JIVE
Best Practice and Commercialisation Report 1

D3.23

Authors:
Klaus Stolzenburg (PLANET)
Nicole and Simon Whitehouse (thinkstep)

Dissemination level: Public
16 August 2019

ZERO EMISSION

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Acknowledgments:
The JIVE and JIVE 2 projects have received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735582 and 779563. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

The authors would like to thank the JIVE and JIVE 2 partners for their input and for the fruitful discussions on which this report is based. Thanks also go to the colleagues from thinkstep Australasia for their support with developing and administering the online questionnaires.

Disclaimer:
Despite the care that was taken while preparing this document, the following disclaimer applies: The information in this document is provided as is and no guarantee or warranty is given that the information is fit for any particular purpose. The user hereof employs the information at his/her sole risk and liability.

Contacts:
Klaus Stolzenburg: k.stolzenburg@planet-energie.de (JIVE)
Nicole Whitehouse: nicole.whitehouse@thinkstep.com (JIVE 2)
Simon Whitehouse: simon.whitehouse@thinkstep.com (JIVE 2)

Approvals	
Work Package Leader	✓
Coordinator	✓
FCH 2 JU	

0 Executive Summary

The monitoring and analysis activities of JIVE project include capturing experiences, lessons learnt and best practice on the path to the commercialisation of Fuel Cell Buses (FCBs). Apart from an internal dimension of this work, results need to be forwarded to external stakeholders. They include decision makers from municipalities and regions, Public Transport Operators (PTOs) and Public Transport Authorities (PTAs) who consider adopting the technology. These, and actors such as policy makers, mainly require high level and strategic information. There are also the "hands-on" people who have to run a project once a decision for FCBs has been made and who need practical details. Detailed information (including expectations of client cities) can also be important for technology suppliers.

To progressively document what works, a series of Best Practice and Commercialisation Reports has been scheduled, reflecting the progress of the projects. This document is the first of these. Its contents are based on the first two rounds of questionnaires and feedback in spring 2018 and winter 2018/19.

While formally this is a JIVE report, it contains information from both JIVE 2 and JIVE, to cover the full range of experiences up to the beginning of 2019, i.e. after about two years into JIVE and one year into JIVE 2. The second of these reports will be a joint JIVE 2 and JIVE submission, to be completed by the end 2019. Generally, there has been a considerable degree of consensus in the responses from JIVE when compared with JIVE 2 partners. This increases the reliability of the information, albeit a small cohort overall.

In line with the progress achieved at most sites by February 2019, this report concentrates on Project Conceptualisation, Financing and Planning, and Procurement:

- Chapter 2 deals with Project Conceptualisation, including aspects such as reasons for participating and expectations of overall project outcomes, using findings from Round 1.
- Chapter 3 is concerned with sourcing Financing and with Planning for Hydrogen Refuelling Stations and for FCBs.

- Chapter 4 reports on Procurement. It also includes topics discussed in project meetings based on the evaluation of questionnaire feedback.

Both chapters 3 and 4 summarise what has been challenging in the local activities, what solutions could look like and recommendations. They also list some resources which have been most useful to the sites. These chapters are mainly based on findings from Round 2.

The report closes with a set of conclusions in Chapter 5.

From the findings concerning project conceptualisation, it can be concluded that in essence, hydrogen as a fuel and FCBs are not exceptional in terms of project management. Their introduction poses challenges very similar to other innovative projects. It is people who make hydrogen happen, so a project deploying FCBs requires knowledgeable and experienced staff, a good project team in place, working effectively to develop the project as well as committed organisational decision makers and elected officials.

Overall, neither Financing nor Planning nor Procurement have been easy activities. There has been no site that enjoyed a trouble free experience, including those that had participated in a previous FCB project.

It can be said that at this stage there appears to be no single “right” or “best” way to successfully plan and implement a FCB project. The context (local, regional and national) plays a very significant role in determining strategy and guiding planning.

It is also important to note that in the face of significant challenges, there has still been significant progress and successes. Many innovative approaches have also been seen.

It is clear that many of the information sources that are available are either not easily or conveniently accessible, perhaps due to language or geographic issues, or partners are preferring to attempt to find their own solutions rather than those that have been used previously. The important role played by suppliers in educating new adopters needs to be recognised, as does the role of cities with previous experience with FCB activities. Making these two sources more accessible will be an issue to be considered in the near future.

Table of Contents

Index of Figures

Index of Tables

List of Abbreviations and Terms

CAPEX	CAPital EXpenditure
CHIC	Clean Hydrogen in European Cities, project co-funded by the FCH JU under the 7th Framework Programme
EU	European Union
FCB	Fuel Cell Bus
FCH JU	Fuel Cells and Hydrogen Joint Undertaking, first phase of the FCH JU under the EU 6th and 7th Framework Programme; abbreviation also commonly used for the FCH 2 JU
FCH 2 JU	Fuel Cells and Hydrogen 2 Joint Undertaking, second phase of the FCH JU under the EU Horizon 2020 Framework Programme
H_2	Hydrogen
HRS	Hydrogen Refuelling Station
HyTransit	European Hydrogen Transit Buses in Scotland, project co-funded by the FCH JU under the 7th Framework Programme
OPEX	OPerational EXpenditure
PTA	Public Transport Authority
PTO	Public Transport Operator
TCO	Total Cost of Ownership

1 Introduction

1.1 Objectives of the JIVE project

The main objectives of the JIVE project are:

- Deployment of 139 zero emission Fuel Cell Buses (FCBs) in 4 EU member states at unprecedented scale (Germany and UK: 3 regions/cities each; Denmark and Italy: 1 city each)
- Advance the commercialisation of FCBs through large-scale deployment of vehicles and achieve commercial viability for bus operators by the end of project (early 2020s) to minimize/ eliminate need for subsidies
- Collaboration of multiple cities and regions in joint procurement processes in 3 regional clusters, allowing large orders to be placed with single bus suppliers. Common specifications for the buses are used to unlock economies of scale.
- Empower local and national governments to regulate for zero emission propulsion for public transport systems

JIVE runs in parallel with the JIVE 2 and MEHRLIN projects and in close cooperation. JIVE 2 deals with the demonstration of further FCBs, resulting in the joint deployment of close to 300 vehicles, while most of the Hydrogen Refuelling Stations (HRSs) for the JIVE sites are implemented and operated under MEHRLIN. JIVE 2 started one year after JIVE and MEHRLIN.

