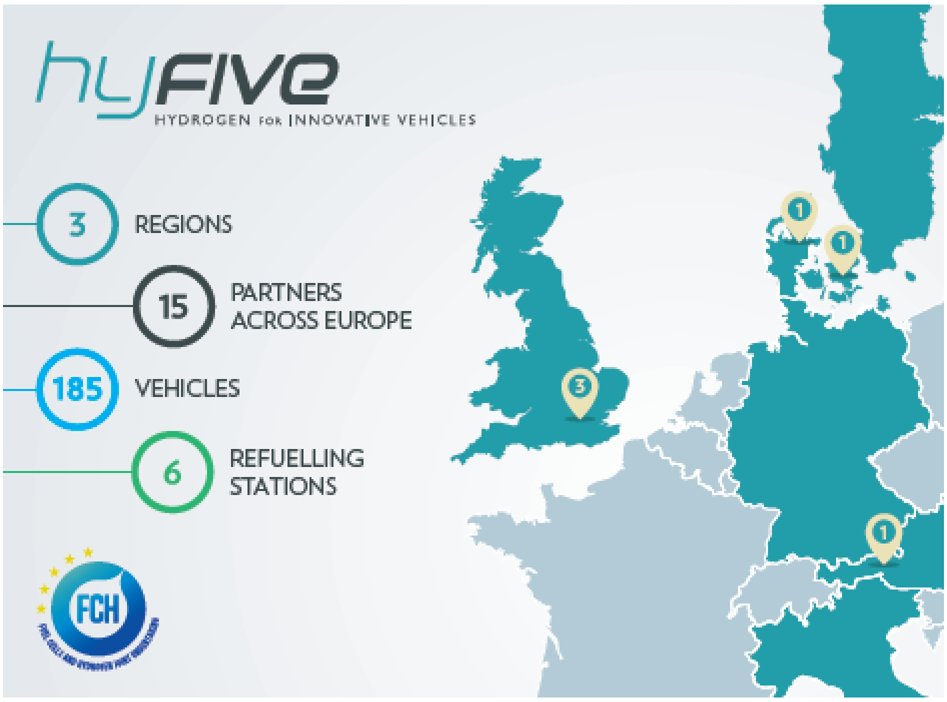
[1] http://www.hyfive.eu/latest-news/danish-government-agree-to-run-tax-exemption-for-fcevs-to-2019/
[2] https://www.iphe.net/italy

1. Project Context and Objectives



1.1 Project Background

- HyFIVE was an FCHJU-funded European project operating between 2014 – 2018, which aimed to deploy up to 185 FCEVs from the five global automotive companies leading the commercialisation of FCEVs (BMW, Daimler, Honda, Hyundai and Toyota);

- The new vehicles deployed have different maturity levels, from prototype level up to commercial production, with performance characteristics and cost reduction targets which will lead to a plausible offer for early adopting customers;

- To serve these vehicles, the project has created clusters of refuelling station networks in three parts of Europe, where there are a sufficient density of hydrogen stations to provide refuelling choice and convenience to early users of FCEVs;

- The project has deployed six new stations: three in the London cluster (ITM Power), two in the Copenhagen cluster (Danish Hydrogen Fuel (DHF)) and one in the Southern cluster (OMV).

These are linked with 12 existing stations[3] orginally supplied by Air Liquide, Air Products, BOC, Copenhagen Hydrogen Network (CHN), the Institute of Innovative Technologies (IIT), Linde, OMV and TOTAL. This has led to new networks in the most promising early adopter regions for FCEVs across Europe – London cluster, the Copenhagen cluster and a southern region comprising Bolzano, Innsbruck, Munich and Stuttgart;

- The project's scale and pan-European breadth has enabled it to tackle all the final technical and social issues preventing the commercial rollout of hydrogen vehicles and refuelling infrastructure across Europe.

1.2 Consortium members and contribution to project[4]

Project participant	Project role
AIR PRODUCTS	**Make two of the three[5] existing Air Products-operated HRSs in the London cluster available to users of vehicles under HyFIVE, and investigate the opportunity to source renewable hydrogen.**
BMW	**Develop, deploy and test three E/F segment FCEVs with a high-performance drive-train. This will allow for BMW typical driving dynamics similar to a conventional gasoline vehicle.**
DAIMLER	**Deploy and test four of the latest generation B-Class F-CELL FCEVs and two of the next generation GLC FCEVs.** **Leader of the Vehicle Deployment and Operation work package.**
Danish Hydrogen Fuel	**Own and operate the hydrogen refuelling station in Aarhus and Korsør.** **Leader of the Infrastructure Development, Deployment and Operation work package.**

[3] Three of the 12 stations do not supply data to the project but continue to officially form part of the project's network (Air Liquide – Malmø, Sweden; Air Products – London, England; and BOC – Swindon, England). Therefore, the three stations have limited reference within this report.
[4] Official delivery partners.
[5] The 3rd station is solely a hydrogen bus station; therefore, Air Products is not responsible for ensuring HyFIVE vehicles have access to refuelling here.

Brintbranchen Hydrogen Denmark	Regional coordinator of activities in the Copenhagen cluster. Support the OEMs in identifying potential early adopters of FCEVs. Brintbranchen ensures effective national dissemination of the key findings and recommendations from the project.
elementenergy	Provide support to the HyFIVE coordinator (GLA) in overall management of the project. Coordinate and facilitate deployment activities in the London cluster. Leader of the Consumer Attitudes and Commercialisation Pathways work package.
GREATERLONDONAUTHORITY	Overall project coordination – manages progress of the project, acts as point of contact with the FCHJU, responsible for finance management, reporting and leads on EU-wide dissemination.
HONDA The Power of Dreams	To deploy six Clarity Fuel Cell vehicles and develop service concepts in the London and Copenhagen clusters.
HYUNDAI NEW THINKING. NEW POSSIBILITIES.	As the first mass production car manufacture, Hyundai intends to supply 150 ix35 Fuel Cell vehicles within the London, Copenhagen and Southern clusters.
iit	The coordinator of the southern cluster, and will make the existing HRS in Bolzano available to users of vehicles under HyFIVE and investigate the opportunity to have 700 bar refuelling in Italy.
ITM POWER Energy Storage | Clean Fuel	Deploy, own and operate three hydrogen refuelling stations in London.
THE LINDE GROUP Linde	Make the existing Linde-operated HRS in Munich and Swindon[6] (via the local subsidiary BOC) available to users of vehicles under HyFIVE.

[6] See footnote 3.

OMV	**Make the existing OMV-operated HRS located at Stuttgart Airport available to users of vehicles under HyFIVE.** **Deploy and operate a new HRS in the Southern cluster (Innsbruck) to connect Austria to the European network of hydrogen refuelling stations.**
thinkstep	**Leader of the Performance and Safety Data Collection, Analysis, and Reporting work package.** **Thinkstep will ensure a comprehensive collection of data throughout the project to test the market readiness of the technology, including analyses of the technical, environmental and economic status of the vehicles.**
TOYOTA	**To deploy and operate up to 20 FCEV vehicles within the London, Copenhagen and Southern clusters.**

2. Work Package Background

2.1 Work Package 1 – Coordination (GLA)

- Managed the overall progress of the demonstration, research and dissemination activities, to ensure the speedy delivery of the project deliverables and milestones;
- Ensured intensive and open communication between the project partners on both a national and international level to encourage partners and stakeholders to share best practices, and to ensure efficient management of the project at each demonstration site;
- Acted as the public face of the project, interfacing with the other major European demonstration projects and communicating about the project on an international level;
- Reported to the FCHJU on the progress of the project via progress reports and personal meetings/teleconferences whenever required;
- Coordinated collaboration and provided access to hardware, relevant learning and data to other FCHJU and EU initiatives;
- Regional coordinators were established in the Copenhagen and Southern clusters to provide local coordination of the demonstration and dissemination activities taking place in each region, ensuring that the refuelling stations and vehicles are delivered on time and that their local impact is maximised.


Left: The GLA, FCHJU and OEMs collaborated with the H2ME and CHIC projects to showcase European projects at the International Transport Forum in Leipzig, Germany (2016).

Right: The first new generation Honda Clarity Fuel Cell vehicles arrive in the UK (2016).

2.2 Work Package 2 – Infrastructure Development, Deployment and Operation

- Deployed and operated six new state of the art hydrogen refuelling stations (compatible with the SAE J2601 and ISO standard) to expand the existing hydrogen networks, maximise refuelling coverage and enable early market deployment;
- Integrated these new stations into existing clusters to create viable networks for the early rollout of hydrogen vehicles in each region;
- Achieved an average price of hydrogen below 10 Euros/kg (excluding VAT) across the HyFIVE network and demonstrated progress in the design and supply of affordable hydrogen refuelling solutions towards the commercial targets required by the H2Mobility initiatives and equivalent activities in other members states;
- Achieved an operational reliability more than 98 per cent for each refuelling facility;
- Collected performance statistics for all operational refuelling stations included in the HyFIVE project;
- Ensured that well over 50 per cent of the hydrogen consumed across the project will be produced from renewables;
- Established forums to allow sharing of knowledge during the demonstration project regarding: the deployment of refuelling stations in each region, the training of technicians, information for first responders, network operation issues and any safety issues encountered;
- Trained of first responders in each region.

Current HRS deployment status (as of March 2018):

- Teddington – National Physical Laboratory – ITM (London Cluster)
- Rainham – Centre of Engineering and Manufacturing Excellence – ITM (London Cluster)[7]
- Cobham – ITM (London Cluster)
- South Copenhagen/Sydhavnen – CHN (Copenhagen Cluster)
- West Copenhagen/Köge – CHN (Copenhagen Cluster)
- North Copenhagen/Gladsaxe – CHN (Copenhagen Cluster)
- Malmö – Hydrogen Sweden (Copenhagen Cluster)
- Aarhus – DHF (Copenhagen Cluster)
- Korsør – DHF (Copenhagen Cluster)

[7] Solar-powered HRS

The above HRSs are currently operational and produce hydrogen through onsite or central generation via the electrolysis of water[8].

