

**elementenergy**

***Strategies for joint  
procurement of fuel  
cell buses***

Final report

for

**The FCH JU**

July 2016

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## 1 Executive summary

### 1.1 Overview

The fuel cell bus is a promising option for the decarbonisation of road transport and elimination of airborne pollutant emissions. This potential has been demonstrated in deployment initiatives such as the CHIC project<sup>1</sup> and numerous reports.<sup>2</sup>

In September 2015, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) commissioned a group of consultants led by Element Energy to help initiate and coordinate a new wave of fuel cell bus procurement activity across Europe. This initiative was a response to the FCH JU's publication "Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe", which mapped out a strategy for commercialising fuel cell bus technology for Europe. The first phase of this strategy is to ensure a step change in the level of demand for fuel cell buses, with a target of 300–400 new buses deployed by 2020.

In order to deliver this ambition a series of cluster coordinators have worked to develop five regional procurement clusters, where a number of bus operators and cities agree to work together to procure a large volume of fuel cell buses. The cluster coordinators have worked with senior decision makers in cities and regions in their areas to develop business plans and funding strategies, which have then been presented for approval at board level.

This report summarises the activity between September 2015 and June 2016.

### 1.2 Main accomplishments and conclusions

The diagram below summarises the cluster coordination team and the current status of expected bus deployment in each of the clusters.

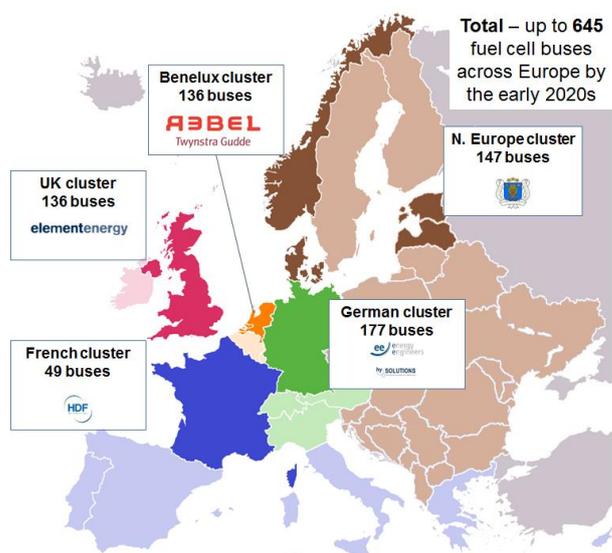


Figure 1: Overview of cluster coordinators and potential demand for fuel cell buses

<sup>1</sup> [www.chic-project.eu](http://www.chic-project.eu)

<sup>2</sup> See: *Urban buses: alternative powertrains for Europe* – FCH JU (2012) and *Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe* FCH JU (2015).

**Higher than expected demand for fuel cell buses** – The cluster coordinators have succeeded in identifying demand for fuel cell buses well in excess of the 300–400 target from the previous FCH JU study. This demand has exceeded expectations. Over 600 buses have been identified across the five clusters and this number keeps rising as more cities become involved in the activity. In the majority of cases cities are interested in zero emission buses due to increasingly urgent needs to address local environmental issues, in particular air quality, and are attracted to hydrogen fuel cell solutions due to the operational flexibility offered by these vehicles.

**A first price point for the industry** – It should be noted that the demand is conditional on certain price expectations and assumptions about the level of funding which might be available. The FCH JU has indicated a maximum price for a 12m fuel cell bus of €650k (compared to a conventional diesel bus priced at €200–250k) and allocated up to €200k to fund each bus in its 2016 Call. Cities have therefore been developing deployment plans on the basis of an effective vehicle price of €450k per bus and the level of demand identified by the cluster coordinators is predicated on this figure.<sup>3</sup> This, we could conclude, represents a price threshold below which genuine demand in the market can be expected, based only on local and national activity.

**New approaches to joint procurement** – In addition to stimulating demand, each cluster has developed strategies for the way in which joint procurement will work in their regions. Two regions have already begun joint procurement (UK and Germany have both issued RFIs to start the process) and two will start shortly (Northern Europe and Benelux). In each case new strategies have been established for the joint procurement activities, which are compliant with European procurement rules and which meet the need for flexibility. The table below summarises the key features of each approach.

UK	Germany	Benelux	Northern Europe
<p><b>Lead authority</b> takes responsibility for running the procurement (TfL)</p> <p>Framework established which other cities can call off to create bilateral supply contracts for each city</p> <p>Multiple lots for different vehicle types, with common specification for each lot</p>	<p><b>Lead authority</b> takes responsibility for running the procurement (WSW)</p> <p>Framework established which other cities can call off to create bilateral supply contracts for each city</p> <p>Single common specification</p>	<p>Concession model for bus operators complicates the procurement process</p> <p>Consideration of a <b>single special purpose entity</b> to carry out a single region wide procurement</p> <p>Common vehicle specification</p>	<p>Development of common vehicle specification is underway</p> <p>For 2016, <b>numerous unilateral procurements</b> (timing of demand prevents formal joint procurements)</p> <p>Joint procurement options being explored for beyond 2017</p>

In addition to the cluster specific activities, all of the clusters have shared specifications and procurement plans with a view to harmonising where possible and hence presenting a common European industry standard. The learning from these joint procurement strategies will be relevant to future activities in both the next fuel cell bus and other innovative technology procurements.

<sup>3</sup> It is recognised that the amount of European funding available to support fuel cell bus deployment in the pre-commercial phase is limited and that there is a limit to the number of buses that can be funded at the level available in the 2016 Call.

**New fuel cell bus suppliers entering the market** – The requests for information phases of the procurement activities have stimulated an impressive response. At the start of the project, there were only two OEMs publicly declaring their ability to supply buses to these projects. The early indications from the procurement activity is that many more suppliers are coming forward than originally expected and with novel bus concepts. In total ten suppliers have expressed interest in offering fuel cell buses of different types across the two active procurements. This is very encouraging progress in a sector which will need competition if it is to prosper. Whilst there is still a difference in the level of experience of the different players with respect to fuel cell buses (and at this stage, these are simply discussions and not formal supply contracts), it does indicate that the procurement activities that have been catalysed by the FCH JU are starting to have an impact on the market. It will be important that this momentum is sustained as the procurements convert into formal contracts – first contracts are expected in early 2017.

**A range of new bus models and drivetrain strategies** – The early indications from the bus suppliers are that a much wider range of buses than initially envisaged may be available. There are indications that single-deck bus lengths from 9–18m could be made available and that double decker buses are an option. In the drivetrain, a variety of strategies have been discussed, ranging from very small fuel cells (10kW+) with large batteries designed for range-extender operation (approximately half of the motive power would come from fuel cells, the remainder from overnight charging of batteries), through to large fuel cell systems with 100kW+ stacks, more akin to the fuel cell buses operating today. It will be important that future funding programmes allow flexibility for these different options and do not accidentally discriminate against the different approaches. Ultimately the operators will need to identify their preferred option.

**Indications of further price reductions with increases in demand** – In addition to these formal procurement activities, the procurement clusters have been an opportunity to begin discussing ways to permanently reach a price level below the €450k threshold which has been identified here without relying on high levels of public subsidy. Very early discussions with certain manufacturers have focussed on orders on 200–300 being sufficient to guarantee prices below this level. It is recommended that further work is initiated to follow up these discussions with manufacturers, as these lower prices could form the basis for the next wave of industry expansion.

**Two large scale European funding proposals** – The other activity catalysed by the project has been the preparation of new funding proposals in consortia, which were facilitated by the connections made through the cluster coordination process (though note that the bidding activity itself was not supported by this project). The two projects are:

- **JIVE** – a project to deploy 142 buses and new fuelling stations in nine European cities in five member states – this bid was submitted to the FCH JU in May 2016. In preparing the bid, many willing cities had to be turned away, creating a pent up demand for any 2017 call on this topic.
- **MEHRLIN** – a bid to the Connecting Europe Facility for funding for hydrogen fuelling stations for buses in cities located on the TEN-T network. This bid was submitted in February 2016, was evaluated positively and is expected to receive funding.<sup>4</sup>

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<sup>4</sup> <http://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/project-funding/doc/cef/2015-cef-selected-proposals.pdf>

The JIVE project funding request is currently under evaluation. If successful, these projects alone will more than double the amount of hydrogen sold to road vehicles in Europe.

**More funding for fuel cell buses will be required** – Even if the projects are successfully evaluated, they will only support 142 of the approximately 600 bus demand which has been catalysed by this process. There is therefore a need for further funding and / or cost reductions if the momentum in the market is to be sustained. This funding would ideally be derived from the FCH JU (in the 2017 and possibly successor calls) and other European institutions. To this end, the consortium partners wrote a letter to the European Commission requesting support for additional funding of fuel cell buses in upcoming programmes. It will also be important to press for increased national funding allowances for zero emission buses of this type. Finally, there is a need for industry to respond to the challenge that, if the buses have a lower cost, the funding will stretch further. Discussions with industry to understand better the potential to increase volumes and lower prices could also help permit the higher volumes which are projected here.

### 1.3 Next steps for the consortium

The approach of funding procurement activity in regional clusters has shown early signs of success. There is still much work to do, but the clusters appear to have cemented demand for a considerable number of vehicles (and hence hydrogen) and started to make the bus industry move towards a more competitive fuel cell bus offer. It is recommended that this cluster activity be continued if possible. The immediate recommended next steps for this consortium include:

- Continue work on the procurement in Germany and the UK – much work lies ahead to go through a formal tendering phase and finalise (by spring 2017) contracts for the early cities committed to fuel cell bus deployment.
- Start the formal procurement for the Northern and Benelux clusters.
- Final business planning and local fund raising to confirm the first wave of deployment projects, ready for projects to start in early 2017.
- Continue to press the case for additional funding for another wave of subsidised fuel cell bus procurement, with a view to initiating further large projects in 2017, in order to bring about further cost reductions through economies of scale.
- Further outreach work to encourage more cities to join the hydrogen bus deployment activities.
- Work with policy makers to demonstrate the potential for fuel cell buses and hence the potential to implement regional policies aimed at zero emission buses in e.g. busy urban centres.
- Work with bus industry partners to define a clear path to the low cost buses needed to allow a self-sustaining sector.
- Work with the bus industry to support initiatives aimed at helping new entrants gain experience and reference projects with fuel cell buses, via small fleet deployment / trial projects.
- Further work with all stakeholders (financiers (notably the European Investment Bank), hydrogen suppliers, bus industry and bus operators) to finance the expansion of the hydrogen bus roll-out beyond these funded programmes,

focussing on the case for hydrogen bus depots and the options for reducing the price of hydrogen supply at a large scale.

Furthermore, given the apparent success of this mechanism, it would be worthwhile for the FCH JU to explore whether a similar mechanism based on demand creation and aggregated procurement could be used in other sectors which are of a strategic interest for the FCH sector. These might include trucks, waste vehicles or even large stationary fuel cells.

## 2 Introduction

### 2.1 Context

The hydrogen fuel cell (FC) bus is one of very few options for the elimination of both local pollutant and carbon dioxide emissions from public transport. Hydrogen can be generated from a range of low carbon sources and, when used in a fuel cell, the only emission is water. Fuel cell buses also offer an equivalent range and refuelling time compared with conventional buses, meaning that they can provide conventional public transport services without any loss of performance, operational flexibility or productivity, and with a reduction in noise. These benefits mean that the technology is very attractive to public transport operators, city administrations, and public transport service users.

While the performance of fuel cell buses has been validated in Europe in recent years through various FCH JU-supported demonstration projects (CHIC, High V.Lo.City, HyTransit, 3EMotion), a number of barriers to commercialisation of the technology remain, including:

- A significant ownership cost premium relative to conventional vehicles.
- Lack of bus operator expertise with the technology and immature supply chains leading to vehicle availability levels below those demanded by public transport operators.
- Provision of infrastructure capable of delivering low cost hydrogen to the vehicles with the ultra-high reliabilities required for public transport operation (>99%).
- Low levels of awareness of the potential for fuel cell buses as a viable option for delivering zero emission public transport systems.

In parallel to the technology demonstration activities mentioned above, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) facilitated a European coalition of companies with an interest in commercialising fuel cell buses in order to develop a commercialisation pathway. This was set out in a report published in September 2015<sup>5</sup> which concluded that:

- Fuel cell buses are an important option for reducing emissions while meeting operational requirements.
- Significant reductions in technology cost have been achieved to date (75% reduction in purchase price since the first prototypes in the early 1990s) and that further cost reductions are possible. These cost reductions will arise from a combination of economies of scale in the supply chain (hundreds of buses are required), as well as technology improvements in the design and manufacture of fuel cell stacks, particularly from the automotive sector.
- Realising the vision of a fully commercial fuel cell bus will require coordinated efforts from a range of stakeholders: industry must continue efforts to reduce technology costs, bus operators need to prepare for large-scale demonstration projects, and the public sector should ensure that funding is in place (European and national level) to support near-term deployment and that the appropriate policy frameworks are adopted to create the right conditions for full commercialisation from the 2020s.

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<sup>5</sup> *Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe*, Roland Berger for the FCH JU (2015).

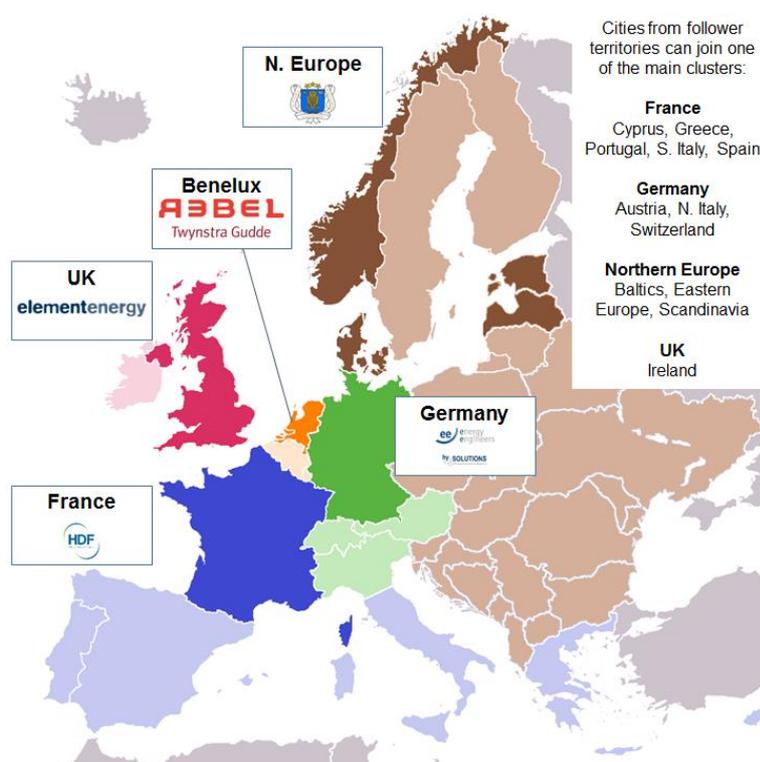
In this context, the FCH JU commissioned a consultancy team in September 2015 to deliver a project with the following overarching vision:

*Develop a procurement programme that will allow the deployment of hundreds of fuel cell buses in cities across Europe before 2020, thus unlocking cost reductions through economies of scale. At the same time, support the fuel cell bus commercialisation process by increasing awareness of and public appetite for fuel cell buses amongst key audiences throughout Europe.*

This report summarises the activities undertaken, and lessons and conclusions from this project, which ran from autumn 2015 to June 2016.

## 2.2 Cluster coordinators

For the purposes of managing the pan-European activities required to meet the project's objectives, five geographic clusters were defined, as summarised in the diagram below.



**Figure 2: Overview of the five geographic clusters and coordinators**

The FCH JU funded cluster coordinators<sup>6</sup> to lead the development of fuel cell bus deployment plans in each area. The cluster coordinators were tasked with:

- Supporting the development of business plans for fuel cell bus procurement within the cities and public transport operators involved in each cluster (including funding plans).
- Orchestrating the development of joint procurement processes for fuel cell buses at a national level.

<sup>6</sup> The project was led by Element Energy Limited (also the UK cluster coordinator). The other cluster coordinators were: RebelGroup Advisory bv and Twynstra Gudde Holding bv (Benelux); Hydrogene de France (France); ee energy engineers GmbH and hy SOLUTIONS GmbH (Germany); and The Latvian Academy of Sciences (Northern Europe).

- Exchanging information between clusters to accelerate the commercialisation process as far as possible.
- Coordinating procurement activities between clusters and communicating the deployment plans / barriers to deployment to the FCH JU to inform future funding calls.
- Raising awareness of fuel cell buses through (i) translation of existing dissemination materials, (ii) outreach to national administrators, and (iii) holding dedicated events to raise the profile of the sector.

### 2.3 Overview of project methodology

The cluster coordinators worked with city representatives and bus operators over the course of the project to prepare plans for deployment of fuel cell buses. The main tasks carried out in this area were similar across all clusters and included:

- **Discussions / workshops with bus operators in each city** – to discuss common specifications for the procurement, understand expectations / requirements in terms of guarantees and after-sales support and explore the willingness to consider different fleet and depot configurations.
- **Engagement with potential suppliers** – to obtain budget quotations, service offers, lead times, and discuss the practicalities of joint procurement.
- **Business plans (city / regional level)** – preparation and presentation of business case papers to senior managers and boards to obtain sign off for proceeding with a deployment project, understanding of the level of funding available locally and hence an estimation of the level of funding needed from different external sources.
- **Overarching plan** – assembly of the business case information into one overarching case for FC bus deployment in each cluster.
- **Funding** – discussions with the FCH JU, other European institutions and national ministries on funding options.
- **Approach to common procurement** – consultation with procurement experts from each bus operator / city to debate options for common procurement at a national level.
- **Action plan for each cluster** – a plan setting out next steps and timescales for procurement process.

Regular meetings of representatives of the cities / regions within each cluster were held throughout the project. These meetings were organised and chaired by the relevant cluster coordinator and provided an opportunity to coordinate the deployment plans being developed in each city / region. Sub-groups comprising city / bus operator representatives were formed as required to address specific issues; for example on the development of a common technical specification for the vehicles or to define a preferred approach to joint procurement.

Effective communication between clusters was achieved via fortnightly update calls between the coordinators and the FCH JU to report on progress and exchange information.

## 3 Fuel cell bus economics and funding strategies

### 3.1 Overview

In this section we provide further context to the information that follows on the activities in each cluster, by considering the economics of fuel cell bus projects using current technology. Example case studies of the costs of introducing fleets of fuel cell buses are included in the appendix, section 9.2.

### 3.2 Illustrative fuel cell bus project economics

Detailed total cost of ownership calculations for fuel cell buses have been undertaken in other studies<sup>7</sup> and are not repeated here. However, in the context of seeking to develop deliverable deployment projects it is worth understanding the overall cost dynamics of a fuel cell bus deployment project at today's prices and energy costs.

The graph below shows the projected costs of deploying and operating a fleet of fuel cell buses over a ten year period and the potential funding contributions from different parties.<sup>8</sup> As this is a generic analysis the precise figures are not shown. However, the key assumptions are based on the targets set out in the FCH JU's Annual Work Plan (2016):

- Fuel cell bus capital cost (standard single deck 12m bus) of 650,000 euro. While this is significantly lower than some of the vehicle costs in existing demonstration projects, this still represents a high premium over diesel buses (which typically cost in the region of 200,000 – 250,000 euro).
- Fuel cell bus fuel consumption of 9 kgH<sub>2</sub>/100km – this is between 10 and 30% lower than a conventional diesel vehicle on a calorific basis.
- Cost of dispensed hydrogen (excluding taxes) of 9 euro/kg.

The costs of deploying and operating the fuel cell buses with associated refuelling infrastructure are shown in the left hand column. The middle column shows the costs of deploying and operating a fleet of equivalent diesel buses over the same period and represents the minimum contribution expected from operators (this is approximately half of the total fuel cell bus project costs). The final column gives an illustrative example of how the gap in funding could be filled, i.e. via a combination of contributions from international, national, and local sources.