1.2 Context and objective of this document

The monitoring and analysis activities of JIVE and JIVE 2 include capturing experiences, lessons learnt and best practice on the path to the commercialisation of FCBs.

To this end, the local demonstration cities and regions are regularly requested to provide, via questionnaires, input on their project successes, challenges encountered and solutions found. This feedback from the sites is compiled and presented and discussed in the regular consortium meetings. This contributes to rapidly transferring local experiences to other project partners and to identifying common ground as well

differences with respect to financing and planning, procurement and deployment, and operations. That is the internal dimension of the activities relating to best practice.

In parallel, experiences, lessons and best practice need to be forwarded to external stakeholders. They include decision makers from municipalities and regions, Public Transport Operators (PTOs) and Public Transport Authorities (PTAs) who consider adopting the technology. These, and actors such as policy makers, mainly require high level and strategic information. There are also the “hands-on” people who have to run a project once a decision for FCBs has been made and who need practical details. Detailed information (including expectations of client cities) can also be important for technology suppliers.

To progressively document what works, a series of Best Practice and Commercialisation Reports has been scheduled, reflecting the progress of the projects. This document is the first of these. Its contents are based on the first two rounds of questionnaire and feedback in spring 2018 and winter 2018/19.

While formally this is a JIVE report, it contains information from both JIVE 2 and JIVE, to cover the full range of experiences up to the beginning of 2019, i.e. after about two years into JIVE and one year into JIVE 2. The second of these reports will be a joint JIVE 2 and JIVE submission, to be completed by the end 2019.

1.3 Scope and structure

Project stages can be described as in Figure 1-1.

Round 1 of sending out questionnaires and obtaining feedback from the Local Coordinators took place in spring 2018, as mentioned. There were 22 responses from 19 sites, as at three of the sites two people responded. At that time, nine of these sites were still dealing with Financing and Planning, while eight were engaged in Procurement, and Deployment had started at one site.

In Round 2 in February 2019, there were 18 responses from 17 sites. All of these sites had started working on Procurement. Most of them were selecting suppliers or developing contracts with them. Deployment was ongoing at one site.

In line with the progress achieved at most sites by February 2019, this report concentrates on Project Conceptualisation, Financing and Planning, and Procurement.

- **Project Conceptualisation**
- **Financing and Planning**
  - Sourcing financing
  - Project planning
- **Procurement of HRS and FC Buses**
  - Development of tender documents
  - Selecting suppliers
  - Development of contracts with successful suppliers
- **Deployment and Operations**
  - Building phase
  - Commissioning/Initial operations
  - Regular operational phase
- **Steps to full Commercialisation**

Figure 1-1 Project stages.
This report concentrates on Project Conceptualisation, Financing and Planning, and Procurement, in line with the progress achieved at most sites by February 2019.

Chapter 2 deals with Project Conceptualisation, including aspects such as reasons for participating and expectations of overall project outcomes, using findings from Round 1.

Chapter 3 is concerned with sourcing Financing and with Planning for HRSs and for the FCBs.

Chapter 4 reports on Procurement. It also includes topics discussed in project meetings based on the evaluation of questionnaire feedback.

Both chapters 3 and 4 summarise what has been challenging in the local activities, what solutions could look like and recommendations. They also list some resources which have been most useful to the sites. These chapters are mainly based on findings from Round 2.

Chapter 5 provides a set of conclusions.

2 Project Conceptualisation and Overall Aspects

2.1 Reasons for participating

The Local Coordinators were asked for the major reasons for their local project being proposed and becoming part of JIVE/JIVE 2. They could choose from six options and select up to three. Table 2-1 presents the findings. Boxes highlighted green represent options that were selected by more than half of the respondents per project.

Table 2-1 indicates that external funding seems to have a lower priority among JIVE 2 cities when deciding upon the local projects. This reduced reliance could be due to increasing external policy pressure to reduce emissions and carbon footprint. It ties in with a more frequent choice of "City committed to combatting climate change".

Table 2-1: Reasons for the local projects being proposed.
Six categories, up to three could be selected; typically two or three were ticked.
Boxes highlighted green: Option selected by more than half of the respondents.
Ordered by the number of ticks by local coordinators from JIVE.
Based on 8 responses from JIVE sites and 14 from JIVE 2 sites.

	JIVE	JIVE 2
City wants cleaner air	**5**	**8**
Funds available from sources outside city	**5**	**6**
Looking for alternative public transport fuel options	**4**	**11**
Part of local environmental programme	**4**	**6**
City committed to combatting climate change	**3**	**8**
Bus manufacturer made an offer	**0**	**1**

The Local Coordinators were also given the opportunity to name other reasons and objectives than those suggested, as in Table 2-1. Also here, the entries increasingly seem to be put into a broader context. JIVE 2 sites mainly mentioned items such as "Part of regional hydrogen strategy" as additional objectives, which are not primarily PTO/PTA related. Entries include:

- Desire to be in the forefront in Innovation generally, and in public transport in particular
- PTO/PTA wants to showcase emission-free transport
- Regional policy on zero emission public transport:
  From 2025 only emission-free buses to be ordered
- Part of regional hydrogen strategy
- Part of an industry strategy
- Trial a hydrogen system in a specific industrial setting
- To use hydrogen for storage of wind energy
- Part of overall transition to renewable energy in the region

2.2 Expectations of overall project outcomes

The Local Coordinators were asked for the expected major outcomes of the project. They could choose from six categories and select one or more. Table 2-2 presents the findings.

Table 2-2: Expected major outcomes of the project
Six categories, one or more options could be selected. Boxes highlighted green: Option selected by more than half of the respondents. Ordered by the number of ticks in JIVE. Based on 8 responses from JIVE sites and 14 from JIVE 2 sites.

	JIVE	JIVE 2
Clear idea of future public transport bus technology	**7**	**6**
Refuelling technology highly reliable and maintenance free	**6**	**8**
Bus technology highly reliable and maintenance free	**5**	**7**
Commit to a future FCB technology in short term	**4**	**4**
FCB technology likely to be too high cost to be sustainable	**1**	**1**
Likely continuance of purchasing fossil fuel technology into the future	**0**	**0**

Again, the boxes highlighted green in Table 2-2 represent options that were selected by more than half of the respondents per project.