- Hatton Cross – Air Products (London Cluster)
- Hendon – Air Products (London Cluster)
- Leytonstone – Air Products (London Cluster)
- Swindon – BOC (London Cluster)
- Demoldstrasse – TOTAL (Southern Cluster)
- Stuttgart Airport – OMV (Southern Cluster)
- The IIT Centre – IIT – (Southern Cluster)
- Innsbruck – OMV (Southern Cluster)
- Munich Lohhof Hydrogen Centre – Linde (Southern Cluster)

The above HRSs are currently operational and use hydrogen that has been obtained via natural gas[9].

ITM Power's third station marked the final station to be delivered in the project (2017). Their station in Cobham, Surrey is the first hydrogen station to be integrated with a large-scale commercial fuel provider which is a testament to the project's success in making hydrogen marketable.

[8] As the cost of renewable energy becomes more competitive, hydrogen can be regularly produced from renewable fuels. In addition to electrolysis from water, other ways of producing hydrogen could include renewable hydrogen being generated through energy from waste facilities, recovery from biogas and/or biomass, and by sourcing it as a by-product from other processes.

[9] Hydrogen can be produced from existing fuels like oil, petrol, liquefied petroleum gas (LPG), natural gas, or by using electricity (including from renewable sources via the electrolysis of water). Currently most hydrogen comes from natural gas, by steam reforming of the hydrocarbon feedstock to produce synthesis gas (syngas), primarily a mixture of hydrogen and carbon monoxide.

2.3 Work Package 3 – Vehicle Deployment and Operation

The overarching aim of this work package was to initially deploy 110 FCEVs, in 2016 this was revised to delivering 185 FCEVs within the three geographic clusters. 154 vehicles were subsequently delivered by BMW, Daimler, Honda, Hyundai and Toyota therefore meeting our original objectives. The vehicle manufacturers prepared and developed the momentum behind the full commercial introduction of FCEVs, which is expected by 2020 for all the vehicle manufacturers in the project.

Achieved sub-objectives include:

- First European test of new fuel cell models: Each of the OEMs manufactured advanced FCEVs which were either designed for either commercial or prototype production. Hyundai delivered a large fleet of their ix35 vehicles already in series production. Honda, Daimler, and Toyota delivered their respective next generation FCEVs which were targeted at series manufacture, and used the project to validate the performance of FCEVs on European roads and with European customers. BMW used the project as an opportunity to demonstrate their new luxury E/F segment FCEV prototype, and to test advanced vehicle operation and maintenance strategies;
- The project enhanced the technical readiness of FCEVs for genuine commercial deployment in Europe from 2014[10];
- The vehicles operated for at least 12 months or 10,000 km and were equipped with a vehicle management system which allowed the OEMs to gather detailed system performance data for analysis of vehicle performance and optimisation of future vehicles incorporating a fuel cell drivetrain. Data from this system was transferred to our data research leader, thinkstep, for each vehicle to assess the fleet performance, and the associated lessons learnt in WP4 and WP5;
- All FCEVs met the FCHJU technical requirements for passenger car demonstration;
- The OEMs each created their own commercial-ready set of support services for the vehicles in the clusters where they are active. This includes maintenance, after-sales support, a strategy for road-calls, a servicing regime, spare parts etc. The lessons learnt and best practice from this after-sales set-up and the major barriers is reported in WP5;
- Established local FCEV servicing capability: BMW, Daimler, Hyundai, Honda and Toyota trained local dealerships and / or technicians on the FCEVs' technical and safety aspects, and upgraded garages for guaranteeing a safe environment for FCEV servicing and develop training protocols;
- Assessed different early adopter strategies – the project included a range of end users from large corporate fleet users to private individuals. These end users were identified by the

[10] 2014 – the year the FCEVs in the project were first delivered to end users.

OEMs during the project, which allowed different approaches for assessment, with the learning shared amongst the OEMs;

- Each OEM used the project to gather consumers' detailed feedback on the real-world performance of their vehicles and the overall consumer experience (i.e. including after-sales support, refuelling, maintenance etc.) to understand customer requirements and fine-tune the vehicle offer before serial production.

First handover of vehicles in the project: 10 Hyundai ix35 vehicles to the IIT Centre in Bolzano, Italy (2014).

2.4 Work Package 4 - Performance and Safety Data Collection, Analysis, and Reporting (thinkstep)

The overall objective of this work package was to collect data to allow policy makers, early adopters of the vehicles and the industry partners to validate the readiness of the technology for full commercial rollout. This required an assessment of the technical, environmental and economic performance of all vehicles and refuelling infrastructure in this project against a common framework. This led to the following completed sub-objectives:

- Framework: Established a common performance data monitoring, gathering and analysis protocol for FCEVs and refuelling infrastructure, based on a) the HyLights' MAF; b) compatibility with the data-sharing principles of the CEP; and c) consistent with the protocols adopted by the other large EU demonstration projects such as HyTEC, H2Moves Scandinavia, CHIC;

- Technical: produced quarterly reports summarising the performance of the vehicles and refuelling stations in operation. Summary statistics will be made available on the project website in autumn 2018;
- Environmental: produced a WTW analysis on the environmental performance of the vehicles and refuelling infrastructure, including the different hydrogen fuel supply options later adopted in the project;
- Economic: carried out a TCO assessment of the vehicles in use based on available data provided by OEMs, and compared the findings against a) incumbent vehicles and b) the projections being used from the latest studies on FCEVs (Power-trains for Europe[11] and the national H2Mobility-type initiatives);
- Safety: recorded the safety issues experienced during the project; assessed the current state of RCS in each region; recorded evidence on safety issues to promote codes and standards development and harmonisation across Europe.

2.5 Work Package 5 – Consumer Attitudes and Commercialisation Pathways (Element Energy)

The overall objective of WP5 was to bring together the project's experiences to develop clear recommendations on appropriate strategies for the early commercial phase of hydrogen rollout, with

[11] http://www.fch.europa.eu/node/786

respect to: identifying the earliest adopters of vehicles, establishing sales and support services, the technical and economic trajectory of the vehicles and the political and regulatory regimes in which the vehicles operate.

The finalised sub-objectives are:

- Use data from the OEMs and surveys with potential customers who have encountered the vehicles to understand the factors likely to affect purchasing decisions of the earliest FCEV customers;
- Developed and refined successful strategies for the commercial rollout of FCEVs by reviewing the early adopter deployment strategies pursued in each of the clusters and capturing lessons learnt;
- Identified barriers to uptake based on the consumers' perception of FCEVs and the associated refuelling networks deployed in the project;
- Interviewed the actors involved with the OEM supply chains (dealerships, customer service, technical centres etc.) to develop in each country an established best practice approach for the after-sales and technical support for the vehicles, and to identify specific barriers which could delay commercial rollout;
- Established a series of task forces to exchange knowledge and best practice on the outstanding technical issues which have the potential to delay the rollout from an HRS perspective: fuel metering, quality assurance, network operation, and rush-hour filling of vehicles and tank behaviour, in collaboration with other FCHJU-backed programmes;
- Provided an assessment of the technology status (based on the demonstration results) and the projected developments in vehicle offers and likely price trajectories from the OEM partners (based on an aggregation of OEMs' proprietary data), which was then used to help justify and develop local policies to underpin FCEV adoption across Europe;
- Assessed the impact of the current policy regime on FCEVs and the likely impact this will have on FCEV uptake in each of the five countries where vehicles are deployed.

Daimler B-Class F-CELL refuelling at OMV's HRS in Innsbruck, the first station delivered in HyFIVE (2015).

2.6 Work Package 6 – Dissemination (GLA)

The overarching aim of this work package was to disseminate a set of messages and lessons which are consistent with the project outcomes and industry plans for the sector to a targeted audience. The dissemination aimed to spread a positive and accurate message about the commercial rollout of hydrogen transport, which ensured buy-in from the key actors (early adopters, political decision makers and opinion formers), informing and engaging the public without mismanaging public perception and leading to ungrounded expectations ('hypes'). This was achieved via the following sub-objectives:

- Tailored and agreed the project's dissemination messages for the target audiences on a cluster-by-cluster basis;
- Ensured that potential early adopters in each of the countries covered by the project (Denmark, Austria, Sweden, Italy, Germany and the UK) were aware of the benefits of FCEVs as a viable zero emission transport solution, and that the future for a hydrogen refuelling network rollout are well publicised;
- Ensured that national and European decision makers are informed of the project's achievements, the industry's plans for the commercialisation of hydrogen and FCEVs, and the political decisions which are required to underpin the rollout;

- Ensured that opinion formers (such as NGOs, television and newspaper reporters, bloggers, tweeters, etc.) are informed about the project's achievements in the context of the wider plans for hydrogen commercialisation;
- Created a project website[12] and social media presence[13] which acts as a platform for pan-European engagement, communication and dissemination activities, and for sharing project data and updates between partners;
- Facilitated the use of the vehicles and stations for other European engagement and dissemination activities;
- Organised a large conference of relevant stakeholders at the end of the project to communicate the results and next steps[14].

The project was showcased at over 100 events across Europe to positively disseminate the capabilities and benefits of hydrogen.