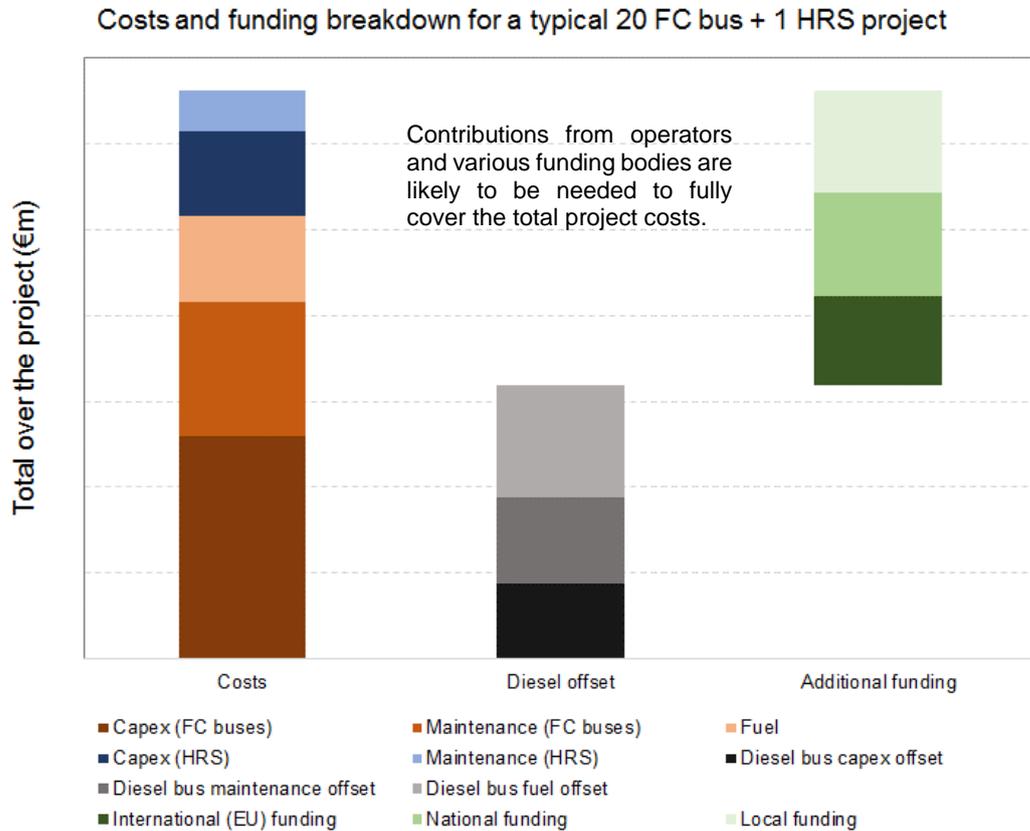
The rationale behind using diesel buses as the counterfactual and therefore the basis for estimating operator contributions is that the majority of buses in operation today run on diesel. Many cities seeking to develop plans for fuel cell bus roll-out are engaging with the technology for the first time. This means that a number of barriers to deployment must be overcome, e.g. familiarisation and training for bus operator staff, installation of new refuelling infrastructure, modifications to depots to facilitate the safe maintenance of vehicles, etc. Where bus services are provided by private sector operators it is important to present these companies with a fuel cell bus offer that is sufficiently attractive. One way to do this is to limit operators' exposure by seeking financial contributions to the project capped at the cost of running equivalent diesel buses. While this may be an appropriate short-term solution, in

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<sup>7</sup> E.g. see *Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe*, Roland Berger for the FCH JU (2015).

<sup>8</sup> Note that costs that are independent of the type of bus being operated (e.g. driver costs) are not included.

the medium to long term all involved in delivering public transport may need to accept that there is a cost premium associated with delivering zero emission services, which suggests operators' contributions may be expected to increase as the vehicles are offered on a more commercial basis. We return to this concept in section 3.3 below.



**Figure 3: Illustrative example of costs and funding sources for a fuel cell bus deployment project**

Note that this is a simplified representation of the project economics which make up a local business case for engaging with the technology. In practice, additional complexity arises from the need to consider details of asset ownership, cash flows over time, the nature of the cash flows between partners, financing arrangements and mechanisms for risk sharing.

### 3.3 Funding strategies

The high-level, illustrative economic analysis above highlights the need to source contributions from various sources in order to deliver fuel cell bus projects in the current pre-commercial phase of development. Details of the preferred funding strategy will vary by city / region but in most cases the approach is generally to seek funding from a combination of:

- **International sources** – in particular the Fuel Cells and Hydrogen Joint Undertaking has budgets to support demonstration projects covering a range of areas, including fuel cell buses.<sup>9</sup> It may also be possible to fund some elements of the project through other initiatives such as the Connecting Europe Facility

<sup>9</sup> E.g. topic 1.9 of the 2016 FCH JU Call was on the subject of *Large scale validation of fuel cell bus fleets*.

programme, which supports the roll-out of infrastructure for clean fuels across Europe's core transport network.

- **National governments** – the potential of fuel cell buses to contribute towards meeting national targets (such as carbon emission reductions, air quality improvements, security of energy supplies) is recognised by the governments of many European countries. As a result, national funding may be available to support projects seeking to contribute towards the commercialisation of this technology and/or for greening bus fleets.
- **Local / regional governments** – a case can be made for allocating some local public sector money to support the deployment of fuel cell buses in a given city / region. This case is typical based on the local benefits such activity delivers - improvements in air quality and new economic opportunities. In some cases such as London or Hamburg, cities are prepared to act as pioneers, supporting the technology development which is required to allow them to achieve their environmental aims.

An advantage of strategies that seek to combine funding from various sources is that contributions from each party are well leveraged – i.e. there is a high level of matching against other funds. On the downside, this type of approach leads to complexity and a number of specific challenges that must be considered on a project-by-project basis:

- **Timing** – it is necessary to have all budgets confirmed simultaneously. In many cases funding from one party will be conditional upon securing contributions from others. This adds complexity and risk to the project.
- **Compliance** – public funding is often allocated via competitive processes and individual funding schemes typically have their own rules on what funding can be used for, timing of spend, etc. Where various sources of funding are sought it is necessary to comply with the requirements of each scheme and with state aid rules.

In many cases there is limited public funding available to help bridge the gap between the costs of running services using zero emission fuel cell buses and those associated with traditional diesel vehicles. Other options for developing fully funded projects in these scenarios include:

- **Seek to reduce project costs** – this could be achieved by putting additional pressure on equipment suppliers to reduce costs (and prices). This is the primary goal of the joint procurement at the heart of this project – i.e. unlock economies of scale in the supply chain by placing a small number of large orders (as opposed to a trickle of small orders for vehicles). In the event that fuel cell buses have a premium over diesel for both the capital and operating costs, other options for reducing project costs could include deploying fewer buses, using lower mileage routes, and / or defining shorter project durations.
- **Request a higher contribution from bus operators** – many of the local projects within each cluster are being developed on the basis that public funding fully covers the cost gap between conventional and fuel cell buses on a total cost of ownership basis. In this case, the request of the operators is to fund “the same cost as you are currently paying for diesel buses”. In some cases operators may be prepared to pay a premium for the opportunity to run a fleet of zero emission hydrogen buses due to the reputational benefits conferred and / or a perceived commercial advantage. An alternative way to extract a higher contribution from bus operators is to deploy the buses in areas in which diesel buses are banned. An example of this is London's

proposed Ultra Low Emission Zone and the mayoral commitment that all single deck buses operating in this area will be zero emission from 2020 – in this case the baseline costs that operators face would be based not on a diesel bus but on the lowest cost zero emission vehicle available.

## 4 Summary of fuel cell bus deployment plans

### 4.1 Benelux cluster

REBEL and Twynstra Gudde have initiated the use of public private partnerships for electric buses and are now conducting the same for fuel cell buses and other heavy duty powertrains, working with a number of relevant public and private parties and developing their shared procurement approach. They have conducted this in the Netherlands, Belgium and Luxembourg.

#### 4.1.1 Overall activities

REBEL and Twynstra Gudde conducted the following activities:

- Cluster management Joint Procurement strategy FC buses in The Netherlands.
- Cluster management Joint Procurement strategy FC buses in Belgium.
- Cluster management Joint Procurement strategy FC buses in Luxembourg.
- Represent the Benelux cluster coordination works at the FCH JU and conducted dissemination activities in all three countries including the TEN-T days.

The Benelux cluster management activities were closely aligned with a number of related activities being carried out by REBEL and Twynstra Gudde in the Netherlands:

- Supporting the national policy for zero emission buses.
- Supporting the agreement between public transport authorities and Dutch government.
- Supporting the national Hydrogen Platform by coordinating the public transport (trains, buses and related infrastructure) in the Netherlands.
- Project management of pilots with both E- buses and FC buses.

#### ***National policy – Zero Emission strategy***

The Dutch government is a strong supporter of the hydrogen economy developed by the Fuel Cells and Hydrogen Joint Undertaking and European Commission and has therefore established a national hydrogen platform of which Twynstra Gudde is coordinating the public transport part.

#### ***Agreement between public transport authorities***

The collaboration between and the regions also implements the administrative agreement signed in April 2016 between the Government and 14 Public Transport Authorities with the aim that all new buses in 2025 must be zero emission (tank-to-wheel). Hydrogen buses are one of the technical solutions, especially for areas outside the city. Rebel and TG are heavily involved in these agreements due an assignment for the ministry. The ministry requested support in establishing an investment strategy for zero emission bus transport as a part of

the so called 'Motion van Veldhoven'. The agreement is the basis for the Dutch financial support both in regions and on national level for the deployment of FC buses including infrastructure.

#### 4.1.2 Fuel cell bus deployment plans

As a consequence of the agreement outline above public transport buses (in total 5,000) must be zero emission in 2030 and from 2025 all new buses must be zero emission. The transport authorities and transport operators have outlined plans for this transition. The first step is large scale demonstration projects with both battery-electric and fuel cell buses.

The following table summarises the current status of fuel cell bus deployment plans in the Benelux cluster.

City	No. of FC buses				Total pre-2020 deployment	
	Projects beginning in 2017		Future projects		12m	18m
	12m	18m	12m	18m		
Rotterdam			18		18	
South-Holland			16		16	
North-Brabant			18		18	
Gelderland			18		18	
Groningen			18		18	
Wallonie			16		16	
Luxembourg			10		10	
Utrecht			22		22	
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>136</b>	<b>0</b>	<b>136</b>	<b>0</b>

Further context for these figures is provided below.

- Metropolitan Region Rotterdam-The Hague expressed interest.
- Province of South Holland expressed interest, and hydrogen tanking facility is part of CEF Innovation call.
- Province of North-Brabant – interest expressed.
- Province of Groningen – interest expressed and hydrogen tanking facility is part of CEF Innovation call.
- Province Gelderland public interest expressed.
- Wallonia expressed interest for and draft letter of intent available.
- Luxembourg market expressed.
- Utrecht market interest expressed.

The commitment of the Benelux cluster to deploying fuel cell buses was formally signalled by the signing of a letter of intent to the FCH JU during the TEN-T days in Rotterdam in June 2016. The letter was signed by representatives of the Metropolitan Region Rotterdam-The Hague, Province of South Holland, Province of North-Brabant and Province of Groningen.<sup>10</sup>

<sup>10</sup>

[http://mrdh.nl/system/files/vergaderstukken/D09.2\\_Conceptletter%20of%20Intent%20of%20the%20Dutch%20Regional%20Authorities%20to%20the%20Fuel%20Cell%20Hydrogen%20Joint%20Undertaking\\_0.pdf](http://mrdh.nl/system/files/vergaderstukken/D09.2_Conceptletter%20of%20Intent%20of%20the%20Dutch%20Regional%20Authorities%20to%20the%20Fuel%20Cell%20Hydrogen%20Joint%20Undertaking_0.pdf).

### 4.1.3 Funding plans

The finance for the upscaling for hydrogen buses in the Netherlands is as follows:

- European funds through the FCH JU call expected in 2017, MEHRLIN project and future European funding calls.
- National funds through the so called *Motion van Veldhoven* (additional 50% of the FCH JU funding per station and bus) and Wallonia region.
- Regional funds from individual regions per project (additional 25% of the FCH JU funding per station and bus).
- Private funds based on a national agreement and/or in individual projects (additional 25% of the FCH JU funding per station and bus).
- European Investment Bank loan is in discussion with support of the Dutch government.

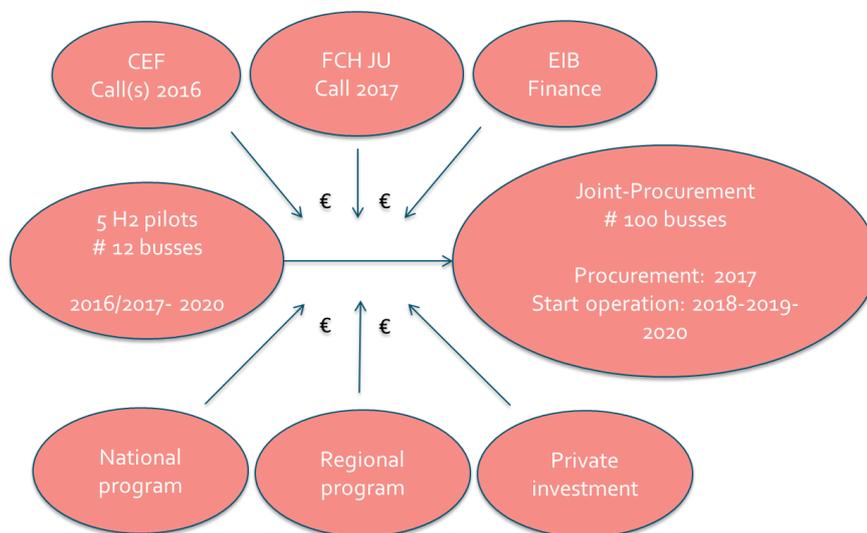


Figure 4: Overview of funding plans for further fuel cell bus deployment in the Netherlands

### 4.1.4 Next steps

Following the signing of the letter of intent to proceed with deployment of fuel cell buses by a number of cities / provinces in the Netherlands (June 2016), the immediate next steps include:

- Ongoing coalition discussions to deliver the deployment plans outlined above.
- Continued collaboration with international partners on coordinated dissemination activities relating to fuel cell buses.
- Further detailed development of fuel cell bus deployment plans and steps to secure all funding necessary to deliver the projects.

## 4.2 French cluster

### 4.2.1 Context

A legislative decree has been under preparation for over a year and is currently in its tenth iteration. The aim of the decree is to push zero emission solutions in public transport, which include fuel cell buses, but some provisions may be inapplicable in the current context. For example, the decree planned to put in place a “zero emission” area in cities where only zero emission buses are allowed to circulate. This means that a majority of buses in many cities must be zero emission because all lines pass through key points. It is not possible to implement such vision in few months. Another example of an impractical suggestion in the previous version of the decree was the intention to mandate that all buses used for school transport must be zero emission vehicles. However, in general coaches are used for these operations and there are currently no viable zero emission solutions in this vehicle segment. After being studied by the commission of standards evaluation on the 9<sup>th</sup> of June 2016 the decree was rejected. The commission has urged the organisations involved to work together to find a suitable solution. A new decision on the decree is expected on the 7<sup>th</sup> of July 2016.

A hydrogen territories initiative was launched in early May 2016 which seeks to identify projects that use hydrogen in multiple applications, including mobility, and that deliver cross-sector benefits. This is a result of discussions in NFI (Nouvelle France Industrielle), an organisation that facilitates discussions between the French government and relevant stakeholders to determine the strategy to increase industry in France. Instead of an amount of funding for projects linked to hydrogen, the hydrogen territories programme will implement a single window to direct funding towards projects identified through this initial stage of activity. However, there is currently no certainty regarding the amount of funding that will be available.

The French cluster through HDF is involved in the writing of the decree and in the establishment of the funding initiative to include fuel cell buses. While these activities have raised the profile of fuel cell buses in France and are expected to be beneficial in the long term, they are currently counterproductive as (a) local authorities are waiting for the legislative decree to be agreed before finalising their public transport strategies and (b) the development of most fuel cell bus projects was put on hold until the hydrogen territories tender was launched, and now these projects are being developed with little certainty over funding sources. The lack of information (objectives, sizing of project) during the preparation process has hindered the development of local projects. Furthermore, local authorities in charge of territory development are looking for local solutions and take into consideration buses at the end of the project definition. As the funding is not yet available and not yet identified, the propositions in preparation are not detailed, so the real preparation of bus project will be studied in the next months.

Another relevant factor is the willingness of French politicians to deploy Bus Rapid Transport, i.e. bus lines with high levels of service and higher frequencies. This puts pressure on operators to maintain very high bus availability levels and therefore increases the reluctance of operators to deploy “new” technology such as fuel cell buses.

Finally, it should be noted that local authorities want to begin to test 1 or 2 fuel cell buses before to deploy a fleet of 10 buses. In this case, hydrogen station costs remain an issue whereas it is possible to experiment 1 or 2 battery buses easily. Furthermore, battery buses benefit from a strong lobbying from French vehicle manufacturers (Bolloré, Heulliez).

## 4.2.2 Potential demand for fuel cell buses

This project has identified potential demand for up to around fifty fuel cell buses across six cities that could be deployed subject to the issues outlined above being resolved.

City	No. of FC buses				Total pre-2020 deployment	
	Projects beginning in 2017		Future projects			
	12m	18m	12m	18m	12m	18m
Artois-Gohelle			6		6	
Dunkerque			10		10	
Marseille			10		10	
Montélimar			3		3	
Paris (RATP)			10		10	
Pau				10		10
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>39</b>	<b>10</b>	<b>39</b>	<b>10</b>

At this stage, all projects are envisaged by cities as a first trial of fuel cell bus and no figures will be decided on future deployment before the results of the initial trial are available. Nevertheless, the aim is to validate this technology. Hence with further price decreases and a viable business case, cities would implement more and more fuel cell buses after 2020.

Pau and Artois-Gohelle consider fuel cell buses in an innovative plan. The project of Montélimar is included in a territory project of use of hydrogen (already planned before the French tender on the subject). For Dunkerque, introducing hydrogen-fuelled buses is a logical continuation of the past trials with hythane (mixture natural gas and hydrogen). In Marseille, huge quantities of by-product hydrogen are available.

The case of Paris is special. Paris with the operator RATP announced an ambitious plan of 4,500 bus renewal before 2025 with 80% electric and 20% CNG. They did not consider fuel cell buses in the original plan due to the pricing information provided by Daimler (more than 1 M€). RATP considers that if an experiment of fuel cell bus is performed, the feasibility of a whole depot in hydrogen (200 bus) must be determined. Nevertheless, the lines in Paris need only a mileage below 180 km and battery buses seem to suit these duty cycles. So efforts are focused on deployment of battery buses and fuel cell buses are considered only on the outskirts of the city. As the first operator in France (representing 50% of bus fleets), RATP's plan is observed by other cities, especially the results of the battery bus trials. While all cities in France are developing plans to reduce their harmful emissions, not all have quantified the ambition to replace traditional vehicles in the way that RATP have done.

Several cities in the cluster (Nantes, Rouen, Le Havre, Belfort) identified the fuel cell bus as a zero emission solution but they are waiting for a net fuel cell bus price below 450 k€ and an effective strategy in place for vehicle maintenance. Currently, they consider purchasing fuel cell buses after 2020.

Several other local authorities are interested in fuel cell buses and have expressed an interest in joining the cluster initiative in the coming months (Toulouse, Versailles). The French cluster is also in contact with the national association (Afhyprac) and local clusters (Energie2020, erh2, phyrennes, tennerdis) promoting hydrogen.

As explained above, most cities are waiting for the legislative decree in order to have enough money to close their budget by implementing a strategy suited to the future constraints.

### 4.2.3 Next steps

A meeting will be planned in September 2016 to provide an overview of the hydrogen territory tender. The aim is to identify concrete commitments of at least three cities to more than 10 fuel cell buses. This first group will allow relaunching discussions with central public purchasers in order to put in place a joint procurement process. Projects with one to five buses would be aggregated into this initiative.

Furthermore, efforts will be made to continue to promote fuel cell buses in future French tender. A specific one, on hydrogen mobility, is pushed by ADEME and NFI.

The aim is also to benefit from the excitement of the territories to implement fuel cell bus projects as part of existing initiatives. In this context, the new offer of PVI for a range extender bus of 9m is adapted with the deployment of small hydrogen refuelling stations and could interest small cities with limited capacity to invest.

## 4.3 German cluster

### 4.3.1 General remarks

Many cities in Germany face severe air quality problems. Some have already been accused by the EU of violating EU regulations and not taking sufficient actions to address this issue.

The cities have therefore decided to take measures to improve air quality which include traffic regulations (e.g. zero emission zones) or restrictions for certain vehicles. These measures target especially the private sector. But since the public transport in Germany belongs in most cases to the cities or the regions (and is not transferred to private companies like e.g. in the Netherlands), the cities themselves can influence how public transport contributes to air quality improvement plans. Therefore, some cities like Hamburg or the Cologne region have already decided that after a certain point in time (2020/2030) no more emission producing vehicles can be purchased. As a result, more and more bus operators seek alternative drive trains for their buses.

One can observe that there is still a big uncertainty among the operators which is the right way to go. The choice is no longer between diesel-hybrid and compressed natural gas buses; there is a general consensus that the future is electric. But if battery buses (with overnight or opportunity charging) or fuel cell buses are the right option is still intensively discussed. This strategic decision has significant implications in terms of future investments and will influence bus operations for decades to come. The reason is not only due to the rolling stock of vehicles but also related to the necessary refuelling / recharging infrastructure. Bus operators have to consider several aspects before they make up their minds: size of the fleet, number of lines to be operated, topography, availability of energy (electrical grid performance, price for energy) etc. The last aspect in particular is a significant factor in determining the operating costs.