- Compared with the previous table, the results are rather similar across the projects, in particular with respect to the Top 3.
- Achieving an acceptable (low) level of cost in the future does not seem a prime concern for most respondents, meaning that there is confidence that this is feasible.
- While fossil fuel technology is not considered to have a future, less than half the respondents seem to expect a commitment to FCB technology at scale in the short-term.

Expectations were also collected with respect to quantitative targets, such as the expected availability of the FCBs and HRSs, and the time required to refuel a bus. In summary, these expectations are high. They sometimes exceed the targets defined in the project proposals. Details can be found in Annex A.

These initial expectations will be compared with what is experienced at mid-term and towards the end of the projects.

In the predecessor project CHIC (2010 – 2016) expectations were also high. When, towards the middle of the demonstration phase, buses or stations did not always perform as anticipated at some sites, this led to disappointment and put local players under pressure from their superiors, funders or the public. It also led to problems between clients and suppliers.

2.3 Solutions and recommendations

The Local Coordinators were asked, notwithstanding problems encountered, why their project had proceeded acceptably or even well and what had been done do to make this happen. The responses are summarised in Figure 2-1.

From this Figure, it can be concluded that:

In essence, hydrogen is a new fuel but it is not exceptional in terms of project management. Its introduction poses challenges very similar to other innovative projects.

People make hydrogen happen:

- **Knowledgeable, experienced staff**
- **Good project team in place**
- **Team working effectively to develop the project despite considerable challenges**
- **Committed organisational decision makers, committed elected officials**

Being organised is important:

- **Do your homework and use experience of previous similar projects**
- **Create a strong business case and be clear with outcomes**

Figure 2-1: Key reasons for activities going well.
The two headlines were chosen by the evaluation team. The points under these headlines are entries from the Local Coordinators.

As regards what could have been done to avoid problems, answers referring to overall project aspects include:

- Having more resources available: people and time
- Undertaking more site visits to ongoing trial projects across the EU and accessing the experiences of other projects
- Being aware that political/legal environment can adversely affect the project (e.g. need to understand national legal framework in relation to tendering; contracting, safety permitting etc.; risk of getting caught up in election cycles)

One of the Local Coordinators stressed the importance of periodically re-reading reports with experiences from previous projects. This approach gave them an ability to recognise important details and issues that had occurred in these earlier projects and that tied in with issues arising in their own. In effect, they started to get a better understanding of the extent of their knowledge gaps.

2.4 Feedback from the JIVE User Group

The findings from the first round of questionnaire feedback were also shared and discussed in the User Group of the JIVE and JIVE 2 projects, composed of PTOs/PTAs

interested in taking up FCB technology in the near future. In the discussion, it was confirmed that:

- Concise summaries of JIVE/JIVE 2 project reports in different languages would be helpful, to supply basic information to senior PTO/PTA staff in an easily comprehensible format
- Site visits would be very important for PTOs/PTAs deciding on FCB technology, sometimes simply to “see that hydrogen buses are not dangerous”
- Stakeholder workshops held in various languages would also be welcome to better get across information on experiences, challenges and solutions

Participants highlighted that visibility of FCBs and HRSs in operation is *very* important to convince their decision makers of the potential and feasibility of the technology. This is an important insight for the dissemination and communication.

3 Financing and Planning

This chapter addresses the sourcing of Financing and the Planning for HRSs on the one hand and for the FCBs on the other hand.

Overall, neither Financing nor Planning (nor Procurement, addressed in the following chapter) have been easy activities. There has been no site that enjoyed a trouble free experience, including those that had participated in a previous project.

However, there was also no typical site, or patterns that could be identified. Much seemed to depend on local or regional circumstances. There have not been notable differences between JIVE and JIVE 2.

The sites were asked to rate the ease of the different project stages on a scale from 1 (not challenging at all) to 5 (very challenging). Even though these ratings have a subjective element and, therefore, cannot easily be compared site-by-site, they do give a valuable indication as to how difficult the individual project stages were perceived.

3.1 Sourcing Financing

The most frequent choice concerning the ease of sourcing financing was 3 (chosen eight times). Entries ranged from 1 (chosen once) to 5 (chosen three times).

3.1.1 Challenges

Challenges reported can be clustered as follows:

- Level and complexity of cost
  - Uncertainties around pricing of FCBs, HRS and hydrogen fuel
  - Inexperience with costing capital expenditure (CAPEX) and calculating revenue in short term projects
  - Inexperience, complexities and uncertainties of costing operational expenditure (OPEX)
  - Weaving costings into routine fleet investment
  - Making sure that different sources of funding do not conflict

- Knowledge of funding sources and interaction with funders
  - Knowing of, and connecting sources
  - Convincing funders
  - Timeliness of information being available, and delivering to funders
- Lack of information
  - Not enough for confident service delivery
  - Lack of information on safety requirements
  - Lack of financial models
- Politics:
  - Uncertainty regarding changes in the political situation/agenda
  - (Potential) advancement of battery-electric alternatives makes project a hard political sell

3.1.2 Solutions and recommendations

The sites were asked what solutions they had identified, what they would do in a different way in a future project, and what they would recommend to other sites. Main entries were:

- Be clear which technology you are looking to compete with (diesel, diesel [hybrid] or battery electric) from the outset, so you can tailor your project and its scope and evaluation accordingly
- Research funding sources well and ensure their criteria (goals, timelines) align with your project /
  Read the terms and conditions of grant funding thoroughly and seek legal support to help understand requirements
- Connect with funders informally, or find good intermediaries or experts
- Know and connect with the political agenda /
  Ensure that low carbon vehicles are well established in local/regional/national policy
- Be thorough with Total Cost of Ownership (TCO) and “beyond project” costing

- Build a comprehensive budget from day one (including e.g. maintenance)
- Learn from other cities with relevant experience;
- Have a long-term vision that is broader and goes beyond the project - broad uses of hydrogen within the industrial and energy systems
- Try to separate funding sources onto separate sub-projects (such as source A for buses and source B for the HRS)

3.1.3 Useful resources

The Local Coordinators were asked what resources they found helpful with respect to Financing. Five options were proposed and they could select as many as the wanted. The 18 respondents chose as follows:

- Knowledge of European sources of money (18)
- Knowledge of National (including local / regional) sources of finance (16)
- Previous experience in preparing funding proposal (14)
- Working with another site to jointly seek finance (12)
- A local politician who was committed to the idea (4)

The option to mention further resources was not used by any of the respondents.