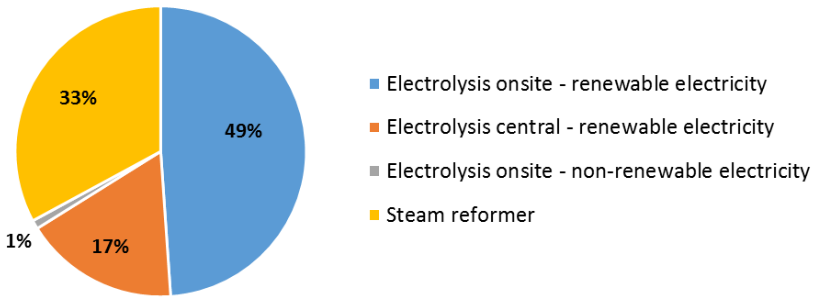
12 www.hyfive.eu
13 www.twitter.com/LDN_environment
14 http://www.hyfive.eu/latest-news/hydrogen-for-clean-transport-conference/

3. Science and Technology Results

3.1 Well-to-Wheel Analysis

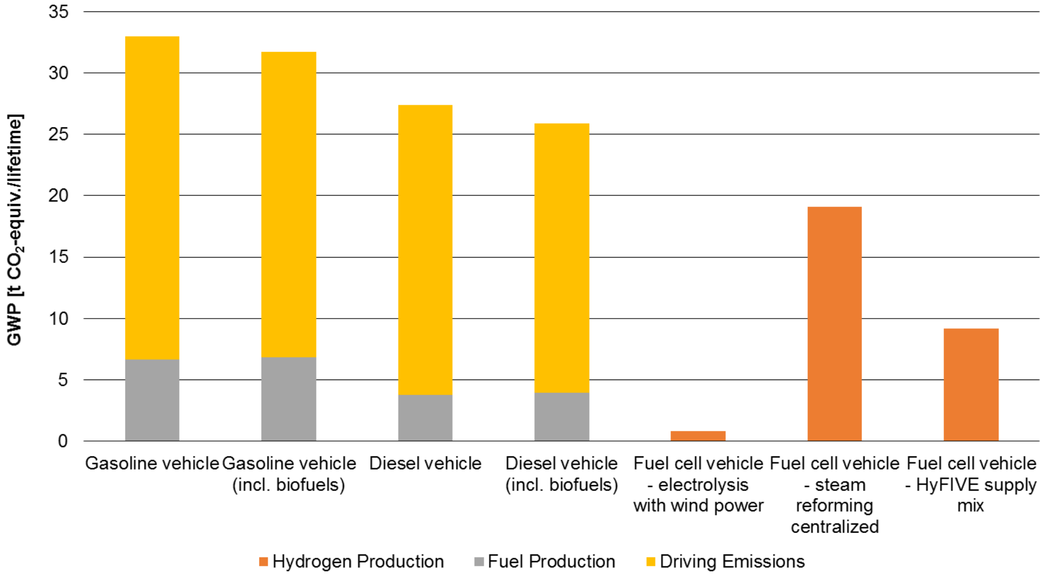
A key objective of HyFIVE was to understand the environmental performance of FCEVs and refuelling infrastructure including different hydrogen fuel supply options. Through analysing the WTW of the project's technology, we achieved an objective comparison with conventional diesel and gasoline vehicles. Our findings also include an environmental benchmark against conventional vehicles.

The diagram below summarises the hydrogen production pathways and energy carriers used in HyFIVE from the project's inception through to the end of 2016. Around two thirds of the dispensed hydrogen were produced via electrolysis with electricity supplied by renewable energy, only 1 per cent was produced via electrolysis using electricity from fossil energy, and one third was produced from natural gas via steam reforming.



Hydrogen supply by technology and energy carrier in HyFIVE (project start – end 2016)

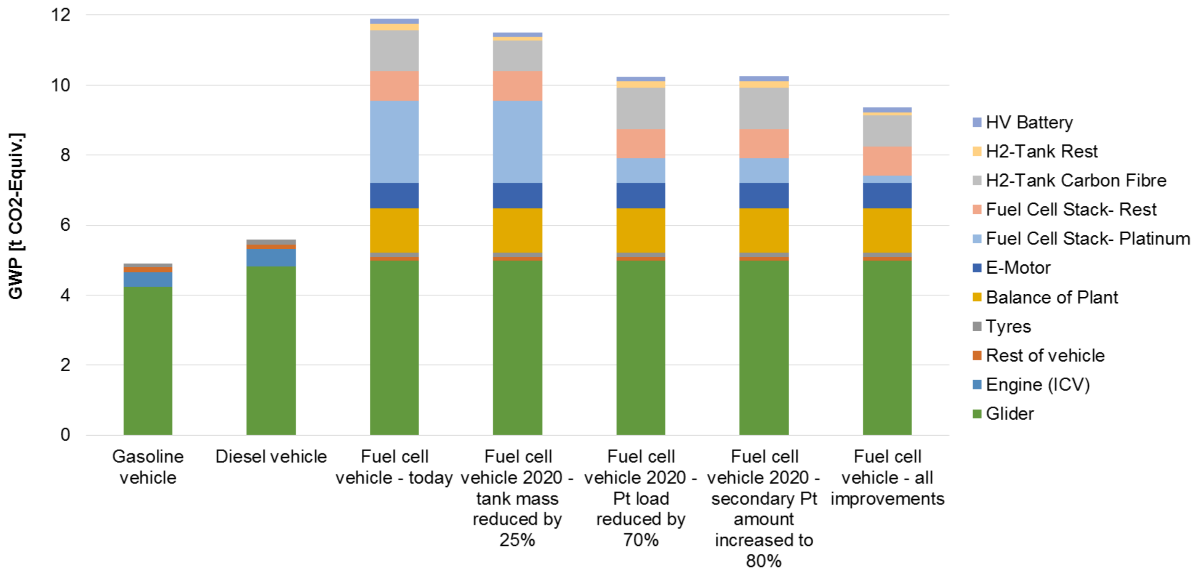
The results presented below follow the approach taken in a classic WTW analysis. The graph below illustrates the GHG of the conventional fuel or hydrogen supply (well-to-tank) and the driving emissions (tank-to-wheel). The GWP including all GHG emissions, expressed in carbon dioxide equivalents, illustrates the clear potential FCEVs have compared to conventional vehicles powered with gasoline or diesel. The usage of hydrogen produced via steam reforming from natural gas in the **FCEV can reduce the GHG emissions by around 40 per cent** compared to a gasoline vehicle or **30 per cent compared to a diesel vehicle**.



WTW - Global Warming Potential

However, where the hydrogen is produced via electrolysis, in which the electricity is supplied from wind power, the **reduction potential is up to 97 per cent** compared to the conventional vehicles. This is therefore the most environmentally-friendly hydrogen production route. The average HyFIVE hydrogen supply mix results in a 70 per cent reduction in GHG emissions compared to the conventional vehicles. In addition to the GHGs, air emissions NO_X, SO_2 and dust have also been investigated.

To get a complete picture of the GHG emissions, a life-cycle approach has been used that also includes the manufacturing and end-of-life of the vehicle. The graph below displays the GWP from the manufacturing of the conventional vehicles and the FCEVs, split by component part.



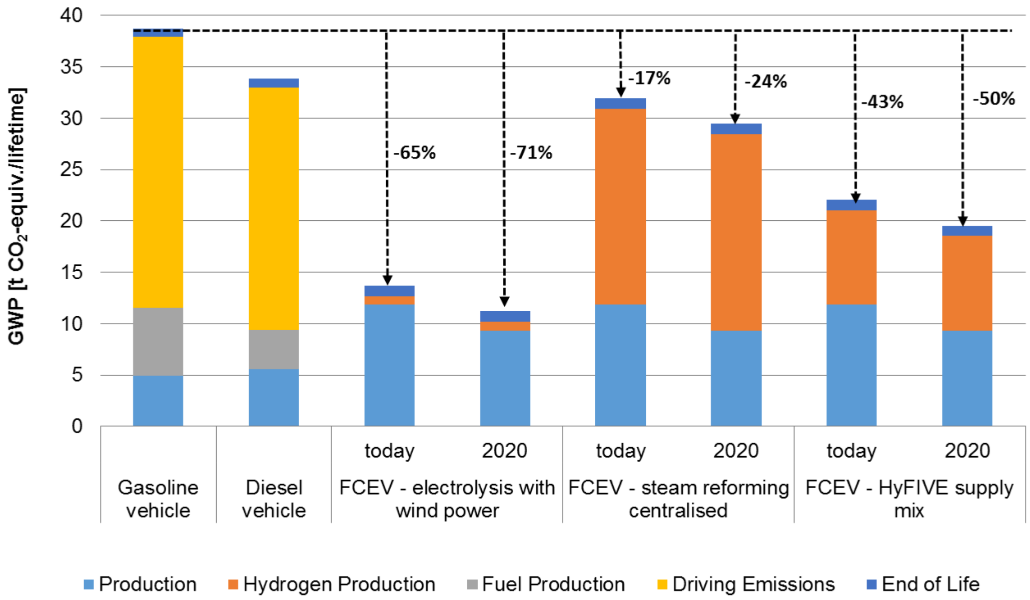
Scenario greenhouse gas emissions for vehicle production

There is a notable difference in the GHG emissions of the FCEV and the conventional vehicles. While the GHG emissions of the conventional vehicles are rather similar, the emissions of the FCEVs are more than twice as large. Around one half of the entire GHG emissions of the production of the FCEVs results from the specific fuel cell components, such as the fuel cell stack and the hydrogen tank. The platinum in the fuel cell stack accounts for 20 per cent of the entire GHG emissions of the vehicle production.

To reduce GHG emissions in FCEV production, several measures are under investigation to design a next generation FCEV in 2020 in which we expect to see:

- a reduction of the platinum load by 70 per cent;
- a reduction of the hydrogen storage tank weight by 25 per cent;
- the positive impact a higher share of secondary platinum has on reduction measures.

Finally, the impacts over the entire life-cycle have been analysed. Exemplarily, the graph below demonstrates the GHG emissions over the entire life-cycle of the vehicles. The actual FCEV generation with a renewable hydrogen supply (electrolysis and wind power) leads to considerable GHG emission reductions over the entire life-cycle compared to the gasoline vehicle (-65 per cent) and the diesel vehicle (-59 per cent). Using the HyFIVE hydrogen supply mix, which contains around one third hydrogen from fossil fuels, GHG emissions can be reduced by more than 40 per cent compared to the conventional vehicles. The manufacturing of the FCEV leads to distinct higher impacts than the conventional vehicles and applies greater importance on the manufacturing stage. The possible improvements in the production of a future FCEV can further increase the advantages of the FCEV in the overall life cycle.



GWP over the whole life-cycle

3.2 Total Cost of Ownership Assessment

An extensive TCO analysis was carried out by the FCH JU coordinated and co-funded study "A portfolio of power-trains for Europe: a fact-based analysis[15]". The methodology for assessing the project's TCO was to ascertain if the key premises and assumptions used in the FCHJU are still valid and up-to-date. The analysis used in the project follows the same approach for the conventional vehicles as the WTW analysis, and uses relevant technical specifications (e.g. NEDC consumption data).

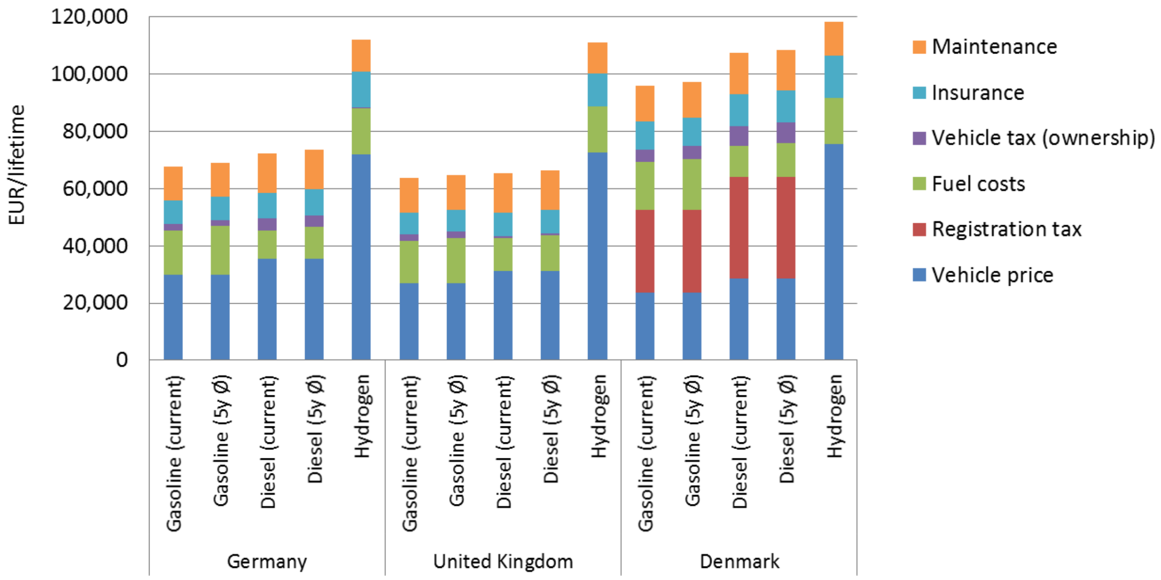
For this assessment, we compared the TCO between the deployed FCEVs in the project and the conventional vehicles. The results of the TCO calculation are presented as total cost over the entire lifetime and as costs per kilometre in the first and second graphs, respectively.

In the case of Germany and the United Kingdom, the purchase price of 72,000 EUR (incl. VAT) for the FCEVs compared to 27,000 – 35,000 EUR for the conventional vehicles leads to a relevant cost surplus for FCEVs over the whole lifetime.

Whereas the purchase price represents around 40-50 per cent of the TCO for the conventional vehicles in Germany or the United Kingdom, it represents approximately 65 per cent for FCEVs. The operational costs of FCEVs are lower overall than for the gasoline vehicle and similar to the diesel vehicle. The insurance costs of FCEVs are estimated to be approximately 30 per cent higher than for the conventional vehicles due to the higher purchase price, which reduces the advantage in operating costs for FCEVs. Fuel costs are similar for gasoline and hydrogen using the HyFIVE average price of 10.1 EUR/kg. Overall the TCO for FCEVs in Germany and the United Kingdom is still 50-75 per cent higher than for the conventional vehicles.

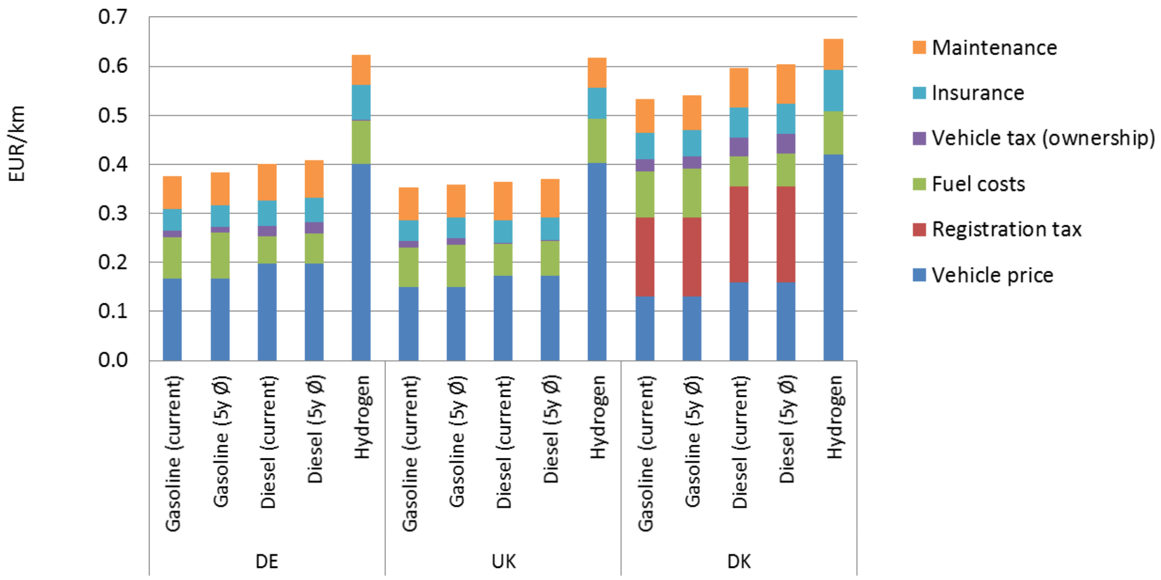
The results also reveal that the TCO is very comparable in Germany and United Kingdom. Major differences between Germany and United Kingdom are the purchase prices for conventional vehicles, which are mainly influenced by the recent changes in the currency exchange rate, and the higher excise tax on diesel in UK, which are around 0.65 EUR/l for conventional in UK16 and 0.47 EUR/l diesel and 0.65 EUR/l gasoline in Germany. The higher excise tax for diesel in UK is compensated by a lower tax on vehicle ownership in UK.

[15] http://www.fch.europa.eu/node/786
[16] 24 July 2017



Total cost of ownership over lifetime

The results for the Danish case highlight the important influence of registration tax on the TCO and especially the current exemption for FCEVs. It should be noted that this exemption was recently extended until end of 2018 after which it will gradually be phased out, to be eliminated by 2023. The gap in the purchase price, including registration tax, between conventional vehicles (especially diesel) and FCEV is considerably reduced with the registration tax exemption for FCEVs. It makes FCEVs nearly cost competitive for private end users compared to conventional vehicles. The cost surplus over the lifetime is about 10-25 per cent for the Danish case.



Total cost of ownership per kilometre

4. Project Impacts

4.1 FCEV Delivery

A total of 154 hydrogen cars were placed with customers and monitored as part of the project, with a total mileage of over 2 million kilometres and an availability of 99.7 per cent over the course of the project. The most heavily utilised vehicle in the project achieved a mileage of 67,800 km over 35 months (an average of 23,000 km per year). **Over the four years, there were no hydrogen or fuel-cell related safety incidents with the vehicles or infrastructure, demonstrating the high level of safety of the technology**[17].

4.2 FCEV Accessibility

The continued commercialisation of FCEVs is mutually dependent on the commercialisation of hydrogen refuelling stations. Increased uptake of FCEVs relies on further development of HRS networks, but the financial viability of hydrogen stations (and to some extent, their capacity to improve performance) relies on the stations achieving a certain level of utilisation. Commercialisation of European hydrogen mobility will therefore depend on the increased availability of FCEVs for sale in European markets.

4.3 HRS Accessibility

As the numbers of FCEV users and hydrogen refuelling stations in Europe have increased, demand has emerged for maps and apps communicating live data on station availability, to allow drivers to plan their routes and ensure that they do not make plans to refuel at a particular station when it is undergoing maintenance. Operators and suppliers should work together to provide more accessible, reliable information on availability of refuelling stations, both to support existing customers and to inform potential FCEV adopters.

4.4 FCEV Lessons Learnt

The Impact of Hydrogen Refuelling Stations on FCEVs

Lack of sufficient refuelling infrastructure can still be one of the major barriers to purchasing or leasing an FCEV.

- Delays to station deployment can jeopardise FCEV sales opportunities. Station suppliers and / or operators must engage with planning authorities at an early stage to reduce delays caused by lack of knowledge of the technology. Policy makers can assist in this process by highlighting the growing experience of hydrogen mobility worldwide. Forming industrial or

[17] The only recorded safety incidents were related to collisions at refuelling stations, typically involving HGVs not heeding height restrictions

industry-government partnerships can be a powerful tool in achieving higher levels of engagement within the relevant authorities;

- Station availability must improve to enable wider adoption levels and to ensure positive experiences among early customers;

- More accessible, reliable information on availability of refuelling stations is needed, both to support existing customers and to inform potential FCEV adopters.

FCEV Costs and Subsidy

- Vehicle ownership cost is another barrier to FCEV sales, particularly for mass-market customers;

- With current FCEV and hydrogen costs, and the state of development of the European HRS network, some of the best opportunities for FCEV sales in Europe over the next few years are likely to be fleet customers with high mileage applications and for which zero emission capabilities directly add value to the business case (for example, taxis operating in areas with congestion and air quality related restrictions). Localised fleet customers are less likely to rely on full nationwide HRS coverage, and tend to be more compatible with the business-to-business payment model currently in place for some European refuelling stations, compared to private customers who see the capability for long distance driving as a higher priority and are likely to prefer credit card payment;

- Policy makers can help ensure that the policy environment relevant to potential FCEV customer groups allows the customer proposition to be sufficiently competitive with that outside Europe. This could include policy that incentivises zero emission driving in polluted areas, or subsidises the sale of renewable hydrogen. In particular, care is needed where incentives are applied both to battery electric vehicles and FCEVs. Where these incentives are to be phased out due to falling prices and increasing sales of BEVs, to avoid negatively affecting early FCEV sales it may be necessary to preserve incentives for FCEVs for a longer period, reflecting their different levels of commercialisation and the different roles that the technology may play in decarbonising road transport.

FCEV Customer Identification Strategy

- Vehicle manufacturers should use the feedback on early sales operations to define the customer types likely to take up FCEVs in the short term, and to use this this to inform their strategy for early model availability;

- Based on HyFIVE‘s results, naturally suitable customer groups include fleet vehicles in cities with current or future restrictions on gasoline and diesel vehicles, or in countries with strong financial incentives that reduce the TCO gap even for relatively high cost first generation vehicles. This is already happening with the highly successful recent FCEV deployments in taxi fleets in Paris and London (through Hype and Green Tomato Cars respectively);

- Existing hydrogen mobility strategy groupings and partnerships between industry and government should be used to maintain communication with key decision-makers for international vehicle manufacturers, to ensure that strategies based on meeting the refuelling requirements of particular customer groups are aligned with vehicle manufacturer plans regarding vehicle availability or model choice for those customer groups.

FCEVs vs Conventional Vehicles

- FCEVs are suitable for use on a wide range of journey types and offer significant emissions savings compared to gasoline or diesel vehicles, both in terms of the WTW emissions for the fuel and on a life-cycle basis. This is true even for hydrogen produced through steam reformation, but emissions savings are increased through the use of electrolytic hydrogen, especially when produced with renewable electricity;

- Overall customer responses to FCEVs have been positive, with high levels of customer satisfaction on the performance and reliability of the vehicles.

Global FCEV Markets

- Car manufacturers must allocate FCEVs to be sold across global markets according to various criteria:
  - Extent of HRS deployment in terms of a) capability for long-distance driving and b) level of local redundancy;
  - Strength of the customer proposition in that market (dependent on the incentives for FCEVs and hydrogen relative to gasoline / diesel vehicles);
  - Size and accessibility of FCEV adopter markets for specific manufacturers (accessible: either within existing customer groups for that manufacturer);
  - Extent to which FCEV adopter markets are complementary to (as opposed to in competition with) EV market share for that manufacturer.

- The number of FCEVs brought to European markets will depend on how these markets measure against other global markets, such as Japan, California and Korea, in terms of the criteria above. Therefore, securing FCEV volumes in Europe will rely on the efficient improvement of these factors e.g. by using a demand-led strategy to expand HRS networks, i.e. locating the largest potential markets for localised fleet FCEV customers, and ensuring that the infrastructure meets the likely requirements of these fleets and making improvements as required. However, partnerships between industry and government should initiate communication with key decision-makers for international OEMs, to ensure that any demand-led strategies are aligned with OEM plans regarding particular markets and / or customer groups.

Future of HyFIVE FCEVs

- Beezero car sharing service, subsidary of Linde, represents a significant milestone for HyFIVE and the wider hydrogen industry as 50 Hyundai ix35s were delivered to the service in spring 2016 making it the world's first fuel cell car sharing service. From 30 June 2018, the service is ceasing operation as it is no longer economically-viable;

- Nevertheless, some of the ix35s will remain in the Linde fleet as pool cars and others will be sold to local users. Therefore this will not impact utilization of the Linde-operated Munich station;

- Over two years of operation, the Beezero cars achieved a total mileage of 500,000 km, translating to an average annual mileage of 5,000 km per vehicle. This is a low level of utilisation compared to the mileage expected for an economically-viable carpooling service, and when taken into consideration the current FCEV costs relative to those of fossil fuel vehicles, it makes sense for Linde to take the decision to end the service. However, Beezero was a successful demonstration activity, with useful lessons for future FCEV customers and for commercialisation in general.[18]

- IIT's warranty for their 10 Hyundai ix35 FCEVs will continue until June / July 2018. Post-warranty, IIT is exploring the possibility to rent the cars to their customers for additional months. Nonetheless, if the cars experience technical damage after the warranty deadline, Hyundai will withdraw the cars from circulation;

- IIT will replace the 10 ix35s with a new generation of FCEV in 2019. The organisation, at time of publishing, is drafting a proposal for a LIFE-funded project. If the project is accepted, IIT will install more HRSs in the South Tyrol region, where their HQ is based. They will also procure more FCEVs (mixture of cars and vans) for their project partners and customers in order to develop the hydrogen network.

[18] Further information regarding the Beezero service is available in Element Energy's *Hydrogen Mobility in Europe: Overview of progress towards commercialisation* report

Key Messages for Communicating FCEV Progress

To encourage positive discussion with regard to the development of hydrogen technology, stakeholders should continue to communicate the short and long-term strategy to the general public, including:

- Clearly articulating the benefits of FCEVs and their readiness for real-world use, and correcting any misconceptions about safety or reliability, or the idea that FCEVs are not yet 'ready';

- The types of customers expected to be the main users of FCEVs in the short-term, and the rationale behind this in terms of the need for fast refuelling and the benefit of clusters of demand in the early stages of HRS rollout;

- The strategy for the rollout of the hydrogen refuelling station network, both to meet the needs of users in the short-term (for example fleets in in major cities) and the national/cross-border mobility of private customers in the longer term;

- The expected market size for FCEVs in the long term in different vehicle segments and customer types, making clear the complementarity with battery electric mobility for long-range, demanding duty cycles;

- The long-term role of hydrogen in the decarbonisation of transport alongside other technologies such as battery electric vehicles. Existing industry initiatives such as the Hydrogen Council and Hydrogen Europe are playing and will continue to play a key role in this.

4.5 HRS Lessons Learnt

Before Station Opening – Station Delivery Time Management

Permitting for the first hydrogen station within an area can be significantly longer due to the unfamiliarity of the technology to the relevant authorities.

Time required for station delivery can be reduced by:

- Identifying at least two back-up sites;
- Gaining an understanding of local and national permitting processes, and the parties involved;
- Engaging with the relevant authorities early in the process to familiarise them with the technology and its benefits;
- Pre-preparation of detailed safety and educational information;
- Thoroughly testing equipment offsite to reduce the time for onsite testing;

- To facilitate the rollout of **initial hydrogen networks** in new countries, suppliers and operators must engage with planning and safety authorities at the earliest possible stage and refer to the experiences of initial stations elsewhere in Europe to minimise delays due to lack of experience of the technology.

Before Station Opening – Station Design and Quality Assurance

- Reducing the footprint of refuelling equipment will be a priority for future hydrogen refuelling within traditional fuel forecourts due to tighter space constraints;
- Large sites offer the most flexibility for expansion of station capacity, particularly for sites using delivered hydrogen;
- Use of containerised station solutions can reduce installation times and provides more flexibility to enable re-siting. However, containerised solutions are unlikely to be appropriate for forecourt-integrated stations;
- Innovative design approach needed to provide an engaging, “cutting edge” experience compared to traditional refuelling;
- Necessary hydrogen quality assurance processes (including at the design stage) depend on the hydrogen supply route;
- For new station designs, demonstrating compliance with latest international standards may require special attention (this may involve clarifications or amendments to some aspects of standards to reflect design differences);
- Innovative design approach needed to provide an engaging, “cutting edge” experience compared to traditional refuelling.

During Station Operation – Station Reliability

High reliability and availability can be achieved through a combination of:

1. **Provision of reliable, high quality components**
   - Station suppliers have identified reliable options for key components, but the supply chain is still maturing.
2. **Identification of preventative maintenance needs**
   - Collecting and understanding data generated by the station (especially remotely) is essential to enable this and to understand how to quickly address any issues;
   - Having an FCEV which can be used by the operator for live refuelling tests can assist in understanding issues.
3. **Swift delivery of both preventative and reactive maintenance as required**

- Where the station supplier is not the station operator, detailed contracts for operation and maintenance responsibilities should be clearly defined prior to construction, and should specify required timescales for maintenance which reflect the targeted levels of availability (98 per cent and above);
- New station operators are recommended to provide 24/7 availability of local technicians to maintain high availability;
- Some minor issues can be addressed remotely (e.g. resets of certain systems);
- Improvement to average availability of stations is required to give consistent quality of service and across network, to fully match the current gasoline / diesel experience; care should be taken that older stations also achieve high availability.

During Station Operation – Communicating Station Status

- To date, station operators have communicated directly with customers regarding any station maintenance or other events impacting availability;
- H2.LIVE map[19] and app covers mainland Europe and shows "live" availability data;
- An SMS[20] availability information service is available for the stations in Denmark;
- Hyundai Fuel Cell app[21] and others include all refuelling stations and are updated regularly but do not yet include live data on station status;
- NOW interactive map depicts the current state of progress for stations within Germany[22]
- Data loggers collecting live availability data have been installed on some stations across Europe to test the concept for a common European availability system, which has been developed as part of an FCHJU project;
- Suppliers are in discussion around inclusion of live availability data provision as part of the requirements for new stations;
- Reliability of availability data is currently uncertain due to varying sources / methods of data collection;
- Lack of connectivity of some older stations is a potential challenge in creating a complete picture of the live availability of the European refuelling network;
- Funding options and responsibility for a complete availability system have yet to be agreed.

[19] http://h2.live/en/
[20] http://brintbiler.dk/tankstationer/
[21] https://itunes.apple.com/cz/app/hyundai-fuel-cell/id1116698160?mt=8
[22] https://www.now-gmbh.de/en/national-innovation-programme/aufbau-wasserstoff-tankstellennetz

During Station Operation – Utilisation

- Fleets seeking to adopt multiple FCEVs should signal this demand both to vehicle manufacturers and HRS suppliers. This allows them to secure favourable prices for large vehicle orders, as well as influencing the locations of stations since they can offer a significant 'base load' of hydrogen demand for a new station;
- Government can facilitate this through funding competitions to identify clusters of FCEV demand in fleets. In the UK, this alignment between HRS deployments and fleet purchases is encouraged by the ongoing funding competitions run by the Office for Low Emission Vehicles;
- HRS operators should also explore whether stations can serve several vehicle types, allowing for a higher utilisation level compared to refuelling only passenger cars. Other vehicle types include light commercial vehicles (i.e. vans) as well as heavier vehicles such as trucks and buses. For heavy vehicles, fleet operators are likely to prefer separate depot-based stations in the long-term, but in the short-term when fleet sizes are low there may be opportunities to share stations to reduce the initial infrastructure costs. In addition, where there is significant hydrogen consumption by trucks or buses, this could allow decreases in the prices of delivered hydrogen within the same city/region even if light and heavy vehicles use different stations;
- HRSs should aim to show that high levels of station utilisation can be reached where a high concentration of hydrogen demand can be found in the local area;
- Reaching fully utilised stations will provide additional technical learning (for example confirming that high station reliability can be maintained with high hydrogen throughputs), as well as confirming to potential investors that hydrogen stations can be operated profitably;
- This is critical in unlocking the significant investments that will be required to continue the build-out of the network in the 2020s.

During Station Operation – Usability and Customer Support

Customers may require guidance the first few times they refuel, which can be effectively provided through:

- Training (leaflet, video or in person) on first use;
- Simple instructions on the station itself;
- A 24/7 assistance hotline;
- An effective balance between station usability and customer support provision is important to ensure that customers can consistently refuel their car on the first attempt;
- Some aspects of hydrogen refuelling can initially be surprising to customers (e.g. sounds, pauses in the process) due to differences compared to traditional refuelling;

- Once customers become familiar with the process, feedback is very positive (and hotline calls are rare);
- Moving away from a "customer training" approach is recommended, as this is costly and may imply that the process is unsafe, but a greater public awareness of hydrogen technology is needed to enable this;
- For forecourt integrated stations, shop staff are likely to be the first point of contact for customers; as a minimum, they should be briefed on the process for customers to seek guidance;
- Lessons on customer support and station usability must be shared across suppliers and operators to ensure that the overall customer experience improves as the network expands.

During Station Operation – Payment and Metering

- A universal method of accessing and paying for hydrogen will be important if hydrogen mobility is to be adopted on a mass market scale; in addition, it would facilitate pan-European journeys;
- Operators must take necessary measures to manage multiple payment methods (e.g. for fleet and individual customers with different preferences) and to enable smooth transitions between approaches;
- Metering issues will need to be resolved through either technical or legal solutions, to allow mass market adoption of hydrogen vehicles;
- Element Energy conducted a survey of customers to analyse their attitudes towards FCEVs and HRSs during pre- and post-operation of their vehicles[23]. The majority of respondents (74 per cent) either had their hydrogen consumption metered and billed on a monthly basis or paid at the pump with a debit / credit card similar to payment at a conventional fuel station;
- At the end of the trial, most of the customers (81 per cent) favoured being charged on their actual consumption, either with a monthly bill or direct payment at the station;
- **Private customers showed a preference for card payment**, whereas **organisation customers had a preference for monthly billing**. Payment by cash, CEP Fuel Card and mobile app were also used or suggested by some users;
- In some countries, on-site payment by cash or credit card is not yet permitted due to metering accuracy of hydrogen. Industry groups are working to address this in order to allow card payments at future stations.

[23] The full report of this survey is documented in Element Energy's *Attitudes of Early Hydrogen Fuel Cell Car Users in Europe* report

During Station Operation – Station Performance

- Older stations without refuelling communication capabilities, and those following certain outdated refuelling protocols, may not deliver complete refuelling, which reduces the maximum range of a vehicle: addressing this should be a priority to ensure that the long distance, zero emission driving capabilities of hydrogen vehicles are maximised;
- Suppliers and operators need to identify cost-effective ways to update older stations to come closer to the latest standards e.g. through software updates and / or replacement of particular components;
- Most stations do not display information on the state of charge (completeness of refuelling) achieved; this would be a useful addition for customers to gauge the distance possible before the next refuelling event.

Network and Interoperability – Network Development

- High station availability is essential for initial basic networks to support the driving needs of early customers;
- Detailed contracts outlining responsibilities are essential for a smooth transition to a centrally operated network;
- Locating stations based on vehicle demand hotspots (e.g. from fleet customers) can help to avoid underutilisation and improve station performance;
- To ensure positive customer experiences as the network grows, network operators will need to monitor and maximise station availability and ability to deliver complete fills, particularly for older stations.

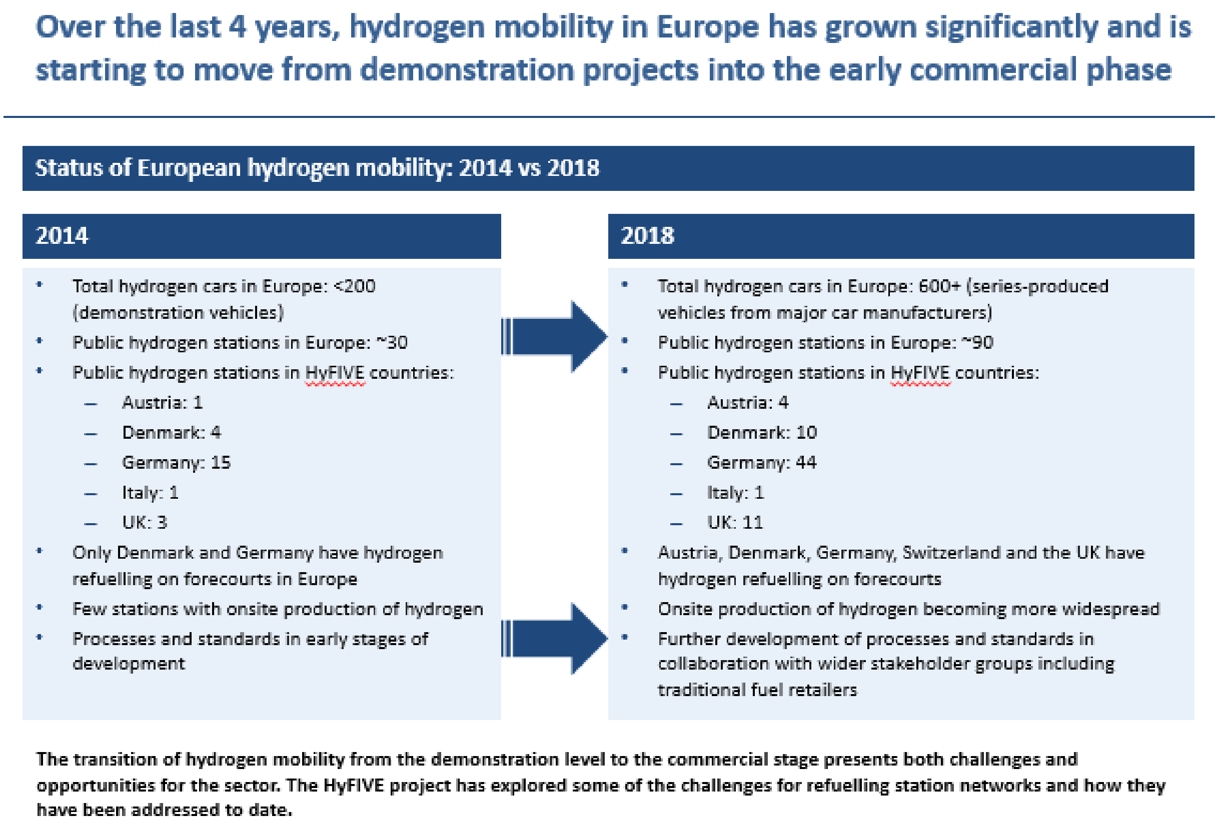
Future of HyFIVE stations – Network Development

- All London cluster stations delivered through the project to continue operation within H2ME1+2;
- All Copenhagen cluster stations delivered through the project to contunue operation within H2ME1+2;
- OMV Innsbruck HRS (the only station within the Southern cluster to be delivered through the project will continue operation through funding sourced directly by OMV. The Bolzano HRS, heavily featured in the project, will remain operational in the future[24]. The other existing stations in the project (OMV Stuttgart, Linde Munich and TOTAL Munich) will continue operation through private funding.

Many of the recommendations in this chapter are already being implemented in the EU-funded projects that have succeeded HyFIVE, such as the H2ME and H2M2 projects. In particular, these

[24] Five fuel cells buses deployed through the CHIC project are currently utilising the Bolzano HRS.

projects have seen the emergence of promising business cases for taxi fleets in Paris and London, and significantly improved HRS utilisation levels for stations due to the presence of base load from these local fleets. A further FCHJU-funded project named ZEPHYR, which began in January 2018, focuses specifically on taxis and government fleets in London, Paris and Brussels, with the aim of demonstrating near 100 per cent utilisation of HRS in those cities. This will be an important milestone, and by proving that stations can see high hydrogen demands even in the early years of the rollout, the project will help attract further investment and new actors into the sector.



4.6 List of dissemination activities

LIST OF ALL DISSEMINATION ACTIVITIES – CHRONOLOGICAL ORDER								
NO.	**Type of activity**	**Main leader**	**Title**	**Date/Period**	**Place**	**Type of audience**	**Size of audience**	**Countries addressed**
1	Event	OEMs	H2FC Hannover Messe	7th – 11th April 2014	Germany	Public / Stakeholders	250,000	Germany
2	Event	ITM	Thüga Power to Gas Inauguration	7th May 2014	Germany	Stakeholders	~50	Germany; UK
3	Programme	Hyundai	Skills for the Future	27th May 2014	Germany	Students / Graduates	~100	Germany

4	Event	IIT	The IIT Opening	5th June 2014	Italy	Stakeholders	~50	Italy
5	Event	Hyundai	SMMT International Automotive Summit	11th June 2014	UK	MDs and Directors in the automotive industry	200	UK
6	Event	Linde	Linde Factory Opening	14th June 2014	Austria	Politicians and ambassadors	~100	Austria
7	Handover	Hyundai	Handover of 10 Hyundai ix35 FCEVs to customers	29th August 2014	Italy	Private customers	~50	Italy
8	Meeting	Daimler	Meeting with the State Minister, Mr. Untersteller	9th September 2014	Germany	Politician	~5	Germany
9	Event	OEMs	Automotive World Megatrends Conference	11th September 2014	Belgium	Stakeholders	400	Belgium
10	Event	GLA	Hydrogen Economy: Providing a Common Energy Vector for the 21st Century	1st October 2014	UK	Policy makers / investors	100	UK
11	Event	GLA	Sustainable Transport Conference	22nd October 2014	UK	Policy makers, universities and local government	~1,000	UK
12	Event	GLA	Smart Future London	27th October 2014	UK	Businesses	~150	UK
13	Exhibition/ Campaign	GLA	Hydrogen Week	9th – 13th March 2015	UK	Policy makers, boroughs, business and the public	N/A	UK
14	Event	GLA	Delivering Hydrogen and Fuel Cells to Market	17th March 2015	UK	Stakeholders	200	UK
15	Handover	Daimler	Handover of one B-Class F-CELL to The Esslingen University of Applied Sciences	18th March 2015	Germany	University	~10	Germany
16	Event	IIT	Klimamobility	26th March 2015	Italy	Automotive industry	~200	Italy
17	Test Drives	IIT	Green Mobility	April 2015	Italy	Stakeholders	~50	Italy
18	Event	Hyundai	ix35 Launch for Dutch Market	8th April 2015	Netherlands	Customers	~100	Netherlands
19	Meeting	Hydrogen Denmark	Hydrogen Denmark Annual Meeting	9th April 2015	Denmark	Politicians / Stakeholders	~200	Denmark
20	Event	OEMs	H2FC Hannover Messe	7th – 11th April 2015	Germany	Public / Stakeholders	250,000	Germany
21	Event	OEMs	Amsterdam Motorshow	17th – 26th April 2015	Netherlands	Customers / Press	~1,000	Netherlands
22	Event	ITM	British Compressed Gases Association Conference	23rd April 2015	UK	Local government	~50	UK
23	Meeting	Hydrogen Denmark	Strategic Meeting with Danish BEV	24th April 2015	Denmark	Automotive industry	~50	Denmark

			Association					
24	Event	Hyundai	Fleet World Event	15th May 2015	UK	Automotive industry	~1,000	UK
25	Inauguration	OMV	OMV HRS Innsbruck Inauguration	21st May 2015	Austria	Local government / Automotive Industry	~50	Austria
26	Workshop	Hydrogen Denmark	Copenhagen Workshop	21st May 2015	Denmark	Sustainable energy stakeholders	~10	Denmark
27	Test Drives	Hyundai	Hyundai Fuel Cell Ride and Drive	1st – 12th June 2015	Spain	Customers	~50	Spain
28	Event	Hydrogen Denmark	The People's Political Festival	12th June 2015	Denmark	General public / politicians	10,000	Denmark
29	Event	Hyundai	Company Car in Action	16th – 17th June 2015	UK	Customers	~50	UK
30	Event	Hyundai	BFP Fuhrpark	17th – 18th June 2015	Germany	Automotive industry	10,000	Germany
31	Event	ITM	Energy Day	19th June 2015	Italy	European policy makers	~1,000	Italy
32	Meeting	GLA	Meeting with Professor Chris Rapley	22nd June 2015	UK	University	2	UK
33	Event	GLA	Hydrogen & Fuel Cells from Research to Market Rollout (TEN-T Days)	22nd – 23rd June 2015	Latvia	European policymakers, automotive industry, stakeholders	~200	Latvia
34	Event	ITM	Low Carbon Vehicle Partnership Annual Conference	24th June 2015	UK	National government	~300	UK
35	Event	Hyundai	FCEV Presentation	24th June 2015	Czech Republic	National government	~300	Czech Republic
36	Event	Hyundai	National Fuel Cell Launch	25th June 2015	Belgium	Stakeholders	~200	Belgium
37	Inauguration	Hydrogen Denmark	HyFIVE Presentation at the Aalborg HRS Inauguration	25th June 2015	Denmark	Local government	~50	Denmark
38	Test Drives	BMW	BMW World Press Event	29th June – 3rd July 2015	France	Journalists	~100	France
39	Test Drives	Hyundai	Royal Norfolk Show	29th – 30th June 2015	UK	General public / Stakeholders	100,000	UK
40	Test Drives	Hyundai	Slovenian Fuel Cell Test Drives	1st – 20th July 2015	Slovenia	Customers	~200	Slovenia
41	Event	Hyundai	Confidence Day	8th July 2015	Germany	Internal stakeholders	~100	Germany
42	Inauguration	BMW	HyFIVE Presentation at the TOTAL HRS Inauguration	16th July 2015	Germany	Stakeholders	~50	Germany
43	Event	GLA	FCEV / Hydrogen Partnership Conference	22nd July 2015	UK	Toyota customers / National government	~150	UK
44	Test Drives	Hyundai	HyFIVE Presentation at National Tucson Press Test Drives	19th – 28th August 2015	France	Journalists	~50	France
45	Event	Hyundai	Alpbach Technology Symposium	28th August 2015	Austria	Stakeholders	~200	Austria

46	Event	ITM	Impact Investor Club	7th September 2015	UK	Stakeholders	~100	UK
47	Event	Honda	Hypothesis XI	8th September 2015	Spain	Stakeholders	~200	Spain
48	Event	GLA	CENEX Low Carbon Vehicle Conference	9th - 10th September 2015	UK	Automotive industry / General public / Local and national government / Stakeholders	~1,000	UK
49	Event	Honda, Hyundai, Toyota	IAA Motorshow	15th – 16th September 2015	Germany	Automotive industry	250,000	Germany
50	Inauguration	DHF	Inauguration of the Korsør HRS	16th September 2015	Denmark	Local government	~50	Denmark
51	Inauguration	ITM	HyFIVE Presentation at the Sheffield HRS inauguration	17th September 2015	UK	Private sector stakeholders / National press	200	UK
52	Workshop	ITM	LowCVP Low Emission Cities Workshop	18th September 2015	UK	Automotive industry / Local government	~100	UK
53	Event	Hyundai	Global Fuel Cell Tour	21st - 25th September 2015	South Korea	Stakeholders	~50	South Korea
54	Test Drives	Toyota	Greenfleet	24th September 2015	UK	Commercial businesses	~400	UK
55	Event	Hyundai	Hyundai Fuel Cell Forum	3rd October 2015	Germany	Stakeholders	~200	Germany
56	Event	Toyota	Fleet Management Live	6th – 7th October 2015	UK	Fleet Managers	~100	UK
57	Event	GLA	Bloomberg Energy Summit	12th – 13th October 2015	UK	National government / Politicians	~300	UK
58	Event	OEMs	World of Energy Solutions	12th – 14th October 2015	Germany	Automotive and energy industry	~500	Germany
59	Event	Hyundai	Equip Motorshow	12th – 16th October 2015	France	Automotive industry	~100	France
60	Event	GLA	Heathrow Clean Vehicle Partnership Seminar / Towards a Zero Emission Ground Fleet	14th October 2015	UK	Automotive industry	~150	UK
61	Workshop	OEMs	Research Centre – BMW Munich	15th October 2015	Germany	HyFIVE OEMs	~10	Germany
62	Test Drives	Hyundai	Association of British Insurers	15th October 2015	UK	Automotive industry	~50	UK
63	Event	Hyundai	Fluvia Congress	17th October 2015	Belgium	Local fire brigades	~50	Belgium
64	Handover	Toyota	Toyota's First UK Handover	19th October 2015	UK	ITM	~10	UK
65	Event	Hyundai	KBC Fleet ECO Day	22nd October 2015	Belgium	Stakeholders	~50	Belgium
66	Event	IIT	Tyrolean County Open Day	26th October 2015	Austria	Stakeholders	~200	Austria
67	Press Release	Honda	Clarity Fuel Cell FCEV launch in Europe and participation in HyFIVE	26th October 2015	Japan	International stakeholders / General public	N/A	Japan

68	Event	ITM	Energy Symposium at the University of Sheffield	27th October 2015	UK	Energy industry	~200	UK
69	Test Drives	Hyundai	Zero Konferansen	27th – 28th October 2015	Norway	Customers	~200	Norway
70	Event	OMV	OMV Austria Pensionisten Conference	30th October 2015	Austria	Stakeholders	~100	Austria
71	Event	Hyundai	3rd Edition Fuel Cell Forum	4th November 2015	Germany	Stakeholders / National government	~200	Germany
72	Event	Air Products	Association of Petroleum and Explosives Administration	5th November 2015	UK	Energy industry	~200	UK
73	Exhibition	Toyota	Energy Management Exhibition	12th – 15th November 2015	UK	Energy industry	N/A	UK
74	Event	Hyundai	Fleet Europe Awards	19th November 2015	Italy	Automotive industry	~800	Italy
75	Event	Hyundai	Fleet Market	24th November 2015	Poland	Automotive Industry	~1,000	Poland
76	Test Drives	Hyundai	Swedish Fuel Cell Test Drives	December 2015	Sweden	Customers	~100	Sweden
77	Event	Air Products	Supergen Conference	11th December 2015	UK	Stakeholders	~3,000	UK
78	Event	Hyundai	Hyundai HRS Ceremony	1st January 2016	Germany	Stakeholders	~200	Germany
79	Inauguration	DHF	Aarhus HRS Inauguration	21st January 2016	Denmark	Stakeholders	~50	Denmark
80	Workshop	OEMs	HyER Workshop on Hydrogen in Regions	26th January 2016	Belgium	Stakeholders	~200	Belgium
81	Event	GLA	HyVolution Conference	4th February 2016	France	European automotive industry	~600	France
82	Handover	Toyota	Toyota Mirai Handover to Transport for London	8th March 2016	UK	Transport for London	~10	UK
83	Event	Hyundai	London Hydrogen Network Expansion M25 Tour	11th – 16th March 2016	UK	Journalists / General public	~50	UK
84	Test Drives	IIT	South Tyrol Test Drives	April 2016	Italy	Customers	~50	Italy
85	Radio Promotion	Hyundai	Radio *Kronehit* Promotion	15th April 2016	Austria	General public	N/A	Austria
86	Event	BMW	Transport Research Arena Conference	16th April 2016	Poland	National government	~3,000	Poland
87	School Activity	IIT	Mobility Week – School Project	19th – 28th April 2016	Italy	Schools (11-14 ages)	~300	Italy
88	Event	Hyundai	Researchers' Night	22nd April 2016	Austria	Stakeholders	~200	Austria
89	Event	Hyundai	IONIQ Preview Event	24th – 26th April 2016	Austria	Journalists	~100	Austria
90	Test Drives	Hyundai	Rattenberg / Tyrol – Autofrühling Event	7th May 2016	Italy	Customers	~100	Italy
91	Events	GLA	International Transport Forum – 2016 Summit:	18th – 20th May 2016	Germany	Automotive industry	~1,000	Germany

			Green and Inclusive Transport					
92	Meeting	Hydrogen Denmark	Hydrogen Transportation Meeting	8th June 2016	Denmark	National government	~100	Denmark
93	Event	IIT	IIT Open Day	10th June 2016	Italy	Local government / Journalists	~100	Italy
94	Test Drives	BMW	ERTAC-EUCAR Innovation Demonstration Day	16th June 2016	Belgium	National government	~50	Belgium
95	Test Drives	BMW, Toyota	World Hydrogen Energy Conference	13th – 16th June 2016	Spain	Stakeholders	~900	Spain
96	Event	Hydrogen Denmark / Toyota	People's Political Festival	16th – 19th June 2016	Denmark	General public / Stakeholders / Politicians	~100,000	Denmark
97	Test Drives	Hyundai	E-Mobility Event	15th July 2016	Germany	Stakeholders	~200	Germany
98	Press Release	Honda	Clarity Fuel Cell arrival in Europe	29th November 2016	Europe	Media	>200,000	Honda Motor Europe
99	Event	BMW, Daimler, Honda, Hyundai, Toyota	Hydrogen Council Launch	17th January 2017	World Economic Forum, Davos, Switzerland	Stakeholders	>200	Switzerland
100	Event	ITM, Honda, Toyota	Cobham HRS Inauguration	22nd February 2017	UK	Stakeholders / Media	>20	UK
101	Test Drives	IIT	Klimamobility	March 2017	Italy	Automotive industry	~400	Italy
102	Test Drives	Honda	European Press Event	April – May	Denmark	Media	>20	Denmark
103	Test Drives / Rally	Honda	i-Mobility Rally	21st April 2017	Germany	Media / General Public / Stakeholders	>100,000	Germany
104	Event	Honda	Formula 1 Grand Prix De Monaco, Lap of Honour	28th May 2017	Monaco	Media / General Public / Stakeholders	>200,000	Monaco
105	Event	IIT	Press Conference	May 2017	Italy	National government / Journalists	~200	Italy
106	Event	IIT	Appassionauto Roadshow	May 2017	Italy	Stakeholders	~100	Italy
107	Event	IIT	E-Drive Day	May 2017	Italy	Automotive industry	~700	Italy
108	Event	Hydrogen Denmark	People's Political Festival	June 2017	Denmark	General public / Stakeholders / Politicians	~100,000	Denmark
109	Test Drives	Hydrogen Denmark	Prehn & Pihl On Tour	August 2017	Denmark	Politicians	2	Denmark
110	Event	Hydrogen Denmark	Copenhagen Cluster Final Conference	September 2017	Denmark	Stakeholders	~60	Denmark
111	Test Drive	IIT	Eco-Dolomites Event	September 2017	Italy	Stakeholders	~50	Italy
112	Event	IIT	Researchers' Night	September 2017	Italy	Stakeholders	~600	Italy
113	Handover	Hyundai	Handover of one ix35 Fuel Cell to the local police in Bolzano	September 2017	Italy	Italian police / Stakeholders	~20	Italy
114	Test Drives	Hyundai	E-Mobility Play Days	September 2017	Austria	General public / Stakeholders	~200	Austria

115	Event	Honda	Honda Clarity Fuel Cell Press Event	September 2017	Italy	Press	~100	Italy
116	Event	Honda, Hyundai, Toyota	World of Energy Solutions	October 2017	Germany	Automotive industry	~10,000	Germany
117	Video Promotion	Hyundai	EuroNews Film[25]	October 2017	Pan-Europe	General public / Stakeholders	Each video is seen by an average of 4 million viewers	Pan-Europe
118	Event	IIT	IIT Clients' Event	March 2018	Italy	Existing ix35 customers	~50	Italy
119	Video Promotion	Hydrogen Denmark	"How to drive a FCEV"	August 2017 – February 2018	Denmark	General public / stakeholders	~300 views (at time of publishing)	Pan-Europe
120	Test Drives	Hydrogen Denmark	Test Drive Strategy	August 2017 – February 2018	Denmark	Politicians, TV personalities	10	Denmark

[25] http://www.euronews.com/video/2017/10/30/tomorrow-s-hydrogen-car

5. Project Contact Information

Further information about the project is accessible via the official website www.hyfive.eu. All public reports will be available to download in summer / autumn 2018 once formally approved by the FCHJU – please contact Stella Yeung - stella.yeung@london.gov.uk for questions regarding the available reports.

For each project partner's contact details, please visit the website for additional information.

6. Societal Implications of HyFIVE - Report

A General Information

Grant Agreement Number:	621219
Title of Project:	Hydrogen for Innovative Vehicles (HyFIVE)
Name and Title of Coordinator:	Dolly Oladini, HyFIVE Project Coordinator

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	**No**
2. Please indicate whether your project involved any of the following issues (tick box) :	
RESEARCH ON HUMANS	
• Did the project involve children?	**Yes**
• Did the project involve patients?	**No**
• Did the project involve persons not able to give consent?	**No**
• Did the project involve adult healthy volunteers?	**No**
• Did the project involve Human genetic material?	**No**
• Did the project involve Human biological samples?	**No**
• Did the project involve Human data collection?	**No**
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	**No**
• Did the project involve Human Foetal Tissue / Cells?	**No**
• Did the project involve Human Embryonic Stem Cells (hESCs)?	**No**
• Did the project on human Embryonic Stem Cells involve cells in culture?	**No**
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	**No**
PRIVACY	

• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No
• Did the project involve tracking the location or observation of people?	No
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	No
• Were those animals transgenic small laboratory animals?	No
• Were those animals transgenic farm animals?	No
• Were those animals cloned farm animals?	No
• Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	No
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	No
DUAL USE	
• Research having direct military use	No
• Research having the potential for terrorist abuse	No

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	0	3
Work package leaders	7	7
Experienced researchers (i.e. PhD holders)	3	5
PhD Students	0	0
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	0
Of which, indicate the number of men:	

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	○ ○	Yes No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	○	○
❑	Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	**Actions to improve work-life balance**	○	○	○	○	○
○	Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

○ **No**

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ **Yes- please specify**: Daimler coordinated several educational and engagement events within schools in Germany.

○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

○ **No**

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ **Main discipline[26]: 2**

○ Associated discipline[26]: | ○ Associated discipline[26]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ ○	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

[26] Insert number from list below (Frascati Manual).

- ○ **No**
- ○ Yes- in determining what research should be performed
- ○ Yes - in implementing the research
- ○ Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes **No**

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ **Yes - in implementing the research agenda**
- ○ **Yes, in communicating /disseminating / using the results of the project**

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ **Yes – as a primary objective (please indicate areas below- multiple answers possible)**
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition **Consumers** Culture Customs Development Economic and Monetary Affairs **Education, Training, Youth** Employment and Social Affairs		**Energy** Enlargement Enterprise **Environment** External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health **Regional Policy** **Research and Innovation** Space Taxation **Transport**	

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- ○ European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	None
To how many of these is open access[27] provided?	
How many of these are published in open access journals?	
How many of these are published in open repositories?	
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[28]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	None

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	

17. How many spin-off companies were created / are planned as a direct result of the project?	None
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑ Increase in employment, or	❑ In small & medium-sized enterprises
❑ Safeguard employment, or	❑ In large companies
❑ Decrease in employment,	❑ None of the above / **not relevant to the project**
❑ Difficult to estimate / not possible to quantify	

[27] Open Access is defined as free of charge access for anyone via Internet.
[28] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:

Indicate figure:

Difficult to estimate / not possible to quantify ❑

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ **Yes** ○ No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ **Yes** ○ No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

❑	**Press Release**	❑	**Coverage in specialist press**
❑	**Media briefing**	❑	**Coverage in general (non-specialist) press**
❑	**TV coverage / report**	❑	**Coverage in national press**
❑	**Radio coverage / report**	❑	**Coverage in international press**
❑	**Brochures /posters / flyers**	❑	**Website for the general public / internet**
❑	**DVD /Film /Multimedia**	❑	**Event targeting general public (festival, conference, exhibition, science café)**

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	❑	**Danish, English, German, Italian**
❑	Other language(s)		