At this point a speciality of the German public transport becomes important which is the fact that the public transport is often operated by the local utility, in general a Stadtwerk (city work). A typical Stadtwerk consists of an energy department and a transport department. A new business model could therefore be that the energy department could deliver the fuel (electricity/hydrogen) at low prices to the bus operator and thus create a win-win situation for both sides.

This approach becomes more and more important with the increasing installation of renewable energy which already today leads to the need to store excess energy. This can (in smaller amounts) be done in batteries, but experts are sure that the most favourable way will be to store it as hydrogen (power-to-gas approach). Several studies have shown that the best use of the stored hydrogen will be as a fuel for fuel cell vehicles. This is the most efficient and the most economically viable way (see below).

### **4.3.2 New business models**

In the following paragraph two of the key business models are described which formed the basis upon which some of the cluster members decided to progress with fuel cell bus deployment plans.

#### **Fuel cell buses as a front end usage of power-to-gas-hydrogen**

As mentioned above, huge amounts of hydrogen will become available from power-to-gas plants all over Germany. The power can come from wind parks, PV plants or even waste incineration plants using biomass. An example for a big power-to-gas plant is the “Energiepark Mainz” where a 6 MW electrolyser has been installed. The hydrogen produced is currently transported by Linde to a chemical plant and will soon also be fed into the natural gas grid. But as said the most economical way is to use it as fuel.

Therefore, the three cluster members from Frankfurt, Mainz and Wiesbaden will refuel their fuel cell buses with the hydrogen from the energy park. It is intended to transport the hydrogen from the park to the station and not to refill the buses at the park. Frankfurt will also refill their buses at the existing filling station at Chemiepark Hoechst. In both cases, the hydrogen is available at prices at or below the level of diesel.

In the city of Wuppertal, the Stadtwerke operate the bus fleet and a waste incineration plant. The heat from the plant is transferred into the local heat grid. While the heat demand is fairly continuous, the demand for the electricity is more variable. In order to avoid losses by selling the unneeded electricity (simultaneous production of electricity and heat) at too low prices at the energy stock exchange in Leipzig, the Stadtwerke has decided to install an electrolyser beside the waste incineration plant and store the electricity as hydrogen. By doing so, the Stadtwerke avoid the extra fees on electricity like feed-in tariff etc. and thus can produce the hydrogen at prices below diesel. Thus the fuel cell buses become a part of the energy economy of the Stadtwerke. So, this approach forms a sustainable business model for both sides.<sup>11</sup>

#### **Fuel cell buses using by-product hydrogen**

In the Cologne area around the cities of Hürth and Brühl we have another interesting business case. Here we have got a strong chemical industry. A separate study found that the capacity of by-product hydrogen stemming from chlorine electrolysis is sufficient to operate some hundred buses. Today, this by-product hydrogen is vented into the air or used a co-fuel for incineration processes in the chemical plant. In 2008 the Stadtwerke of Hürth and Brühl which are the shareholders of the bus operator RVK decided to make use of the hydrogen which led to the development of the APTS Phileas fuel cell bus in a NRW/Dutch project and the following operation of these buses since 2011. Later, RVK also purchased two Van Hool FC buses.

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<sup>11</sup> A further factor in the choice of fuel cell buses in Wuppertal is the fact that the region is rather mountainous, which means battery electric buses are not a technically feasible option based on existing technology.

The HRS is located directly beside the chemical plant where the hydrogen is produced. Therefore, logistics costs are avoided which makes the hydrogen extremely cheap. The price is 4–5 €/kg which is below the price of diesel.

In the meantime, Hürth and Brühl have told the RVK not to purchase any more emissions producing buses after 2030 (a similar approach to that taken in Hamburg, see below).

As a result of the favourable conditions in the region, the RVK has decided to base its transition plans on fuel cell buses instead of battery buses and, as a consequence, will seek to procure 30–40 fuel cell buses in the coming years.

### **4.3.3 Political engagement in the case of Hamburg**

Hamburg belongs to the growing cities in Germany with a high proportion of innovative industries, e.g. in the aviation and renewable energy sectors. Therefore, Hamburg competes with other cities to attract young and well-educated people and a decisive factor for choosing a location is, besides income, the quality of life.

As in other cities, about 30 percent of emissions are caused by traffic. Given this situation, the city of Hamburg has started to introduce and use electric vehicles. Currently, more than 500 electric vehicles are used by the authorities and public companies, and 600 charging stations for electric cars in public areas have been installed. In parallel, four hydrogen refueling stations have been set up and a fifth one is planned, thus providing a link with the already very advanced wind industry in the region and the plans to use hydrogen from renewable sources for transport activities. Two of the existing hydrogen refueling stations already produce hydrogen via electrolysis using energy from renewable sources. In addition, a power to gas plant with a capacity of 1.6 MW has been operating since 2014 and other plants are planned.

Another motivation for a rapid transition to low emission traffic is that Hamburg, like other cities, currently violates European regulations on air quality, and recognizes the urgent need to achieve a rapid implementation of appropriate improvement measures.

Against this background, the Hamburg government has issued a directive specifying that Hamburg transport companies may procure emission-free buses only from 2020 which makes comprehensive and systematic tests of innovative bus drives necessary to establish the remaining optimization needs to ensure a complete technical and functional maturity. It also needs to be seen which drives are most suitable to ensure the requirements of line operation as sufficient daily mileage or a rapid supply of energy without productivity losses.

Since 2003, HOCHBAHN employs fuel cell buses in different development stages and vehicle generations in line service to provide relevant experience from day-to-day operation to the industry and thus contributes to a continuous further development. Currently, various types of innovative buses (hybrid buses, plug-in hybrid buses, fuel cell hybrid buses and battery buses with fuel cells as range extenders) are employed together on the so-called innovation line 109 which allows a direct and immediate comparison and determination of the pros and cons of the drives. The advantages of fuel cell buses or battery buses with range extenders are that they can be applied flexibly and do not require additional unproductive load times. However, the vehicles have not yet achieved the technical maturity and availability for full line services like diesel buses.

Against the background of the directive and the proven advantages of fuel cell buses in line service, HOCHBAHN participates in the European network for the procurement of fuel cell

buses with the aim of accelerating the commercialisation of the technology so that a full transition to zero emission buses can be achieved in the near future.

#### 4.3.4 Procurement plans

As shown above, there are numerous reasons behind the cluster members' interest in fuel cell buses. All cities have spent a long time considering all aspects of alternative drive trains like reliability, technical state-of-the-art, performance, operability, infrastructure and of course the costs associated with the transition to new technologies. The companies executed intensive evaluations and developed business plans. Currently all models include external funding as the buses are two to three times as expensive as conventional vehicles. But the operators are well aware that funding will not be available indefinitely. Therefore, the long-term plans are based on significant cost reduction both for vehicles and for hydrogen. Without these assumptions, none of the cluster members would start with the implementation of fuel cell buses now.

The figures below reflect their considerations. While for some it is already clear that in the future they will operate fuel cell buses (e.g. RVK) and therefore plan with high numbers of fuel cell buses, others are still cautious and observe the development on the vehicle market (e.g. Stuttgart). And some (like Münster and Hamburg) will test both alternatives, i.e. batteries as well as fuel cells.

Here it should be pointed out clearly: all ambitious plans of the operators will not become reality if the bus OEMs do not develop and introduce fuel cell buses and then offer those at competitive prices.

City	No. of FC buses				Total pre-2020 deployment	
	Projects beginning in 2017		Future projects		12m	18m
	12m	18m	12m	18m		
Münster				10		10
Hamburg			7	13	7	13
Stuttgart				15		15
Köln	30		10		40	
Potsdam				2		2
Mainz-Wiesbaden-Frankfurt	7	4	7	12	14	16
Wuppertal	10		10		20	
Düsseldorf			10		10	
South Tyrol	10	5	5		15	5
Rovereto			10		10	
<b>TOTAL</b>	<b>57</b>	<b>9</b>	<b>59</b>	<b>52</b>	<b>116</b>	<b>61</b>

The local feasibility work carried out in collaboration with the cities in the German cluster indicates that there could be demand for over one hundred fuel cell buses. Discussions with representatives of other cities that have recently joined the cluster indicate that this number could even become much higher.

## 4.4 Northern Europe cluster

### 4.4.1 Overview and context

Fuel cell bus deployment project development activities in the Northern Europe cluster were coordinated by the Latvian Academy of Sciences and spanned an area including Denmark, Norway, Sweden, Finland, Estonia, Lithuania, Latvia, Poland and the Czech Republic. The cluster coordinator worked closely on a zero emission bus development programme and liaised with other national cluster coordinators, including:

- EUE ApS in Denmark.
- Vatgas (Hydrogen Sweden) in Sweden.
- OREEC Oslo Renewable Energy and Environment Cluster in Norway.
- Czech hydrogen platform in Czech Republic.

Developing an approach to joint procurement of fuel cell buses in the Northern Europe cluster is challenging given the wide geographic spread of the cities involved and is further complicated by the differing national regulations and transport operation entity structures, which include:

- In Riga (Latvia) the public transport operator is MLLC “Rigas Satiksme”. “Rigas Satiksme” is also the public transport authority. The same structure is in Tallinn (Estonia), Lithuania and Poland.
- In the city of Oslo (Norway) the public transport authority (Ruter AS) outsources the public transport operator services to private companies.
- In city of Slagelse (Denmark) the public transport operator is a local entity but the public transport services are centrally procured by a national agency (Movia). In collaboration with the Slagelse representatives a working relationship with Movia has been established in order to progress with fuel cell bus deployment plans.
- In Pärnu (Estonia) the hydrogen refuelling stations will be owned by a private company. The municipality of Pärnu provides the public transport authority services but the municipality outsources the public transport operator services to private companies. The private company will own any fuel cell buses deployed.

Independent of the differing public transport models outlined above, the Northern Europe cluster partners recognise the benefits of developing a common technical specification for fuel cell buses and a common joint procurement strategy. This process has been started in the course of this project and is expected to continue throughout 2016 as the first movers prepare to implement their fuel cell bus deployment plans.

### 4.4.2 Cluster management and expansion

To attract more interest from potential partner cities in Northern Europe cluster the Latvian Academy of Sciences attended meetings and events in all Northern Europe cluster countries including the TEN-T days 2016 in Rotterdam and actively promoted the possibilities of FCH JU activities and received active interest from other cities. Specific activities included:

- On 24<sup>th</sup> of February 2016 a seminar was held in Lithuania during which the hydrogen vehicle usage in public transport was promoted to ministries of Lithuania and public

transport authorities. The Ministry of Transport and Communications were asked to actively participate and to request immediate actions from regions.

- On 20<sup>th</sup> and 21<sup>st</sup> of April 2016 the Northern Europe cluster joint procurement possibilities were promoted at the Clean Hydrogen in European Cities (CHIC) project biannual meeting in Oslo, Norway to synchronize the active cluster actions with near-term strategies.
- From 25<sup>th</sup> to 29<sup>th</sup> of April 2016 in Hannover messe group exhibit hydrogen fuel cell batteries a hydrogen tour was held for Northern Europe cluster cities combining the representatives from Poland, Estonia, Denmark, Sweden and Norway.
- On 31<sup>st</sup> of May 2016 a seminar was held in the Czech Republic regarding the invitation from Czech Hydrogen technology platform representatives. During this seminar two cities expressed an interest in deploying fuel cell buses. This opens a possible cooperation with Czech Hydrogen Technology platform. In the Czech Republic, the gradual expansion of the use of hydrogen drives is planned over the long term. As with other alternative fuels, legislative support, the selection of vehicles and the establishment of sufficient infrastructure is necessary. Currently there are 19 public operators and 17 battery electric buses operating in the Czech Republic. Possible regions for hydrogen buses in public transport in the Czech Republic are in Ostrava and in North-West Bohemia. The main interest to deploy fuel cell vehicles is to reduce emission levels and to develop zero emission zones.
- The Latvian Academy of Sciences is actively working with Sweden partners to support the development of fuel cell bus roll-out plans in a number of Swedish cities. To date the Latvian Academy of Sciences as Northern Europe cluster coordinator has received three letters of support from possible partners from Sweden (City of Ulmea; Region of Gävleborg; municipality of Uppsala) to participate as observers in the JIVE project. The letters of support confirm the readiness of Swedish regions to develop further fuel cell bus activities and to participate in joint procurement.
- Active discourse with possible partners from Finland is underway. On 17<sup>th</sup> of August 2016 a seminar will be held in Helsinki Finland to promote fuel cell buses as a viable zero emission solution for public transport. All political decisions to implement zero-emission transport are amended. At the moment two hydrogen refuelling stations are deployed in Helsinki but due to lack of fuel cell vehicles, it is impossible to use it at full capacity. One of the stations belongs to private company Woikoski, the second one is owned by municipality. The stations were deployed to boost the uptake of fuel cell passenger vehicles.

#### **4.4.3 Potential demand for fuel cell buses**

The initial list of cities seeking to deploy fuel cell buses is given in the table below, which implies a potential demand for around 150 vehicles in the period to 2020.

City	No. of FC buses				Total pre-2020 deployment	
	Projects beginning in 2017		Future projects		12m	18m
	12m	18m	12m	18m		
Riga, LV	10			20	10	20
Other Latvian cities			10		10	
Parnu, EE			12		12	
Slagelse, DK	10				10	
Other Danish cities (Copenhagen, Aalborg, Aarhus)			20		20	
Swedish cities (Ulmea, Uppsala, Region of GäVleborg)			20		20	
Warsaw, PL			10		10	
Oslo and Akershus County, NO			35		35	
<b>TOTAL</b>	<b>20</b>	<b>0</b>	<b>107</b>	<b>20</b>	<b>127</b>	<b>20</b>

Further context behind these figures at a national level is as follows:

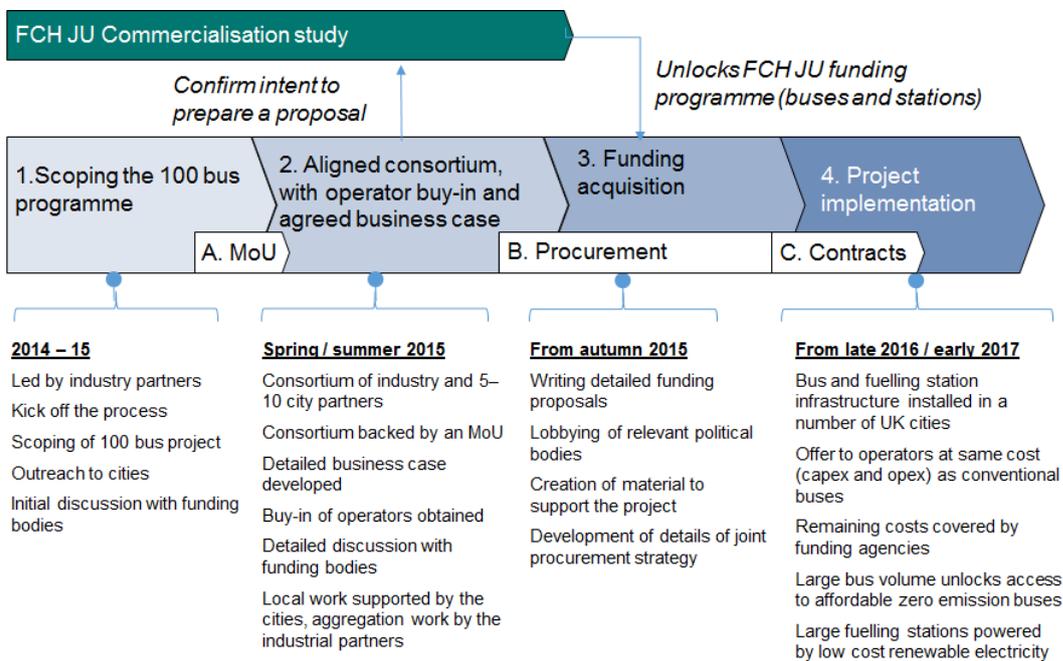
- Latvia** – all preparatory works for fuel cell bus deployment in Riga are completed. A national procurement strategy with a common technical specification and defined contractual requirements is established. On June 10<sup>th</sup> 2016 a seminar combining the biggest transport operators in Latvia was held in Latvian Ministry of Transport to promote the necessary actions of potential cluster partner cities to implement fuel cell vehicles in regions. The transport operator in Riga (MLLC “Rigas Satiksme”) has developed a ramp up strategy and associated business plan for further replacement of the existing vehicle fleet with fuel cell vehicles. Rigas Satiksme has announced the intention to procure ten fuel cell buses and plans to award the contract in the next few months. Financing for this initial wave of deployment will be provided with a loan from the European Investment Bank. European Investment Bank representatives have confirmed that the same kind of structure is replicable to other partner cities if the necessary requirements are fulfilled. Rigas Satiksme will be the owner of fuel cell buses deployed in Riga. At the moment Riga is the example to take experience for other Northern European cluster cities to actively participate in joint procurement.
- Denmark** – with the support of the Latvian academy of Sciences and the Rigas example in place, the city of Slagelse developed a strategy to deploy fuel cell vehicles for public transport and created a business case. The Slagelse experience will be the basis for other Danish cities to participate in joint procurement exercises for fuel cell buses. Although there has been limited examination of the optimal vehicle type for Slagelse, the Riga study is applicable given that public transport is operated in a similar way in both cities.
- Norway** – the Municipality of Oslo has declared a commitment to implement renewable energy powered vehicles in city. Five fuel cell buses are already operating in Oslo and the business case for further fuel cell vehicle is being prepared. Again the Rigas experience and studies are relevant and have been shared with Oslo to facilitate the rapid completion of the business case preparation work. Participation of Oslo in joint procurement of fuel cell buses is dependent upon this work being completed.
- Poland** – the Municipality of Warsaw has declared a commitment to implement zero emission vehicles in city. Warsaw’s transport operator “NZA” is currently engaged in testing battery electric buses for public transport needs. NZA has expressed interest in deploying fuel cell vehicles in the city and the Latvian Academy of Sciences is sharing relevant existing experience and studies to support the development of strategies and similar studies into fuel cell vehicle use in Warsaw.

- **Estonia** – the Municipality of Pärnu has declared a commitment to implement renewable energy powered vehicles in the city. The strategy of fuel cell vehicle deployment is under preparation and due to lack of experience it may take additional time for Pärnu to complete the preparatory tasks needed to participate in joint procurement exercises. The Latvian Academy of Sciences actively promotes the Riga experience and existing studies to increase the readiness for fuel cell bus deployment in Pärnu.
- **Czech Republic** – the Czech Republic government announced a commitment to implement zero emission vehicles across the country, which marks the starting point for further activities. The Latvian Academy of Sciences is working with Czech Republic representatives to share the Riga experience and to spread the knowledge of fuel cell vehicle implementation.

After the commitment of mentioned Northern Europe cluster cities to participate in joint procurement is made and the readiness level of all cities have levelled it will be possible to fully use the benefits of joint procurement strategy.

## 4.5 UK cluster

The process of developing a large-scale coordinated fuel cell bus deployment project in the UK was initiated in 2014. The original ambition was to implement a programme that leads to the introduction of approximately one hundred fuel cell buses into fleets in cities across the UK. The initial scoping phase was industry-led and involved discussions with representatives of the UK's major cities to understand their interest in joining a fuel cell bus deployment project, scoping the overall programme, and holding initial discussions with potential funders. This was followed by a period of detailed feasibility work in each city that expressed an interest in adopting fuel cell buses, a process that led to a number of cities moving into an observer role (rather than progressing with deployment plans in the short term) and others deciding to progress with the plans. Further details of the planned deployment projects were established during the third phase of the programme, which also focused on seeking funding from a range of sources to support the projects into the implementation phase. The overall programme is summarised in the diagram below.



**Figure 5: Overall programme for development of the 100 Fuel Cell Bus Project in the UK**

City councils in the UK express an interest in fuel cell buses for similar reasons, primarily an urgent need to take action to address poor air quality and commitments to reducing greenhouse gas emissions. The status in terms of potential for fuel cell bus deployment in the UK cluster as of mid-2016 is given in the table below. Note that at the time of writing none of the cities listed has committed to deploying new fuel cell buses. The figures correspond to the numbers of buses that are included in deployment plans under development and are therefore subject to change. The potential demand numbers for the cities in Scotland come from feasibility work undertaken by the Scottish Cities Alliance and are consistent with the SCA's hydrogen strategy and ambition to kick-start a hydrogen economy in Scotland.