3.2 Project planning: Hydrogen Refuelling Stations

The most frequent choice concerning the ease of this stage was 4 (six times). Entries ranged from 2 (chosen twice) to 5 (four times).

Planning for HRSs was considered more challenging than Planning for the FCBs at most sites.

3.2.1 Challenges

Challenges reported can be clustered as follows:

- Calculating costs
  - Accuracy

- Developing a business plan which showed parity with diesel
- Optimising TCO

- Matters of risk
  - Difficulty in determining risk: Need to specify to know risk - need to know risk to specify
  - Determining risk sharing
- Determining size
  - Optimising the size of the HRS (not too big not too small)
  - Forecasting size of hydrogen storage required / Planning for fluctuations in usage in winter months but also not over-specifying size causing additional cost
  - Risk of “locked specifications” (no scale up available)
- Design and location of the HRS
  - Identifying the right location that meets the operator requirements/engaging with all stakeholders;
  - Siting determines its planning and operational constraints;
- Numbers and complexity of decisions
  - PTOs not used to this (e.g. locating; permitting/regulations) / Lack of experience with HRS
  - Setting HRS supply contract / Terms and conditions
  - Technical planning affected by changing national regulations

3.2.2 Solutions and recommendations

- Sell the Vision
  - Set HRS operation in the context of city or regional social/economic development or as part of an overall "carbon reduction" strategy
  - Know and sell broader opportunities for its use

- Engage early, often and widely
  - City administration, local authorities (including firefighters etc.), potential Industry partners; consider also (experienced) turnkey suppliers
  - Try to get technical concepts from more than one potential supplier in the pre-tender stage
- Hydrogen fuel supply
  - Make sure to understand the pros and cons of on-site or off-site production of the hydrogen. Be open minded to all hydrogen supply chain solutions and locations.
  - The market is very limited, therefore consider all hydrogen sources – an electrolyser is not always the most environmentally friendly source of hydrogen. Do a proper well-to-wheel emission calculation to evaluate benefits of every proposal.
- Make early decisions
  - Define "must haves" to guide decisions; decide on scale
  - Know permitting requirements
  - Develop strategies to address TCO
  - Determine location and design
- Ensure that vehicles and HRS delivery aligns
- Involve an expert who supports you with their experience and know-how
- Be aware that an HRS requires a considerable surface area of your depot

3.2.3 Useful resources

The Local Coordinators were again asked what resources they found helpful with respect to Planning for their HRS. They could select as many as options as they wanted. The 18 respondents chose as follows:

- Talking to HRS suppliers (17)
- Talking to sites with HRSs in operation (14)
- Talking to the JIVE/JIVE 2 project coordinator (13)

- Written resources:
  - Reports from NewBusFuel (13)
  - Reports from JIVE [option for JIVE 2 sites] (11)
  - Reports from other ongoing or completed projects (9)
  - Reports from CHIC (7)

Two respondents used the opportunity to mention additional resources. They mentioned knowledge from previous local power-to-gas project, and using external know-how.

The CHIC project is a predecessor project of JIVE and JIVE that demonstrated FCBs and HRSs between 2010 and 2016. Many of the vehicles and station from that project are still in operation today.

The goal of the NewBusFuel project (2015 – 2017) was resolving the knowledge gap for establishment of large scale hydrogen refuelling infrastructure.

A list of written resources can be found in Annex B.

3.3 Project planning: Fuel Cell Buses

The most frequent choices concerning the ease of this stage were 2 and 4 (six times each). Entries ranged from 2 to 5 (once); only thirteen entries in total.

3.3.1 Challenges

Challenges reported can be clustered as follows:

- Achieving PTO buy-in due to concerns about
  - Operational and maintenance costs, fuel consumption figures and drive power, safety, training requirements, timeliness
  - Specification detail in general
  - Hydrogen and fuel cell technology in general
- Modifying existing depots and routes
  - Possibly more space needed in the depot

- Possibly not all routes are suitable
- Different or additional maintenance issues

- Operation and maintenance
  - Determining routes
  - Ensuring the bus maintenance requirements are prepared adequately
  - Ensuring that the business model on which the standard bus contract is based can be maintained over the course of 10 to 15 years
  - Predicting availability of vehicles to ensure route service reliability is maintained. This could be a major issue when "zero emission only bus zones" come into effect and if there are reliability problems, the FCBs cannot be replaced with diesel buses.

3.3.2 Solutions and recommendations

- Get political support
  - Sell on basis of appeal to the political agenda (zero emission, environmental zones)
- Develop good partnerships
  - With the PTO (involve early and understand the impact of the new technology on them)
  - With potential FCB suppliers (use Request for Information)
  - With those who will work on the buses (e.g. drivers and maintenance people)
  - Make sure that all are committed to exploring a new technology
- Source existing information
  - Talk to experienced cities
  - Get as much understanding of the technology as possible
- Develop careful and inclusive costing: Calculate OPEX & TCO
- Ensure that
  - Technicians are well trained and that spare parts are available quickly

  - The manufacturer's supply chain is robust and the suppliers meet obligations on warranties and repairs
- Consider carrying out part of the maintenance in-house. This will help you understand the technology more rapidly
- Ensure consideration of scalability of solutions to enable options for the future

One important lesson is that the language used can be very important. For example referring to the buses as "fuel cell" or "fuel cell electric" rather than "hydrogen" can help to reduce public concerns over safety.

3.3.3 Useful resources

The Local Coordinators were again asked what resources they found helpful with respect to Planning for their FCBs. They could select as many as options as they wanted. The 18 respondents chose as follows:

- Talking to sites with FCBs in operation (15)
- Talking to FCB suppliers (14)
- Talking to the JIVE/JIVE 2 project coordinator (12)
- Written resources:
  - Reports from CHIC (11)
  - Reports from JIVE [option for JIVE 2 sites] (10)
  - Reports from other projects (7)

The overall pattern resembles that regarding Planning for HRSs. However, here the contact with sites that operate FCBs was more important than talking to suppliers. Since there was no project similar to NewBusFuel, the CHIC reports were of greater importance.

Two respondents used the opportunity to mention additional resources. One highlighted internal experience from an earlier FCB project. Another mentioned the value of close cooperation between PTA and PTO regarding route planning.

4 Procurement

A cluster coordination initiative was supported by the FCH 2 JU. This was designed to aggregate demand for FCBs and to develop approaches to Joint Procurement in five geographic clusters, to achieve in cost reductions via standardisation and economies of scale. These clusters comprise

- the Benelux countries,
- France and Southern Europe,
- the German speaking countries including Northern Italy,
- Northern and Eastern Europe, and
- the UK and Ireland.

