European Hydrogen Transit Buses in Scotland

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List of Abbreviations

ACC	Aberdeen City Council
AIP	Annual Implementation Plan
CHIC	Clean Hydrogen In Cities
CO_2	Carbon dioxide
CO_2e	CO_2 equivalent, considering emission of carbon dioxide (CO_2), methane (CO_4) and nitrous oxide (N_2O)
DoW	Description of Work
DRB	Diesel Reference Bus
EURO V	Emission standards for heavy-duty diesel engines (trucks and buses), in effect for new type approvals since 1 October 2008
EURO VI	Emission standards for heavy-duty diesel engines, in effect for new type approvals since 31 December 2012
FC	Fuel Cell
FCB	Fuel Cell Bus
FCH JU	Fuel Cells and Hydrogen Joint Undertaking
GHG	Greenhouse Gas(es)
High V.	
LO-City	Cities Speeding up the Integration of Hydrogen Buses in Public Fleets
HPU	Hydrogen Production Unit
HRS	Hydrogen Refuelling Station
HRU	Hydrogen Refuelling Unit
JIVE	Joint Initiative for hydrogen Vehicles across Europe
KPI	Key Performance Indicator
LCA	Life-cycle assessment
LEZ	Low Emission Zone
OEM	Original Equipment Manufacturer

OPEX	OPerational Expenditure
NCV	Net Calorific Value (also called “lower heating value”)
NO_x	Nitrogen Oxides, emitted in the form of Nitric Oxide (NO) and Nitrogen Dioxide (NO_2)
PM	Particulate Matter
SME	Subject matter expert
SORT	Standardised On-Road Test cycle
TCO	Total cost of ownership
WP	Work Package

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1 Executive summary

The HyTransit project began in January 2013 to demonstrate the viability of operating fuel cell electric buses (FCBs) in inter-urban, public transport services. To this end, HyTransit aimed to deploy a fleet of six FCBs and one state-of-the-art hydrogen refuelling station (HRS) into everyday operation in Aberdeen, Scotland. By 2015, the HRS had been commissioned and the FCBs had begun operating on a variety of Stagecoach routes across Aberdeen's city centre and suburbs. By March 2019, the FCBs and the HRS had amassed 4 full years of operation, and the project concluded after a successful demonstration. Based on the experience gathered in the project, Stagecoach and Aberdeen City Council have committed to keep the HyTransit FCBs in regular operation until at least September 2019, 6-months after project conclusion, with further contract extensions under consideration.

Throughout the project period, the Aberdeen Kittybrewster HRS, built and operated by BOC, performed exceptionally well demonstrating some of the highest utilisation and availability figures seen across hydrogen projects in Europe. Over the four years of operation, an average availability of 99.5% was achieved, with ~147,000kg of hydrogen dispensed and ~5,400 successful refills made directly to the 6 HyTransit buses. BOC attribute this high level of performance to two main factors: the innovative station design which factors in great levels of redundancy into the station, and a dedicated on-site technical engineer who visits and monitors the site every day to assess performance and conduct pre-emptive maintenance. Based on the success of the station, the HRS was upgraded in 2018 to include a 700-bar refueller on-site. This opened the station to passenger cars and other smaller goods vehicles, increasing the utilisation of the facility and expanding Aberdeen City Council's (ACC) potential for hydrogen deployments.

Overall, when compared with previous demonstration projects, the HyTransit FCBs have performed well, responding positively to the heavy-duty cycles enforced by Stagecoach. Through rigorous operation, the FCBs have demonstrated that the technology can meet many of the operational requirements of an equivalent diesel bus, especially when considering the range and refuelling time of the technology. However, when placed in comparison with their diesel counterparts, which have an average availability target between 85 to 95%[1], the availability of the FCBs has been a challenge for Stagecoach averaging 80% across the project period, excluding the teething period of the FCBs and the HRS. Despite these availability challenges, the 6 HyTransit buses have been operated stringently in the project, driving approximately 1.4 million kilometres and transporting over 1.3 million passengers. As a result, the consortium has been able to compile a detailed dataset which has facilitated the development of a new generation of FCBs capable of matching the full operational requirements of a conventional diesel bus.

By creating a detailed dataset for the project, the HyTransit consortium could also closely monitor the performance of the HRS and the FCBs. Data from the electrolysers, refuelling station and the FCBs was collected throughout the project period, creating a detailed 4-year record of performance. Annual data reports and project deliverables have analysed the performance of the project equipment against 'state-of-the-art' counterfactuals to assess project performance and define key points for improvement. One of the key learnings harnessed from the HyTransit project highlights the need to improve energy consumption at the HRS and refuelling speed at the dispenser. This has informed technological development for the component manufacturer, and the HRS operator, which has led to improvements in these elements across the hydrogen sector.

Equipped with the positive results from the deployment project, Aberdeen City Council and HyER worked to communicate the project to a variety of audiences, from the local Scottish public to new bus customers and European decision makers. This included press releases, project leaflets and presentations at a number of European events. These activities have passed the learnings of the project on to other cities, regions and interested parties, increasing the knowledge base for hydrogen deployments both in the public domain and the FCB sector.

The HyTransit project has therefore been a success, with both the FCB and HRS technologies surpassing all expectations for a demonstration project. The HyTransit buses will remain in operation beyond the end of the project period, until at least

[1] Lozanovski, A, Whitehouse, N. Ko, N. Whitehouse, S. (2018) Sustainability Assessment of Fuel Cell Buses in Public Transport (https://www.mdpi.com/2071-1050/10/5/1480/pdf)

September 2019, when leasing contracts will be reassessed. However, as the HyTransit FCBs come to the end of their operational lifetime, ACC are already preparing to build upon the HyTransit trial by expanding their FCB fleet with 15 new generation buses funded via the JIVE initiative. This represents the next phase of a master plan to transition the city's whole public transport network to zero-emmission.

Key conclusions

- The Aberdeen Kittybrewster hydrogen refuelling station has exceeded industry expectations with the highest average availability (99.5%) and utilisation (46%) results seen to date across hydrogen projects in Europe. Based on this success, the innovative designs of the HRS have been carried forward into other hydrogen projects and have been embedded in BOC's strategy for future station deployments.
- The HyTransit fuel cell buses have been rigorously tested in the project and exposed to real world commercial operation. In most cases, the buses have met the operational requirements of an equivalent diesel bus, offering the same range and operational flexibility expected by the bus operator.
- Public and driver acceptance of the FCBs has been very positive throughout the project. No major safety concerns have been stated by those who use the buses. In fact, of the passengers and drivers surveyed in the project, many stated that they preferred using the FCBs to diesel buses as they find them quieter and more comfortable to use.
- Passengers showed clear indications that environmental and air quality issues were key concerns for public transport in Aberdeen. There is appetite for zero emission buses in the area and this will likely increase in the coming years, both in Aberdeen and more widely across Europe.
- Based on their experience of trialling the FCBs Stagecoach, the bus operator, remains open to the opportunity of using the technology in the future provided that a reasonable price of hydrogen can be established, and that bus OEMs stand behind their products.

2 Introduction

2.1 *The project*

2.1.1 Background

Over the past decade, the European Union (EU) and its Member States have published increasingly aggressive policy objectives to mitigate against climate change and air pollution. One area of attention has focussed on zero-emission transport, with the aim to reduce harmful transport emissions by moving away from fossil fuelled petrol/diesel vehicles to cleaner, greener alternatives. For example, in August 2019 the European Commission revised the Clean Vehicle Directive to set a minimum target for 24% of all public transport buses in each EU member state to be 'clean'[2] by 2025, with this minimum quota increasing based on the country's GDP. Hydrogen has therefore enjoyed increased levels of interest and political support in recent years as vehicles with fuel cell electric drivetrains, using hydrogen as a transport fuel, can produce zero harmful tailpipe emissions and have the potential for zero well-to-wheel CO_2 emissions[3].

Furthermore, relative to other zero emission options such as battery powered vehicles, hydrogen offers a rapid refuelling time and longer range. This makes hydrogen a particularly attractive option for larger, longer-range vehicles such as buses as the technology can provide a viable alternative to their diesel counterparts without any loss of performance, operational flexibility or disruption to customers using the service[3].

Based on the associated benefits of hydrogen technology, first European deployments projects for fuel cell buses began in 2001 with the CUTE project which aimed to deploy a fleet of 27 FCBs across 9 European cities. Based on the emerging results, a number of follow-up deployments were initiated to expand the use of FCBs, and their

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[2] Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019L1161&from=EN:

[3] Fuel Cell Electric Bus – Potential for Sustainable Public Transport in Europe: A study for the Fuel Cells and Hydrogen Joint Undertaking https://www.fch.europa.eu/sites/default/files/150909_FINAL_Bus_Study_Report_OUT_0.PDF

supporting infrastructure, across Europe. As can be seen in the timeline in Figure 1, this included the CHIC, High V. Lo. City and HyTransit projects. The JIVE and H2Bus Europe initiatives represent the next generation of deployment projects, focussed on much larger scale deployments, in the order of 300 to 600 buses, aimed to drive down the purchase price of the buses.

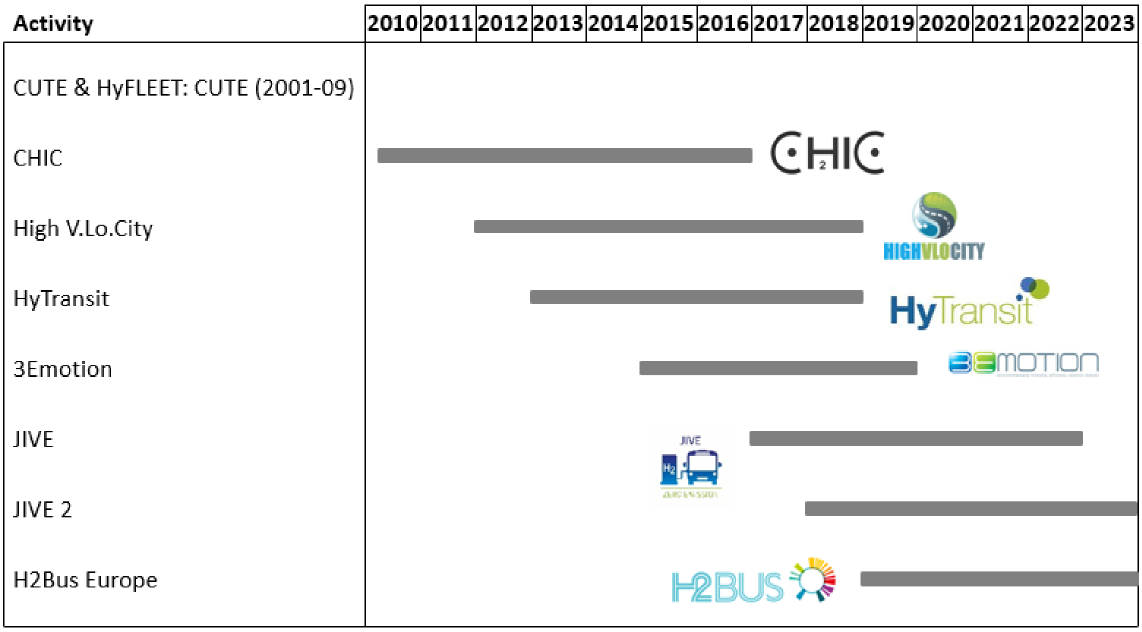


Figure 1: Timeline of European demonstration projects

2.1.2 Project description and objectives

HyTransit trialled a fleet of six fuel cell buses in daily fleet services, together with one state of the art hydrogen refuelling station in Aberdeen, Scotland. This project was designed to contribute to the commercialisation of hydrogen buses in Europe by achieving the following objectives:

- **Coordinate** an industrial consortium from across Europe to deliver the project.
- **Develop** six A330 hybrid fuel cell buses specifically modified for long sub-urban routes.
- **Develop** the concept design for the world's first fuel cell coach for long-route transit applications.
- **Expose** the six buses to real world operation with exactly the same service requirements as diesel buses.

- **Deploy** a state-of-the-art hydrogen refuelling station to serve the bus fleet.
- **Initiate** the first step for a large-scale rollout of hydrogen buses in Scotland.
- **Prove** that a fuel cell bus is capable of meeting the operational performance of an equivalent diesel bus on demanding UK routes (including urban driving), whilst considerably exceeding its environmental performance.
- **Address** the main commercial barrier to the technology (namely bus capital cost) by deploying state of the art components.
- **Disseminate** the results of the project to the public and key stakeholders who will be responsible for decisions on the next steps towards commercialisation of the technology.

However, it should be noted that the HyTransit project provided a unique opportunity for the FCB sector as it aimed to build upon and develop learnings generated from preceding projects (CHIC and High V. Lo City). HyTransit was differentiated by three main factors:

1. **Demonstration of inter-urban transit buses** – the HyTransit demonstration focused on inter-urban transit buses, when previous deployments only concentrated on short-distance urban buses. HyTransit therefore aimed to address this gap in the market and demonstrate that the FCB can match the operational performance of an equivalent diesel bus in long route operation.
2. **Industrial consortium –** The HyTransit project brought together representatives from every relevant area across the FCB supply chain and the local political landscape. For example, the consortium included the bus OEM, the fuel cell supplier, the bus operator, local policy makers and communication and analysis partners. In this way, the project was extremely well placed to draw on a diverse range of expertise, generating a wider array of learnings than previous projects.

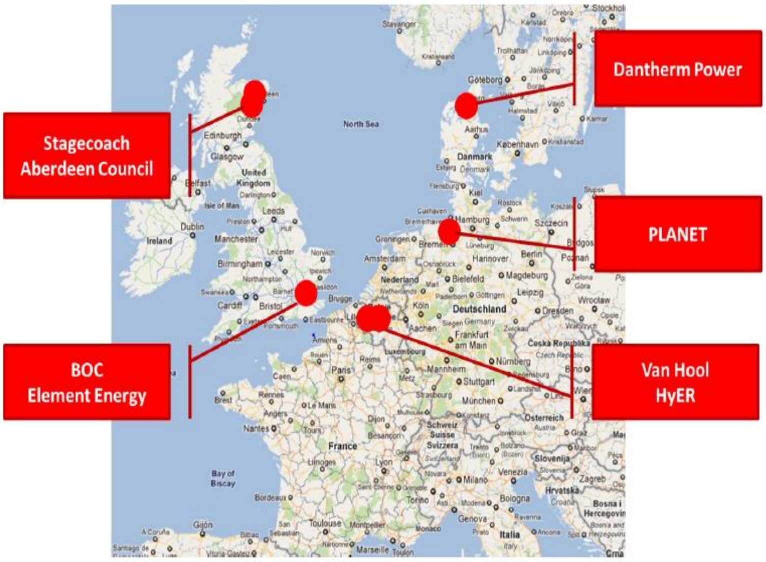


Figure 2: International spread of HyTransit project

By having close interaction between manufacturers and users, any issues encountered in the project could be used to develop lessons learnt and 'best practices', directly informing future generations of FCBs.

The following beneficiaries were included in the project:

	Participant name	Short name	Description
1	BOC LIMITED	BOC	BOC is part of the Linde Group, a world-leading gas and engineering company. In the project, BOC supplied and operated the hydrogen refuelling infrastructure.
2	VAN HOOL N.V.	VH	Van Hool is a leading bus and coach manufacturer located in Belgium. Van Hool were responsible for designing and supplying the 6 hybrid FCBs for the project.
3	ABERDEEN CITY COUNCIL	ACC	Aberdeen aims to become a pioneer in hydrogen technology. The city council headed the local project management for the project, leading deployments on-the-ground.
4	STAGECOACH BUS HOLDINGS LIMITED	STG	Stagecoach is a leading international public transportation group, with extensive operations in the UK, US and Canada. In this project, Stagecoach was responsible for integrating and operating the buses into their everyday commercial service.
5	HYDROGEN, FUEL CELLS AND ELECTRO-MOBILITY IN EUROPEAN REGIONS	HyER	HyER was established in 2008 to foster the deployment and uptake of hydrogen and fuel cell technologies in Europe. As a dissemination partner, HyER were responsible for the European dissemination of the project.

6	PLANET PLANUNGSGRUPPE ENERGIE UND TECHNIK GBR	PLA	PLANET is an engineering and consulting service with a specialism in hydrogen and fuel cell technology. PLANET was responsible for collecting project data and producing performance and environmental assessments of the technology deployed in HyTransit.
7	BALLARD EUROPE	DNTH	Ballard Europe (previously Dantherm Power AS) is a world leading fuel cell integrator company located in Denmark. They were responsible for building, supplying and servicing the fuel cell stacks installed in the HyTransit buses.
8	ELEMENT ENERGY LIMITED	EE	Element Energy is a leading low carbon energy consultancy, with a speciality in hydrogen and fuel cell technology. In HyTransit, EE were responsible for assessing, and producing, an economic analysis of the FCBs, as well as creating a strategy for FCB expansion.

Table 1: Partners in the HyTransit project

4. **Largest fleet in Europe –** at the time of deployment, and in collaboration with the four buses deployed in Aberdeen through High V.LO-City, the project led to the deployment of Europe's largest fleet of hydrogen buses. This allowed the project to stress-test the hydrogen infrastructure in Aberdeen under high utilisation and demonstrate how a large hydrogen fleet can fit into a public transport operator's day-to-day service. These learnings generated from the project have been instrumental in informing the strategy for the next phase of FCB projects and deployments (e.g. JIVE, JIVE 2, H2Bus Europe), and ultimately into the commercial phase of the technology.

Figure 3: Picture of the H2 Aberdeen fleet, including 6 FCBs from HyTransit and 4 FCBS from the High V Lo. City project

3 Main Science and Technology Results and Foreground

3.1 *Main project information and achievements*

Basic project information

Project Context	
Duration of project	1st January 2013 – 31st March 2019 (75 project months)
Number of project partners	8
Total Project Spend	€17,850,708.85
FCH JU contribution	€6,999,999.00
Fuel cell buses demonstrated	6 Van Hool A330 hybrid fuel cell electric buses: - Class I bus – right-hand drive - Passengers – 44 (seated) - Top speed: >80km/h - Hydrogen storage: 35kg - Fuel economy >11km/kg - Range >350km - Fuel cell life >12,000 hours under warranty
Hydrogen refuelling station demonstrated	One HRS with on-site hydrogen production via electrolysis, capable of producing and dispensing 300kg/day at 350bar. Supplied by renewable electricity, the station produces green hydrogen for the 10 buses in operation in Aberdeen (6 from HyTransit and 4 from High V.Lo-City. Equipment installed on-site includes: - 3 'Hydrogenics Hystat 60' on-site electrolysers. - Twin IC90 (Ionic Compressor) compression units to ensure dispensing capacity >~250kg/day. - Large on-site high pressure (500-bar) storage to secure supply. - 2 dispensers capable of refuels at 350 bar.

Overall assessment of project performance

KPI	Target	Overall Performance
Hydrogen Production Unit		
Efficiency of on-site hydrogen production (entire HPU and per electrolyser)	> 50%	**> 50%**
Hydrogen Refuelling Unit		
Availability of the HRU	> 98%	**99.5%**
Amount of hydrogen dispensed to the project buses	> 140,000 kg	**146,823 kg ***
Entire Hydrogen Refuelling Station		
Specific OPEX per kg hydrogen dispensed	< 10 €/kg	12.31 €/kg
Fuel Cell Buses		
Availability - HyTransit target for the fleet - Annual Implementation Plan (AIP)** target for the fleet	> 90% > 85%	78 %
Distance travelled by the fleet	1,600,000 km	1,378,129 km
Operating hours drivetrain	70,000 hours	**88,824 hours**
Specific hydrogen fuel consumption per 100 km - HyTransit target - AIP target	< 10 kg 11 – 13 kg	10.7 kg
Number of passengers	> 1,000,000	**1,302,487**

Table 2: Key performance indicators, performance targets and actual overall performance. Target figures are HyTransit targets unless stated otherwise. Bold figures in the "Overall Performance" column indicate that the related HyTransit target was achieved.
* Additional hydrogen was supplied to High V.LO-City buses. In total, if hydrogen dispensed to the High V.Lo City buses and the fuel cell cars in Aberdeen were taken into account, the Kittybrewster HRS would have dispensed ~200 tonnes of hydrogen over the project period.
** The Annual Implementation Plan (AIP) was defined by the FCH JU in 2011 to provide general targets for upcoming funded projects.

3.2 *Explanation of results*

3.2.1 Infrastructure development and deployment

The HyTransit Hydrogen Refuelling Station (HRS) is situated to the North-West of Aberdeen City Centre on the council's Kittybrewster maintenance depot (see Figure 4 and 5)

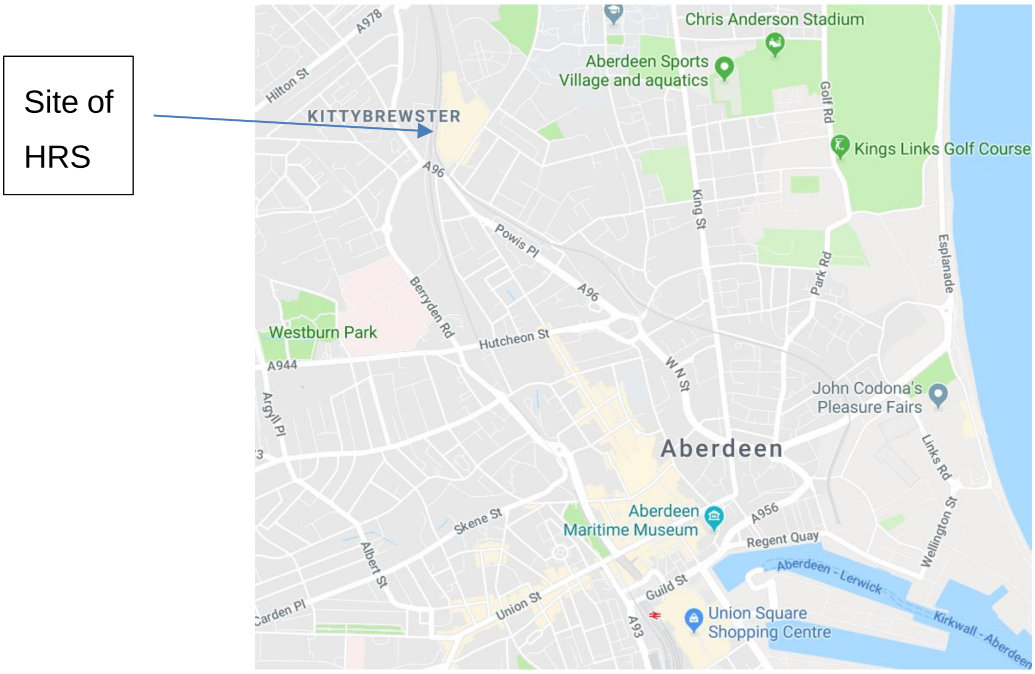


Figure 4: Map of Aberdeen Credit: Google maps

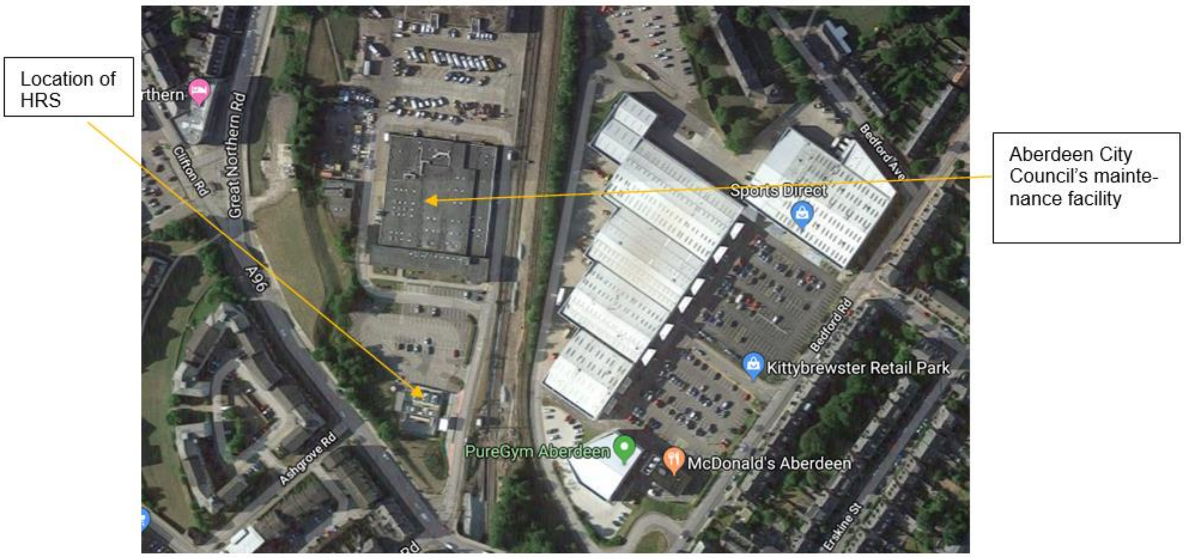


Figure 5: Satellite image of the Kittybrewster site Source: Google maps

One of BOC's primary challenges in Aberdeen was the design of the Kittybrewster HRS into a small urban bus depot. The layout of the Kittybrewster site, and its location in a built-up residential area, meant that innovative and original designs for the station had to be drawn to minimise the footprint of the HRS.

Designs and planning

Key to the success of an FCB demonstration project is a reliable fuel supply system. In order to operate the buses as per conventional diesel vehicles, operators need to have fuel available at the appropriate quantity and quality, when they need it. This being the case, HyTransit set strict performance requirements which helped determine the engineering designs for the station. For example:

1. Sufficient production and dispensing capacity was required to meet the fuel requirements of both Stagecoach and First (10 buses in total), whilst concurrently allowing the electricity provider, SSE, the opportunity to undertake trials on grid balancing activities.
2. A highly reliable station was required to ensure security of supply to the bus operators and to demonstrate the viability of hydrogen as a commercial alternative to petrol/diesel.

Based on these criteria, BOC designed the station with a 'N+1' philosophy, where redundancy was added to the electrolysers, compressors and dispensers to ensure that there would always be sufficient supply to satisfy the demands of the project buses. This meant that the station could:

- **Have extra production and dispensing capacity** - Between the three electrolysers, daily production capacity at the station is ~390kg, while the buses only require ~250kg H2/day. This surplus capacity allowed BOC to ensure that there would always be sufficient hydrogen on-site to meet the demands of the 10 FCBs in operation in Aberdeen, whilst also leaving open the opportunity to upgrade the station for passenger car refuels. Additionally, surplus supply allowed BOC to test the value of grid balancing on-site with SSE to assess whether operational costs for the station could be reduced via smart operation of the electrolysers at peak electricity demand times.
- **Support the refuel of all 10 buses over a 6-hour period overnight –** the two compressors and high capacity storage on-site at Kittybrewster meant that the

station could do high intensity back-to-back refuelling, allowing all 10 buses to be refuelled within a short timeframe (6 hours). This minimised disruption to Stagecoach and First's routine for refuelling.

- **Guarantee higher availability at the station** – by factoring redundancy into the station, BOC could reduce the wear and tear on key components and support operation during maintenance and repair situations, or when one part fails. This allowed BOC to keep the station running, providing security of supply for the bus operators.

Civil works and construction

Civil works on the HRS site began in August 2014 following the acceptance of all necessary planning permissions and the procurement of a contractor for the works. Equipment was delivered on-site in November 2014 and was stored at BOC's Aberdeen depot for safe keeping until civil works were complete. This pre-planning allowed the HRS commissioning process to progress rapidly once foundation works were completed, meaning that the site was fully commissioned and open for operation just 7-months (2^{nd} March 2015) after groundworks began. This represents a greatly accelerated build and commissioning period for a large bus refuelling station, highlighting the calibre of BOC's pre-planning and installation.

Station performance

Throughout the project period, Aberdeen's HRS has performed exceptionally well demonstrating the highest availability figures seen across hydrogen projects in Europe. Over the four-years of operation, an average availability of 99.5% has been achieved, with 146,823kg of hydrogen dispensed and 5,374 successful refills made across the 6 HyTransit FCBs. This secure supply of hydrogen has enabled Stagecoach to operate the HyTransit fleet rigorously, with little to no operational disruption caused by HRS downtime.

Due to the size of the fleet relying on the station, the station also shows some of the highest utilisation figures across Europe. The overall average over the project period is 46%, more than double the capacity factors experienced in other demonstration project such as CHIC. There were even some instances where the station was operating at ~80% capacity, a loading level which is largely unchartered in the FCB sector. This highlights the capability of the technology to meet the demands of public transport applications which have heavy duty cycles and high demands.

3.2.2 Deployment and operation of FCB's

A key focus of the HyTransit project was to rigorously test the operation, practicality and commercial viability of FCBs to serve long inter-urban bus routes. Stagecoach, a major public transport operator in the UK, joined the project to trial a fleet of FCBs in their daily services to understand whether the technology could provide a viable alternative to the diesel counterpart bus which currently operates on their services in Aberdeen.

Since March 2015, Stagecoach implemented the FCBs into their everyday operations, servicing long inter-urban bus routes. Initially, the buses were foreseen to be used predominantly on the X17 route between Aberdeen city centre and the Westhill area, a route approximately 23 miles long. However, following good performance, Stagecoach's confidence in the technology grew over the project period and the buses were increasingly used on more diverse routes across the city, providing a test for the technology against different driving conditions and terrains. By fully integrating the FCB fleet into Stagecoach's fleet, HyTransit demonstrated that the technology can easily work alongside diesel buses, with no compromise on the range and refuelling time of the vehicles.

The HyTransit project also acted as a test to understand the public's perception on hydrogen and FCBs. Yet, over the project period, no major safety concerns were flagged by the drivers or the customers. In fact, by the end of the project period most drivers and customers who participated in the project surveys stated that they would choose to use the FCB over a conventional diesel vehicle as the commute was both quieter and more comfortable.

Delivery of the vehicles

The HyTransit FCBs were produced by Van Hool and designs were based on the original diesel A330 transit bus operated in cities across Europe and the US. However, in order to fit the vehicle to the project's requirements and comply with UK and Scotland's regulations, Stagecoach, ACC and First Group (the operator of 4 buses under the High VLO City project) created a working group to adapt the design of the bus to their requirements. By June 2014, the designs were finalised based on a single passenger door with an emergency door at the rear, and space for wheelchair access. Further details on the specification of the buses can be found in the 'basic project information' section above.

The vehicles were delivered in batches to Aberdeen due to the plan to phase bus roll-out to ease loading stress on the HRS. The first bus arrived in July 2014, and the final bus was delivered in November 2014. As the Kittybrewster HRS was still undergoing construction and commissioning at this stage, the FCBs were used only used for driver training, using an interim hydrogen supply provided by BOC. This left many of the buses lying relatively idle for between 4 to 9 months. Although no problems arose as a result of this in HyTransit, Van Hool strongly advise against leaving a vehicle underused for an extended period as lack of use can lead to a number of technical malfunctions (e.g. drain of the battery, ceasing of parts etc). A recommendation from the project is therefore to secure hydrogen supply on-site before the vehicles are delivered to minimise the technical problems encountered in the teething phase of operations.

Depot upgrades and maintenance regime

A number of safety precautions had to be taken into account to ensure the safe maintenance and operation of the FCBs. As ACC were the owner of the vehicles, the main maintenance house for the FCBs was hosted at the council's Kittybrewster Fleet Depot, adjacent to the refuelling station, to guarantee a maintenance site for the vehicles after the conclusion of the project. Although one bay in Stagecoach's depot could house the buses, this separated the maintenance of the vehicles from the bus operator's depot, causing some disruption to Stagecoach's usual operations. Future projects are therefore advised to find a solution on-site at the bus operator's depot.

Due to the nature of hydrogen and the risk of a hydrogen leak while the FCBs are being maintained indoors, a number of modifications had to be made to the Kittybrewster depot to allow for safe maintenance, and storage, of the vehicles. To help understand the scope of upgrades, ACC contracted an external consultancy (TUV Rheinland) to visit Aberdeen and inspect the Kittybrewster and Stagecoach depots to provide advice on the alterations required to make the depots hydrogen safe. This allowed ACC to gather an exhaustive list of modifications, meaning that no additional upgrades would have to be made to the depots after the buses were delivered, minimising long-term disruption to the maintenance house.

As the purchaser of the Van Hool FCBs, ACC also assumed responsibility, and signed the legal contract for drive line maintenance and parts assurance package with Van Hool. This entailed hosting a Van Hool trained technician full-time on-site at the Kittybrewster station to tackle any drivetrain faults or maintenance. The introduction of ACC as a third party in the discussions surrounding maintenance of the buses is not a standard arrangement. More typically, the vehicle operator and manufacturer would liaise on these matters directly, to minimise the risk of delay or miscommunications. During future projects and the commercial rollout phase of FCBs, it is recommended that maintenance agreements follow as closely as possible the typical arrangements between operator and manufacturer to improve the efficiency of communication. Further, Stagecoach indicated that if they were to expand their fleet of FCBs, they would endeavour to take over full responsibility for the maintenance of the technology, training their in-house technicians to repair and maintain the vehicles. This would help reduce costs and downtime, whilst simultaneously integrating the technology into their normal operations and services.

Another learning regarding the maintenance of the buses relates to the supply chain. Due to the precommercial stage of the sector when the HyTransit project began, availability of the specialised spare parts required for FCBs was a challenge. When mechanical/technical problems arose on the FCBs, downtime of the buses was often extended as the technician awaited the shipment of specialist parts from international suppliers (Van Hool and Ballard). This had a negative effect on the availability of the buses and caused bus downtime to be extended unnecessarily, increasing disruption to Stagecoach’s operations.

To mitigate against the risk of a shortage of spare parts, in 2016, ACC installed a container in the Kittybrewster depot to house a selection of spare parts, especially ‘problem’ components which had been identified to fail most regularly. Parts in storage include a high voltage battery (~€60,000) which has been funded by Van Hool, spare invertors for the buses and rotrex compressors for the fuel cell stack. This provided a partial solution to the problem whilst the supply chain developed and moved towards commercialisation. However, should Stagecoach wish to expand their FCB operations, they have stated that they would require greater guarantees and response times from suppliers to reassure them that maintenance tasks are not substantially longer than that for a diesel vehicle. This learning is already being implemented across current deployment projects such as JIVE, with bus operators demanding increasingly secure contractual guarantees for parts supply from bus OEMs.

Bus operation

The 6 buses began operation in March 2015, following the commissioning of the Kittybrewster HRS. By the end of the project period, the HyTransit buses had amassed a total of 4 years of operation, transporting ~1.3 million customers over ~1.4 million kilometres. This resulted in >400,000 litres of diesel saved, and >1,000 tonnes of direct GHG emissions avoided in terms of CO2 emissions.

Overall, when compared with previous demonstration projects, the vehicles have performed well and have responded positively to the heavy-duty cycles enforced by Stagecoach, highlighting the capability of the technology to meet the operational demands of a conventional diesel bus. Despite this, when placed in comparison to their diesel counterparts, with an average availability between 85-95%, the availability of the FCBs has been a challenge for Stagecoach averaging 80% over the project period, excluding the teething period of the technology. However, it is important to note that this lower level of availability is expected from a precommercial technology which has not had the same amount of time and resource dedicated to its research and development as the incumbent diesel vehicles. The HyTransit project therefore provided an invaluable opportunity to test and closely monitor how the vehicles are performing in real-world operations to produce learnings/recommendations which are now implemented as standard into the new generation of buses.

One of the key learnings from the project came from an analysis of the faults that caused bus downtime. This indicated that nearly 80% of all downtime hours related to an issue with:

- Fuel cell systems (28%)
- Electric drivetrains (22%)
- Electricity storage (batteries) (14%)
- Conventional parts of the vehicle (15%)

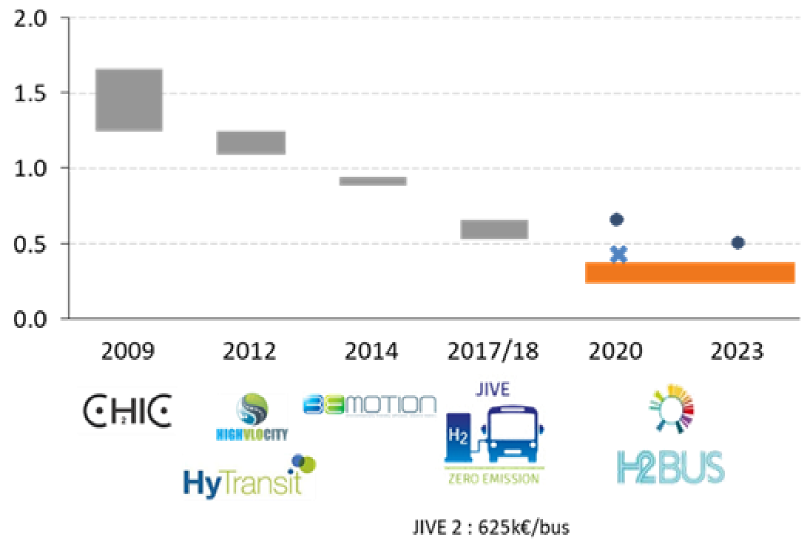
By distinguishing the root cause of the problem and working with the component suppliers, the HyTransit project has directly informed product development. This has allowed partners, and the wider hydrogen sector, to improve their technologies to an extent that target availability figures of 98% are quoted by most FCB manufacturers in 2019.

Stagecoach's experience

Based on their experience in the HyTransit project, Stagecoach remain open to expanding their FCB fleet following the conclusion of the project. However, Stagecoach have suggested that a number of improvements would be required to improve their confidence for this expansion to take place, such as:

- **Improvements in the supply chain and product support offered by the** FCB **manufacturer** – bus operators need to see OEMs standing behind their product and supporting early adopters of the technology. One step in this direction is to improve the maintenance and parts assurance package available to operators. In HyTransit, the buses were often off the road for extended periods waiting for the arrival of parts. Improvements in the supply chain would therefore dramatically reduce vehicle downtime. Supply chain improvement is expected to occur naturally as the sector expands, and FCBs become more commonplace. Until this expansion occurs, operators are recommended to include specific arrangements within the contracts with vehicle manufacturers to ensure a steady supply of spare parts for the FCBs. This learning has been applied to subsequent projects.
- **Advancements in the performance of the technology –** improvements in product quality are required to increase the availability of the buses. These improvements are already being incorporated into the next generation of FCBs, from Van Hool, and other FCB manufacturers, as well as from fuel cell system and parts suppliers. A marked improvement in vehicle availability is expected to arise from these improvements.
- **Reductions in the cost of the technology -** with technological improvements, cost reductions are required to make the vehicles less capital intensive. By the end of the project (2019), a FCB still came at a premium of £65,000/year in comparison to a diesel/petrol counterpart, which in the small margin market of

public transport operators, makes the technology harder to justify. However, cost reductions have already been achieved through the scale-up of demand created by the JIVE initiative, with OEMs required to offer FCB at less than €625,000 per bus. Further cost reductions have been indicated by the H2BusEurope project, with the consortium suggesting prices below €375,000 for a 12-metre single-deck bus are achievable.



- Objectives of the FCH JU Multi-Annual Work Plan: €650k/bus in 2020, €500k/bus in 2023

× Proposals for >100 buses in Scandinavia

- Hypothesis announced by the H2 Bus Europe consortium of <€375k

Figure 6: Graph indicating the cost reductions in FCBs across deployment project

3.3 *Post-project operation of the HRS and the FCBs*

At the beginning of the project, it was envisaged that the HyTransit buses would operate only for the project period and retire thereafter, as per the nature of demonstration projects. However, as Aberdeen City Council prepare to order 15 FCBs through the FCH JU funded JIVE project, the council wish to keep the pre-existing fleet of 10 FCBs and the HRS in operation to mitigate the risk of technical problems arising with low utilisation of the HRS. Continued operation is also seen to aid the economics of operating the HRS, especially when taking into account the small number of passenger cars currently using the new 700-bar dispenser installed in October 2018. To date, a contract has been signed between BOC, ACC and Stagecoach to operate the FCBs until September 2019. A further contract extension could be negotiated, however, as the buses come to the end of their operational lifetime and require greater level of maintenance, the decision as to whether this is financially achievable or operationally desirable will require careful consideration by Aberdeen City Council.

4 Potential impact, major dissemination activities and exploitation of results

During the course of the project, dissemination activities undertaken by project partners aimed to:

- **Create** a comprehensive visual branding for the project, which was incorporated into Aberdeen City Council's branding for all hydrogen projects in the city (H2-Aberdeen).
- **Communicate** the existence of the project to the general public in Aberdeen in order to ensure that bus users are well informed about the new technology and supportive of the deployment of the buses in the city.
- **Disseminate** the results and learnings of the project to identified key target groups (industry, policy makers, transport operators).
- **Enable** interested stakeholders to take part in local site visits (buses, refuelling station, maintenance depot).
- **Ensure** synergies with other EU projects to guarantee that the learnings of the HyTransit project are shared with other FCH-JU FCB deployment projects, and vice-versa, as well as maximising the impact of dissemination activities of the FCH-JU projects.
- **Participate** in and provide input for policy discussions at the local level as well as European levels based on the learnings from the project.

Target audience

In 2016, HyER compiled a communication strategy document, and associated plan, to determine the target audience for dissemination, synergies with other EU projects and the 'key messages' the project aimed to disseminate over the project period. The aim of the communication strategy was to ensure that the results of the project would be disseminated widely, and to an appropriate audience.

Initially, it was decided that dissemination efforts should focus on 4 main target groups in order to maximise the impact of the HyTransit project. The following groupings were defined:

- Policy makers
- Transport operators

- General public
- Industry

The strategy also identified two of these groups as priorities for the last two years of the project: policy makers and transport operators. Three levels of dissemination were identified, to determine the type of information to be shared with each target group:

<table>
<tr><th>INFORM</th><th>PROMOTE</th><th>ENGAGE</th></tr>
<tr><td colspan="3">Policy makers</td></tr>
<tr><td colspan="3">Transport operators</td></tr>
<tr><td colspan="2">Industry (FC buses and HRI)</td><td></td></tr>
<tr><td>General public</td><td colspan="2"></td></tr>
</table>

'Inform' represents the lowest level of dissemination: general information about the project and the fuel cell technology that could be communicated to the general public.

'Promote' represents a more targeted level of dissemination aimed at policy makers, transport operators and the FCB industry. This encompasses the overarching results and learnings of the project, with the aim to increase the uptake of FCB and hydrogen technology across Europe.

'Engage' represents the highest level of dissemination. This includes detailed information about the performance of the buses and the refuelling infrastructure which could be shared with policy makers and transport operators.

Branding

As stated above, the HyTransit project was part of a wider ambition for Aberdeen to become a pioneering city for hydrogen deployment. This being the case, the branding for the project was integrated into the H2-Aberdeen template to provide a consistent message for Aberdeen on hydrogen deployments (see examples below).

H2 Aberdeen

Figure 7: Examples of the H2-Aberdeen branding

Figure 8: Examples of the H2-Aberdeen branding both on buses, and passenger cars

Dissemination activities

Dissemination activities have been integral to informing the public and the wider FCB community on the progress of the demonstration and the on-going results of the project. To keep such a diverse audience interested in the project, and its associated technology, the project has had to employ a variety of dissemination methods such as:

***Leaflets* –** throughout HyTransit two leaflets have been produced to introduce the public and new interurban bus customers to the project and disseminate the initial results of the demonstration. The leaflets were handed out both on the buses when Stagecoach first deployed the service and distributed at project events encompassing a wide variety of audiences, from the general public to experts in the FCB sector.

The first leaflet was prepared for the Hydrogen Summit in March 2017. To avoid confusing the audience about individual European projects, the project decided to proceed with a ‘Aberdeen H2 Bus Project’ approach. The leaflet therefore covered the fleet of 6 HyTransit buses, as well as the 4 additional buses from the High V.LO-City project.

Figure 9: Snapshot of first leaflet

A second leaflet was produced at the end of the project to include the main lessons learned from the project. It includes all key facts and figures from the project, general information about fuel cell buses as well as key learnings from the project.

Figure 10: Snapshot of leaflet 2

Website content – HyTransit does not have a dedicated website, as the consortium agreed to consolidate information into two main areas:

- Fuel cell buses Knowledge Base - A website for fuel cell buses was developed as part of the High V.LO-City project to provide a consolidated base for all knowledge on FCBs. The website, www.fuelcellbuses.eu, gathers comprehensive information about fuel cell bus demonstration projects in Europe including information about the buses deployed, locations, data, reports etc. This being the case, the HyTransit project now utilises this network as its project website. When www.hytransit.eu is typed into an internet explorer, the page is automatically redirected to the FCB website, on the HyTransit page.

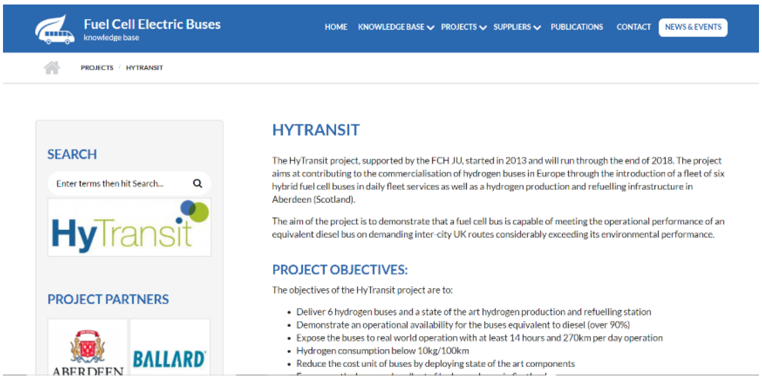


Figure 11: Snapshot of the HyTransit page on fuelcellbuses.eu

- H2-Aberdeen website – as part of Aberdeen City Council's wider strategy to disseminate information about hydrogen deployments in the city the project regularly updates the H2-Aberdeen website (**http://www.h2aberdeen.com/).**

Events – Aberdeen City Council hosted a number of events to educate a wide audience about the project and offer the public the opportunity to tour and learn from the hydrogen facilities in the area.

One of the main dissemination events for the project was the 3-day '*Hydrogen Summit'* held between 15th-17th March 2017 in Aberdeen, Scotland. Collaborating with High V.Lo-City and the NewBusFuel project, this event brought together over 150 participants from different EU projects to discuss, and learn from, Aberdeen's demonstration experience. The audience included bus operators from regions in Scotland, oil & gas organisations and key people in the hydrogen sector. High profile attendees included members of various international Hydrogen Associations, the FCH JU and governmental representative from the UK.

Figure 12: H2 Summit (Day 1/3)

Figure 13: H2 Summit (Day 3/3) tours of the Kittybrewster facility

To maintain the engagement of the general public in the project, each year the City Council hosted the ‘Doors Open Day’ event where a number of city attractions are opened free of charge to inform locals on the council’s activities. Each year a guided tour of the Kittybrewster station was given to participants and the HyTransit buses were used to transport people around the city to a range of local attractions.

Over the course of the project life, ACC has also engaged with various cities, towns and regions to disseminate the learnings of the project to new bus customers, to share the operational learning from HyTransit and offer any knowledge or guidance that can assist any organisation looking to trial hydrogen buses. Frequent calls were organised with the Scottish region Fyfe to exchange on experience with building a hydrogen re-fuelling station. More recently, in 2018, calls were held with the island of Orkney, North Scotland and Pau, France to share lessons learned and operational experiences. It is hoped that these workshop-based calls will assist other regions/cities to achieve cost and time savings going forward.

There has also been strong engagement with the JIVE project consortium since the launch of this project in January 2017. At the early stage of JIVE project development, ACC passed on its learning on a variety of aspects such as bus specification, parts availability, all the way through to the requirement of project management from a bus manufacturer. These lessons have been channelled through the JIVE partnership, to allow the other cities to achieve efficiencies through HyTransit learning.

Key dissemination messages and lessons learnt from HyTransit

During the course of the project, a number of key lessons learned were gathered by the partners for the operation of the buses and the refuelling station. These lessons learned are summarised below:

Why hydrogen and fuel cell buses?

- The data collected in the HyTransit project shows that fuel cell buses can help reduce emissions coming from public transport in cities, thus improving air quality at the local level. If the hydrogen is produced from renewable energy, fuel cell buses also become a zero-emission solution from well-to-wheel.
- Fuel cell buses offer the same range and operational flexibility as conventional fuel buses.
- Fuel cell buses have reduced noise and vibration levels.
- As is the case in Aberdeen, fuel cell buses can be integrated into a wider strategy to help decarbonise end users across transport, industry and buildings.

Infrastructure

- The Kittybrewster refuelling station was highly reliable throughout the project. With a 99.5% average availability it exceeded industry expectations.
- The refuelling station has exceeded expectations due to innovative designs and the use of state-of-the-art equipment.

- An on-site HRS maintenance manager is key to ensuring high availability of the station.
- The project has helped Aberdeen to reach a certain scale: the station is now being upgraded to service other fuel cell vehicles in the city such as garbage trucks, cars and vans.

Operation of buses

- The technology has been tested to its limits during the course of the project: buses have been exposed to real world commercial operation and have met the operational requirements of an equivalent diesel bus in most cases.
- A direct relationship between bus manufacturer and bus operator is vital to ensure the quick resolution of any mechanical problems
- Development of the bus supply chain is required to reduce downtime caused by mechanical faults.
- Storage of spare bus parts and a trained local engineer on site can dramatically reduce maintenance downtime caused by sourcing parts and expertise from across the world

Social acceptance – passengers and drivers

- For both passengers and drivers, the acceptance of the buses has been very good. There are no main concerns about the safety of the buses and there seems to be no reticence towards hydrogen as a technology.
- There are clear indications that environmental and air quality concerns are becoming more important issues for passengers. There will probably be an increased public push towards zero emission buses in the next few years as passengers recognise hydrogen as a potential solution. If more of these buses were to be deployed in the future, covering more routes, most passengers would welcome them.
- Passengers enjoy travelling on the hydrogen buses because they less polluting, but also mainly because they are less noisy and more comfortable.
- Some of the drivers encountered technical problems while driving the buses and did not feel trained or informed enough to handle them. Training is therefore of paramount importance before and during the deployment of the buses.

General conclusions from the project and learnings

- HyTransit has proved that fuel cell buses, and the supporting infrastructure, are a viable solution to decarbonise public transport fleets.
- The unique combination of stakeholders across the entire hydrogen and fuel cell buses supply chain enabled a thorough understanding of the technical and operational demands on fuel cell buses in commercial fleet operation and what is required to ensure their smooth integration into fleet service.
- Customers accept the hydrogen technology as a safe, zero-emission alternative to diesel buses
- Bus operators are happy to continue to use the technology providing a reasonable price of hydrogen can be established

Section A (public)

No scientific publications have been written and published as part of the HyTransit project.

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	**Type of activities[4]**	**Main leader**	**Title**	**Date**	**Place**	**Type of audience[5]**	**Size of audience**	**Countries addressed**
1	Project conference	ACC/HyER	Hydrogen Summit / HyTransit mid-term conference	15-17th March 2017	Aberdeen	Local stakeholders and international experts	175	UK, European countries
2	Project workshop	HyER	Fuel cell buses workshop –	20 May 2016	Brussels	Policy makers	15	Belgium – European countries

[4] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[5] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias ('multiple choices' is possible.

			High V.LO-City + HyTransit					
3	Dissemination stand	HyER	Ten-T Days 2016	20-22 June 2016	Rotterdam	International experts, policy makers	300	European countries
4	Conference / speaking slot	HyER	World Hydrogen Economy Conference	13-16 June 2016	Zaragoza	International experts, scientific community	40	Spain, European countries
5	Conference / speaking slot + presentation	HyER	FCH-JU Programme Review Days 2016	21 November 2016	Brussels	International expert audience, policy makers	20	European countries
6	Conference / speaking slot	HyER	FCH-JU Stakeholder Forum	23 November 2016	Brussels	International exert audience, policy makers	200	European countries

7	Conference / speaking slot	HyER/ACC	International Fuel Cell Bus Workshop	1 December 2016	London	International expert audience, policy makers	60	European countries/ US
8	Poster	HyER	FCH-JU Programme Review Days 2017	23 November 2017	Brussels	International expert audience	30	European countries
9	Workshop / speaking slot	HyER	GIANTLEAP Project Workshop, part of the VPPC 2017 (Vehicles Power Propulsion Conference)	12 December 2017	Belfort	International expert audience	30	European countries

10	Conference / speaking slot	HyER	European Fuel Cells Conference	14 December 2017	Naples	International expert audience, scientific community	40	Italy / International
11	Conference / speaking slot	HyER	LowCVP workshop on buses	8 March 2018	Glasgow	Bus operators, policy makers	100	UK
12	Conference/ speaking slot	HyER	FCB Oslo 2018	17 April 2018	Oslo	Bus operators, policy makers	50	Norway
13	Conference / speaking slot	HyER	Clean Bus Conference 2018	18 April 2018	Amsterdam	Bus operators, policy makers	150	UK, Germany, Netherlands, France, Norway etc.

14	Conference/ speaking slot	HyER	All Energy 2018 (Sustainable Urban Mobility Solutions)	6 May 2018	Glasgow	International expert audience, policy makers	40	UK
15	Dissemination stand	HyER	Zero Emmission Bus Conference	November 2018	Cologne	International expert audience	200	UK, France, Belgium, Germany etc
16	Press release – in cooperation with the other FCH-JU bus projects	HyER	Launch of the FCB website	29 November 2016	London	Bus operators, policy makers	Sent to 1000+ contact list	European countries
17	Press release	ACC (with HyER)	H2 Summit (mid-term conference)	February 2017	Aberdeen	Local stakeholders +international experts, bus operators	Sent to 500+ contact list	UK + European countries

						and policy makers		
18.	Press article - international	ACC	Aberdeen's Oil Curse - POLITICO	8 August 2016	POLITICO European edition	General public	500+	European countries
19	Press article - international	ACC	The odorless gas that's transforming the way we travel - CNBC	5 January 2018	CNBC	General public	500+	Europe + rest of the world
20	Press article -national	ACC	Pastille power to Glenfiddich gas: the green energy revolution	3 May 2016	Financial Times	General public	500+	UK + international

			Some of the projects in Great Green Britain – Financial Times					
21	Video + press article	ACC	Europe's oil capital turns to clean, green hydrogen buses - CNBC	20 October 2017	CNBC	General public	500+	Europe + rest of the world
Publication	PLANET	D4.2 "Environmental Benefits of the HyTransit Buses in Operation"	March 2019	n/a	Scientific Community, Industry, Civil Society, Policy makers		EU and beyond	Publication

Publication	PLANET	Publishable Summary of D4.1c "Performance Assessment Report"	May 2019	n/a	Scientific Community, Industry, Civil Society, Policy makers		EU and beyond	Publication

Section B (Confidential[6] or public: confidential information to be marked clearly)

Part B1

The applications for patents, trademarks, registered designs, etc. shall be listed according to the template B1 provided hereafter.

No new patented technology was produced as part of this project.

[6] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

Part B2

Please complete the table hereafter:

Type of Exploitable Foreground[7]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[8]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
Commercial exploitation of R&D results	Knowledge gained from the Performance Assessment and Environmental Analysis work	Yes	N/A	Knowledge for consulting on zero emission mobility / deploying fuel cell buses and other vehicles and their (green) hydrogen supply infrastructure	H49 M71 D35	Ongoing	No	PLANET

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[8] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

Type of Exploitable Foreground[7]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[8]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
Design	Concept design for an intercity coach	YES	N/A	Potential design for a new generation of inter-city coach.	Automotive	N/A	NO	Van Hool (owner)
Design	Design of the Kittybrewster HRS	Yes	N/A	Flagship design for an HRS with exceptionally high availability figures	Refuelling technology	N/A	NO	BOC (owner)

In addition to the table, please provide some text to explain the exploitable foreground, in particular:

- Its purpose
- How the foreground might be exploited, when and by whom
- IPR exploitable measures taken or intended
- Further research necessary, if any
- Potential/expected impact (quantify where possible)

Societal impact

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	303467
Title of Project:	HyTransit
Name and Title of Coordinator:	Mark Griffin

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) :	***No***
RESEARCH ON HUMANS	
• Did the project involve children?	***No***
• 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	0
Work package leaders	2	3
Experienced researchers (i.e. PhD holders)	0	1
PhD Students	0	0
Other	7	7

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

D Gender Aspects

5. **Did you carry out specific Gender Equality Actions under the project?** ○ ○ ***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:	Each organisation followed its own policies on the topics.

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?**

○
○ 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)?**

○
○ No

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

○
○ No

F Interdisciplinarity

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

○ Main discipline[9]:
○ Associated discipline**Error! Bookmark not defined.**: ○ Associated discipline**Error! Bookmark not defined.**:

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

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

○ No

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

12. Did you engage with government / public bodies or policy makers (including international organisations)	
○ 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 **secondary** objective (please indicate areas below - multiple answer possible)	
13b If Yes, in which fields?	
Energy Environment Public Health Regional Policy Transport	

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

13c If Yes, at which level?

- ○ National level
- ○ European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**0**
To how many of these is open access[10] provided?	**0**
How many of these are published in open access journals?	**0**
How many of these are published in open repositories?	**0**
To how many of these is open access not provided?	**0**
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[11]:	**N/A**

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).*		0
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		**0**

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

❑
❑
❑

❑ None of the above / not relevant to the 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:* *N/A* ❑

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 ○

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

○ Yes ○

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

❑		❑	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
❑		❑	Event targeting general public (festival, conference, exhibition, science café)
❑	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?

❑	Other language(s)		
❑			

Question F-10: Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

[10] Open Access is defined as free of charge access for anyone via Internet.

[11] For instance: classification for security project.

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 Engineering and technology

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. Medical Sciences

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. Agricultural sciences

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]