City	No. of FC buses				Total pre-2020 deployment	
	Projects beginning in 2017		Future projects			
	12m	18m	12m	18m	12m	18m
Aberdeen	10		10		20	
Birmingham	20				20	
Dundee	10		10		20	
Edinburgh			10		10	
Glasgow			10		10	
Inverness			10		10	
London	26				26	
Perth & Kinross			10		10	
Stirling			10		10	
<b>TOTAL</b>	<b>66</b>	<b>0</b>	<b>70</b>	<b>0</b>	<b>136</b>	<b>0</b>

The indicative commitments above assume that:

- Any deployment of fuel cell buses is contingent upon receiving suitable offers for bus and hydrogen supply through the procurement process (currently on-going), as well as securing all the necessary funding. The numbers of buses listed above should therefore be interpreted as aspirational rather than definitive – i.e. as of mid-2016 none of the cities listed has contractually committed to deploying new fleets of fuel cell buses<sup>12</sup>, these formal commitments are expected in early 2017.
- These figures are based on the results of local feasibility work on the potential for fuel cell bus deployment undertaken in each city. The “2016 Call” numbers refer to vehicles included in a funding application made to the FCH JU in response to topic 1.9 of its 2016 Call.<sup>13</sup>
- The “Future funding calls” figures correspond to the numbers of buses that could be included in projects seeking funding from 2017. There is therefore more uncertainty associated with these numbers compared to the “2016 Call” figures.
- There is very little demand for 18m (articulated) buses in the UK. In fact, even a 12m bus causes issues in some cities where shorter vehicles are preferred (e.g. 10.5m) due to road layouts, congested streets, etc.
- At the time of the detailed feasibility work, fuel cell buses were only available as single deck vehicles with a minimum length of 12m. The lack of a double deck offering severely restricts the potential market for fuel cell buses in many UK cities and was the primary reason for at least one city moving to an observer role.
- A number of cities decided not to progress with deployment plans after investigating the potential to introduce fuel cell buses during 2015. Reasons included a lack of local political engagement, insufficient local match funding available, and suitability concerns relating to the lack of a proven double deck vehicle at the time of the detailed study.<sup>14</sup> Cities expressing an initial interest included:
  - Leeds – concluded that they could not continue to engage without a double deck offer.

<sup>12</sup> The final approvals processes will run in the second half of 2016 for those cities seeking funding from the FCH JU’s 2016 Call.

<sup>13</sup> Due to high demand for vehicles and a limited amount of funding the bid to topic 1.9 included Dundee in a follower role.

<sup>14</sup> See appendix for a list of contacts for each city in the UK cluster and the reasons for not proceeding with fuel cell bus procurement in the near term (if applicable).

- Sheffield – lacked operator buy-in until prices fall further.
- Nottingham – lacked an operator with a local budget to engage with the deployment.
- Cardiff – need further time to prepare budgets and approvals, but remain highly interested in future deployments.
- Tees Valley – have a supportive hydrogen strategy, but are currently focussing on other sources of hydrogen demand as the local operator interest is not high enough.
- Based on initial interest demonstrated in the initial discussions, other cities who would be worth re-approaching once tendered costs for buses are available include: Oxford, Swindon, Manchester and Newcastle.
- The ongoing tender process (see below) is indicating that a double deck fuel cell bus may become available. If this occurs, it will be worth revisiting these cities once a double decker offer is confirmed through the procurement process.

The following map shows the potential geographic spread of fuel cell buses across the UK based on the deployment plans summarised above.

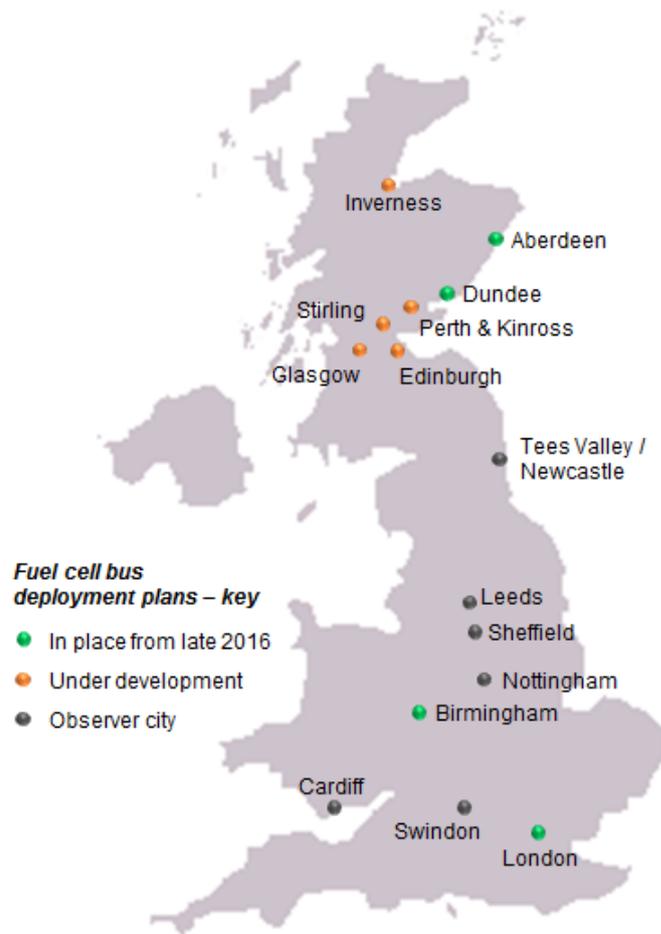


Figure 6: Cities involved in the UK’s 100 Fuel Cell Bus Project

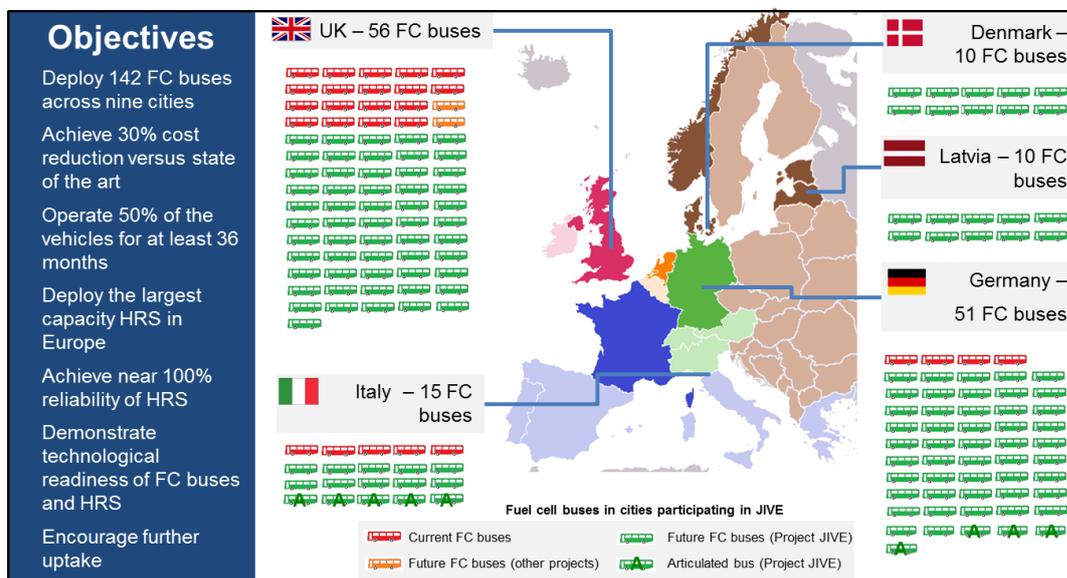
## 4.6 Large-scale European funding proposals initiated as a result of this project

The project has also catalysed the preparation of new funding proposals in consortia, which were facilitated by the connections made through the cluster coordination process (though note that the bidding activity itself was not supported by this project).

### 4.6.1 JIVE

**JIVE** (Joint Initiative for Hydrogen Vehicles across Europe) is a project to deploy 142 buses and fuelling stations in 9 European cities in 5 member states – this bid was submitted to the FCH JU in May 2016. In preparing the bid, many willing cities had to be turned away, creating a pent up demand for any 2017 call on this topic.

#### JIVE: Joint Initiative for hydrogen Vehicles across Europe



**JIVE will be a six year project, with an anticipated start date of early 2017**

**Figure 7: Overview of the JIVE project**

The project has the following features:

- JIVE will seek to deploy 142 hydrogen fuel cell buses and associated refuelling infrastructure across nine cities in five European countries.
- This project alone will more than double the size of Europe's fuel cell bus fleet (from c.90 by the end of 2016 to >220).
- Economies of scale are expected to reduce the capital cost of fuel cell buses (to <€650k for a standard bus and <€1m for an articulated bus).
- Demand is being aggregated through the joint procurement processes already underway, which are encouraging manufacturers to develop and refine their fuel cell bus offers.
- A campaign of monitoring and dissemination of the project results will ensure the lessons learned on the readiness of the project reach a target audience of bus operators and policy makers, with a view to expanding who can take action to expand the market for fuel cell buses.

Development of the JIVE project revealed strong demand for fuel cell buses across Europe. In fact, the number of deployment locations in JIVE had to be reduced from twelve to nine due to funding limits and the project includes follower cities ready to deploy fuel cell buses should funding become available. A second call would ideally be launched (in 2017) to help satisfy the unmet demand.

#### 4.6.2 MEHRLIN

MEHRLIN (Models for Economic Hydrogen Refuelling Infrastructure) is a bid to the Connecting Europe Facility for funding for hydrogen fuelling stations for buses (and other vehicles) in cities located on the TEN-T network. This bid was submitted in February 2016 and evaluated during spring 2016. The MEHRLIN proposal scored sufficiently highly in the evaluation process to be included on the list of projects approved for funding that was published in June 2016.<sup>15</sup>

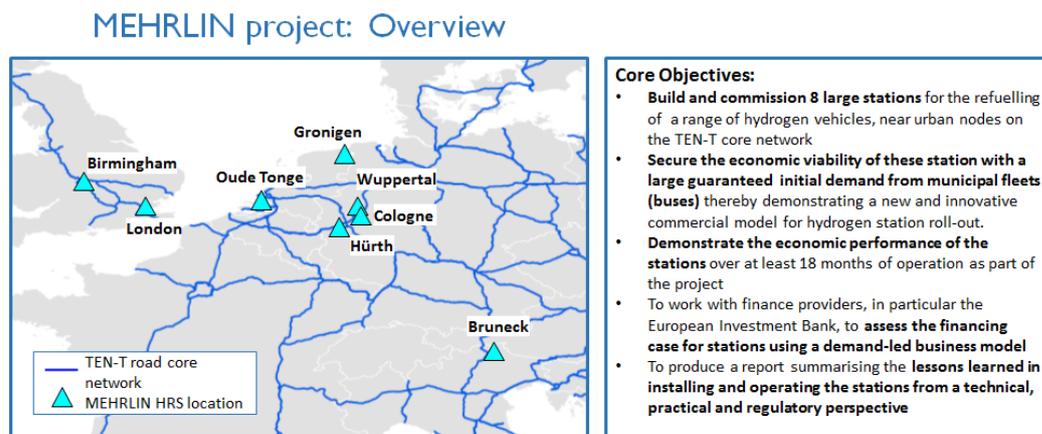


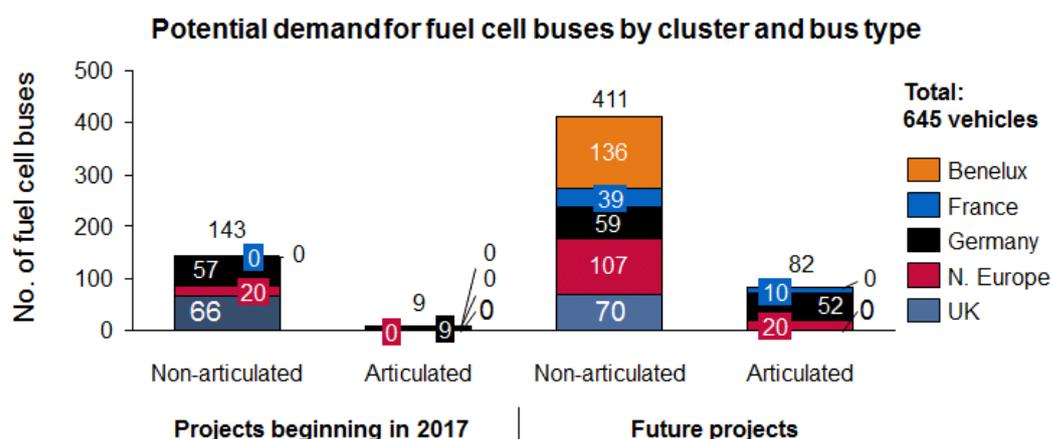
Figure 8: Overview of the MEHRLIN project

15 <http://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/project-funding/doc/cef/2015-cef-selected-proposals.pdf>.

## 5 Outlook for Europe's fuel cell bus sector

### 5.1 Potential near-term demand for fuel cell buses

By aggregating the figures of demand for fuel cell buses by cluster presented above, we gain an insight into the overall potential demand at a European level. The figure below shows the number of buses included in projects that are due to begin from 2017 or that are in preparation and expected to commence beyond this date.



*Note that these are provisional estimates based on the work of the cluster coordinators to date. No firm commitment has been made by the cities listed above. While the cluster coordinators have sought to provide realistic and relatively conservative deployment numbers, in practice these figures may fall as more detailed local feasibility work is undertaken.*

**Figure 9: Potential demand for fuel cell buses across Europe in the period to 2020**

The project development work undertaken on a city-by-city level within each cluster suggests that there could be demand for over 600 fuel cell buses across Europe over the period to 2020. This figure is somewhat higher than the estimated demand of 300–400 vehicles from cities participating in the fuel cell bus commercialisation study and indicates that momentum in this sector continues to grow.<sup>16</sup> The figure is based on the assumption that non-articulated fuel cell buses are available at a net cost of below €450k. Clearly, failing to achieve these pricing levels would reduce the size of the market. The following sections explore the evolution of this demand over time and the implications for the various stakeholders involved.

### 5.2 Comparison against commercialisation scenario

The fuel cell bus commercialisation coalition developed a *European ramp up scenario* characterised by the number of vehicles deployed and number of deployment locations. This was based on reaching 8,000 – 10,000 fuel cell buses delivered by 2025, a figure deemed necessary to achieve the cost reductions in the *production-at-scale* scenario. The projection of fuel cell buses deployed across Europe suggests 400 delivered by 2020, an increase of around 300 from the circa 100 vehicles expected to be in operation as of mid-2017 under the existing demonstration projects CHIC, 3Emotion, High V.Lo City and HyTransit.

<sup>16</sup> *Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe*, p.46, Roland Berger for the FCH JU (2015).

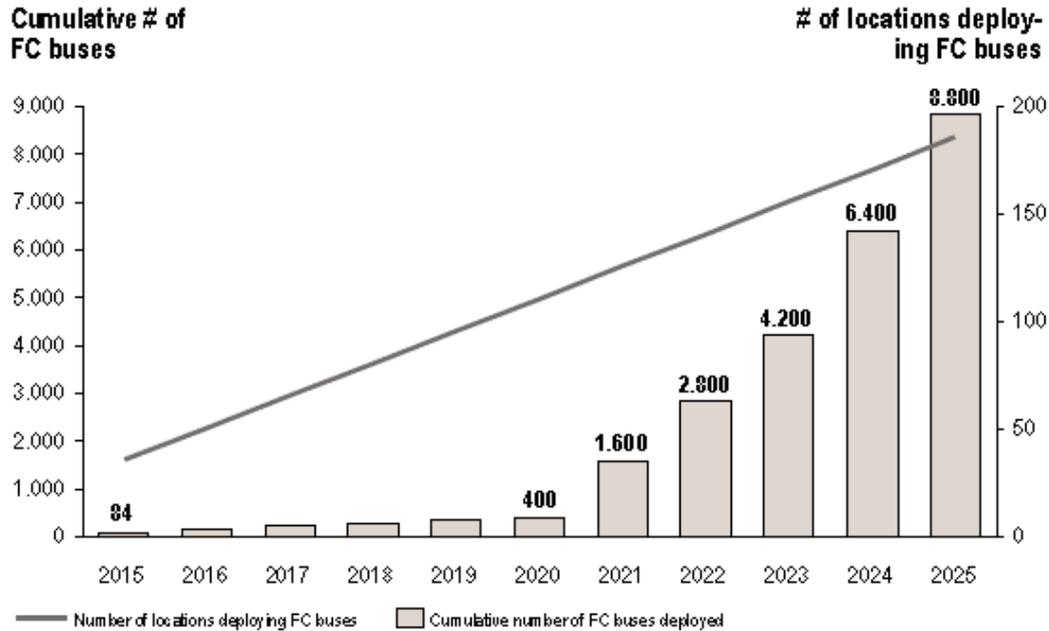


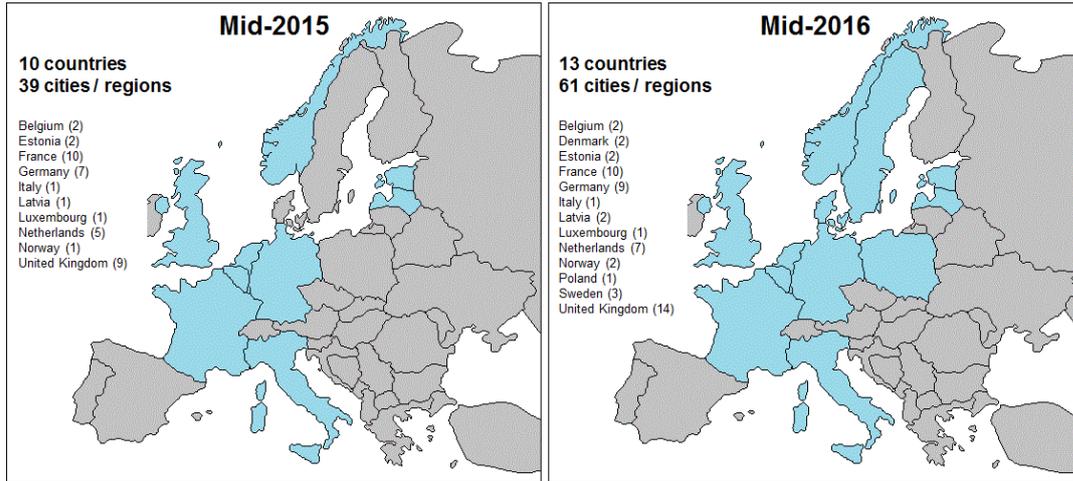
Figure 10: Fuel cell bus commercialisation coalition ramp-up scenario<sup>17</sup>

Further context behind this scenario is given by the commercialisation study report's authors:

*“The 35 currently participating locations of the FC bus coalition are committed to deploying 300 to 400 FC buses until 2020 in the framework of this initiative. These are included in the ramp-up scenario. Beyond 2020, it is assumed that these locations start replacing larger parts of their fleet with FC buses within their regular annual replacement schedules: It is assumed that these pioneering locations deploy 20 FC buses each in 2021 and continue to deploy up to 40 FC buses each year until 2025. This would sum up to 1,400 FC buses in 2025. In order to reach the target number of 8,000 buses, further locations willing to deploy FC buses need to be engaged. For the ramp-up scenario as shown below, it has been assumed that from 2015 onwards each year 15 new locations can be attracted which intend to deploy FC buses in the future. This number conservatively reflects the growth rate of the existing coalition in its first year. If these additionally mobilised locations start deploying FC buses from 2021 onwards with a modest annual deployment schedule of 10 FC buses going up to 15 buses in 2025, significant volumes of FC buses can be reached.”*

The current project, which focused on developing joint procurement programmes to allow this projection to be met, began by working with 39 cities / regions across ten countries in autumn 2015. By mid-2016, membership of the clusters had expanded to over 60 cities / regions in 13 countries, as shown below. This development is consistent with the assumption above that at least 15 new locations with intentions to deploy fuel cell buses need to be attracted to this sector each year.

<sup>17</sup> Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe, Figure 29, p.48, Roland Berger for the FCH JU (2015).



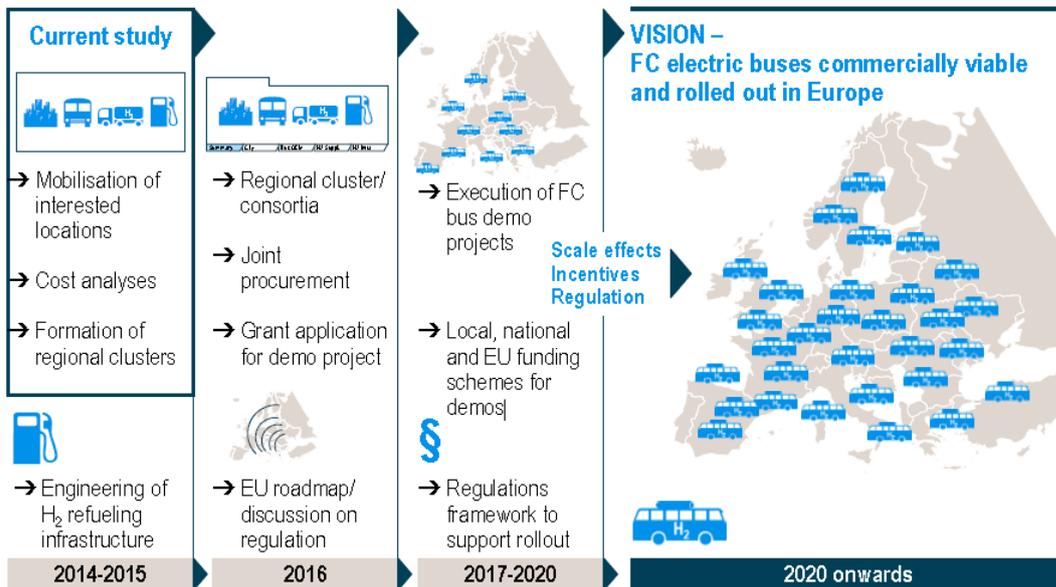
Figures in brackets indicate number of cities / regions / principalities in each country with an active interest in developing fuel cell bus deployment plans.