As part of JIVE, the German speaking cluster and the UK/Ireland cluster each published a joint tender. The latter was successful and resulted in a framework agreement with two bus manufacturers. This framework can also be used by PTAs/PTOs from other countries to order their FCBs. The tender by the German speaking cluster was not successful and the JIVE partners from this cluster then tendered individually.

A reference for the cluster activities can be found in Annex B.

There was also some cooperation with respect to procuring HRSs but no joint tendering

4.1 Procurement: Hydrogen Refuelling Stations

4.1.1 Development of HRS tender documents

The most frequent choice concerning the ease of this stage was 4 (seven times). Entries ranged from 2 (four times) to 5 (once).

(Note that the number of entries concerning Procurement is smaller than regarding Financing and Planning because not all sites had started Procurement by the time of Round 2, as mentioned.)

Challenges reported repeatedly:

- Determining capacity and redundancy needed

- Specifying the HRS requirements so that the station meets vehicles' fuelling requirements
- Implementation of the HRS in a bus depot with limited space, and coordinating with other new technologies / Allowing for flexible solutions within the constraints of existing depot and supplier capability

Challenges reported once:

- Lack of HRS standardisation
- Synchronising bus and HRS delivery
- Developing the evaluation criteria to match the requirements
- Permitting requirements

4.1.2 Selecting HRS suppliers

The most frequent choice concerning the ease of this stage was 3 (five times). Entries ranged from 2 (three times) and 4 (four times).

Challenges reported repeatedly:

- Lack of feedback to calls for tender, sometimes only one supplier responding
- Poorly written tenders
- Technology offered not meeting expectations/specifications /
  Matching outcomes wanted with manufacturer capability
- Due to quite different concepts presented, deciding which supplier is best choice

Challenges reported once:

- Agreeing on a general contractor approach
- Negotiating the whole package to a commercially viable cost

4.1.3 Development of contracts with successful HRS suppliers

Entries ranged from 3 (five times) to 4 (three times).

Challenges reported repeatedly:

- Legal details / Ensuring that risks and responsibilities are correctly apportioned amongst the partners under the contract and that partners are fully aware of these

- Contract details, particularly price and delivery time

Challenges reported once:

- Complying with national and EU regulations (triangle of PTA – PTO – HRS supplier)

4.1.4 Solutions and recommendations regarding HRS procurement

Note that the entries come from different sites. Therefore they are not necessarily comparable, because circumstances vary from location to location.

- Gather a multi-skilled team and involve them early (legal / technical / finance - purchasing / energy / mobility) /
  Know-how with contracts and the technology is equally important
- Ensure that all stakeholders are engaged in aspects of evaluation and set up regular dialogue with them during the process
- Learn from the experience of others
- Get your technical specification to be output-based and get it signed off
- Use a “Request for information” and stay open to a range of options/solutions / Undertake soft market testing and pre-engagement to ensure that the suppliers fully understand your requirements before entering into the tender process
- Make sure that you choose the correct tendering procedure. The HRS market is relatively immature. So while you have large gas companies, smaller companies may also be able to provide the HRS. /
  Ensure that no micro and start-up entities are excluded during supplier selection/ prequalification phase
- Visit and know your site and its constraints as best you can – at least better than your suppliers
- “Consider whether to separate into two (HRS build and fuel supply contracts)” but also opposite view “Tender for complete system, i.e. buses with fuel supply and maintenance”

- Set up fuel supply contracts for as long a term as possible (such as 15 years) to help encourage new investors.
- "Be clear on outcomes required and have them confirmed by suppliers (revenue implications, warranties, maintenance), particularly where there are sub-contracted suppliers to the main supplier"
- Also opposite view, but not favoured by many: "Have very precise specifications, and be ready to adjust some expectations to the standards of the market"
- Include innovation in your evaluation criteria – technical and commercial (e.g. scalability) /
  Set targets for technical outputs such as fuel fill times but do not score or pay more for times that beat them
- Invite quotes for standard and variant bids (delivered hydrogen or on-site production) to see what can be offered
- Set a price cap / Set target prices for tender of fuel (combined fuel and maintenance)
- Evaluate on whole life cost basis

In addition to the questionnaire feedback, Procurement was (further) discussed in project meetings:

(1) The option of all-inclusive tenders versus separating activities was debated, i.e. tendering HRS and civil works separately.

Advantages of all-inclusive tenders include

- Reduced number of procurement exercises, and
- Potentially lower risk for the customer.

In some cases, bundling all aspects is necessary, for example where the procurement was for zero emission buses without specifying the technology type (and the choice of solution affects the civil engineering works needed). However, there are several drawbacks to this approach: HRS suppliers are not generally specialists in site preparation works and an all-inclusive tender may deter some from bidding, and

in many cases the local partners (i.e. PTA/PTO) would be better placed to procure a contractor for site preparation works (rather than the HRS provider having to do this). Having recently completed a procurement exercise for an HRS including site preparation works, one site generally recommend separating the civils works from the HRS where possible.

(2) There is a feeling at some sites that tendering for HRSs and for hydrogen supplies is “harder” than procuring FCBs, partly due to the range of potential technical solutions and partly due to the need for multi-way contracts (e.g. between HRS supplier and PTA / PTO / landlord etc.) that add significant complexity.

(3) Buyers should not expect HRS suppliers to understand or appreciate the constraints of operating a bus depot. Site visits with potential suppliers are crucial. For example, one sites hosted two site visits with each supplier before tender submissions were due, and at least one site visit was mandatory.

(4) It is possible to obtain a long-term (such as ten-year) contract for hydrogen supplies provided that the customer commits to a reasonably high level of demand and break clauses are included. Accordingly, some sites commit to paying for a daily minimum amount of hydrogen in order to assure the fuel supplier of a minimum turnover.

(5) It is important to keep some flexibility in the specifications.

(6) It was confirmed that the most appropriate method for procuring HRSs is likely to depend on the local context, including the structure of and level of resources available in the organisation tendering.

(7) Some sites will own their HRS equipment after a certain period (such as ten years). This prevents the supplier charging them much higher hydrogen prices after the contract period. From conversations, hydrogen fuel suppliers seem to have little problem with operating another supplier’s equipment.

4.1.5 Useful resources

In the questionnaire, the Local Coordinators were asked what resources they found helpful with respect to Procurement of their HRS. They could select as many as options as they wanted. The number of responses here is smaller than with respect to Fanning and Planning because not all sites had reached the Procurement stage yet.

- Talking to HRS suppliers (12)
- Access to sample tenders and supplier contracts (11)
- Talking to other JIVE/JIVE 2 sites (10)
- Talking to the JIVE/JIVE 2 project coordinator (10)
- Joint procurement activities with other sites from their regional cluster (2)
- Written resources:
  - NewBusFuel Reports (13)
  - JIVE Reports [option for JIVE 2 sites] (10)
  - Reports from other ongoing or completed projects (4)
  - Reports from CHIC (2)

4.2 Procurement: Fuel Cell Buses

4.2.1 Development of FCB tender documents

The most frequent choice concerning the ease of this stage was 4 (six times). Entries ranged from 1 (once) to 5 (twice). The “1” came from a PTA where the entire procurement process was devolved to PTOs as part of bidding, so the process was easy from the PTA’s perspective but not necessarily for the PTO.

Challenges reported repeatedly:

- Design and specification of tender document:
  - Lack of mutually recognised guidelines for FCB specifications (standardisation)
  - Details such as fuel consumption
- Specifying the buses so that they meet the requirements of all the partners involved in a joint procurement activity
- Project compliance requirements / Sticking to tender laws

4.2.2 Selecting FCB suppliers

The most frequent choices concerning the ease of this stage were 3, 4 and 5 (three times each). 1 and 2 were each chosen once. Regarding the "1" rating see "Development of FCB tender documents" above.

Challenges reported repeatedly:

- Manufacturers unresponsive to tender /
  Manufacturers not convinced of commercial viability of FCBs, particularly in comparison with battery buses
- Technology offered from manufacturers not meeting expectations/specifications (such as buses equipped with a combination of fuel cell and battery with insufficient power to cope with operation in a hilly environment)
- Unwillingness of manufacturers to supply relatively small numbers of buses (e.g. when the demonstration site is far from their nearest service hub)

Challenge reported once:

- Help required to evaluate responses

4.2.3 Development of contracts with successful FCB suppliers

The most frequent choices concerning the ease of this stage were 3 and 4 (three time each). 2 was chosen once.

Challenges reported repeatedly:

- Lack experience in procuring FCBs: Technical and legal details
- Lack of competition leading to weak negotiating position (price, delivery time, ...) / Suppliers site can dictate the negotiations/conditions

Challenges reported once:

- Agreeing and defining roles and responsibilities in terms of risk
- Joint Procurement:
  - Multiple stages of review required prior to suppliers accepting the framework contract and arrangements for subsequent procurement of varying numbers of buses

- Agreeing and defining roles and responsibilities in terms of risk
- The contract needed to be bespoke and allow for a multitude of variations on the service offering which increases risk to the supplier.

4.2.4 Solutions and recommendations regarding FCB procurement

Again, note that the entries come from different sites. Therefore, are not necessarily comparable.

- Do a market consultation/review
  - Determine which manufacturers are willing and able to deliver
  - Talk to other cities with experience of FCB procurement
- Negotiation and communication with suppliers were critical throughout the tender process. Due to lack of experience in this area, reliant on the suppliers to validate assumptions and provide input into the most efficient way to procure, particularly regarding the supporting services.
- PTA perspective: Put responsibility into the hands of the PTO to undertake the purchase through normal purchasing arrangements (greater leverage and understanding of their own operating requirements)
- Absolute clarity between all parties on outcomes wanted and compliance with tender/contract details especially where there are sub-contractors involved
- Joint procurement:
  - More willingness to compromise on a standard bus by the PTOs /
    Precise definition of a standard fuel cell bus as a basis for discussions with suppliers, central project coordinator for the procurement phase
  - Developing a framework that is scalable and allows for all interested cities to use was critical as it provided manufacturers with a level of security over the volume of buses to be procured despite the non-committal nature of a framework
  - Joint procurements and contract frameworks are the best approach as they specify the contract conditions before tendering. Once these are in place, the contracts are relatively simple to put in place.

- Opposite view: The requirements by different PTOs are considered too heterogeneous for beneficial joint procurement and the effort is considered high.

Points (further) discussed in project meetings include:

(1) Suppliers seem to be offering different prices in different locations for similar sized orders. This could be because of factors related to the bus specifications, including liabilities, warranty and damages. It is clear that some manufacturers have been more able, and perhaps more willing, to lower prices in response to scale.

(2) While there has been a lot of focus on bus prices (capital cost), it was noted that maintenance costs form a high proportion of the total cost of ownership and must be considered carefully. Evidence from some of the existing procurement exercises suggests that maintenance costs can increase significantly after around the third year of operation, due to increasing replacement/refurbishment costs of some components.

(3) Bus tenders of under ten vehicles seem to struggle attracting interest from suppliers. If manufacturers have congested order books they will prioritise the higher volume orders.

4.2.5 Useful resources

In the questionnaire, the Local Coordinators were asked what resources they found helpful with respect to Procurement of their FCBs.

- Talking to suppliers (12)
- Talking to the JIVE/JIVE 2 project coordinator (10)
- Talking to other JIVE/JIVE 2 sites (5)
- Access to sample tenders and supplier contracts (4)
- Centralised national bus procurement (3)
- Joint procurement with other sites from their regional cluster (2)
- Written resources:
  - Reports from CHIC (10)

- Reports from JIVE [option for JIVE 2 sites] (9)
- Reports from other ongoing or completed projects (2)

One site in addition pointed out the help from a national office that supports the usage of hydrogen in their country.

5 Conclusions

In conclusion, it should be said that at this stage, there appears to be no single "right" or "best" way to successfully plan and implement a FCB project. The context (local, regional and national) plays a very significant role in determining strategy and guiding planning.