**Figure 11: Evolution of the composition of the clusters seeking to embark on joint procurement exercises for fuel cell bus deployment**

While this project has continued to build momentum in terms of demand for fuel cell buses, further coordination work is needed to continue to (i) support the development of joint procurement approaches and (ii) expand the clusters, both in terms of additional cities / regions in countries already represented and expansion to new member states.

### 5.3 Timescales for fuel cell bus commercialisation

The FCH JU’s vision for the commercialisation of hydrogen buses is summarised in the fuel cell bus commercialisation study.



**Figure 12: Vision for the commercialisation of fuel cell buses<sup>18</sup>**

Results from the existing demonstration projects provide a solid basis for the vision of fuel cell buses being deployed across Europe on a commercial basis from the 2020s. A number

<sup>18</sup> Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe, Figure 5, p.16, Roland Berger for the FCH JU (2015).



numbers are positive from the perspective of seeking to achieve the volumes needed to commercialise the technology and imply the following:

- **A multi-billion euro market could be created** – based on a demand for 600+ vehicles, the potential cumulative market size for fuel cell buses in Europe by 2020 is of the order 1.5bn euros.<sup>21</sup> This represents a significant opportunity for suppliers of fuel cell buses and associated hydrogen refuelling infrastructure.
- **Innovative funding strategies will be required** – in the fuel cell bus topic of its 2016 Call, the FCH JU stipulated a capital cost target of 650k euro for fuel cell buses and a grant of up to 200k euro per vehicle, leading to a net cost to the customer of up to 450k euro per vehicle.<sup>22</sup> The projected demand of >600 buses across Europe is based upon the sector finding mechanisms for achieving this effective pricing level. With a total of 32m euro of FCH JU funding allocated to this topic, the 2016 funding round could support up to around 150 vehicles (on the basis that funding for refuelling infrastructure is sourced separately). If a demand for 600 vehicles were to be realised and a similar funding level offered, the implication would be a need for an additional c.90m euro of funding to support the buses alone. This figure exceeds FCH JU budgets currently allocated for this sector, which implies some combination of lower cost vehicles and / or increased contributions from other sources will be needed for all of the vehicles to be delivered.
- **Increases in vehicle production capacity will be needed** – investments from the supply side are likely to be required to ramp up production capacity for fuel cell buses to meet this level of demand within the envisaged timescales. The developments in this project have been communicated to potential suppliers through a number of engagement activities to allow suitable preparations to be made. However, in these discussions with suppliers, a number have expressed concern about their ability to ramp up production of fuel cell buses sufficiently rapidly – this issue will need to be carefully managed to avoid disappointing customers.
- **Follow-on deployment plans should be considered** – the cities with an interest in deploying fuel cell buses are engaging with the technology on the basis that it could form a major component of their future fleets. While the initial deployment plans involve around 10 / 20 / 30 vehicles in each location, there is a need to begin planning for larger scale uptake, e.g. involving dedicated hydrogen bus depots. This has a number of implications, for example on the requirement for large modular refuelling solutions (a topic being investigated in the on-going NewBusFuel project), and arrangements for vehicle maintenance, spare parts supplies, etc.

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<sup>21</sup> Based on a total cost of ownership of 3.65 euro/km (Roland Berger, 2015), and an average bus lifetime distance of 720,000 km.

<sup>22</sup> These are the figures for standard non-articulated buses. The corresponding numbers for articulated buses were capital cost target of 1,000k euro and a grant of up to 250k euro.

## 6 Procurement processes

### 6.1 UK cluster

#### 6.1.1 Objectives and challenges

A procurement working group comprising representatives of Aberdeen, Birmingham, Dundee and London was formed in the UK cluster. This group was chaired and coordinated by Element Energy and had the remit to develop an approach to jointly procuring fuel cell buses in a way that maximised the potential economies of scale whilst meeting the needs of all potential customers. The main dimensions to the challenge of how to procure fuel cell buses in a coordinated way were identified as:

1. Type of procurement process – i.e. which type of process and award procedure is best suited to the project objectives and current state of the market.<sup>23</sup>
2. Structure (grouping) of organisations involved – who should run the process, how others can become involved, which entity is most appropriate to undertake the required procurement.

Additional challenges facing the group included:

- **Scope of equipment being procured** jointly – fuel cell buses (limited no. of suppliers) / hydrogen refuelling stations (more choice available).<sup>24</sup>
- **Variation in technology specification** – a common basic technical specification for a standard single deck fuel cell bus was defined as part of the project.<sup>25</sup> However, operators in the different cities have their own specific requirements in terms of the detailed specification and the procurement arrangements needed to be sufficiently flexible to accommodate orders with various optional extras.
- **Geographic scope** – procurement must suit different cities / regions across the UK, and potentially beyond (further investigations required).
- **Ownership structures** – in some cities the buses are expected to be owned by the local council and leased to an operator, whereas in others the operator is likely to own the vehicles. The procurement exercise therefore required flexibility in terms of contractual arrangements and ownership.
- **Wide range of stakeholders** – with funding to deliver the project potentially from local, national, and international sources, various stakeholders need to be satisfied that the procurement process delivers good value for money.
- **Timescales** – some cities are expected to be ready to deploy new fuel cell buses in advance of others and the group aimed to implement a solution that would allow vehicles to be purchased in a number of waves.

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<sup>23</sup> The EU Utilities Contracts Regulations (2016) provides five award procedures: open, restricted, competitive dialogue, competitive with negotiation, and innovative partnership approach. For further details see [http://www.legislation.gov.uk/ukxi/2016/274/pdfs/ukxi\\_20160274\\_en.pdf](http://www.legislation.gov.uk/ukxi/2016/274/pdfs/ukxi_20160274_en.pdf).

<sup>24</sup> Note that the group originally considered the option of joint procurement for the hydrogen refuelling infrastructure as well as the buses but identified a number of issues (e.g. differing technical specification needed between sites), found that the potential benefits were limited, and concluded that refuelling solutions should be put in place on a city-by-city basis.

<sup>25</sup> This was included in the RFI published by the UK cluster – see section 9.5.

### 6.1.2 Approaches considered

Upon consideration of the type of procurement process, the group recommended that the UK coalition should seek to undertake a **fully compliant** (but conditional) procurement exercise. It was felt that any other options such as informal market tests would in effect delay rather than remove the need to go through a compliant process.

On the issue of structure / grouping of organisations involved, the working group considered a number of options:

- **Use an established procurement body** – there are a number of organisations in the UK that can carry out joint procurement on behalf of multiple customers. Examples include the Crown Commercial Service and Scottish Futures Trust. The group decided against this option due to the specific nature of the procurement exercise (i.e. seeking to buy highly innovative products from a relatively small number of suppliers) and the timescale risks arising from essentially outsourcing the procurement.
- **New entity** – councils involved create a new legal entity (company) to lead the procurement process. Under this concept other organisations (public and private sector) could become members of the new entity and obtain the option to procure vehicles via this route. An extension of this model is for the new entity to actually procure and own the vehicles, leasing them on to operators. This approach is familiar to many councils in the UK but the group decided against it on the grounds of complexity.
- **Lead authority approach** – whereby a public sector authority leads the procurement on behalf of a group of authorities.

The UK cluster decided to conduct a joint procurement exercise using the **lead authority approach**. The option of using a private sector bus operator as the procurement lead was also considered as this could give increased leverage, more competition, and thus help to secure the lowest possible prices. However, the group decided that it would be preferable for a public sector body to act as the lead authority as (a) it can be difficult for public bodies to use a procurement framework resulting from an exercise led by a non-compliant body and (b) using a member of the core project team provides greater control of the process. Transport for London is leading the joint procurement exercise in the UK as (i) the organisation has the relevant experience and in-house expertise to run this type of process and (ii) of the cities involved, London is expected to order the largest number of vehicles via the framework.

### 6.1.3 Selected approach to joint procurement

The UK cluster's procurement working group decided to seek information on potential products that could meet the cities' requirements by engaging with the market via a request for information (RFI).<sup>26</sup> The RFI explained the context of the project and included a draft technical specification for the vehicles. Suppliers were asked whether they could offer products that meet the high level specification and were requested to provide indicative cost information for the procurement and on-going maintenance of the buses. The RFI also sought information on warranties / guarantees and lead times for delivering the vehicles.

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<sup>26</sup> A copy of the RFI is included in the appendix, section 9.5.

Following the collection of responses to the RFI, meetings with suppliers were arranged to discuss the potential offers in more detail. The information collected through this process informed the procurement strategy, which is due to be finalised during summer 2016. The strategy and desired technical specification for the vehicles were also informed by feedback from bus operators, who were engaged at various points during the course of the project, including at a dedicated workshop where specifications and approach to procurement were discussed.

Responses to the RFI confirmed that fuel cell buses are expected to be available at or below the cost level set as a criteria in the FCH JU's 2016 Call (650,000 euros for a standard (non-articulated) single deck bus). This provided the group with confidence that the budgets being prepared will be sufficient to deliver the planned projects but also highlighted a potential concern relating to procuring products in a market with falling prices. The UK's joint procurement strategy was developed to mitigate the risk of committing to purchase fuel cell buses at a certain price level when further reductions may be possible in the near term. The overall approach planned is summarised below.

1. Inform the market of the intention to procure fleets of fuel cell buses by the issuing of a prior information notice (PIN).
2. Request information from the market on products available and indicative price ranges via a request for information (RFI).
3. Engage with potential suppliers to explore offers in more detail via bilateral meetings.
4. Initiate a formal procurement process by publishing an OJEU notice which will publicise that the UK cluster seeks to establish a framework, potentially consisting of multiple lots (differentiated by bus type – single vs. double deck).<sup>27</sup>
5. Evaluate responses to the Invitation to Negotiate (ITN) and appoint suppliers to the framework.
6. Run mini-competitions at pre-determined stages within the year for vehicle supply from the framework, once details of all customers' requirements are known and all required funding is in place. This procedure will assist with achieving higher economies of scales by collating cities' requirements by conducting mini-competitions for larger quantities of orders. This shall also assist with manufacturers' production plans and supply chain management.

As of summer 2016, the first three steps outlined above are complete. The details of the procurement strategy along with the procurement documents (ITN, draft contract, technical specification) are being finalised and the procurement exercise is expected to begin by autumn 2016 (see timescales section below).

The framework is expected to be in place for a fixed period of three years with an option to extend for a further one year and could be used by a wide range of other contracting authorities, i.e. not limited to the four public authorities that will jointly establish the mechanism. Furthermore, options to design the framework so that other bodies outside the UK can have access to the prices offered within the framework are also being considered. Precise details of how the call-off process will work remain to be defined but the intention is to use the framework to place a small number of relatively large orders for fuel cell buses

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<sup>27</sup> Note that while it is possible to tender for the framework and the first call off simultaneously, doing so would require the contracting authorities to specify the exact number of buses (by type) being procured. These details are expected to be informed by the responses to the ITT, hence the approach is to run mini competitions to award contracts for vehicle supply after the framework is established.

against the common specification and using the model contract which will be agreed as part of the framework tender.

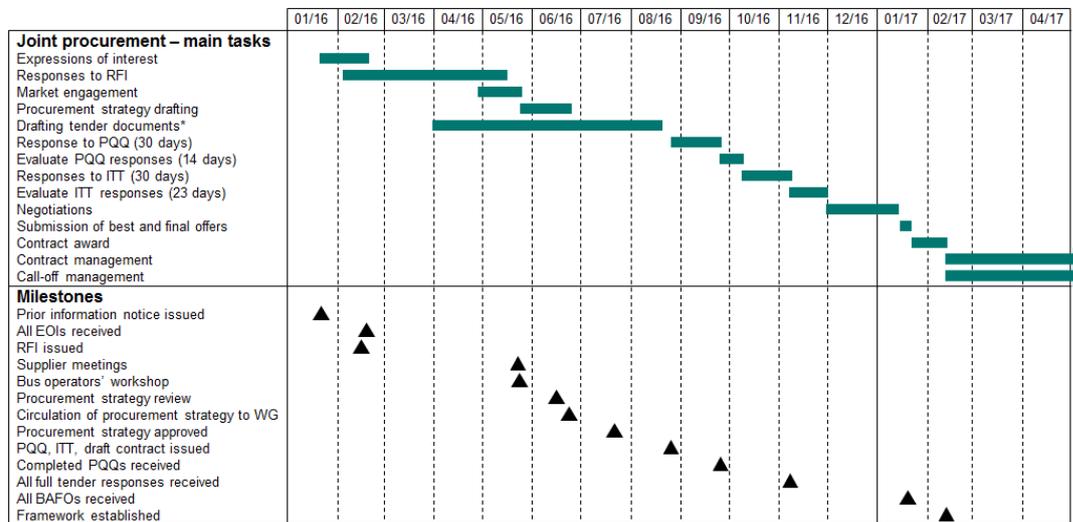
Two contracts will be involved in the process:

- A framework agreement, a standard form of contract which binds the suppliers to the terms of the procurement framework
- Call Off Contracts – these will be negotiated bilaterally between the bus supplier and each of the bus purchasers. These bilateral agreements will be based on a model contract which will be agreed and defined as part of the framework, but will be tweaked to suit each specific bus operator situation. In particular, we expect different maintenance regimes to be required in the different locations.

In terms of the procurement procedure, the UK working group decided that given the lack of scope for negotiation, the open procedure would not be a suitable route and that a **negotiated process** would be preferred.

#### 6.1.4 Procurement timescales

The joint procurement exercise for fuel cell buses in the UK was formally initiated with the publication of a prior information notice in January 2016, followed by a RFI in February 2016.<sup>28</sup> The UK project partners are seeking to place orders for fuel cell buses as promptly as possible following confirmation that all match funding is in place (expected by the end of 2016), hence the plan is to run a conditional procurement exercise in parallel to funding acquisition activities. The proposed timescales for the UK joint procurement exercise are shown below.



\* Including technical specification, PQQ, ITT, and draft contract.

RFI = request for information, PQQ = pre-qualification questionnaire, ITT = invitation to tender, EOI = expression of interest, BAFO = best and final offer, WG = working group.

Figure 14: Timescales for joint procurement in the UK cluster

These overall timescales are fairly typical of the period needed to run a fully compliant procurement process based on the experience of members of the UK's procurement working group. Completing this type of exercise generally takes between nine and twelve months: around three months to implement a procurement strategy and six months to run the tender

<sup>28</sup> [www.publiccontractsscotland.gov.uk/search/show/search\\_view.aspx?ID=JAN231981](http://www.publiccontractsscotland.gov.uk/search/show/search_view.aspx?ID=JAN231981).

exercise. Note that the programme set out above shows the tasks required to establish the procurement framework. Once this is in place the process of running mini competitions between suppliers to award contracts is relatively rapid (a matter of weeks per competition).

## 6.2 German cluster

### 6.2.1 Objectives and challenges

The procurement group of the German cluster consists of representatives of the transport operators of Wuppertal, the Cologne region, Mainz, Wiesbaden, Frankfurt and Bozen. These are the cities which have also participated in the application for the 2016 call for funding by the FCH JU. Other transport operators potentially interested in purchasing fuel cell buses in a next phase e.g. Hamburg, Münster and Rovereto (as a potential fast follower in an observer and learner role) are also members of the group that has prepared the common technical and functional specification for the fuel cell buses as well as started the joint procurement process.

As all of the German bus operators are publicly owned either by the city or the region the procurement of buses must comply with the European Utilities Directive's rules on public contracts. Therefore an open public tendering process is necessary. Today in Germany each operator usually tenders buses by and for himself alone. In order to achieve a clear view on the legal conditions and requirements for a common tender of fuel cell buses in Germany a working group of experts from Hamburg, Cologne, Munich and Frankfurt was founded.

However, there are existing models in which a joint procurement of transport companies is exercised. A good example is the "Kooperation östliches Ruhrgebiet" (Cooperation Eastern Ruhr Area) which consists of the operators Bochum-Gelsenkirchener Straßenbahnen AG (BOGESTRA), the Straßenbahn Herne-Castrop-Rauxel GmbH (HCR), the Vestische Straßenbahnen GmbH and the Dortmunder Stadtwerke AG (DSW). This joint procurement network works as follows:

- One partner tenders the procurement of the respective products such as spare parts etc. within a common framework contract for e.g. tyres. Within the tender documents it has already been stated that the lead partner issues the tender on behalf of a group of companies and that the subsequent purchase will be made in specific lots by each company individually.
- After the negotiation process each partner purchases the units individually with reference to the joint tender. Also each partner is invoiced separately.

Thus, the first question that had to be solved was if such a model could also be executed in the joint procurement of the buses in an EU project, or if it would be necessary that each company issues separate tenders.

Regarding the formalities and the content of the common tender, the relevant questions to be answered were more or less the same like in the tender that has been initiated in the UK cluster in parallel. On this background the requirements as well as the lessons learnt between the two clusters have been exchanged on a regular basis and documents such as vehicle specifications have been exchanged to allow as much standardization as possible to achieve economies of scale once the formal process is started. Regarding the market development as well as the formal tender procedure the core questions are:

- Is it possible to achieve a common and standardized specification of the buses that facilitates a joint approach, or do the local specifications (both for 12 m and 18 m buses) differ so significantly that a joint specification and procurement effort is unrealistic?
- Which formal procedure is advisable and which is the relevant legal framework for such a process?
- Can a tender be made by an external body or which type of organization fits best with the procurement exercise intended?

Besides these questions also the requirements of both the German as well as Italian specific regulatory directives needed to be evaluated to secure the integration of the Italian cluster members into this process.

### 6.2.2 Approaches considered

In order to find appropriate solutions for the organisational and legal questions mentioned above, the cluster initiated two working groups:

#### **Legal aspects:**

This working group dealt with the legal framework as it exists today for joint procurement initiatives. This includes clarifications especially with regard to which procurement processes comply or stand in conflict to European and National legislation. This working group was led by HOCHBAHN and consisted of procurement experts from the partners in Cologne, Münster, Wuppertal and Frankfurt. The working group was formed in June 2015 and has met four times to date. Besides the expert discussion additional input was given through an external consultancy by a lawyer firm specialising in public procurement.

#### **Technical specifications for the buses:**

This working group was led by Stadtwerke Münster with the objective to define a common specification for fuel cell buses in the 12m and 18m layout. The initial draft was partly based on recommendations as issued by German Public Transport Association (Verband Deutscher Verkehrsunternehmen, VDV) for battery electric buses. The aim was to realise as many synergies between these technologically related vehicles as possible.

The work of this group consisted mostly of the definition of the standards for all technical and operational requirements. The exchange was done by e-mail and the members of this group discussed the status of the definition process at the regular meetings of the overall cluster.

### 6.2.3 Selected approach to joint procurement

After a thorough and intensive evaluation of the relevant legal European and National framework the working group on the legal aspects suggested to the cluster

- To conduct a joint procurement exercise using a lead authority approach and for the process to be led by a transport operator.
- The fact that the lead transport operator represents a growing number of interested operators in an emerging market will be made clear through the procurement exercise. The aim is to maximise interest from and competition between OEMs in order to create a market and secure the best value vehicles.
- In order to achieve the necessary information on availability and prices of the buses early enough to harmonize the eventual purchase of vehicles with the requirements to

deliver the buses at an appropriate time to achieve the full funding the first step should be to engage with the market via a request for information (RFI).

- Within the RFI all necessary information on the objectives and the context of the joint procurement initiative as well a brief description and the potential number of the buses to be delivered should be given.
- Also the RFI should ask for information on the expected costs of the buses (indicative TCO), as well as the warranties / lifetime of components and the number and delivery dates of the buses.
- A process that allows for an open negotiation with the OEMs is preferred by all partners.
- The working group also proposed to use a framework agreement for the latter common procurement of the buses.

The working group concluded that the legal framework allows a common procurement of buses based on standardized specification books. Further, the aim of creating economies of scale requested by the bus manufacturers by a joint procurement initiative is not opposed to the competition law. Further, a common communication (e.g. in the known trade journals, etc.) should be developed which aims to ensure a sufficient perception of the joint initiative by the major bus manufacturers.

#### **6.2.4 Technical specification of the buses**

Regarding the technical specifications it was decided to commonly develop the basic specification document for the buses. This should mainly

- Describe the drive train of the bus with a detailed breakdown of the functionalities such as requested daily mileage, hydrogen consumption, pay load etc. According to the bus manufacturers those are the relevant aspects that have the biggest influence on the costs of the buses.
- Besides the common components, technical performance and layout requirements for all partners individual and specific installations for each operator, such as number of seats, driver working place, painting, hand rail and seat colours, shall be described in an appendix to the specification sheet.
- Although the individual components are cost relevant too, they shall not be a criterion for the decision of the selection of the FC bus manufacturer.

An important aspect that needs to be taken into consideration was advice from the legal experts that the specification sheet must not exclude any OEMs as a result of requirements that can only be fulfilled by one manufacturer alone.

#### **6.2.5 Procurement timescales**

A big advantage of the European bus procurement cluster approach is the exchange and adoption of successful procedures between the different national clusters. Here the UK cluster exchanged their draft for their RFI with the German colleagues and the document was then adapted to the national requirements. After that the documents were formally issued in the respective announcement media for tenders (TED – Tenders Electronic Daily) and then sent together with the specification sheet to the OEMs on the market that have shown an interest in the documents.

This process took place in parallel to the preparation of the bid for the JIVE project in March / April 2016. Responsible for this process were the Stadtwerke Wuppertal as the lead partner on behalf of the whole cluster.

At the cluster meeting of April 8 2016, the results of the RFI were presented. Three OEMs had responded to the document. A first evaluation of the responses from the OEMs has confirmed that all documents received fulfil the requirements from the RFI.

As a next step all OEMs who replied to the RFI will be invited to a first round of information exchange in July 2016 to explain their strategies, products and their price and cost assumptions. Also potential delivery dates and numbers will be discussed. Representatives from all cluster members, not only those who participate in JIVE, have been invited to join the meeting.

Based on the results of these talks, the tendering process will start in summer 2016. It will be jointly coordinated by the Wuppertaler Stadtwerke and RVK (Cologne). Within the whole tendering process an intensive exchange of information with the other clusters will be initiated. The group intends to finalise negotiations with the OEMs in autumn 2016 in order to be ready for ordering as soon as the FCH JU funding for the JIVE project is confirmed and funding contracts are signed.

In parallel the specification sheet has been finalised in detail and will now be used as one of the leading documents in the next steps of the process especially the concrete tender exercise with the OEMs.

As the procurement of the fuel cell buses cannot be funded fully by the FCH JU, it was expected that the regional clusters and the bus operators seek the necessary national or regional co-funding.

While the bus operators talked to their local authorities (city and State governments), the cluster coordinators negotiated with the agency responsible for the German National Innovation Program Hydrogen and Fuel Cells (NIP). This agency (NOW GmbH) works on behalf of the federal government. The discussions indicate that a co-funding via the Block Exemption Regulation is possible and that it is the aim of the federal government to support the bus projects. These talks have already taken place (end of 2015 till spring 2016), and will be continued once the details of the new federal funding programme are published.

#### Integration of North Italian Partners in the further cluster activities

Bozen has indicated (with backing of the regional government of South Tyrol) to join the procurement process in Germany in so far as they will participate in the formulation of the specifications and also in the meetings with the bus OEMs. It is also intended to join the tendering process (in so far as it increases the number of buses described in the tender). However, the concrete procurement of buses will then be made independently according to the Italian regulations. Rovereto (which does not participate in JIVE) will be an observer to make learnings for future procurements.

However, it is already clear from today's point of view that – in case further Italian cities should show an interest in the procurement of fuel cell buses – it will be necessary to form an Italian cluster of its own, This makes sense not only from language perspective but also with regard to the specific Italian regulations for the technical equipment of buses and the procurement procedures. Nevertheless, in the phase described in this report it made sense to integrate Bozen and Rovereto into the German cluster in order to facilitate the work in Northern Italy by the practised “learning from each other”.

### 6.3 Benelux cluster

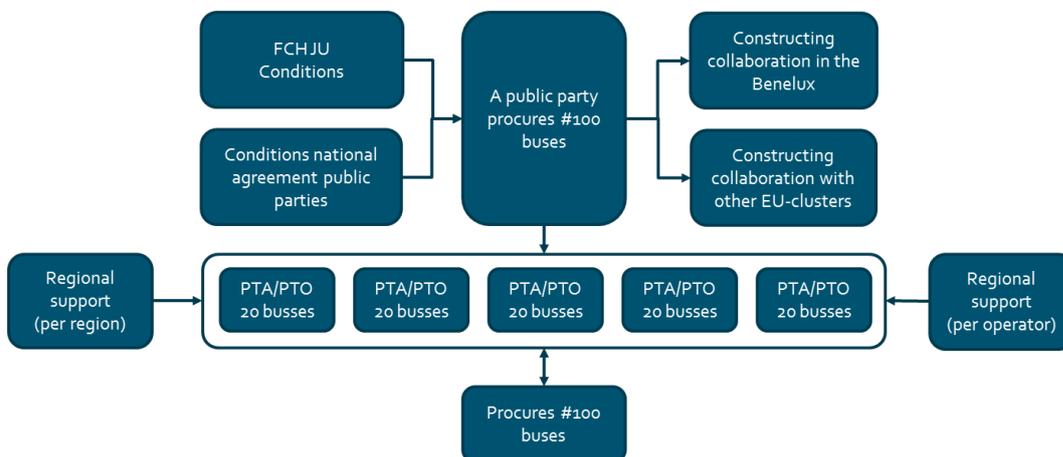
In the Benelux cluster several scenarios for joint procurement have been developed and discussed. The situation in the Netherlands is complex due to market circumstances. The Netherlands is a frontrunner in Europe and opened the market for public transport. Therefore, in almost all regions there is tendering of concession for a given period. These concessions cover three elements: fleets, services and energy. This means that in the majority of cases fleets and energy are procured through the PTO.

This unique situation requires extensive knowledge of the Dutch legal system, political knowledge and a vast network with respect to PTOs, PTAs, bus manufacturers, hydrogen producers and infrastructure providers. The cluster managers have this knowledge and were able to define potential approaches to joint procurement for the Netherlands, Luxembourg, and Belgium. In Belgium there are only four operators, and in Luxembourg there is one operator and all are state owned. Procurement is done through these companies with a large influence by the regional politics. The Benelux cluster managers have put much effort into understanding the politics in Belgium and Luxembourg and acquired a good network and were able to secure a letter of support from Wallonia.

The scenarios for joint procurement of one hundred fuel cell buses in the Benelux cluster considered in this project were:

1. A public party procures 100 buses.
2. One PTO (or a collaboration of PTOs) procures 100 buses.
3. A legal entity (as part of the National Hydrogen Platform) procures 100 buses.
4. Five different projects procure via five procurements 100 buses.
5. Procurement in two segments of 60 and 40 buses fitted on the Dutch situation.

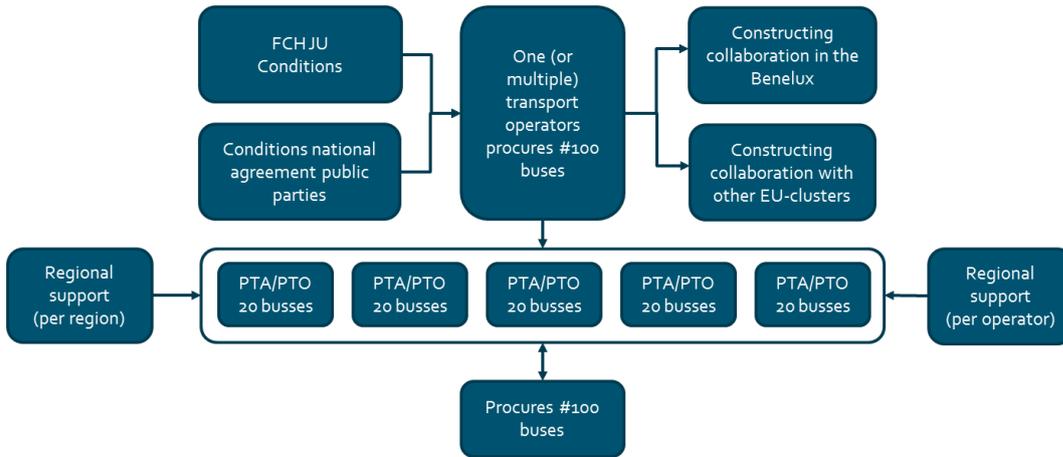
#### Scenario 1: A public party procures 100 buses



Comments:

- There is no experience for procuring buses by public parties.
- The procurement risks lie with the public parties.

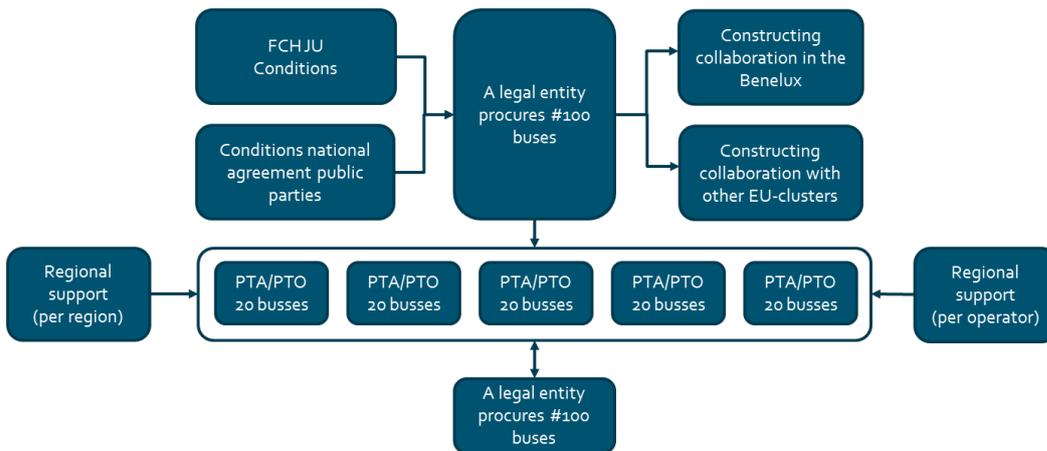
**Scenario 2: One PTO (or a collaboration of PTOs) procures 100 buses**



Comments:

- Practice has proven that cooperation in organising a joint procurement with multiple PTOs is not viable due to competition between operators.

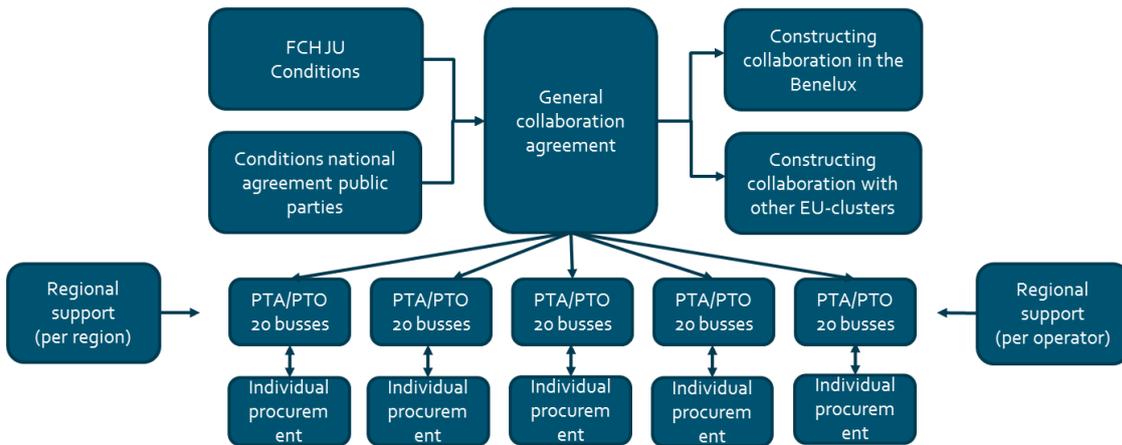
**Scenario 3: A legal entity (as part of the National Hydrogen Platform) procures 100 buses**



Comments:

- A separate legal entity with both transport authorities and operators such as a Rolling Stock company, could be a consequence of the working group public transport of the National Hydrogen Platform.
- This requires a joint agreement between public and private parties and is under construction.

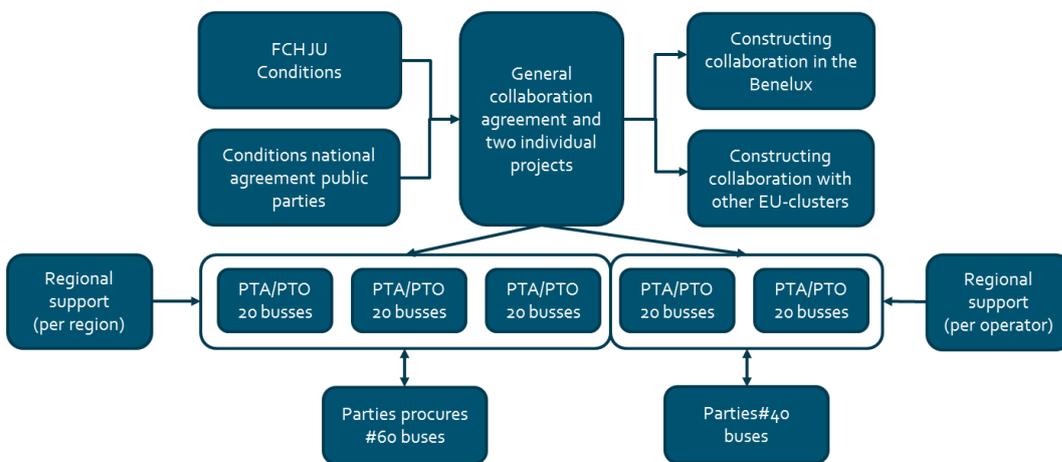
**Scenario 4: Five different projects procure via five procurements 100 buses**



Comments:

- It is possible that this individual procurement per authority / operator does not match the FCH JU requirements regarding large-demonstration projects.
- Alignment is difficult which makes success not likely.

**Scenario 5: Procurement in two segments of 60 and 40 buses fitted on the Dutch situation**



Comments:

- A pragmatic approach that addresses the Dutch situation and relationships between operators.
- Up to 40 and 60 buses per procurement.

**Conclusions and recommendations**

- Scenario 1 does not match the Dutch situation and is therefore not likely.
- Scenario 2 does not match the current cooperation between the operators and is therefore not likely.
- Scenario 3, the rolling stock, is an ideal scenario and is under construction.

- Scenario 4 does not match the FCH JU requirements.
- Scenario 5 is a no regret scenario and should be implemented as a plan B.

## 7 Dissemination

### 7.1 Context

The FCH JU has recognised that a lack of budget for supporting the “hardware” aspects of dissemination in the on-going demonstration projects (mainly making buses available and booking stands at large events) has limited the effectiveness of dissemination activities carried out by the FCH JU’s funded projects. As a result, a campaign of dissemination was included in this initiative, leading to an increase of the presence of the fuel cell bus sector in congresses and fairs (e.g. presence at *Transports Publics* for the first time).

As far as “hardware” is concerned, it has proved to be challenging to secure the attendance of fuel cell buses at events for different reasons – primarily the fact that the buses are providing daily service in cities and can therefore not be taken out of service for other purposes, even when funding was available to cover all costs (driver costs, costs to cover a replacement bus, hydrogen refuelled etc.).

The dissemination activity was undertaken in a collaborative fashion as a complement to the activities led by the dissemination leaders of the current FCH JU fuel cell bus projects, the FCH JU communication manager and Hydrogen Europe, each of them being aware of the communication activities developed within the cluster.

### 7.2 Communication tools

The level of understanding being different in each cluster, different communication tools and approaches have been developed. A summary of communication tools developed and the dissemination activities undertaken by all clusters is given below.

Tools	Lead	Content	Use	Remarks
Website: <a href="http://www.h2bus-france.fr/">http://www.h2bus-france.fr/</a>	HDF	General info on FCB in French Updates/news of the sector	Regularly	Useful in France given the lack of knowledge of the topic and as no information was available in French
CHIC Emerging Conclusions (translation)	EE	The detailed results were translated into French and German	On a case by case basis	Update of data upon request (English version updated regularly)
Roll-up banner	HDF/EE	Basic information about the cluster	Transports Publics (in French) TEN-T days (in English)	



Figure 15: Roll-up in English developed to represent the clusters activities

### 7.3 Communication activities

The cluster coordinators represented the fuel cell bus sector at a number of conferences and events throughout the duration of this project; the most significant of which are summarised below (note that this is a non-exhaustive list).

Event	Date	Location	Lead / Support	Attendees	Activity	Target audience
F-cell	12/10/2015	Stuttgart	DE cluster	Frank	Presentation	H <sub>2</sub> community
Hyvolution	05/02/2016	Paris	H2F	Benoit	Workshop on FCB	PTOs / PTAs
Elektromobilität vor Ort	09/03/2016	Aachen	DE cluster	Frank	Presentation	DE local authorities
Hannover fair	26-27/04/2016	Hannover	Latvia/EE	Aivars, Benoit	Cities tours FCB present	PTAs
trolley motion	31/05-01/06/2016	Berlin	DE cluster	Heinrich	Presentation on FCB and cluster	PTOs, PTAs
Transports Publics	14-16/06/2016	Paris	HDF/EE	Benoit/Damien, Sabine (on 15/06)	Stand	PTOs, PTAs, bus industry

WHEC	15/06/2016	Zaragoza	DE cluster	Frank	Presentation	H <sub>2</sub> community
TEN-T days	20-22/06/2016	Rotterdam	EE: stand TG/Rebel: Signing ceremony	Sabrine, Aivars Ben, Ellen, Jan Willem, Marc on 21/06	Information on fuel cell buses at the stand including clusters activities Signing ceremony	
European bus forum	23/06/2016	Manchester	Scottish alliance/EE	none	Presentation from Fiona Goodenough	PTOs, PTAs, bus industry
Journées hydrogène dans les territoires	29/06/2016	Grenoble	HDF	Benoit	Presentation	H <sub>2</sub> community
EcoShell Marathon	30/06-04/07/2016	London	Tower Transit /EE	none	Shuttle bus	Low carbon mobility stakeholders
LCV event	14-15/09/2016	Milbrook	EE/Tower Transit	Sabrine	Shuttle bus Bus presentation (tbc)	Low carbon mobility stakeholders

The events listed show a shift from focus on communicating towards the hydrogen community solely to address the key audiences the sector is looking at convincing: PTOs, PTAs and other transport stakeholders.

## 7.4 Impact of dissemination activities and next steps

The dissemination campaign, along with the numerous exchanges with cities, PTOs, regional, national and EU policy makers has contributed to the following:

- Increasing interest in the work of the clusters and expanded groups of city / regional representatives considering deploying fuel cell buses (see Figure 11, section 5.2).
- Commitment of international and national funding to support fuel cell bus deployment plans and engagement with funding / financing organisations such as the European Investment Bank, which is now considering options for a zero emission bus financing mechanism.
- Hydrogen fuel cell buses becoming increasingly recognised by political leaders as a viable solution to many of the challenges cities face. For example, the new Mayor of London specifically referred to hydrogen buses in his manifesto: *“I will set a target of only buying clean electric or hydrogen buses from 2020, seeking an agreement*

*across other major European and global cities to do the same, in order to send a signal to bus manufacturers and create a race to the top in clean bus technology.”<sup>29</sup>*

This evidence suggests that dissemination efforts should continue in the context of the ongoing demonstration projects and any follow-on coordination activities.

A key aspect for effective communication is to ensure all speak with one voice, as otherwise the message is diluted, and it can be counterproductive. As part of this process, high-level joint messages for the fuel cell bus sector have been developed, based on activities undertaken within the clusters. Messages have been developed for the general public, PTAs, PTOs, and other EU stakeholders.

Securing speaking opportunities for the fuel cell bus sector at large public transport conferences is challenging, but there are more chances to succeed when working in a coordinated way. A crucial aspect in the dissemination of the fuel cell bus sector is to ensure a coordinated action amongst the main stakeholders. The CHIC project, being the oldest and largest fuel cell bus deployment project in Europe, takes the lead in this process. Yet the project will end at the end of 2016, and there is a need to identify which organisation will take over this leading role. The JIVE project would be a natural candidate, as it will be a large deployment trial covering multiple member states and is expected to start in early 2017 subject to the funding application being successful.

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<sup>29</sup> [http://www.sadiq.london/a\\_greener\\_cleaner\\_london](http://www.sadiq.london/a_greener_cleaner_london).

## 8 Conclusions and next steps

### 8.1 Conclusions

In the context of the original objectives of this project, the main conclusion is that the process of coordinating efforts to deploy fuel cell buses is beginning to bear fruit, as evidenced by the joint project formed in response to the *large-scale demonstration of fuel cell buses* topic of the FCH JU's 2016 Call and the number of cities / regions preparing to apply for funding to deliver further projects from 2017.

The aggregated demand figures for fuel cell buses across Europe give cause for optimism that the vision set out by the FCH JU's commercialisation coalition can be met. Furthermore, initial information from potential suppliers via the early phases of the procurement exercises suggests that the supply side is preparing to offer an increasing range of fuel cell buses and that economies of scale will provide the opportunity to deliver significant cost reductions. These offers will be formalised through the full procurement processes due to be finalised at the start of 2017 and further information on products available is expected to be published over a similar timeframe.

Rather than embarking on a single pan-European joint procurement programme, the cities / regions seeking to procure fuel cell buses are implementing a series of national initiatives in a coordinated way. Where possible the procurement exercises developed through this project will allow contracting authorities from other countries to make use of the frameworks / agreements put in place, which will maximise the scale effects and thus should lead to the greatest possible vehicle cost reductions.

### 8.2 Next steps

This project represents a further step on the path to commercialisation of fuel cell buses in Europe. While the actions required to continue to develop the deployment projects now planned will be taken in the context of specific projects emerging from this coordination activity, the FCH JU can continue to play a central role in maintaining momentum in this sector by:

- Funding further coordination of joint procurement of fuel cell buses. Feedback from representatives of the cities / regions involved in this project suggests that further coordination support would be valuable to facilitate the continued sharing of information and best practice. Appointing organisations to act as national / cluster representatives will ensure opportunities for collaboration and coordination at an international level are maximised.
- Including fuel cell bus deployment topics in its up-coming funding calls for practical demonstration projects. The project confirms an appetite for at least the magnitude of calls proposed in 2016, if not for considerably more funding.
- Based on the local feasibility work undertaken and engagement with suppliers through this project, we recommend including a high level of flexibility in any future

#### Over-arching project objectives

*Develop a procurement programme that will allow the deployment of hundreds of fuel cell buses in cities across Europe before 2020, thus unlocking cost reductions through economies of scale. At the same time, support the fuel cell bus commercialisation process by increasing awareness of and public appetite for fuel cell buses amongst key audiences throughout Europe.*

calls with respect to bus type (i.e. including double deck, articulated) and drivetrain design, which should accommodate the fuel cell dominant range extender concepts.

- Investigating options for further leveraging FCH JU funding in future calls. For example, by working with other international / national funders on match funding strategies for all elements of a fuel cell bus demonstration project. Work in this area should consider not only the absolute budgets required but also the cash flows over the lifetime of a bus and hence financing issues.
- Continuing to engage with bus OEMs and other relevant suppliers to inform them of the size of the potential market for fuel cell buses with the aim of ensuring that supply will be available to meet the growing demand.
- Engaging with bus OEMs and the supply industry to encourage a better articulation of the cost down curve for buses and using this information, working with suppliers to develop strategies for making best use of European funding options (e.g. seeking to support more buses at less funding support per bus, by encouraging economies of scale).
- Helping to support the numerous new entrants identified by this project to gain the technical maturity which is required to compete for bus orders in the 100s of buses. This could be achieved via smaller calls for small fleet deployment of newer bus types.
- Outreach to member states and cities to encourage policies which can support further uptake of fuel cell buses beyond the demonstration programs. These include zero emission zones and procurement policies for cities and green bus subsidies for national governments.
- Increase the number of national clusters (including national cluster coordinators) if the number of interested cities in a country rises. For example, if further Italian cities express an interest in procuring fuel cell buses, the initiation of a separate Italian cluster would be a logical next step.
- Facilitating further dissemination efforts (e.g. via the demonstration projects that will run to the end of the decade) to make other cities, operators, and political decision makers aware of the potential of fuel cell buses to address a range of environmental challenges.

## 9 Appendix

### 9.1 Status of fuel cell bus deployment in Europe

The diagram below provides an overview of the numbers of fuel cell buses currently in operation or soon to be introduced as of mid-2017. The total number of buses across all projects listed is c.90 buses in operation / about to start operation and over 100 buses in all planned projects.

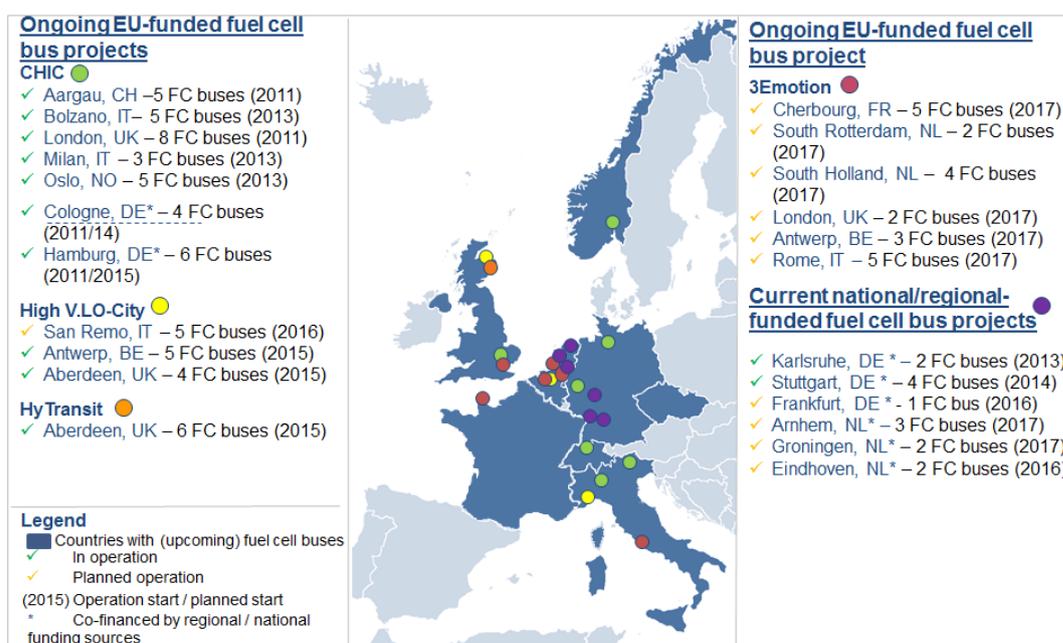


Figure 16: Overview of EU-funded fuel cell bus projects

## 9.2 Fuel cell bus deployment case studies – costs and funding

### 9.2.1 Overview

As mentioned above (section 3.2), the focus of this project was not on undertaking detailed total cost of ownership calculations for fuel cell buses (a topic covered in other studies), but on supporting city and bus operator representatives with developing business cases for fuel cell bus deployment. While the individual business cases are specific to each location and generally remain confidential to the parties involved, it is possible to gain an understanding of the current and future cases for fuel cell bus deployment through a simple analysis using published data and data representative of the discussion with industry during the project. In this section we present these costs for two example cases:

- A fleet of 20 fuel cell buses with a new depot-based hydrogen refuelling station with on-site production.
- A fleet of 50 fuel cell buses with a new depot-based hydrogen refuelling station using delivered hydrogen from a local, relatively low cost source.

In both cases we analyse the costs at current (2015/16) prices and with technology cost and performance assumptions which are representative of the more ambitious prices that have been discussed with industry representatives for the deployments which could follow this subsidised phase – note that these require considerable bus volumes (in the hundreds of units per manufacturer), but are based on the costs of components being offered to the market today.

## 9.2.2 Assumptions

Results of a simplified project costing calculation for fuel cell bus deployment and operation over ten years are given below based on the following assumptions.<sup>30</sup>

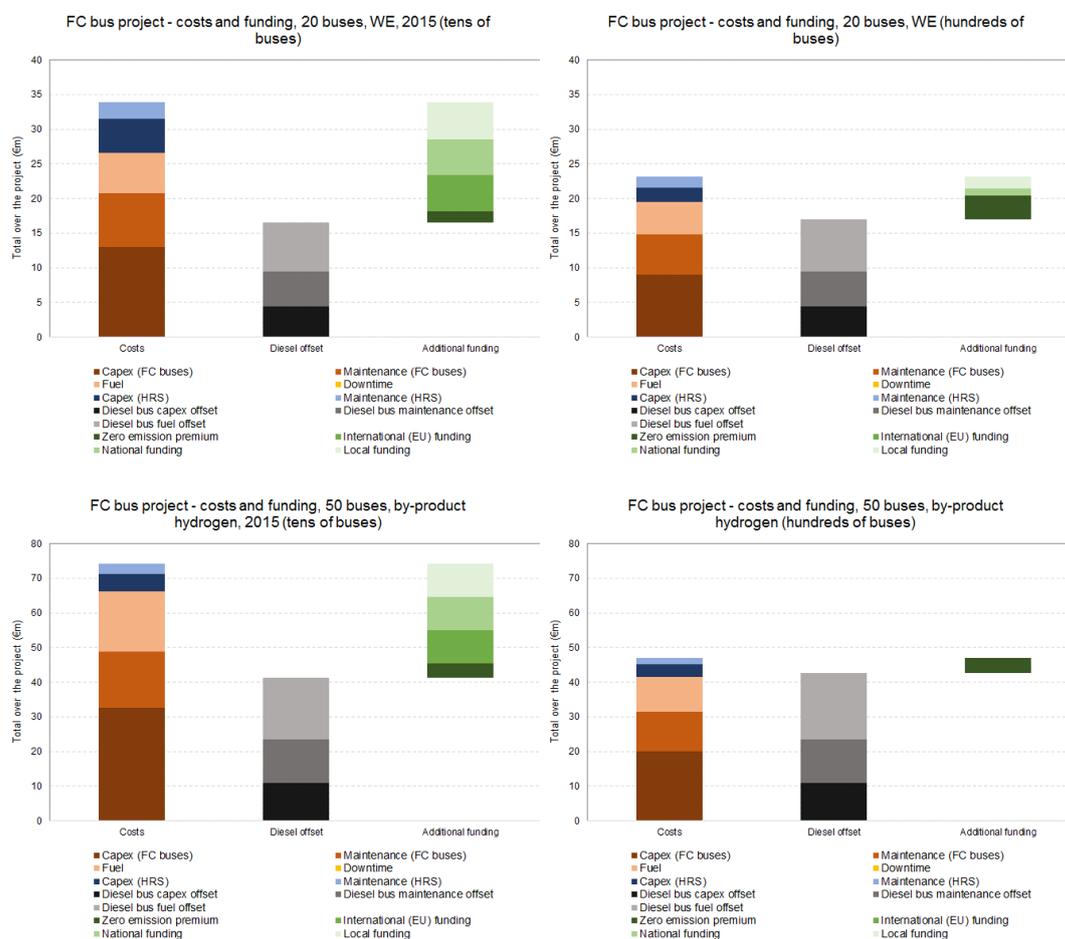
Metric	20 bus project, on-site production, 2015 (tens of buses)	20 bus project, on-site production (hundreds of buses)	50 bus project, delivered H <sub>2</sub> , 2015 (tens of buses)	50 bus project, delivered H <sub>2</sub> , (hundreds of buses)
Fuel cell bus capex (euro)	650k	450k	650k	400k
HRS capex (total installed cost) (euro)	4.9m	3.0m	5.0m	3.8m
HRS fixed opex (euro/yr)	243k	162k	302k	186k
Electricity price (euro/MWh)	85	85	85	85
Cost of delivered hydrogen (euro/kg)	N/A	N/A	6.0	4.0
Annual mileage per bus (km/yr)	65,000	65,000	65,000	65,000
FC bus fuel efficiency (kgH <sub>2</sub> /100km)	8.6	7.3	8.6	7.3

This is a simplified analysis and a number of costs are assumed to be comparable between diesel and hydrogen projects and hence not included, including costs associated with financing (this is an undiscounted analysis), depot upgrades, drivers (employment), training, legal work, project management, etc. In practice, many of these are slightly higher for a hydrogen bus project and would need to be incorporated in any local plan.

<sup>30</sup> The assumptions in this table are based on the data published in Annex 3 and Annex 4 of *Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe*, Roland Berger for the FCH JU (2015). Assumptions for the equivalent diesel buses include: capex 220k euro, maintenance 25k euro/yr, fuel consumption 42 litres/100km, diesel cost 1.3 – 1.4 euro/litre.

### 9.2.3 Results

The costs and potential approaches to funding fuel cell bus deployment projects are presented in the following graphs. In each case the left hand column shows the total costs of the fuel cell bus project, the middle column corresponds to the costs of deploying and operating an equivalent fleet of diesel buses and the final column gives an illustrative example of how funding from difference sources could be combined to bridge the cost gap.



*Fuel cell bus project costs and funding strategies for a 20 bus project with on-site hydrogen production (upper graphs) and a 50 bus project using locally sourced by-product hydrogen (lower graphs). The graphs on the left correspond to current costs (cumulative deployment of tens of buses) while those on the right represent post-2020 figures (hundreds of fuel cell buses in operation)*

These results suggest that:

- At current technology costs there is a significant premium for operating fuel cell buses that cannot generally be covered by the willingness of a city / operator to pay a premium for zero emission technology. Hence funding strategies are required that combine contributions from multiple sources, including European and national sources. This conclusion typically holds independent of the method of hydrogen supply.
- Significant further fuel cell bus cost reductions appear to be achievable with increased volume (discussions suggest that volumes of hundreds of units can lead to a bus cost at or below €400k in the early 2020s, using technology available

today). In this case, the premium over diesel vehicles appears to be within reach of any bus operators and / or local politicians prepared to pay a 10–20% premium for the privilege of operating zero emission buses. There is also the potential for small amounts of national funding helping to tip the balance in favour of the fuel cell option. This is particularly true for larger fleets where the cost of hydrogen infrastructure is spread over more vehicles.

- Given that all-electric buses are on a similar trajectory, this suggests that cities / operators can begin to make regulations or corporate decisions to exclusively use zero emission buses (e.g. zero emission zones in city centres) from 2020. Cities will need to budget for slightly higher costs, but manageable costs if ambitions to transition to fully zero emission bus services are to be fulfilled in the early 2020s. It is reasonable to expect these costs to fall further as demand is increased by legislation of this type.
- Further work is required to define better the potential for these ~2020 deployments and this could be included in any follow up to this work (the analysis here is indicative and will need to be followed up with more detailed discussions with suppliers).

### 9.3 German Cluster meetings

#### Administrative meetings

Date	Location	Topics
March 27, 2015	Brussels	Cluster meeting
April 14, 2015	Hannover	1st cluster meeting, Org. of joint procurement, legal aspects, management
May 21, 2015	Düsseldorf	2nd cluster meeting, Org. of joint procurement, legal aspects, management
Sep 9, 2015	Münster	3rd cluster meeting, Org. of joint procurement, legal aspects, management
Nov 27, 2015	Düsseldorf	4th cluster meeting, Org. of joint procurement, legal aspects, management
Dec 4, 2015	Brussels	Cluster Coordination Workshop
Feb 19, 2016	NOW, Berlin	5th cluster meeting, Org. of joint procurement, legal aspects, management
April 8, 2016	Wuppertal	6th cluster meeting, Org. of joint procurement, legal aspects, management
June 9, 2016	Frankfurt/Main	German/Norther Italy Cluster meeting

#### Meetings on legal aspects of joint procurement

Date	Location	Topics
June 5, 2015	Brussels	Workshop Roland Berger
Sept 1, 2015	Hamburg	Meeting Working Group "Commercial Aspects of Procurement"
Nov 17, 2015	Hamburg/Telco	Meeting Working Group "Commercial Aspects of Procurement"
Jan 21, 2016	German Ministry of Transport	Cluster Follow up

## 9.4 Detailed record of dissemination activities

### Benelux cluster

Multiple sessions to share and gain knowledge were held in the course of this project. During these sessions representatives from PTAs, PTOs, OEMs, hydrogen producers and infrastructure providers were present mainly in the context of the National Hydrogen Platform.

Under the umbrella of the Foundation for Zero Emission Bus Transport, TG / Rebelgroup developed a Total Cost of Ownership (TCO) model for zero emission buses. This model was designed as a decision support tool for investment decisions for both public and private parties. The model incorporates a specific module concerning fuel cell buses and hydrogen fuel cells, which allows financial and societal effects of zero emission buses to be quantified. In the Pilot of the province of Brabant this model is tailor-made for the project and available on demand.

Date	Event / meeting	Venue	Cluster coordinator attendees	Other information
20, 21 & 22 June 2016	TEN-T days	Van Nelle Fabriek, Rotterdam	Marc van der Steen, Ellen Lastdrager, Jan Willem de Kleuver	Organised signing of letter of intent by governors of Groningen, South-Holland and Rotterdam and representative of the ministry.
11th Dec. 2016	Knowledge sharing event in relation to other zero emission activities	Different locations	Marc van der Steen, Ellen Lastdrager, Jan Willem de Kleuver	Actively involved in knowledge sharing between representatives of public parties.
16th Dec. 2016	Knowledge sharing event in relation to other Zero emission activities	Different locations	Marc van der Steen, Ellen Lastdrager, Jan Willem de Kleuver	Actively involved in knowledge sharing between representatives of PTAs, PTOs and OEM.
As of July 2016 on a six-weekly bases	National Hydrogen Platform, working group buses	Different locations	Marc van der Steen, Ellen Lastdrager, Jan Willem de Kleuver	Actively involved in knowledge sharing between representatives of PTAs, PTOs, OEM, hydrogen producers and infrastructure providers.
7 <sup>th</sup> June 2016	Specific event - National Hydrogen Platform, working group buses	Different locations	Marc van der Steen, Ellen Lastdrager, Jan Willem de Kleuver	Actively involved in knowledge sharing between representatives of PTAs, PTOs, OEM, hydrogen producers and infrastructure providers.
28 <sup>th</sup> Feb. 2016	Zero emission bus foundation event	Amersfoort	Marc van der Steen, Ellen Lastdrager, Jan Willem de Kleuver	Actively involved in knowledge sharing between representatives of PTAs and PTOs.

German cluster

Date	Event / meeting	Venue	Cluster coordinator attendees	Other information
10/02/15	Schienerverkehrs-konferenz	Berlin	Heinrich Klingenberg, hySOLUTIONS	Representatives of industry, bus operators, presentation of EC FC activities
11/03/15	Visit Lothian Buses	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Representatives from bus operator Lothian buses and HOCHBAHN
06/05/15	Visit of four County Councils, Norway	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS (CS)	Representatives from Norwegian regional authorities
08/05/15	Delegation Nantes	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Mayor and other representatives of City of Nantes, France
23/06/15	TEN-T Days	Riga	Heinrich Klingenberg, hySOLUTIONS	Participation in Hand-over ceremony of LoU to EU-Commissioner V. Bulc and participation in Round Table discussion
15/07/15	Regionales Bustreffen Rheinland-Pfalz	Infraserv. Höchst	Frank Koch, Energy Engineers	Bus operators in the Frankfurt area, presentation of FC bus state-of-the-art
24/07/15	Visit of Rheinbahn	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Member of Bundestag, Representatives of board of public transport Rheinbahn, presentation of EC FC activities
13/08/15	Visit of public transport Zurich	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	representatives of Swiss public Transport, presentation of EC FC activities
05/10/15	Presentation at Rheinbahn, Düsseldorf	Düsseldorf	Frank Koch, Energy Engineers	Board of Rheinbahn, presentation and discussion
13/10/15	World of Energy Solutions	Stuttgart	Frank Koch, Energy Engineers	Congress about Fc technology, presentation of EU programs for Fc buses
04/11/15	HIT 2 Corridor Conference	The Hague	Frank Koch, Energy Engineers	Conference, partners from the Netherlands and Germany
11/11/15	Industry Conference	Oslo	Philipp Krüger, hySOLUTIONS	presentation of EC FC bus activities

19/11/15	Annual Meeting of Fuel Cell and Hydrogen Network NRW	Düsseldorf	Frank Koch, Energy Engineers	conference, German companies and institutes, presentation of cluster activities
20/11/15	Wasserstoff in Kreis Steinfurt	Steinfurt	Heinrich Klingenberg, hySOLUTIONS	presentation of EC FC bus activities, representatives from local authorities and industry
26/11/15	Visit of Delegation Gelderland	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Representatives of cities and university of Arnheim, Gelderland, presentation of EC FC activities
07/12/15	HyCologne	Köln	Heinrich Klingenberg, hySOLUTIONS	Representatives of City of Cologne, industry, bus operators, presentation of EC FC activities
25/01/16	Visit Philippe Hérisse	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Interview with journalist from Ville, Rail et Transport
03/02/16	FC Expo	Tokyo	Frank Koch, Energy Engineers	Workshop, attendees from Japan, presentation about EU Fc bus activities
29/02/16	VDV-Konferenz	Berlin	Heinrich Klingenberg, hySOLUTIONS	Briefing for participation HOCHBAHN board reg. EC FC activities
09/03/16	Elektromobilität vor Ort	Aachen	Frank Koch, Energy Engineers	Conference, attendees from cities, operators etc., presentation about Fc buses
22/03/16	Visit ineris	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Assistance request how to implement FC technology in France
06/04/16	Czech Hydrogen Days	Prague	Heinrich Klingenberg, hySOLUTIONS	presentation of EC FC activities, international audience
12/04/16	H2Mobility Congress	Berlin	Heinrich Klingenberg, hySOLUTIONS	Conference attendees mostly from cities in Germany as well as political institutions (ministries etc.)
22/04/16	Next Energy Oldenburg	Oldenburg	Heinrich Klingenberg, hySOLUTIONS	presentation of EC FC activities, attendees from regional authorities and industry
04/05/16	Kommunale Mobilität	Bonn	Frank Koch, Energy Engineers	representatives from municipalities, administration,

				presentation about FC buses
04/05/16	Delegation Nantes	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Delegation from City of Nantes, presentation of EC FC activities
18/05/16	IPHE	Berkeley, California	Heinrich Klingenberg, hySOLUTIONS	International audience, presentation of EC FC activities as a Keynote and in panel discussion
28/05/16	Visit Swedish journalist	Hamburg, HOCHBAHN	Heinrich Klingenberg, hySOLUTIONS	Interview with journalist from Buss magasin
31/05/16	International E-Bus conference, Metropolitan Solutions	Berlin	Philipp Krüger, hySOLUTIONS	presentation of EC FC activities
03/06/16	Nachhaltigkeitstag	Hamburg, University	Heinrich Klingenberg, hySOLUTIONS	attendees: students and scholars, presentation of EC FC activities
15/06/16	World Hydrogen Energy Conference	Zaragoza	Frank Koch, Energy Engineers	presentation about EU FC bus activities, participation at German booth
04/07/16	Wirtschaftsforum Mobilität	Bonn	Frank Koch, Energy Engineers	representatives from operators, presentation about FC buses
10/09/16	Elektromobilität im ÖPNV	Münster	Frank Koch, Energy Engineers	Bus operators from Germany, workshop and presentation, test rides with buses

## UK cluster

The principal dissemination activities undertaken by the UK cluster coordinator in this project are summarised below.

Date	Event / meeting	Venue	Cluster coordinator attendees	Other information
22/07/15	Meeting with Scottish Government	Aberdeen, Scotland	Michael Dolman	Updated SG representatives on FC bus deployment plans and discussed potential for national funding.
18/08/15	Meeting with UK Government	London	Ben Madden, Michael Dolman	Updated UK Government representatives on FC bus deployment plans and discussed potential for national level funding support.
10/09/15	Meeting with Transport Scotland	Millbrook, Bedfordshire	Michael Dolman	Discussion of initial request for funding from Scottish Government.
15/12/15	Meeting with Scottish Government	Glasgow, Scotland	Michael Dolman	Update on project plans and discussion of funding arrangements.
21/01/16	Meeting with Scottish Government	Glasgow, Scotland	Michael Dolman	Discussion of potential funding for FC bus deployment in Scotland.
15/02/16	Meeting with Scottish Government	Glasgow, Scotland	Michael Dolman	Follow-up discussion on funding for FC bus deployment in Scotland.
19/05/16	UK Government meeting	By phone	Michael Dolman	Call to discuss funding application for FC bus deployment project.
07/06/16	Meeting with Transport Scotland	Edinburgh, Scotland	Michael Dolman	Review of funding request and overall FC bus deployment programme in Scotland.
16/06/16	World Hydrogen Energy Conference	Zaragosa, Spain	Ben Madden	Presentation on development of fuel cell bus deployment projects.
30/06/16 – 03/07/16	Shell Eco-Marathon	London	Sabrine Skiker	
14/09/16 – 15/09/16	LCV 2016	Millbrook, Bedfordshire	Sabrine Skiker	Fuel cell bus for delegate transport planned.

## 9.5 Request for information from the UK's joint procurement exercise

# 100 Fuel Cell Bus Project

## Request for information

### The 100 Fuel Cell Bus Project

The project is being coordinated by Element Energy on behalf of a consortium of city representatives and private partners. The procurement exercises are joint exercises on behalf of the relevant authorities, led by Aberdeen City Council. The core city authorities which intend to deploy fuel cell vehicles, and their estimated requirements, are set out in the table below.

Aberdeen City Council	10 buses
Dundee City Council	10 buses
Birmingham City Council	22 buses
London	26 buses

A number of other local authorities and public sector organisations are also involved in the project and are exploring the feasibility of deployments in their areas. It is anticipated that the total volume of vehicles required under any resulting contract will be c.100 but this is purely an indicative figure at this stage.

### Purpose of the request for information

The partners in the 100 Fuel Cell Bus Project are conducting a supplier engagement exercise and would be grateful for your input by responding to this Request for Information (RFI) using the reply form at the end of this document. The project partners are requesting information to assist in understanding the current costs of purchasing and maintaining fuel cell buses, and the manufacturing maturity of the market to help to scope and structure the funding applications, the procurement exercise and the contract for delivery of the requirement.

### Background

Poor air quality in urban areas is becoming an increasingly pressing issue for cities across the UK. Internal combustion engine vehicles are a major source of local pollutants, and diesel engines are responsible for a significant proportion of harmful NOx emissions.

In this context representatives from many major cities across the UK have been working together to plan a coordinated project to deliver zero tailpipe emission hydrogen fuel cell buses into a number of urban fleets.

The UK's *100 Fuel Cell Bus Project* seeks to supply cities with a commercial and affordable offer for zero emission buses that provide the same range and operational flexibility as diesel buses, lead to improvements in local air quality, and offer a route to decarbonising public transport.

By working in collaboration and using joint procurement, the group of participating cities will acquire and deploy around 100 hydrogen fuel cell buses in daily operations on suitable routes. The project will involve a range of partners: city councils, technology providers (vehicles and refuelling infrastructure), and bus operators. By making use of local, national and international funding the buses will be offered to operators at the same cost as conventional vehicles on a total cost of ownership basis.

This project's concept is to procure a large number of fuel cell buses with identical base specifications, and some level of tailoring to provide vehicles that meet the needs of each city / operator. The project envisages fleets of ten or more fuel cell buses per operating location, and dedicated hydrogen refuelling facilities will also be installed to provide a reliable source of fuel for the vehicles.

Following a detailed local feasibility stage, the project is now in a funding acquisition phase. A robust funding strategy is in place and 2016 will see a series of applications made at a European and national level (all of which are believed to have a good chance of success).<sup>31</sup> The results of this request for information will inform the funding applications. During 2016 (and in parallel with the funding acquisition), the project partners intend to complete a procurement exercise and enter into a framework contract with a supplier, ready to place orders towards the end of 2016 / start of 2017. The aim of the framework is to allow partners access to the economics of scale which will arise from a large and coordinated procurement.

The successful tenderer for fuel cell buses will be expected to work with UK city representatives and bus operators during the delivery phase of the project from 2017.

### **Proposed requirement of Overall Project**

This proposed requirement is given as background to the overall project and is not the requirement of this RFI.

The project partners would like to enter into a framework agreement with a supplier whereby all of the city and operator partners in the project can place orders for fuel cell buses within a specified, pre-agreed time frame.

The successful tenderer will be a bus supplier able to supply and support the operation of fleets of hydrogen fuel cell buses in cities across the UK. The operational period will be a minimum of ten years for all buses deployed through the project.

A fundamental aim of this project is to procure fuel cell buses at a scale that allows significant cost reductions relative to previous deployments of similar technology. The project has been developed on the basis that the same base vehicle will be used in each location, with the opportunity for operators to specify options to tailor the non-powertrain elements to their individual needs. Details of the preferred technical specification for the vehicles are given in Question 1 of the reply form.

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<sup>31</sup> The Fuel Cells and Hydrogen Joint Undertaking's 2016 Call is one example of a potential source of funding for large-scale deployment of fuel cell buses. The Call requirements include, amongst other things, a maximum vehicle price to the customer of €650k (standard bus) / €1m (articulated bus).

The cost of the fuel cell bus (both capex and opex) will be a major determinant in the viability of the project as a whole and also the total number of buses which can be ordered. Potential suppliers who would be interested in taking part in a formal tender are encouraged to develop strategies to reduce costs, using the opportunity presented by this large order to unlock economies of scale and to bring the fuel cell bus closer to the point of commercial viability.

While the project is seeking to deploy around one hundred fuel cell buses in total across multiple UK cities, the exact number of vehicles that will be procured remains to be confirmed.<sup>32</sup> The procurement exercise is expected to lead to the acquisition of between zero and three hundred fuel cell buses, in batches of around ten, or twenty vehicles per city. The first wave of buses under the call off contract is expected to be around 70. Respondents are therefore requested to provide capital and maintenance cost estimates for the supply of differing total numbers of vehicles (see Questions 3 & 4).

The supplier will need to be prepared to work with bus operators with varying levels of experience in operating hydrogen fuel cell vehicles. Some proposed deployment locations (e.g. London and Aberdeen) have existing fleets of fuel cell buses, whilst others have no experience of operating these types of vehicles. The supplier must be prepared to offer tailored training and maintenance support packages that fit with the experience and requirements of each operator.

## **Objectives of RFI**

The project partnership is keen to understand the current state of the fuel cell bus market with respect to cost and manufacturing capability. We therefore request that you respond to the following questions using the reply form below. This will help us to further define our requirements should we wish to progress to a formal tender process.

Aberdeen City Council reserves the right not to progress a formal tender for this or any other requirement associated with the project.

Neither this RFI nor the supplier's response will constitute an offer capable of acceptance.

To clarify, in issuing this Request for Information (RFI) Aberdeen City Council are asking for estimations and not quotations. **Your decision to respond to this RFI or not will have absolutely no bearing on your ability to participate in and resultant tender exercise.**

Please send your response and any queries to [alix.butler@tfl.gov.uk](mailto:alix.butler@tfl.gov.uk)

Deadline for responses: **12 noon GMT, 13<sup>th</sup> June 2016.**

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<sup>32</sup> This uncertainty arises from a number of factors, principally technology costs (to be informed through request for information exercise) and the outcome of efforts to secure funding from local, national, and international sources.

## Request for Information (RFI) - Reply Form

### Question 1.

Please describe any vehicles that your organisation could offer that are capable of meeting the technical specification set out in the reply form. It would be helpful if you could indicate whether the vehicle meets the preferred specification set out in Table 1, by placing a cross next to the item your vehicle is able to meet.

The preferred technical specification, and following questions regarding the estimated price range for vehicles, is based on a c. 12 m single deck, two axle design, as this is preference of most of the customers for the buses in the UK. We would also be interested if your organisation is able to offer a double deck vehicle or an articulated vehicle as an option, such that the same framework would allow the partners to procure articulated and non-articulated vehicles. Furthermore, as the market for single deck buses in certain UK cities (e.g. London) is dominated by sub-11m vehicles, the consortium would like to understand whether (and under what conditions) this length of bus could be made available using a hydrogen fuel cell based powertrain.

Table 1 Preferred technical specification for the fuel cell buses

Item	Please enter an x if you are able to meet this specification
Right hand drive low entry single-decker vehicles	
Capable of high frequency, long running, fully passenger laden PSV operational schedules, and undertaken in adverse traffic conditions	
c. 12m, single deck, two axle design	
One passenger door set	
Able to accept hydrogen dispensed into the buses as a compressed gas at 350 bar	
Geometry of the refuelling nozzle – receptacle interface will be consistent with SAE J2600	
Vehicles should be capable of receiving a hydrogen flow of at least 6 kg H <sub>2</sub> /minute and capable of being fuelled from empty in 7 minutes or less. Please provide a description of the refuelling protocol under which this can be achieved.	
Minimum passenger capacity of 38 seated and 24 standing.	

Average fuel consumption must not exceed 9kg/100km during the SORT (Standardised on-road test cycles) 1, heavy urban cycle test. Fuel consumption of the buses will be an important consideration in the eventual selection of tenderers.	
Range of greater than 400 km	
Capable of speeds of at least 80km/hour	
Acceleration from a standing start: 25m in 8 seconds; 50m in 11.5 seconds; 100m in 18.5 seconds and 200m in 31 seconds.	
Gradeability of at least 11% fully laden.	
<p>Availability, defined as:  <math>Availability (\%) = ((P-M)/P) \times 100</math></p> <p>Where:  P = total number "peaks" – points in time which are 15 minutes before the start of each half day period - in the relevant month; and  M = number of peaks in the relevant month when the vehicle was not available for service.  must be greater than 90% for each vehicle, for all of the maintenance regimes which are identified.</p>	
Capable of operating in a range of climatic conditions – ambient temperature range from +40°C to -20°C.	
Bus must be capable of maintaining temperature of 18°C in the saloon in winter conditions. Respondents should specify the performance of their heating system	
The fuel cell buses will be capable of being kept outdoors and out of operation for extended periods, in all climatic conditions (ambient temperature -20°C to +40°C) subject to overnight heating of the fuel cell.	
<p>Bus noise:  Exterior – 75 dB(A) in accordance with EG 70/157 (legal drive-by-test) at 40 km/h on ISO asphalt.  Interior – 70 dB(A) with all auxiliaries not in operation measured at 40 km/h on ISO asphalt.</p>	
All health and safety risks associated with the supply and operation of fuel cell buses have been identified and mitigated in accordance with the FMEA requirements (Failure Mode and Effect Analysis).	
<p>Start-up and standby modes:  Fuel cell should automatically go in stand-by mode, to reduce hydrogen consumption.  Fuel cell buses should have a driver operated engine shut down and start-up.  The system start-up should not take more than 1 minute, depending on drive mode (battery, fuel cell or both) and due to obligated system tests to be done before every system start-up.</p>	
Exhaust (water vapour) delivered at the rear left hand side of the buses.	

<p>The fuel cell buses will need to either be fully certified for public service operation in the UK at the point of delivery or, if certification is not available, appropriate dispensations to allow vehicle operation should be obtained from the UK Department for Transport during the project. Will your vehicle be capable of meeting the appropriate criteria?</p>	
<p>The vehicle will need to comply with, and have the appropriate certifications for the following:          Public Service Vehicle Accessibility Regulations 2000.          All other legal UK Public Service Vehicle documentation at the time of fuel cell bus certification or appropriate dispensations.          All relevant safety standards for the storage and use of hydrogen on vehicles in the UK applicable at the time of delivery of the fuel cell buses.          Electromagnetic Compatibility (EMC) type approval to the requirements of the United Nations Economic Commission for Europe (UNECE) Regulation no 10.</p>	
<p>The supplier will be able to provide full training for the drivers and support personnel for the fuel cell buses.</p>	
<p>The option to have the above but as a left hand drive vehicle</p>	

Question 2.

In terms of add-on systems, bus operators will wish to tailor the buses so they are compatible with the rest of their fleet. Table 2 below sets out the potential options that the bus operators may wish to select for their buses. In order for the project team to establish what options would be realistic for the market place to accommodate responders should state which of these options they can accommodate, alongside any other options not identified here.

Table 2 Aspects that individual operators may wish to tailor

Item	Please enter an x if your organisation would be able to allow individual operators to tailor these items
Number of door sets – either one or two door sets may be required	
Flexibility to have fewer tanks for hydrogen for those cities who require a range of less than 400 km	
Folding seats	
Broadband back-up alarm	
Panic button	
Hidden starter switch arrangement	
Electric sliding ramp	
Metallic outside paint colour	
Second outside paint colour	
Livery	
Grabhandle cover	
Tarabus flooring	
Driver's air conditioning	
Saloon air conditioning	
Ticketing machine	
Cash Vault	
Destination signs	
Interior signs	
CCTV system	
Green Road equipment	
WiFi	
Voice alarm system	
Reversing sensors	
Induction hearing loop	
Operating system	
Seat type	

Driver's seat type	
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Please provide any other relevant technical information in the table below. A few questions are included.

Item	Please enter an x if your organisation is able to provide this option, or enter details as appropriate
Please describe the turning circle for the length of vehicles you are able to offer.	
Please give an estimated range of prices for requesting two passenger door sets.	
Please state whether the vehicle is a fully hydrogen powered vehicle or a plug-in hybrid fuel cell vehicle.	
Please specify the minimum standard of hydrogen purity the vehicle can accept – the project would be pleased to see vehicles which can accept a low specification as this reduces fuel costs.	
Please state the operational design life of the major components of the buses.	
Please state whether overnight heating of the fuel cell would be a requirement to ensure that the fuel cell buses are capable of being kept outdoors and out of operation for extended periods, in all climatic conditions (ambient temperature -20°C to +40°C).	
Is your organisation able to offer a double deck bus as an option under the framework?	
Is your organisation able to offer an articulated vehicle under the framework?	
Is your organisation able to offer any other lengths of vehicle? If so please specify.	
Please give any other relevant technical information here, or appended to the reply form.	

Question 3.

Please provide an indication of the likely price per bus by placing an “x” in the appropriate cell in the table below. The price range indicated should be for providing a bus which meets or exceeds the technical specification for a base bus set out in Table 1 as part of question 1. It should not include the price for supplying a bus with all of the potential options the operators may wish to add set out in Table 3 as part of Question 3 above. The price range should be for the potential quantities set out below:

Price per bus in euros		€500,000 or less	€500,001 – 550,000	€550,001 – 600,000	€600,001 – 650,000	€650,001 – 700,000	€700,001 – 750,000	€750,001 – 800,000	€800,001 – 850,000
Total number of buses to be procured through the contract	0–50								
	50–75								
	75–100								
	100–125								
	125–150								
	150–200								

If the estimate is for a vehicle which differs materially from the technical specification set out in Table 1, please attach a technical specification for the vehicle highlighting the differences. Please also indicate the time range over which you expect these price estimates to remain relevant.

Question 4.

Please provide a high level estimated cost range for maintaining the buses. This estimate should be an average cost range to cover all of the cities mentioned on page 2 above, taking into account their geographical spread. We expect these estimates to vary by the service level required, and by the number of buses operating at a particular location. We currently foresee two different levels of service being required, depending on the experience of the city with the technology. The two different service levels are described below. We therefore ask for your price estimates depending on the number of buses and the service level, as set out in the tables below.

Service level 1 – Operator has experience of running fuel cell buses

Bus owner and operator already has experience of operating and maintaining fuel cell buses. Bus operator has personnel in place who are trained and experienced in maintaining fuel cell buses. Bus operator will be responsible for maintaining the conventional parts of the buses and the bus supplier will be required to provide:

Training on the specific vehicle for the maintenance personnel

Spare parts for the buses, including for all preventative and corrective maintenance within 24 hours of request.

An expert technician to resolve any issues keeping the vehicles off the road, at the location in person within 48 hours of request.

All special tools for maintenance of the buses

Service technical assistance, including a 24/7 English speaking helpline

Access to engineering and after sales technical staff for any technical service issues which require factory assistance

Annual inspection of the hydrogen fuel cell and storage system

#### Service level 2 – Operator has no experience of running fuel cell buses

Bus operator and owner have no experience of operating and maintaining fuel cell buses. Bus operator does not have personnel who are trained and experienced in maintaining fuel cell buses. Bus operator will be responsible for maintaining the conventional parts of the buses and the bus supplier will be required to provide:

All of the requirements of service level 1, plus

A full-time on-site assigned and trained mechanic working on behalf of the bus supplier, available during working hours and on 24 hour call out for emergency issues.

Cost estimates for all service levels should exclude the following items, which will be carried out by the bus operators:

- Weekly vehicle inspections
- Regulatory brake test
- Daily checks (fuel, water, air, lights, brakes, tyres, heating, battery tension etc.)
- Bus fuelling
- Legal and safety inspections including recertification of the hydrogen tanks
- Towing
- Installation and removals of decals, adds etc.
- Internal and external cleaning
- Tyres, windscreen wipers, fuses, 24V batteries
- Removal and (re)fill of water, including de-ion water, and all other coolants
- Removal and (re)fill of grease, oil and other lubricants
- Repairs due to accident, vandalism, elements of nature
- Daily parking and 24V plug-in connection
- On-board equipment supplied by the operator
- All equipment specific to the operator and which is not part of the base technical specification

- Replacement of windscreens, glass in windows and mirrors
- Repairs and replacements following defects and incidents not covered under warranty
- Diagnose time
- Test drives after repair or replacement

Please provide your price estimate range in the tables below, in €/km, assuming the bus mileage is 90,000 km/year:

Price range in €/km for maintaining a fleet of 10 FC buses												
	<€0.3 0	€0.31 -	€0.36 -	€0.41 -	€0.46 -	€0.51 -	€0.56 -	€0.61 -	€0.66 -	€0.71 -	€0.76 -	>€0.8 0
	€0.35	€0.40	€0.45	€0.50	€0.55	€0.60	€0.65	€0.70	€0.75	€0.80		
Service level 1												
Service level 2												

Price range in €/km for maintaining a fleet of 20 FC buses												
	<€0.3 0	€0.31 -	€0.36 -	€0.41 -	€0.46 -	€0.51 -	€0.56 -	€0.61 -	€0.66 -	€0.71 -	€0.76 -	>€0.8 0
	€0.35	€0.40	€0.45	€0.50	€0.55	€0.60	€0.65	€0.70	€0.75	€0.80		
Service level 1												
Service level 2												

Question 5.

Please provide details of the standard guarantees/warrantees that would be included in the price estimates for the FC buses. What would the standard warranty period for the fuel cell system be? What would the standard warranty for other components of the vehicle be?

Question 6.

Please set out the lead time for the manufacture and delivery of a fuel cell bus under an order of this sort i.e. the time between signature of a contract and the delivery of a first bus, together with an indicative delivery schedule for subsequent buses on an order of (say) 20 buses. What would a realistic capacity for orders be over a calendar year period?

General information

Name of organisation	
Name of contact person	
Email address	
Direct telephone number	
Is this commission something you would be interested in undertaking should an invitation to tender be issued?	

Organisations are welcome to include any other relevant information.