However, some shared, clear challenges have emerged. In no particular order these are:

- Support from the political / policy environment must be constantly attended to. It can be essential in ensuring the success in establishing the project but can also quickly obstruct and kill the project.
- The nature of innovative projects, such as this, is that they are inevitably lacking in time and resources. They are driven by project funding deadlines. Having enough access to expertise in the areas of finance, law (regulations & procurement) and technology is essential.
- It appears that industry is still not at a stage where multiple, commercially competitive suppliers are available to bid on projects such as JIVE/JIVE 2. Interestingly more difficulty seems to have been experienced in procuring HRSs than FCBs. While the latter field is still small, the technicalities surrounding procuring the buses seem to be easier.
- All partners repeatedly emphasise the importance of early, frequent and targeted communication with stakeholders at all stages of the project. This reiterates the critical importance of communications both within projects and at a broader level. It also raises a question, which will be further explored, as to why this continues to emerge in best practice discussions?
- A point recently emerging from bilateral discussions more than from questionnaire feedback is that a strategy of devolving responsibility for FCB and HRS acquisition to a PTO may be more likely to lead to difficulties and delays in the process, than a strategy where the PTA undertakes these actions. This may be a reflection that the current state of the market for and understanding of these technologies and projects is not sufficiently mature for a PTO to have access to good knowledge and skills in the area. It may also reflect that the focus of PTO activities is much

more dedicated to achieving good public transport services at minimal cost, rather than undertaking innovative, cutting edge projects. It is also fair to say that the PTA is much more likely to be closer to the political decision makers and therefore be more able to smooth the path of the project, both initially and if any obstacles arise.

It is important to note that in the face of these challenges, there has still been significant progress and successes. Many innovative approaches have also been seen. These include:

- Locating the FCB solution within a regional energy system, currently referred to as the "Hydrogen Valley" approach.
- All sites appeared to have taken on board the lesson from previous projects of the critical importance of developing maintenance and supply chain solutions as part of the project initiation.
- Recognising unlikely options and innovations to leverage advantages in hydrogen production.
- Focussing on outcomes rather than prescribing detailed specifications can even result in a widely technology-open approach. At one site, the PTA called for innovative solutions to provide a specific transport solution. Based on the offers received, the FCB was judged best solution against a range of criteria developed by the PTA.

It is clear that many of the information sources that are available are either not easily or conveniently accessible, perhaps due to language or geographic issues, or partners are preferring to attempt to find their own solutions rather those that have been used previously. The significant role played by suppliers in educating new adopters needs to be recognised, as does the role of cities with previous experience with FCB activities. Making these two sources more accessible will be an issue to be considered in the near future.

The questionnaire responses have highlighted the usefulness of exploring and understanding project development issues, especially solutions to challenges, that can be shared among project partners. The responses have been used to guide discus-

sion in project consortium meetings and to inform the authors of where more information should be targeted.

Annex A Quantitative Expectations

Expectations were collected on the following topics:

- Availability of HRS and FCBs,
- Cost of hydrogen and bus operating costs,
- Acceptable wait time for repairs,
- Time to fill a bus,
- Specific fuel consumption,
- Fuel cell stack lifetime, and
- The Technology Readiness Level (TRL) at the start and at the end of demonstration.

Methodology of evaluation

The responses the JIVE and JIVE 2 Local Coordinators were evaluated with respect to:

- the lowest and highest values
- the median, which is the centre of a dataset
  (the middle figure on a list sorted in ascending/descending order)
- the arithmetic mean (referred to as “mean” in the following)

When the mean and the median are similar or the same, the dataset is more or less evenly distributed from the lowest to highest values. The median helps eliminate the impact of outliers.

- Example 1: 1 – 2 – 3 – 4 – 5 – 6 – 7
  Median: 4
  Mean: 4
- Example 2: 1 – 2 – 3 – 4 – 5 – 6 – 100
  Median: 4
  Mean: 17.3

When the dataset analysed comprises an even number of figures, the median is the mean of the middle two figures of the sorted dataset.

- Example 3: 1 – 2 – 3 – 4 – 5 – 6
  Median: 3.5
  Mean: 3.5
- Example 4: 1 – 2 – 3 – 4 – 5 – 100
  Median: 3.5
  Mean: 19.2
- Example 5: 1 – 2 – 3 – 3 – 5 – 100
  Median: 3
  Mean: 19

Table A-1 shows the lowest figure, the median and the highest figure for each of the above categories, distinguishing between JIVE and JIVE 2.

Summary

- The expectations of the performance of both the HRSs and the FCBs are high. Even the median values in some cases exceed the targets defined in the projects' work programmes.
- In terms of medians, the results are typically similar across the two projects while there are marked outlier values when comparing the highest expectations.

1. Availability HRS

- The expectations range from 98% to 99.9% in JIVE and from 90% to 99.9% in JIVE 2.
- The medians are 99% for both projects. They are in line with the work programme targets, which in both projects are to reach 98% with aspiration to achieve more than 99% (downtime for scheduled preventive maintenance excluded).
- HRSs in the CHIC and HyTransit projects have proven that availabilities above 90% are feasible. However, making a HRS supplier guarantee 99.9% would certainly result in extra costs for a very high level of redundancy.

Table A-1: Quantitative Expectations.
* Another site is cautious and expects 75% "in the beginning"
TRL = Technology Readiness Level, see Table A-2.

	JIVE	JIVE 2
	lowest / median / highest	
1. Availability HRS [%]	98 / **99** / 99.9	90 / **99** / 99.9
2. Availability Buses [%] *	85 / **93** / 98	80 / **90** / 99.9
3. Cost of hydrogen [€/kg]	4 / **6** / 11	4 / **5** / 12
4. Bus operating costs relative to standard fleet [%]	100 / **142** / 300	75 / **150** / 400
5. Maximum wait time for Repairs HRS [hours]	4 / **18** / 24	0 / **6** / 120
6. Maximum wait time for Repairs FCBs [hours]	2 / **24** / 48	2 / **24** / 72
7. Specific fuel consumption [kg/100 km]	8 / **8.8** / 9	8 / **10** / 12
8. Time to fill [minutes]	5 / **10** / 10	5 / **10** / 15
9. Fuel cell stack lifetime [hours]	20,000 / **25,000** / 30,000	7,000 / **22,500** / 50,000
10. TRL of the HRS at the start of demonstration	7 / **8** / 9	7 / **8** / 9
11. TRL of the HRS at the end of demonstration	8 / **9** / 9	8 / **9** / 9
12. TRL of the FCBs at the start of demonstration	7 / **8** / 9	7 / **8** / 9
13. TRL of the FCBs at the end of demonstration	8 / **9** / 9	8 / **9** / 9

2. Availability FCBs

- The expectations range from 85% to 98% in JIVE and from 80% to 99.9% in JIVE 2.
- The medians are 93% and 90%, respectively. Again, these are in line with the targets, which in both projects are to reach more than 90% after an initial six-month ramp-up phase.
- None of the local fleets in CHIC reached 90% availability. The target in CHIC was 85% and it what met at one site only. Therefore, achieving the JIVE/JIVE 2 availability target for the FCBs seems to be more challenging than reaching the availability target for the FCBs.

- The highest expectations of 98% and 99.9% do not appear to be reasonable. No supplier would guarantee such a level of availability even for diesel buses.

3. Cost of hydrogen

- The JIVE and JIVE 2 targets are reaching less than 9.0 €/kg hydrogen dispensed (excluding taxes) at the end of the project(s). However, even the medians based on the expectations collected are significantly smaller.
- The median across the CHIC sites for OPEX alone was 17 €/kg (target: 10 €/kg), but these HRSs were highly underutilised. The best OPEX figure for the HRS in HyTransit was of 10.67 €/kg over one calendar year at a rate of utilisation of 51%.

4. Bus operating costs relative to standard fleet [%]

- The JIVE and JIVE 2 targets are to achieve a maximum of 200% of what is required to maintain an equivalent a diesel bus, aiming at 150% by the end of the project.
- The medians are in line with the project targets.

5. Maximum wait time for repairs of the HRS

- Achieving the median figures of 18 and 6 hours, respectively, will require very good support from the technology suppliers.
- There is no target defined in the projects' work programmes regarding wait time for repairs.
- Wait time for repairs was not analysed in previous projects, but certainly the above median values were not achieved then.

6. Maximum wait time for repairs of the FCBs

- Achieving the median figure of 24 hours will require good support from the technology suppliers.
- There is no target defined in the projects' work programmes regarding wait time for repairs.
- Wait time for repairs was not analysed in previous projects, but certainly the above median values were not always achieved then.

7. Specific fuel consumption

- The median figures of 8.8 and 10 kg/100 km are in line with the targets of less than 9 kg/100 km for standard solo buses of 12 to 13.5 metres length.
- The medians are also to be feasible given that 12 m FCBs in CHIC achieved less than 9 kg/100 km and 13.2 m FCBs with three axles 10.7 kg/100 km on average.

8. Time to fill

- The projects do not have targets with respect to time to fill but in terms of speed of dispensing. The intention to refuel faster than 3 kg/minute.
- Assuming a required range of 330 km/day and the above 9 kg/100 km specific fuel consumption, close to 30 kg hydrogen would have to be dispensed. At 3 kg/minute this would take 10 minutes and would be in line with expectations in terms of the medians.
- In previous projects, 2.8 kg/minute was the highest average speed achieved (across some 1,800 fills).

9. Fuel cell stack lifetime

- The JIVE and JIVE 2 target is operating hours per fuel cell system.
- The medians based on expectations are somewhat higher at 22,500 hours and 25,000 hours.
- A few of the stacks in CHIC buses have already surpassed 20,000 operating hours. The manufacturer of a recently presented fuel cell for heavy duty mobility applications states a stack lifetime > 30,000 hours.

10./11./12./13. TRL at the start/end of demonstration

- For both the HRSs and the FCBs, the expectations in terms of the medians (TRL 8) correspond to products beyond prototype status (which would be TRL 7) at the beginning of the project(s) and fully commercial equipment at the end (TRL 9).

Table A-2: Definitions of Technology Readiness Levels.
As used by the FCH JU in their Multi-Annual Work Plan 2014 - 2020.

TRL	Definition
9	Actual system proven in operational environment
8	System complete and qualified
7	System prototype demonstration in operational environment
6	Technology demonstrated in relevant environment
5	Technology validated in relevant environment
4	Technology validated in lab
3	Experimental proof of concept
2	Technology concept formulated
1	Basic principles observed

Annex B Written Resources

If you cannot get access to the below documents, please contact the authors of this reports as on page 2.

Regional Clusters / Joint Procurement

- Strategies for joint procurement of fuel cell buses. A study for the Fuel Cells and Hydrogen Joint Undertaking ISBN: 978-92-9246-325-0, DOI: 10.2843/459429, 2018.

at: https://www.fch.europa.eu/publications

NewsBusFuel

- Hydrogen Bus Refuelling – NewBusFuel Study – Summary Report, 2017
- Hydrogen Bus Refuelling – NewBusFuel Study – Guidance Documents, 2017
- Common Bus Operator Requirements for Future Tendering Processes, 2017
- Review of Regulations Codes and Standards Issues, 2017
- Agreed Definition of Availability for Bus Depot Fuelling Stations and Recommendations, 2016
- Strategies to Ensure Adequate Redundancy, 2017
- Business Cases to Support FC Bus Commercialisation, 2017

at: http://newbusfuel.eu/publications/

CHIC

- Final Publishable Summary Report, 2017
- Guidelines for Delivering Fuel Cell Bus Projects, 2016
- Recommendations for Hydrogen Infrastructure in Subsequent Projects, 2016
- Public Executive Summary of the Report on Hydrogen Infrastructure Operation and Performance, 2016
- Sustainability Assessment of FC Buses and Related Infrastructure, 2016.

- Issues of Concern to External Stakeholders and Critics and Pathways to their Resolution, Reflections on Change after 2 Years, 2015
- Analysis of Investments in Workshops for Fuel Cell Buses and Hydrogen Refuelling Stations, 2015
- Experiences with the Implementation of Infrastructures for Hydrogen Refuelling and Lessons for Future Installations, 2014
- Influencing Factors to the Acceptance Process of FCH Technologies in Public Transport , 2013
- Issues of Concern to External Stakeholders and Critics and Pathways to their Resolution, 2013Report Collecting the Experience from the Phase 0 and Phase 1 Cities with respect to Certification of the Buses and Hydrogen Refuelling Infrastructure

The former CHIC project website is no longer active. However, the reports listed above should soon be available at: https://www.fuelcellbuses.eu/projects/chic

CUTE and HyFleet:CUTE (FCB demonstration projects 2001 – 2009)

- Licensing Hydrogen Refuelling Stations – Experiences from a Multi-Site Project, 2011
- People, Transport and Hydrogen Fuel. Guidelines for Local Community Engagement when Implementing Hydrogen Powered Transport, 2008

NOW (National Organisation Hydrogen and Fuel Cell Technology in Germany)

- Approval Guidelines for Hydrogen Refuelling Stations

The website is currently under construction but should on-line again soon http://www.h2-genehmigung.de/ Index/Index?lang=1

ZERO EMISSION

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING