JIVE
Best Practice and Commercialisation Report 2

JIVE 2
Best Practice Information Bank Report 1

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ZERO EMISSION

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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Executive Summary

The Fuel Cell and Hydrogen 2 Joint Undertaking (FCH JU) has provided funding to the JIVE and JIVE 2 projects to support the deployment and commercialisation of Fuel Cell Buses (FCBs) across Europe. Both projects have similar objectives and are following similar project trajectories. They are also encountering similar challenges and solutions.

Capturing Challenges and Best Practice Solutions

The monitoring and analysis activities of the projects include capturing Challenges and Best Practice solutions. This document constitutes the second Best Practice Report under JIVE and the first under JIVE 2, and reports on the activities from both projects which have been brought together and are being run collaboratively. It documents, primarily for the benefit of new users of the technology, the learning that has occurred up to and including the procurement of the FCBs and Hydrogen Refuelling Stations (HRSs). It aims to be concise, presenting most of the information in tables, supported by introductory and explanatory text.

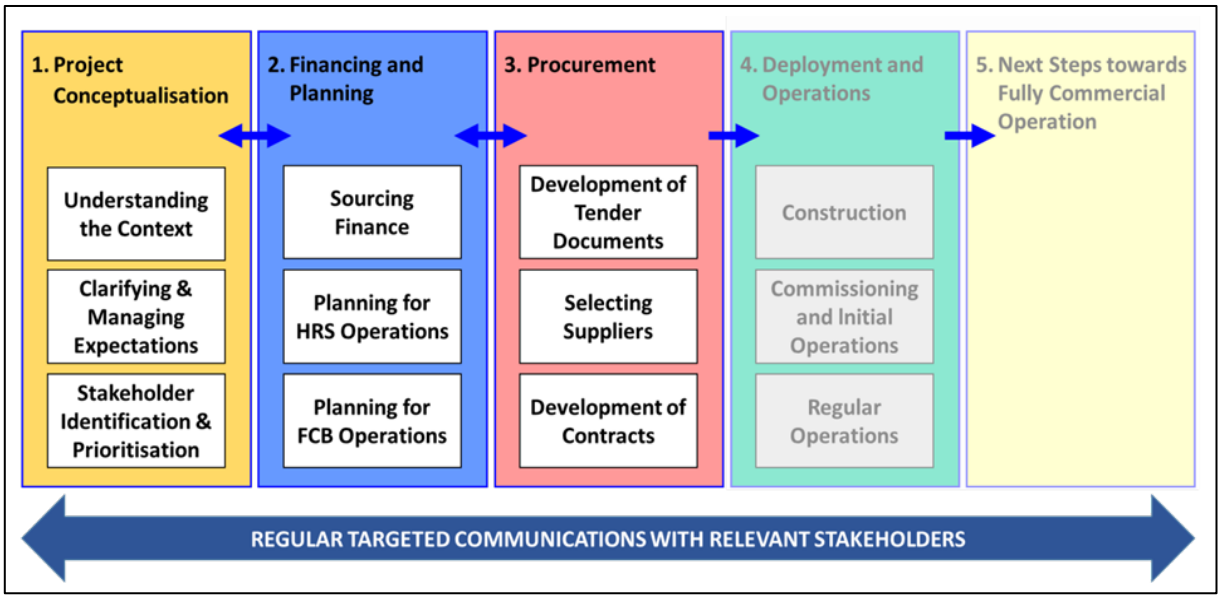
Information Gathering and Processing Method

The local coordinators of the demonstration cities and regions are regularly requested to provide input on their project progress, successes, challenges encountered and solutions found. This input has been supplemented by interviews with some of the local coordinators along with a number of site visits to gain additional on the ground insights, and other input from relevant sources.

The feedback from the sites is compiled, presented and discussed in the regular consortium meetings. In September 2019 a special workshop was held to sum up and validate the information that had been reported and findings derived, as well as gain any additional insights.

Project Stages

The project development and implementation process is being considered in 5 major stages as shown in the chart below. In step with the progress of the JIVE projects to date, this document focusses on key issues relating to the first three of these stages: Project Conceptualisation, Financing and Planning, and Procurement. Information is provided for each stage, plus references on further resources that have been of use for the JIVE/JIVE 2 sites or in earlier demonstration activities.



Stages and Sub-stages of a project to demonstrate FCBs and their hydrogen fuel infrastructure.

Stage 1 – Project Conceptualisation

Establishing the overall concept of a FCB project sets the scope and, in many ways, the basis for the overall success of the project. It can also facilitate a broader framework within which other applications of hydrogen and fuel cell technology can be developed and utilised.

Two key factors stand out in identifying those FCB projects which are more likely to both be, and be perceived to be, successful:

- Projects which have been established within a broad context provide the community, including industry, with an understanding of the role that hydrogen and fuel

cells can play in the clean energy, environmental and economic objectives of the community. Clean vehicles can be an effective pathway to achieving other goals.

- Establishing and communicating realistic project expectations is also key.

Identifying the key stakeholders and understanding their issues is vital. Not all stakeholders will have the same level of potential positive or negative impact on the project. Prioritisation can be done by mapping them on a matrix with respect to concern and impact/importance. A Communication Plan for engaging with the stakeholders in a targeted manner needs to be established and implemented early.

Committing time and resources to this foundational stage of the project is essential. Getting to understand the benefits and limitations of the technology, building a knowledgeable and committed project team, identifying and connecting with key stakeholders, and networking with other FCB project groups and individual experts are all part of laying a strong and enduring foundation for the project.

Stage 2 – Financing and Planning: Co-Funding to Cover the Additional Costs

Getting the money for the project and starting planning are the next tasks. It is highly likely that some source of grant funds will be needed to cover the additional costs of acquiring and operating FCBs and HRSs over and above the costs of buying and operating conventional diesel or natural gas buses. To encourage Public Transport Operators (PTOs) to embrace the new technology, it is still necessary to de-risk FCB acquisition from a commercial point of view.

No JIVE/JIVE 2 site, including those with experience from previous projects, has found this trouble free, with no obvious patterns that could lead to success or problems. Much seems to depend on specific knowledge of local, regional and national funding programmes, and local circumstances at the time, particularly political support. The existence of EU and national targets for emission reduction and clean vehicles have provided strong incentives. In addition, seed funding through various programmes (in particular the FCH JU) has been crucial.

To establish the additional costs currently due to operating FCBs requires precise estimates of all elements of the Total Cost of Ownership (TCO). This includes the investment and all operations-related direct and indirect cost elements, as well as 'beyond project' items arising after the co-funded phase up to the vehicles' end of life. Deciding on which bus type to use as the base case for comparison is important as well (e.g. diesel or battery electric).

While TCO calculations typically do not include the external impacts of operating conventional buses, such as health and environment, these costs are clearly increasingly relevant and significant. Estimating these externalities in the context of Life-Cycle Costing, that is the external costs avoided through operating zero emissions buses, can provide a useful argument when negotiating for additional funds or, in the future, cheaper loans from government for whom these external costs are a large budget item.

Stage 2 – Financing and Planning: Planning for Operations

The operational stage is the most important aspect of a FCB project. It will be the most public activity of the project and therefore most open to scrutiny. The key to achieving successful operation is comprehensive and meticulous planning.

General Best Practice solutions, applicable to both HRS and FCBs, include:

- Specifying for local needs, in line with the specific local/regional broader framework ('vision') that has been developed
- Visiting and talking to experienced sites and potential suppliers
- Engaging early, often and widely; planning for clear and consistent communication with the stakeholder groups identified and in line with their needs (including e.g. bus drivers, maintenance staff, entities providing funding, ...)
- Having clear and specific responsibilities, boundaries and accountabilities among the local project partnership
- Be open to reason as everyone is still learning

There is a large amount of written information and both formal and informal learning among experienced cities that can and should be accessed to assist with this planning – most of which is either included or referenced in this resource. These will provide excellent guidance and help avoid repeating previous mistakes. The other critical issue is to adequately resource this stage of the process – particularly in terms of personnel expertise and time set aside for the planning process. Plan to set up a broadly-based tender team.

Stage 3 – Procurement

The procurement of FCBs and HRSs is considered from the point of view of developing the tenders, selecting the suppliers and developing the contracts. While the general steps and processes are well known, the procurement of FCBs and HRSs introduces additional complexities which are likely to be new to the particular site and persons responsible for conducting this activity. It is important therefore that procurement is managed by the most appropriate people. PTOs are experienced bus procurers but may not be the best suited to manage the procurement of a HRS which is fundamentally different from a refueller for diesel.

The FCBs and the HRS must be compatible and be able to combine to ensure quick and reliable refuelling. For example, the type of hydrogen tanks onboard the buses does have an impact on the design of the HRS. It is also highly desirable that the timing of the arrival and commissioning of the FCBs and HRS are coordinated so that, ideally, neither one sits idle waiting for the other to be available. The procurement of both items should therefore be done in close collaboration, in order to ensure this happens.

While FCBs are zero emission locally, operating them should also contribute to reduce emissions overall. This is why aiming for ‘green’ hydrogen fuel supply is important. However, a widely agreed definition of ‘green hydrogen’ is not yet available, and some suppliers will want to provide individual solutions. Staying open to these is key to achieving a satisfactory outcome.

Specifying for outcomes can largely overcome many of the issues related to procuring of FCBs and HRSs (for example, specifying the required dispensing capacity of the HRS during an overnight refuelling window rather than its storage tank size). It is also important that issues of performance, warranty, maintenance and supply of parts are clearly understood and agreed by all parties and well documented in the contracts. Only this will count after the contracts are signed.

Summarising Case Study

Telling the story of an 'ideal' FCB acquisition project provides a more digestible summarising tool for the wealth of information within this resource. If only this is considered, readers will have had an overview of much of what the experience of others can provide. Hopefully, however, it will also encourage them to delve further.

Issues to be Addressed to Support Future FCB Deployment

The gathering of Best Practice information from the participants in the JIVE and JIVE 2 projects has produced a number of insights and suggestions on resolving issues relevant to supporting an easier uptake of FCBs. These may also be useful in speeding up the pathway to full commercialisation of FCBs. They relate to:

- Further Growing and Better Supplying the Demand
- Ensuring Experience is Shared
- Providing the Right Frameworks.

Tackling these issues could be considered for action by the FCH JU and other European public and private sector groups and organisations, as well as by stakeholders at the national level. In some cases, suggestions are made on how to address these matters.

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List of Abbreviations and Terms

BEB	Battery Electric Bus, sometimes referred to as 'battery-only bus' because a Fuel Cell Bus also carries a small battery that supports the fuel cell and recovers energy when breaking
CAPEX	CAPital EXpenditure
CEF	Connecting Europe Facility
CHIC	Clean Hydrogen in European Cities, project co-funded by the FCH JU under the 7th Framework Programme (2010 – 2016)
CVD	Clean Vehicles Directive – Directive 2019/1161 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles
EIB	European Investment Bank
EU	European Union
FCB	Fuel Cell Bus (an electric bus powered by a fuel cell that runs on hydrogen fuel, supported by a small battery for e.g. energy recovery)
FCH JU	Fuel Cells and Hydrogen Joint Undertaking, first phase of the FCH JU under the EU 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
GHG	GreenHouse Gas
H_2	Hydrogen
HRS	Hydrogen Refuelling Station
HyFLEET:CUTE	FCB Demonstration Project co-funded by the FCH JU under the European Union's 6th Framework Programme (2006 – 2009)

HyTransit	European Hydrogen Transit Buses in Scotland, project co-funded by the FCH JU under the 7th Framework Programme (2013 – 2019)
JIVE	Joint Initiative for Hydrogen Vehicles across Europe, project co-funded by the FCH 2 JU under the European Union's Horizon 2020 Framework Programme (2017 – 2022)
JIVE 2	Second Joint Initiative for Hydrogen Vehicles across Europe, project co-funded by the FCH 2 JU under the European Union's Horizon 2020 Framework Programme (2018 – 2023)
LCC	Life-Cycle Costing, takes in account, in addition to the Total Cost of Ownership, costs related to environmental externalities; these may include the cost of emissions of greenhouse gases and of other pollutant emissions and mitigation costs (climate, health …)
MEHRLIN	Models for Economic Hydrogen Refuelling Infrastructure, project – co-funded by the European Commission's Connecting Europe Facility (2017 – 2022)
NGO	Non-Governmental Organisation
OPEX	OPerational EXpenditure
PTA	Public Transport Authority
PTO	Public Transport Operator
RED II	Renewable Energy Directive II – Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)
RFI	Request for Information
TCO	Total Cost of Ownership, includes the CAPEX and OPEX over the life cycle of a product, service or works

0 Introduction

Increasing numbers of local and regional public governments are requiring public transport bus operations in their jurisdictions to be locally emission free in the near future. Hydrogen Fuel Cell Buses (FCBs) are one option that can achieve this outcome. The Fuel Cell and Hydrogen 2 Joint Undertaking (abbreviated FCH 2 JU or simply FCH JU) has provided funding to the JIVE and JIVE 2 projects to support the deployment and commercialisation of FCBs.

0.1 Objectives of the JIVE / JIVE 2 projects

The JIVE and JIVE 2 projects are closely linked. While the JIVE 2 project started one year after the JIVE project (JIVE on 1 January 2017), both projects have similar objectives and are following similar project trajectories. They are also encountering similar challenges and solutions. Two sites, Cologne and Wuppertal, are participating in both projects.

The objectives of both projects can be summarised as follows:

- Deployment of 291 zero emission FCBs across Europe (Figure 0-1)
- Achieve a maximum price of €650,000/€625,000 (JIVE/JIVE 2) for a standard bus (single deck, typically 12 m), advance the commercialisation of FCBs through large-scale deployment of vehicles and facilitate commercial viability for bus operators by the end of the projects (2022/23) to minimize/eliminate need for subsidies
- Operate buses with an average fleet availability of at least 90%, and reduce environmental impact of bus operations by operating fuel cell buses in place of diesel buses for extended periods
- Demonstrate routes to low cost, renewable hydrogen
- Stimulate further uptake of FCBs via a comprehensive, high impact dissemination campaign

- Empower local and national governments to regulate for zero emission propulsion for public transport systems
- Share data and best practice to support the adoption of the technology and provide evidence of the suitability of fuel cell buses for wider roll-out.

The JIVE and JIVE 2 projects are also running in parallel and in close cooperation with the MEHRLIN project, which is funded under the Connecting Europe Facility (CEF) for Transport. Most of the Hydrogen Refuelling Stations (HRSs) for the JIVE sites are implemented and operated within the MEHRLIN project. Its overall objective is to demonstrate a financeable demand-led business model for HRSs.

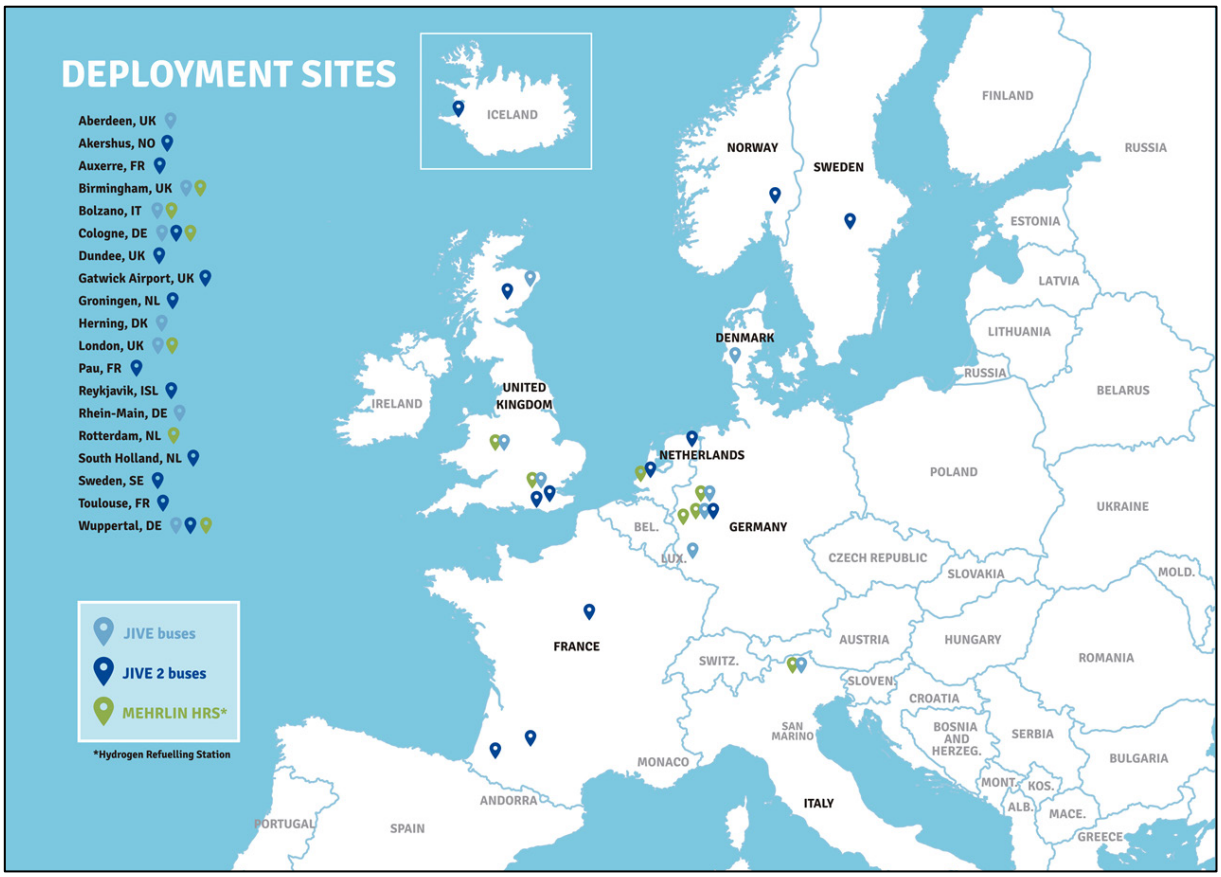

Figure 0-1: Deployment site in JIVE and JIVE 2.
The local fleets range from 5 to 50 FCBs, typically 10 to 20. Chart as of September 2019.

The number and location of sites in the JIVE and JIVE 2 projects has varied over time as some cities have left and new ones have joined, sourced from a reserve list of interested cities. The reasons for this have ranged from loss of local support due to changes

in the political environment as the result of elections, budgetary constraints (e.g. costs turning out to be much higher than excepted than at project proposal stage) through to lack of interest from suppliers in locations remote from their current commercial activities.

0.2 Context and objective of this document

In any project there is nearly always more than one way to undertake the various tasks, and some are more likely to be successful than others. There are also lessons to be learned from actions that work, as well as actions that were not successful. The monitoring and analysis activities of JIVE and JIVE 2 include capturing Challenges and Best Practice solutions on the path to the commercialisation of FCBs.

The main objective of this document is to bring that information together in one place so that it can readily be forwarded to external stakeholders. External stakeholders include decision makers from municipalities and regions, Public Transport Authorities (PTAs) and Public Transport Operators (PTOs) who may be considering adopting FCB technology. Some actors, such as policy makers, mainly require high level and strategic information. Others, the “hands-on” people at PTA/PTO level who have to deliver project outcomes, need more practical details. Detailed information (including expectations of deployment sites) can also be important for technology suppliers.

This report documents the learning that has occurred in the JIVE/JIVE 2 projects up to and including procuring the FCBs and HRSs.

The Best Practice solutions documented here are those actions and approaches that have worked well. They are reported along with the Challenges encountered that often prompted a need for a solution or different approach. It is important to note that some of these actions and approaches occurred and were successful because of the specific context they were in. This may include the specific local public transport arrangements and organisational responsibilities, local, regional or national political agendas, financial or environmental policies. This should be considered when reviewing and evaluating Best Practices for possible use in other contexts.

The Challenges recorded are problems reported from the deployment sites that threatened the success and/or significantly delayed the local activities, often resulting from actions and policies that did not work as well as anticipated. The lessons from 'difficulties' encountered are often at least as important, or arguably more important, than approaches that worked well from the start.

A series of Best Practice and Commercialisation Reports has been scheduled as the projects progress. This contributes to rapidly transferring a range of local experiences on to other stakeholders. This document constitutes the second Best Practice Report under JIVE and the first one under JIVE 2. Note that this document is concise and focusses on key issues, rather than trying to cover every possible aspect or issue that may occur in the course of demonstrating FCBs. Key information is provided for each stage, plus references on further resources that have been of use for the JIVE/JIVE 2 sites or in earlier demonstration activities.

0.3 Information gathering and processing method

The local coordinators of the demonstration cities and regions are regularly requested to provide input, via questionnaires, on their project progress, successes, Challenges encountered and Best Practice solutions found. Three rounds of questionnaires have been used as the basis for gathering information so far. Added to these have been one-on-one interviews with some of the local coordinators along with a number of site visits to gain additional on the ground insights.

To assist respondents to focus on particular areas of the projects, the information requested has been broken down into Stages and Sub-stages. Project Stages have been described as in Figure 0-2. While these are documented as a sequential process, in practice the process is commonly iterative and circular, with different stages being revisited as issues emerge and are resolved.

This report is structured according to the Stages and Sub-stages defined in Figure 0-2 (see Section 0.4 below). In line with the progress achieved at most sites by September

2019, it concentrates on Project Conceptualisation, Financing and Planning, and Procurement.

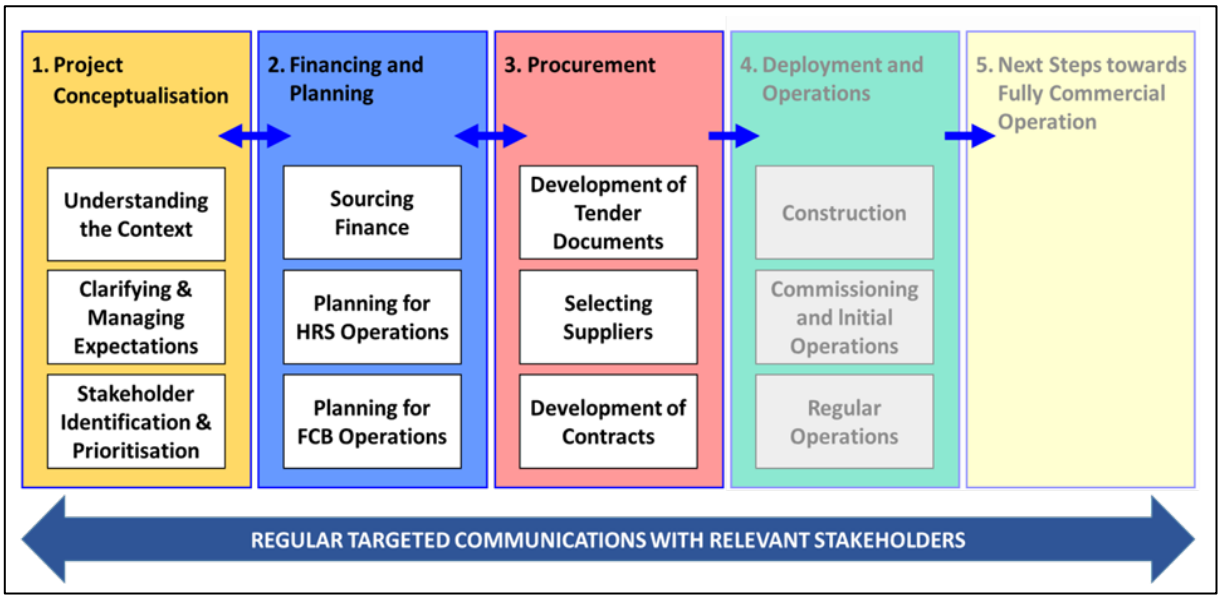

Figure 0-2: Stages and Sub-stages of a project to demonstrate FCBs and their hydrogen fuel infrastructure.
This report concentrates on Project Conceptualisation, Financing and Planning, and Procurement, in line with the progress achieved at most JIVE/JIVE 2 sites by autumn 2019. Developing a plan for "Regular targeted communications with relevant stakeholders" is part of Stage 1, in the context of "Stakeholder Identification & Prioritisation".

Round 1 questionnaires were sent to all JIVE and JIVE 2 local site coordinators in spring 2018. Because two people responded at three of the sites, there were a total of 22 responses from 19 sites[1]. At that time, ten of these sites were still dealing with Financing and Planning, eight were engaged in Procurement, and preparations for Deployment had started at one site.

In Round 2 in February 2019, there were 18 responses from 17 sites. Construction as part of Deployment had started at one site. All others were working on Procurement, most of them selecting suppliers or developing contracts with them.

In Round 3 in June 2019, there were 18 responses from 18 sites. Most had started working on Procurement. Construction was progressing at one site. The observation

[1] Cologne and Wuppertal being involved in both projects are counted separately for JIVE and JIVE 2 because their state of progress has not always been the same in two the projects, e.g. regarding FCB procurement.

that not all sites were at Procurement Stage (like they were during Round 2) is explained by that fact that two sites had to go back to Planning after an unsuccessful round of tendering (no or no adequate offers received) and one that responded in June but had not done so in February.

The feedback from the sites is compiled and presented and discussed in the regular consortium meetings. In September 2019 a special workshop was held to sum up and validate the information that had been reported and findings derived, as well as gain any additional insights. All consortium members present were able to participate.

Some supplementary inputs of information derived from previous FCB projects and from discussions with external PTOs and PTAs interested in implementing FCB technology in the near future (referred to as the User Group) have also been included.

0.4 Structure of report

Apart from the introduction, this report has 5 chapters:

- **Chapter 1** discusses **Stage 1 – Project Conceptualisation**. This Stage has been addressed in three Sub-stages
  - Understanding the Context
  - Clarifying and Managing Expectations
  - Stakeholder Identification and Prioritisation
- **Chapter 2** discusses **Stage 2 – Financing and Planning**. This stage also has been addressed in three Sub-stages
  - Sourcing Finance
  - Planning for HRS Operations
  - Planning for FCB Operations
- **Chapter 3** discusses **Stage 3 – Procurement** of HRSs and the FCBs. Each is discussed in relation to:

- Development of Tender Documents
- Selecting Suppliers
- Development of Contracts

- **Chapter 4** presents a **Case Study** which provides a narrative summary of key points presented in tabular form in the preceding chapters.
- **Chapter 5** puts forward a number of **Issues to be Addressed to Support Future FCB Deployment** and, in some cases, suggestions are made on how to address these matters.

Some issues are discussed in more than one Stage or Sub-stage. This replication frequently reflects the importance of the issue throughout the project, while in some instances it is due to the iterative and circular nature of project development as mentioned above.

Stage 4 – Deployment and Operations is not covered in this report because at the time of writing no site was in regular operational service although commissioning was ongoing at few of them. Findings from this stage will be presented in a forthcoming JIVE/JIVE 2 Best Practice report.

Next Steps towards Fully Commercial Operation (Stage 5) are considered in Chapter 5 in compiling issues to be dealt with to support the further deployment of FCBs.

1 Stage 1: Project Conceptualisation

1.0 Introduction

Developing the overall concept of a FCB project sets the scope and, in many ways, the basis for the overall success of the project. The Project Conceptualisation Stage provides the context within which the buses will operate and be perceived by the key stakeholders.

It can also facilitate a broader framework within which other applications of hydrogen and fuel cell technology can be developed and utilised. These can provide a means to address energy system wide and environmental issues as well.

A key factor in this and all subsequent Stages is deciding which organisation will be the lead partner, its roles, responsibilities and accountabilities, and those of other key partners in the project. Commonly the lead partner is either the PTA or the PTO.

In general terms, the PTA is the organisation within the local or regional public administration that has the legal responsibility for making sure that there is a public transport system, its general terms and conditions, and arranging the contracts with operators. The PTO is the organisation, frequently but not always a private company, that operates the public transport service, in this case, the FCBs and their routes. There are many variations to these general arrangements and relationships. For example bus ownership might be with the PTA or PTO, the PTO might be an independent company or owned by the local administration, the PTO may maintain the buses or contract that out to another organisation.

This project Stage has been considered in three Sub-stages:

- **Understanding the Context** – why does a city or region decide to participate in a FCB project and what links can such a project have to other plans and activities of the city or region (Section 1.1)

- **Clarifying and Managing Expectations** – understanding what expectations the relevant stakeholders may have of the project outcomes, and ensuring they are realistic (Section 1.2)
- **Stakeholder Identification and Support** – developing a Stakeholder Map (including prioritisation) and Communication Plan and implementing it early in the project (Section 1.3)

These Sub-stages are likely to run in parallel and influence each other, rather than being addressed one by one.

1.1 Sub-Stage: Understanding the Context

JIVE and JIVE 2 local site coordinators were asked to provide the reasons for participating in the projects. Table 1-1 summarises the findings.

The site coordinators also provided insights into the major Challenges encountered and solutions found in this initial project stage. Why had "selling" the project been relatively smooth and easy, and what had been done do to make this happen? Why had problems emerged and what could have been done to avoid them? Table 1-2 summarises this feedback.

Table 1-3 gives an overview of useful resources when starting a FCB project. More details in terms of resources are presented in the following chapters.

Overall, there are two aspects of developing a FCB project which have considerable influence on the ease and success of the future project path. FCB projects which have been established:

- within a broader industry / energy system / environmental context,
- with realistic expectations which recognise that the technology is still developing (see next sub-stage),

are more likely to be, and be perceived to be, successful by immediate stakeholders, as well as the broader community.

One of the site coordinators stressed the importance of periodically re-reading written resources. This approach gave them an ability to recognise important details and issues that had occurred in earlier projects and that tied in with issues arising in the course of their own one but were not obvious when studying the documents at an earlier stage. In effect, they started to get a better understanding of the extent of their knowledge gaps. Their project has progressed well.

Table 1-1: Project Conceptualisation – Major reasons why the JIVE/JIVE 2 sites decided to start a FCB demonstration project.
Based on 22 responses. Six category options were provided, up to three could be selected; typically two or three were ticked.

What have been the major reasons for sites deciding to start a FCB project?	Number of respondents choosing this option	Comments
Looking for alternative fuel options	15	• FCB activities are being increasingly put into a broader context - such as part of a regional hydrogen strategy. This can also help facilitate support from a broader range of stakeholders not directly involved in the FCB project • National and local emission and clean energy requirements are playing an important role • The future ambition / next step, expressed via channels outside the questionnaire round, is 50+ buses per site and whole depots moved over to FCBs
City wants cleaner air	13	
City committed to combatting climate change	11	
Funds available from sources outside city for bus projects	11	
Part of local environmental programme	10	
Bus manufacturer made an offer	1	
Other reasons and objectives mentioned by the respondents include: • Ambition to be in the forefront in innovation generally, and 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 • To use hydrogen for storage of wind energy • Part of overall transition to renewable energy in the region		

Table 1-2: Project Conceptualisation – Challenges and Best Practice Solutions.
Based on 22 Responses.

Challenges	Best Practice Solutions
Starting with an innovative project • Hydrogen is a new fuel in public transport, and its introduction poses challenges very similar to other innovative projects • While there is nothing exceptional in terms of project management when setting up and running a FCB project, such highly innovative activities require considerable resources. Many respondents mentioned that, in addition to finance issues, they did not have enough people and time for the project	**Build a vision** • Communicate how your FCB project links to/supports a vision which includes local or national industries, community use for hydrogen and/or clean energy supply in general; this may have to start with very basic facts, such as battery electric buses (BEBs) being not the only zero-emission option • Know and connect with the political agenda for low carbon vehicles at any or all of local, regional or national levels
	People make hydrogen happen You will need: • A committed Project Team consisting of knowledgeable and experienced staff • Effective, collaborative team work to develop the project and overcome challenges • Committed and well informed organisational decision makers and elected officials
Political/Legal environment can intervene • The political/legal environment can adversely affect the project e.g. elected supporters can lose an election, complying with national laws can delay action	**Know your context** • Avoid or mitigate against getting caught up in election cycles • Understand legal frameworks for tendering, contracting, safety permitting
Preparatory work can be extensive • Innovative projects mean a lot of information needs to be gathered and there are not a lot of templates available to follow • A key challenge is to understand and accept that there will be things you don't know that you don't know, and that you cannot absorb and understand every piece of information when you e.g. read recommendations from an earlier project for the first time	**FCBs and HRSs** • Find out as much as you can about FCBs and HRSs early in your project conceptualisation; re-visit resources regularly as questions arise • Be clear on the benefits of FCBs – but be equally honest about the costs and risks • Visit sites where FCBs are in operation to obtain first-hand information • Attend workshops offered by ongoing projects to learn about experiences, challenges and solutions • Try to obtain written information in local language to forward to your stakeholders

Table 1-3: Project Conceptualisation – Useful Resources.

General	Setting up a FCB Project	Information to assist Communications
• Knowledge of Local/Regional/National zero and low emission vehicle policies. For example: ➢ The "Clean Vehicles Directive" on the promotion of clean and energy-efficient road transport vehicles has recently been revised. It is going to impact on the procurement strategies of PTAs/PTOs: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0033 • FCH JU has co-funded the major FCB demonstration projects under the 7th Framework Programme and Horizon 2020. It can be expected that its work is going to continue under Horizon Europe (2020 - 2027), particularly in terms of promoting "hydrogen regions" https://www.fch.europa.eu/ • Basic properties of hydrogen including comparisons with other energy carriers/fuels: http://www.h2data.de/ Dedicated resources for Funding, Planning and Procurement can be found in corresponding tables in the following chapters. *Note:* A paper documenting all European Union Policies that link to FCBs will be published as part of the JIVE 2 project by December 2020.	• Visiting and talking to experienced cities in your country/elsewhere in the EU • An "Operators Guide' to Fuel Cell Bus Deployment" can be found on https://fuelcellbuses.eu/projects/jive-2 • More reports from JIVE and JIVE 2 will become available over the coming months at https://fuelcellbuses.eu/projects/jive and https://fuelcellbuses.eu/projects/jive-2. They will include details on the different local projects, such as FEBUS in Pau (France) as part of JIVE 2: https://fuelcellbuses.eu/public-transport-hydrogen/brochure-fuel-cell-bus-pau-busworld-2019 • Reports from CHIC project for FCB demonstration (2010 – 2016): https://fuelcellbuses.eu/projects/chic including: ➢ Recommendations for Hydrogen Infrastructure in Subsequent Projects • Reports from the NewBusFuel project on large scale HRSs, including a Guidance Document: http://newbusfuel.eu/publications/	• Further reports from CHIC project at https://fuelcellbuses.eu/projects/chic including: ➢ Influencing factors to the acceptance of fuel cell and hydrogen technologies in public transport (focussing on bus drivers, stakeholders and the general public) ➢ Extract from the above report with key learnings ➢ Issues of concern to external stakeholders and critics and pathways to their resolution; also includes an update of this report regarding changing views after two years • "People, Transport and Hydrogen Fuel: Guidelines for Local Community Engagement when Implementing Hydrogen Powered Transport", from the HyFLEET:CUTE project (2006 – 2009) https://fuelcellbuses.eu/publications • "Sustainability Assessment of FCBs in Public Transport", March 2018 http://www.mdpi.com/2071-1050/10/5/1480/pdf

1.2 Sub-Stage: Clarifying and Managing Expectations

Local JIVE and JIVE 2 coordinators were asked about their expectations for the major project outcomes. Table 1-4 presents the findings. These expectations and the reasons for starting a FCB project (Table 1-1) constitute important elements of the narrative ('story') to be communicated to stakeholders. The focus of the communication, and the level of detail depends on the individual stakeholder group (see Section 1.3).

Expectations were also collected on quantitative targets e.g. expected availability of the FCBs and HRSs, fuel consumption, time required to refuel a bus. In summary, site coordinators have high project expectations. 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 preceding 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, this led to disappointment and put local players under pressure from their supervisors, funders or the public. It also led to some problematic relationships between some of the demonstration sites and their FCB or HRS suppliers.

Setting up a FCB project today still requires the strong support of many stakeholders to provide personnel capacity and relevant expertise, money etc. Acquiring this support can also bring the risk of 'overselling' the technology and raising very high expectations. On the other hand, high initial expectations may be necessary to get such a project approved at all. These expectations must be well managed during the course of the project. For example, stakeholders must be prepared for challenges, have them explained when they occur and feel comfortable that solutions will be found.

Interviews carried out in the acceptance study of the CHIC project showed that a perceived lack of communication led to irritations and scepticism, and, at worst, loss of support. The study concludes that whenever there is a lack of official information,

there is a risk of unofficial stories emerging, made up and communicated by people looking for a story or wanting to influence the process (see report "Factors influencing the acceptance of fuel cell and hydrogen technologies ...", Table 1-3).

Table 1-4: Project Conceptualisation – Expected major outcomes of the local projects.
Six options provided, one or more options could be selected. Based on 22 responses.

Expected major outcomes of the local FCB Projects	Number of respondents choosing this option	Comments
Refuelling technology highly reliable and maintenance free	14	• While the current bus prices and operating costs were a concern (see Chapter 2), most respondents anticipated that an acceptable (low) level of cost will be achieved in the future. • 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. This uncertainty is no doubt common among early stages of adoption of new and disruptive technology.
Clear idea of future public transport bus technology	13	
Bus technology highly reliable and maintenance free	12	
Commit to a future FCB technology in short term	8	
FCB technology likely to be too high cost to be sustainable	2	
Likely continuance of purchasing fossil fuel technology into the future	0	

1.3 Sub-Stage: Stakeholder Identification and Support

There is a wide range of stakeholders who can provide important and powerful support to your FCB project, or just as powerful opposition. On the support side, as an example, an influential and involved Steering Committee can provide very important 'political' support. It might consist of senior representatives from the local administration and the PTA/PTO, as well as respected political leaders (political 'champions'), to maintain support and obtain advice. On the opposition side, this may be very local, such as neighbours to the proposed refuelling site, or quite distant, such as national or international environmental organisations.

The relevant stakeholders need to be identified, their field of impact mapped, and a Communication Plan for engaging with them established and implemented. Not all stakeholders will have the same kind or level of potential impact or be relevant to every stage of your project

Figure 1-1 shows a *sample* Stakeholder Map that distinguishes between project Stages. In addition to stakeholders as such, it includes other parties of key relevance, for example cities/sites with existing experiences in FCB demonstration, and potential suppliers of HRSs and FCBs.

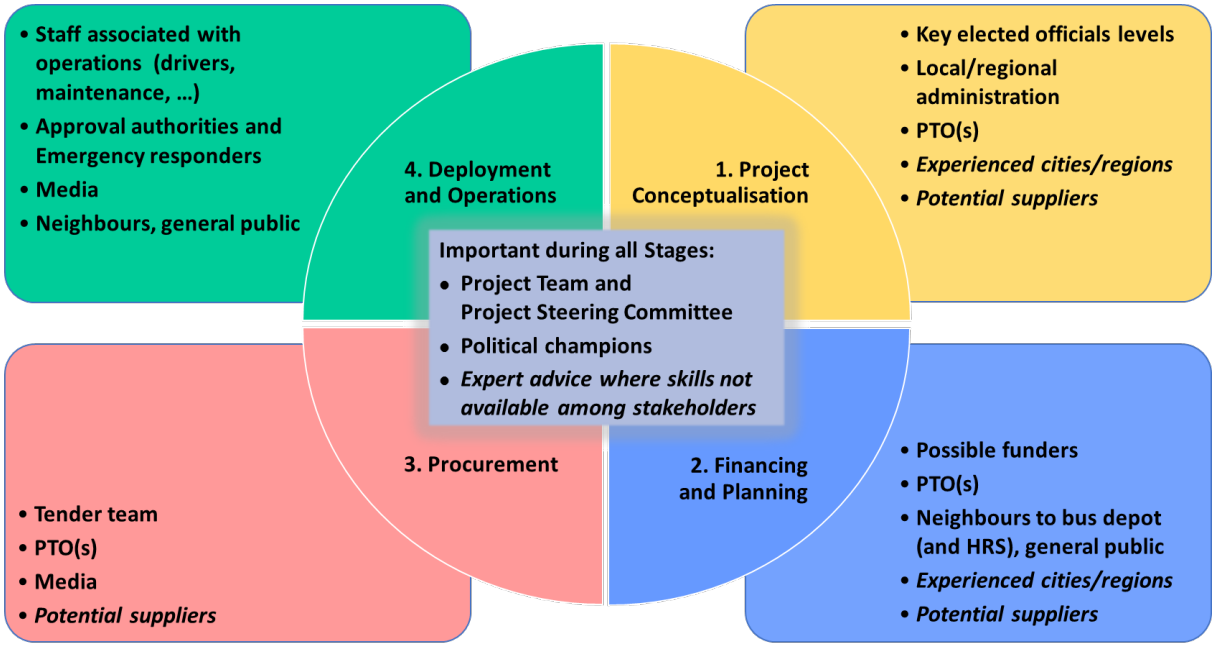

Figure 1-1: Sample Map of important Stakeholders and (in italics) further parties of key relevance during the Stages of a FCB deployment project.

The task of working with the different stakeholders needs to be prioritised. For instance, when and how to engage with the media must be carefully thought out and how you communicate with influential decision makers must be appropriate.

The prioritisation can be done by mapping the stakeholders on a matrix with respect to concern and impact/importance, as exemplified in Figure 1-2.

Good FCB specific templates for stakeholder interaction and developing a Communication Plan are available. For example, the document "People, Transport and Hydrogen Fuel" (see Table 1-3) provides some detail on this.

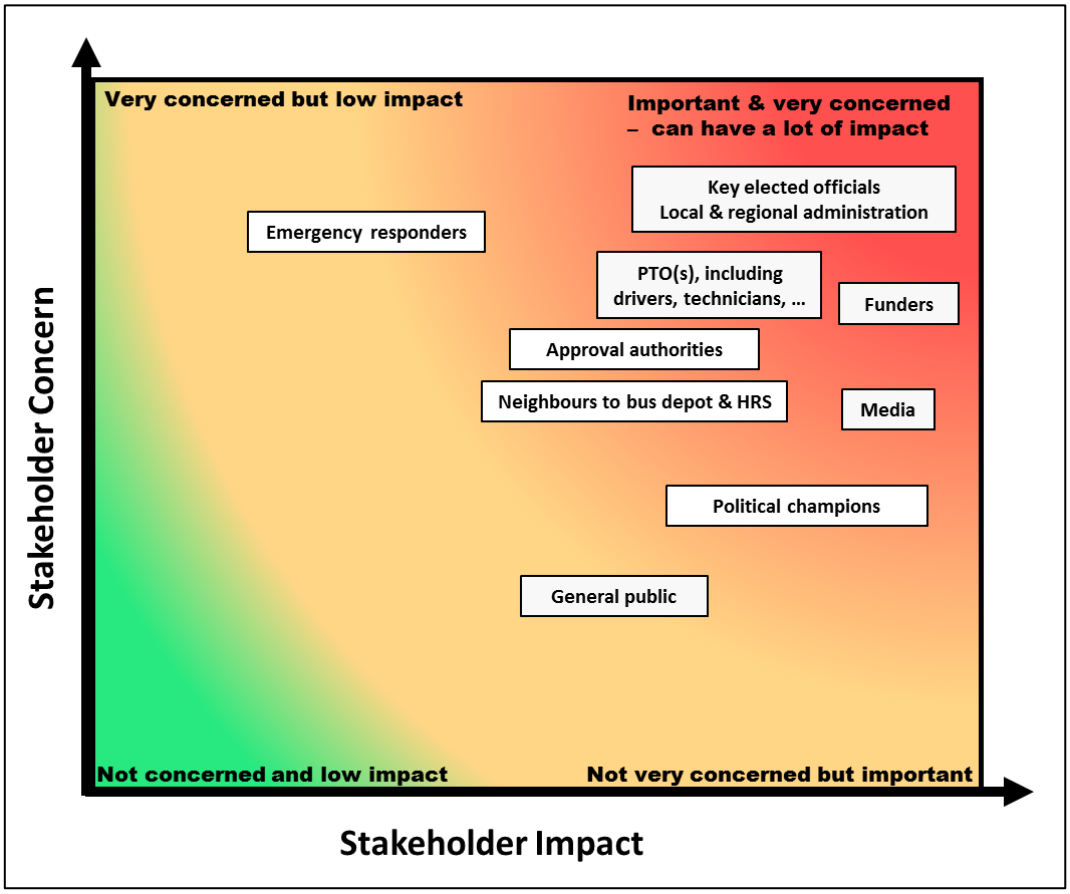

Figure 1-2: Example of a Community Stakeholder Prioritisation Map.
It is important to be aware that the criticality of the individual stakeholder groups varies from site to site, so this is just a sample map for illustration. Note also that individual players can have different roles (and, therefore, different criticalities) at different times during a project. In particular, the fire brigades are part of the Emergency Response but usually also have a say when it comes to permitting of the HRS and the FCB maintenance workshop.
Chart based on "People, Transport and Hydrogen Fuel, Guidelines for Local Community Engagement when Implementing Hydrogen Powered Transport" (see Table 1-3 above). HyFLEET:CUTE, 2009.

While this attention to stakeholder engagement appears self-evident, it is often overlooked under the pressure of other more immediate tasks. One essential element of this activity is the requirement to keep in contact with the stakeholder through active, customised engagement. Passive communication such as Newsletters, Press Releases and Social Media updates are useful communication channels but cannot replace face to face discussions with key stakeholders. Personal communication of project status and listening to concerns and issues are very important in heading off possible obstacles, and potentially re-shaping project elements to address questions that have been raised.

Planning to maximise the leverage that can be gained once your FCBs are operating is also important. Experience has shown that some of the best ambassadors for the new technology are bus drivers who thoroughly enjoy the opportunity to be part of an innovatory programme. They are also the people who have the most contact with the general community. This is an important insight for on-going broad dissemination and communication.

2 Stage 2: Financing and Planning

2.0 Introduction

As can be seen from the Stages chart (Figure 0-2), following Conceptualisation of the project, the next task is to find ways to meet the costs of the project and commence planning. Given the current state of development of FCBs and HRSs, it is highly likely that today the additional costs over and above the costs of buying and operating conventional diesel or natural gas buses can only be met by grant funds of some sort and not from normal commercial finance arrangements. One of the goals of FCB demonstration at scale is to reduce these additional costs and advance the shift from grant funds for projects to normal (i.e. commercial) bus fleet finance arrangements.

2.1 Sub-stage: Sourcing Finance

Getting the money for any innovative initiative can frequently be complex and difficult. This is especially so when the initiative is being developed and implemented within a commercial public transport bus operating environment. While money to buy (capital expenditure; CAPEX) and operate (operating expenditure; OPEX) conventional buses is clearly available, additional CAPEX and OPEX associated with the project (for purchase, training, maintenance and other operating costs) will need to be met to fully cover the increased Total Cost of Ownership (TCO).

The major source of this additional money in JIVE and JIVE 2 has been the FCH JU. Funds from the CEF through the MEHRLIN Project have also supported the HRS implementation in many JIVE sites. Various levels of local, regional and national government have also contributed. In some cases, such as in the UK, funding from low emission vehicle and government innovation initiatives has been provided. Some funding, such as for the Groningen project in the Netherlands, has also come as one element of a much broader, energy system or economy wide vision for hydrogen (H_2) and fuel cells.

Complicating the process of raising external funding is also the fact that establishing the additional costs that are expected to arise from a FCB project is not an easy task at

present. Some of these costs may well arise after the end date of the co-funded phase ('beyond project' costs), resulting from the potential for ongoing use of the FCBs and HRS up to the end-of-life of the buses. Nonetheless, being able to present reliable cost figures is essential to gain support from stakeholders and for applying for financial support from whatever source. Table 2-1 and Table 2-2 summarise the Challenges encountered, and Best Practice solutions found, with respect to expenditure and funding. Table 2-3 provides useful information for sourcing finance.

Overall, sourcing funds in addition to the FCH JU funding has not been easy. No site has found this trouble free, including those that with experience from previous projects. However, there were no patterns that could be identified that could lead to success or problems. Much seemed to depend on specific knowledge of local, regional and national funding programmes, and local circumstances at the time, particularly political circumstances. Possibly the only common driver for funding is the existence of supranational (EU) and national targets for emission reduction. These have clearly acted to galvanise action from those involved in the provision of public transport. The pressure in this respect is going to increase via the revised Clean Vehicles Directive (CVD) that sets out mandatory minimum procurement targets for clean light-duty vehicles, trucks and buses for 2025 and 2030, including zero emission buses.

A challenge for the nearer future will be to move from co-funding models to commercial financing models.

Beyond TCO, it can be beneficial to undertake Life-Cycle Costing (LCC). This takes into account, in addition to TCO, costs resulting from the consequences of emitting greenhouse gases (GHG) and other pollutants. These result in costs associated with health treatment and climate change impacts as well as mitigation and adaptation policies. The savings achieved by replacing conventional buses with zero emission alternatives can be a useful argument when negotiating for additional funds or, in the future, cheaper loans from government for whom these costs are a large budget item.

Table 2-1: Sourcing Finance – Determining the costs.

Challenges	Best Practice Solutions
Level and complexity of costing: • Uncertainties around pricing of FCBs, HRSs, and H_2 fuel • Demand for FCBs is currently higher than supply, so the industry competition is immature • Inexperience with costing CAPEX and calculating revenue in short term (demonstration) projects • Inexperience and complexities of costing OPEX • Costing uncertainty is compounded by multiple options for H2 fuel supply **Lack of Information:** • Not enough general experience to be confident about bus performance in operations • Lack of financial models	• Build a draft but comprehensive business case from day one; then refine it as your project progresses, thereby improving accuracy • Learn from other cities with experience; some will be willing to provide sample specification information and provide figures from their operations **CAPEX:** • Consider procuring jointly with other sites to get better prices for the FCBs through higher volume (see Chapter 3). This can work, provided the sites have similar requirements and specifications, and similar regulatory structures • Consider including preventative maintenance costs in the capital costs of the buses to reduce the operating costs, which are a key consideration for any operator **OPEX:** • H_2 pricing can be difficult. A lower price can be achieved if a minimum purchase quantity is guaranteed to the supplier and the contract is lengthy and offers break clauses (ability to stop the contract at defined points in the future) • Seek to define Green H_2 and be aware that sources can be limited (for information on H_2 supply and Green H_2 definitions see Table 2-5 and Chapter 3 on Procurement) **TCO:** • Be thorough with TCO, including 'beyond project' costs after the co-funded phase. This includes being clear which technology you are looking to compete with from the outset (diesel/diesel hybrid/battery electric). Generally speaking, PTOs are looking for parity with diesel, but BEBs are the competitor in terms zero emission propulsion. • Be sure to include the requirements of maintenance, training and certification for a new technology • Be sure to include the residual value of the buses and the HRS

Table 2-2: Sourcing Finance – Covering the costs.

Challenges	Best Practice Solutions
Knowledge of Funding Sources and Interaction with Funders: • Knowing and connecting possible funding sources • Convincing funders • Timeliness • Making sure that interactions between different sources of funding do not interfere with each other • Weaving purchase of new buses into routine fleet investment **Politics:** • Changes in/uncertainty regarding the political situation/agenda • Competition from other zero emission buses (BEBs)	• Research funding sources well and ensure their criteria (goals/timelines/limits) align with your project; read the terms and conditions of grant funding thoroughly and seek legal support to do so • Sources generally include a component of investment from the PTO or the PTA allocated to normal purchases; useful additional sources are government (all levels) low/zero emission and energy programmes • Connect with funders informally or find good intermediaries or experts • Present a thorough business case to show that you are serious about your project • Service funders well; never assume reliable, lasting commitment • Consider working with another site to jointly seek funds; • Consider employing experts to seek & prepare funding proposals • Be aware there may be issues that arise: ➢ from providing subsidies to private organisations (e.g. PTOs) ➢ about the ownership of assets purchased with funder input and ➢ in trying to coordinate with the investment cycle of PTOs • Try to separate funding sources into separate sub-projects but also try to avoid feeding funds from different sources into the one item (e.g. source 1 = FCBs, source 2 = HRS, rather than sources 1 and 2 = FCBs, sources 3 and 4 = HRS) • Consider LCC to estimate the avoided external costs via savings of emissions of GHG, NOx and particulate matter and strengthen your case; there is information available to help quantify external costs (see Table 2-3)

Table 2-3: Sourcing Finance – Useful Resources.

Resources	Where to find the Resources
Knowledge of funding sources at European, National (including local / regional) levels *Note:* Resourcing can flow from having a political advocate. However, be aware of the impact of election cycles and the importance of regular communication with these champions	**European** • The FCH JU publish regular calls for project proposals, commonly requiring partners from at least three member states: https://www.fch.europa.eu/ • The EC has set up an Innovation Fund for demonstration of innovative low-carbon technologies. The first call for expressions of interest is planned for 2020: https://ec.europa.eu/clima/policies/innovation-fund_en • Other possible streams of funding include cross-border cooperation under the INTERREG programme with various regional activities, such as for the North Sea region: https://northsearegion.eu/, and further programmes under European Structural and Investment Funds umbrella: https://ec.europa.eu/regional_policy/en/funding/ • As purchasing moves from project funding to regular financing, support from the European Investment Bank (EIB) is expected to come into focus: https://www.eib.org/en/; national/local banks can be expected to follow **National** • Project funding provided by National Governments such as the German National Innovation Programme Hydrogen and Fuel Cell Technology (NIP): https://www.now-gmbh.de/ • General funding databanks, such as https://europa.eu/youreurope/business/finance-funding/getting-funding/eu-funding-programmes/index_en.htm
Suppliers: While immature, Industry may work flexibly with purchasers to help them achieve their goal	• https://www.fuelcellbuses.eu/suppliers lists the known manufacturers of FCBs, HRSs & some component suppliers • https://www.hydrogeneurope.eu/directory/industry provides a directory of their industry members
Appeal to social, environmental & cost benefits of clean air/reduced emissions	**Calculating external costs avoided** • Costs associated with the health impacts of transport emissions have been examined in some depth. As a starting point see: https://www.eea.europa.eu/signals/signals-2016/articles/transport-and-public-health • "Sustainability Assessment of FCBs in Public Transport": http://www.mdpi.com/2071-1050/10/5/1480/pdf

2.2 Sub-stages: Planning for HRS Operations and for FCB Operations

Clearly the operational stage is the most important aspect of a FCB project. It is the reason for embarking on the project and will provide critical information to determine the future of the application of H_2 and FCB technology at that site. It will also be the most public activity of the project and therefore most open to scrutiny. Success is critical and only careful and thorough planning can achieve this. The saying *"Failing to Plan is Planning to Fail"* certainly holds true when applied to a FCB Project.

While there are some Best Practices that are applicable to only the planning for the bus or the HRS operations, there are some general approaches and actions that are applicable to both. These are laid out in Table 2-4.

Challenges and Best Practice Solutions related specifically to HRSs or to FCBs are set out in Table 2-5 and Table 2-6.

Some of the most useful resources for planning for operations can be found in Table 2-7.

Annex A summarises quantitative expectations for FCB and HRS performance as expressed by the sites at the beginning of the JIVE and JIVE 2 projects (as explained in Section 1.2).

Table 2-4: Planning for Operations – General Best Practice Solutions.

	Best Practice Solutions
1	Visit/talk to experienced sites: This strategy is perhaps the most helpful for all stages of developing and implementing your project. It can help you at the outset to understand the complexity of issues and for just in time advice at a later date
2	Align the timing of delivery and commissioning of HRS and buses: Buses need a refueller during their commissioning phase
3	Plan for slow progress: Roadblocks and delays are common when introducing innovations – prepare all stakeholders for this and think in terms of Plan Bs as much as possible. Allow for the possibility of significant delay on your timescales. Sites in JIVE/JIVE 2 have encountered up to 18 months delay. While this should not happen to this extent in the future, be prepared
4	Plan for clear and consistent communication: While this may seem obvious, it is not attended to due to a perception of more urgent issues. Have a Communication Plan for stakeholders and be rigorous in following it (see Section 1.3 on this matter). Assign responsibility for making it happen
5	Have clear and specific responsibilities, boundaries and accountabilities, e.g.: • A PTO may not be the best to procure a HRS but they know a lot about buses • PTO or PTA may be better able to procure HRS location site works than the HRS supplier • A single “turnkey” HRS supplier has been found to be a better option by some
6	Resource the planning stage well (people and time) : Thorough planning = smooth(er) procurement; expert assistance will be of help
7	Plan to set up a broadly-based tender team: Tender teams need to have a wide range of expertise: apart from at least one member experienced with conventional tendering this includes understanding of technical (FCBs/HRSs), financial, risk management, contracting and legal frameworks issues(more on this in Ch. 3)
8	Engage early, often and widely: political advocates, city administration; local authorities (including firefighters etc.); in particular: • PTO(s): These have a pivotal role in in ensuring the success of the introduction of this new technology. Brief all levels within the PTO(s) from CEO level to bus drivers with the appropriate information; a new fuel and new technology need thorough introduction • Talk to FCB and HRS suppliers: Get as much understanding of the technology as possible (see also following table)
9	Permitting: Permitting remains a big job in the context of planning and deployment; difficult to know how long this will take - not just because of delayed granting of permission but the fact that many regulators do not know how to handle it; Best Practice has been to “Educate your Regulator” i.e. have "unofficial" discussions with the authorities before handing in your applications for permits, introducing them to the field and to what has been successfully deployed at other sites, presenting your plans/solutions, never asking them “What should I do?”; be willing to compromise on technical details
10	Be open to reason as everyone is still learning

Table 2-5: Planning for HRS Operations – Challenges and Best Practice Solutions.

Challenges	Best Practice Solutions
• Risk: Determining risk sharing among the local partners can be difficult because you need to specify the equipment and its capabilities to know the risk and you need to know risk to specify • Determining Size: Optimising size (not too big not too small); forecasting size of hydrogen storage required now and in the future as well as planning for seasonal fluctuations in usage can lead to specifying unnecessary capacity resulting in additional cost; suppliers may offer equipment with "locked specifications", so no scale up is available later on • Design and Location of HRS: Identifying the right location that meets the operator requirements; siting determines the HRS planning and HRS and FCB operational constraints and costs • Numbers and Complexity of Decisions: Most PTOs and PTAs lack experience with HRS hardware and H_2 fuel supply, especially with location /permitting/regulations issues; setting HRS supply contract terms & conditions is complex; technical planning can be affected by changing national regulations	• Specify for Local Needs: As part of the dialogue among local stakeholders, review and refresh local needs such as HRS ideal location(s); be aware that a HRS requires a considerable area of a bus depot if that is where it is to be located; work out supply chains for H_2, including back up • Inform yourself of the Legal Framework in which the HRS will operate, certification and permit requirements for the new technology and fuel; be prepared for lack of knowledge among regulators • Use Pre-Tender Processes such as Requests for Information; the limited and non-standardised market means that you will not be overwhelmed with information, but early necessary decisions will become clearer; try to get technical concepts from more than one potential supplier in the pre-tender stage • H_2 Supply: All H_2 supplied must be 'green' to fully address climate issues in particular; definitions of Green H_2 are still developing and in the short term green supply may not be possible (see Table 3-3); consider all supply pathways offered and source well to wheel investigations of emissions - there are quite a few available that may be adaptable to your context; encourage the industry to provide the solution i.e. make it an industry problem not an operator problem; make sure you understand the pros and cons of on-site and off-site production of the hydrogen; think about the need for redundancy (back up supply) • Make early Decisions: Define "must haves" to guide decisions; decide on scale; know permitting requirements; develop strategies to address TCO (price of the H_2 can be pivotal here); note any imperatives for location and design • Options: Consider turnkey suppliers to buy a HRS from OR simply tender for a H_2 per kg price at the nozzle with the HRS built and operated by a contractor • Involve an Expert who supports you with their experience and know-how • Plan for the Future: Scalability and flexibility of the HRS is important for growing fleets and, possibly, for joint use with other vehicles

Table 2-6: Planning for FCB Operations – Challenges and Best Practice Solutions.

Challenges	Best Practice Solutions
• Achieving PTO Buy-In: Some PTOs have concerns about becoming involved because of operational and maintenance costs & safety; training requirements; technical performance of H_2 technology • Modifying Existing Depots / Routes: FCBs may need more space in depots; determining routes - not all routes are suitable; different or additional maintenance equipment and skills will be needed • Lack of Information: Bus fuel consumption figures and drive characteristics and power specification details are not as readily available as for their diesel counterparts • Operation and Maintenance for the Long Term: Ensuring the bus maintenance requirements are adequately met; ensuring the existing or new bus contract is competitive and can be maintained over the course of 10 – 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 it is not possible to replace these buses with diesels	• Develop indicative costing and opportunities to de-risk for PTOs: Calculate TCO and consider de-risking options for engaging with commercial PTOs • Develop good Partnerships: Involve the local stakeholders early & understand the impact of the new technology on them; engage the FCB supplier through Request for Information (RFI); engage with those who will work on the buses such as drivers and maintenance people and ensure that all are committed to exploring a new technology and making it successful • Become familiar with Local Needs: Review and refresh local needs – buses (routes, depot locations, saleability; supply chain requirements; warranties and repair arrangements); understand the issues • Training: Plan for bus driver and maintenance technician training which can be a significant cost factor • Supply Chain: Plan for an efficient and timely supply of parts; ensure that the FCB manufacturer's supply chain is robust and the suppliers have clear and firm obligations on warranties and repairs • Maintenance: Consider carrying out part of the maintenance in-house - this will help you understand the technology more rapidly • Insurance: Engage early with insurers as few have experience of FCBs • Plan for the Future: Consider scalability of solutions to enable options for the future

Table 2-7: Planning for Operations – Useful Resources.

Resources	Where to find the Resources
Talking to FCB and HRS suppliers and question them on their product specifications and experiences	For lists of suppliers see: https://fuelcellbuses.eu/suppliers or search the membership list of: https://www.hydrogeneurope.eu/directory/industry If possible, visit their factory and use your performance criteria to question them on performance. For a map of sites with existing and planned HRSs for FCBs in Europe see: https://www.fuelcellbuses.eu/
Talking to and/or visiting demonstration sites with operating FCBs and HRSs	For JIVE sites see Figure 0-1 or: https://www.fuelcellbuses.eu/projects/jive and https://www.fuelcellbuses.eu/projects/jive2 Currently (December 2019) the most experienced active sites are Aberdeen, Bolzano, Cologne and London. The authors of this report can provide personal introductions, see their e-mail addresses on page 2.
Reports from JIVE & JIVE 2 and from other ongoing and from completed projects, including CHIC and New-BusFuel	On https://fuelcellbuses.eu/publications for example: • Public summary of the Final Report of the CHIC project (2010 – 2016) • Guidance for HRS consenting phase (JIVE 2) • Introduction to fuel cell buses: Guidelines for operators (in German)
Particular reports on planning for HRSs	On https://fuelcellbuses.eu/publications for example: • Info pack about the hydrogen infrastructure in Pau/France (JIVE 2) • Recommendations for hydrogen infrastructure in subsequent projects (CHIC) On http://newbusfuel.eu/publications/ for example: • Guidance document on large scale hydrogen bus refuelling • Review of regulations codes and standards with respect to hydrogen bus scale fuelling
Particular reports on planning for FCBs	On https://fuelcellbuses.eu/publications for example: • Operator's Guide to Fuel Cell Bus Deployment (JIVE 2) On http://newbusfuel.eu/publications/: • Business cases to support fuel cell bus commercialisation

3 Stage 3: Procurement

3.0 Introduction

Procurement of the FCBs and HRS is the Stage that will determine the fundamental performance of the project. While the general steps and processes are well known, the procurement of FCBs and HRSs introduces some additional complexities. The technical details are likely to be new to the particular site and persons responsible for conducting this activity. For example, standards for refuelling heavy duty vehicles (fills of > 10kg H_2) are still under development, so HRS performance is difficult to assess.

An additional element that must be managed is the requirement for a close linkage between the FCB and HRS technology. The buses and the refueller must be compatible and be able to 'talk' to each other, to ensure quick and reliable refuelling. For example, the type of H_2 tanks onboard the buses does have an impact on the design of the HRS[2]. It is also highly desirable that the timing of the arrival and commissioning of the FCBs and HRS are coordinated so that, ideally, neither one sits idle waiting for the other to be available.

These factors have led some sites to procure both FCBs and HRS through a single process conducted by a single organisation such as the PTO. One city site even put out a single 'outcomes-based' tender for the complete system of buses and refuelling station. This was successful, and other sites consider this as an option for the future.

Generally, however, while the PTO is likely to have considerable expertise in purchasing buses and be well placed to undertake this task for the FCBs, they are unlikely to have much, if any, expertise in HRS procurement. Accordingly, the PTO is likely to require external expertise for procuring the HRS, or this process should be led by a different party.

[2] Type IV tanks, fibre-wrapped plastic vessels, require pre-cooling of the H_2 or a close regulation of its flow rate. Type III tanks, fibre-wrapped metal vessels, do not unless buses are refuelled very fast.

Some sites have circumvented this challenge (lack of experience with HRSs) by procuring 'H_2 refuelling as a service', rather than buying and operating the actual refuelling hardware themselves. This puts the responsibility and accountability on the contractor to provide the required quantity and quality of H_2 and refuel the FCBs where and when required.

This solution is also one way to address a request frequently made by both HRS and FCB suppliers that tender documents should focus on the performance outcomes required. In the case of the HRS, this could include the daily hydrogen demand, the length of the overnight refuelling window and the maximum allowed time to fill per bus, while not stipulating technology details such as HRS storage size. This allows the suppliers to shape their tender solution in the most efficient and effective way, and at the best price. Tendering for performance outcomes is generally recommended as is keeping some flexibility in the specifications where possible.

It is important that issues of performance, warranty, maintenance and supply of parts are clearly understood and agreed by all parties and well documented in the contracts. Only this will count after the contracts are signed. Do not accept non-disclosure clauses that forbid you to talk to third parties when problems occur.

This Chapter is structured by initially documenting Challenges and Best Practice Solutions that are common to HRS and FCB procurement (Table 3-1). Subsequently, technology specific issues relating to the Procurement of the HRS (Table 3-2) including H_2 fuel supply (Table 3-3) and Procurement of the FCBs (Table 3-4) are dealt with separately. Each of these processes is considered individually with regard to the Sub-stages of Developing of Tender Documents, Selecting Suppliers, and Development of Contracts in Table 3-2 and Table 3-4.

Sources of further information for this Stage are listed in Table 3-5.

Table 3-1: Procurement of HRS and FCBs – Challenges and Best Practice Solutions applicable to both.

Challenges	Best Practice Solutions
Running separate but linked tenders for FCBs and HRS in order to time them to come online together	PTOs know about buses; other players such as energy suppliers are more likely to know more about HRS equipment; PTA/PTO know about site works etc.
The market for both HRSs and FCBs is immature	• Do a market review: Determine which manufacturers are willing and able to deliver • Very important to use manufacturers and experienced sites as knowledge resources; use a RFI to the test market
Finding a tender team that has the expertise to integrate FCB/HRS specifics in line with local tender and contract law	Gather multi-skilled team and involve them early – legal / technical / finance – purchasing / energy / mobility; ensure that relevant stakeholders are engaged in aspects of evaluation and set up regular dialogue with them during the process
Issues such as warranties and responsibility for maintenance and spare parts in a non-standardised supply chain; responsibilities of suppliers' third-party contractors add to complexities; unclear responsibilities for solving challenges that may arise can derail the installation of innovative systems	• Matters that are standard to diesel buses need to be made explicit with FCBs e.g. type and size of fuel tanks; intended refuelling regime (max. allowed time to fill etc.) • Ensure that all parties involved on the supplier side are clear on who has ultimate responsibility and accountability for problems that may arise • Iterative process to contracts, particularly if many parties involved • Detailed and clear contractual agreements will be paramount in resolving problems
Ownership of equipment can be complex	Where there are multiple funders, ownership of the HRS and buses needs particular attention; ownerships arrangements can vary, e.g. one site arranged to become owners of the HRS after ten years when the H_2 supply contract with the HRS supplier ends, to ensure they could continue to get a competitive H_2 price
Reliability and scalability cannot be assumed	Negotiate for scalability and specifically address reliability requirements – the most important factor for a public transport system (e.g. the length of the overnight windows during which the HRS will always be available)
• Maintaining communications with stakeholders throughout procurement process • Significant training time is required for bus drivers/maintenance technicians/bus depot people	• Communications: These need to be continued throughout the procurement process with the relevant stakeholders, in particular local authorities (including fire brigades); funders should feel informed at all times • Training by suppliers: Factor this into all procurement documentation
Safety assessments require attention	To address potential reservations by local authorities lacking experiences, be pro-active; consider resourcing an assessment for the HRS and the Bus Maintenance Facility; professional expertise can be very helpful to ensure compatibility

3.1 Procurement of the HRS

As outlined above, the procurement of HRS has generally been more difficult than acquiring the FCBs. This is partly due to the PTOs/PTAs having good communication networks with bus suppliers while mostly this is not the situation with HRS technology or suppliers yet. Therefore, careful consideration needs to be given about which entity is best placed to conduct HRS procurement.

Nevertheless, both procurement processes need to be closely coordinated from the perspective of technology and timing. Tender documents should include a requirement for the successful HRS and FCB suppliers to consult and collaborate on solutions in terms of interfaces and timing of commissioning. Table 3-2 summarises Challenges and Best Practice Solutions for the HRS side.

As also mentioned previously, there are alternatives to procuring and owning the HRS hardware. Some sites have tendered for supply of H_2 to the refuelling nozzle. That can be based on hydrogen generated locally or trucked in from remote production sites, but the responsibility for fuel supply and being able to refuel FCBs at any point in time as required will lie with a third party rather than with the PTO whose core business is bus operations. Table 3-3 lays out some of the issues that need to be considered in relation to H_2 supply. The advantages and disadvantages of these alternatives should be considered in the context of any long-term plans for FCBs, and possibly other fuel cell vehicles, in the region.

Table 3-2: Procurement of HRS – Challenges and Best Practice Solutions.

Challenges	Best Practice Solutions
1. Developing Tender Documents	
• Specifying the HRS requirements so that the station meets vehicles' fuelling requirements; lack of HRS standardisation • Determining capacity and redundancy needed • Meeting innovative technology requirements; developing the evaluation criteria to match the requirements • Permitting requirements • Synchronising bus and HRS delivery • Implementation of HRS in bus depot with limited space and coordinating with other new technologies (e.g. BEBs); allowing for flexible solutions	• Write technical specification output-based; consider the need for redundancy (e.g. two compressors in parallel to account for possible outages) • Set targets for technical outputs e.g. fuel fill times, but do not score or pay more for times that beat them • Be clear on outcomes required and their consequences (revenue implications; warranties; maintenance) and have them confirmed by the potential suppliers • Require at least one visit of potential suppliers to location for HRS; the site specifics will affect proposal details • Choose correct tendering procedure: large gas companies and smaller companies can provide the HRS, the latter may be more interested in submitting a proposal • Set target fuel price (combined fuel and maintenance) and set a price cap. • Consider whether to separate into two: 1. HRS hardware; 2. Fuel supply contract (see also following table)
2. Selecting Supplier	
• Manufacturers unresponsive; poorly written proposals • Matching proposal specifications with tender specifications / technology offered not meeting expectations • Deciding which supplier is best choice due to quite different concepts presented	• Invite quotes for standard and variant bids (delivered or on-site) to see what can be offered • Include 'innovatory solutions' as one of the evaluation criteria – technical and commercial (e.g. scalability) • Evaluate on TCO basis, including 'beyond project' costs
3. Developing Contracts	
• Negotiating the whole package to a commercially viable cost	• Be flexible with proposed solutions • Clarify issues of ownership and responsibility (see Table 3-1)

Table 3-3: Procurement of H_2 Supply – Challenges and Best Practice Solutions.

Challenges	Best Practice Solutions
'Green' H_2: • A widely agreed definition of 'Green' H_2 is still not available • 'Green washing' by providers is also still an issue. • Funding bodies generally want Green H_2;	Currently, Hydrogen Europe[3] has a working party dedicated to the current Renewable Energy Directive (RED II) – trying to ensure that the Green H_2 definition is dealt with. While Green H_2 has commonly been seen as H_2 produced by an electrolyser powered by renewable energy, other forms of low carbon H_2 production are being considered. In the UK, Green H_2 is also emerging as steam methane reforming with offsetting arrangements. Other candidates could include by-product hydrogen, or reforming hydrocarbons in conjunction with carbon capture and storage (CCS). The CertifHy 1 and 2 projects have developed a system for guarantees of origin for Green H_2 (from renewable sources) and low carbon H_2, having a GHG balance below a defined threshold. The final threshold will be based on requirements defined in RED II. The preliminary figure is 36.4 gCO_2eq/MJ (131 gCO_2eq/kWh) using the lower calorific value of H_2.
H_2 Price: Difficult to get a definitive price	• Set up fuel supply contracts for as long a term as possible (such as 10 or 15 years) to help encourage new investors and to improve price offered • It is possible to get a long term contract at a better price if significant volume is assured. These contracts can contain break clauses (see Table 2-1). • Set a target price and a price cap • Evaluate on TCO basis, including 'beyond project' costs
H_2 Purity: Purchasing very pure H_2 required by fuel cell manufacturers can be difficult	High levels of purity are obtainable but at increased price; changes to the purity standards are being discussed but have not as yet been implemented
H_2 Metering: Measuring accurately enough the amount of H_2 refuelled (and supplied from external sources, if applicable) is still not a fully resolved issue	Ensure this issue is discussed with suppliers and understood by the local stakeholders; more accurate technology is being developed

[3] Hydrogen Europe represents many players from the European industry, national associations and research centres active in the hydrogen and fuel cell sector.

3.2 Procurement of the FCBs

Procurement of FCBs, which still is more complex than procurement of diesel buses, has generally not been as difficult as procuring HRSs. Commonly the PTO, in agreement or collaboration with the PTA has conducted the FCB procurement. Tender documents should include a requirement for the successful HRS and FCB suppliers to consult and collaborate on the interfaces and timing of commissioning, as mentioned earlier.

As also mentioned above, most FCB manufacturers have emphasised that detailing performance outcomes in tender documents is preferable to detailing technology. They argue that this approach gives them optimum flexibility to shape their technology and tender proposals in the most cost effective and efficient way to meet the customer's needs. This approach is perhaps most pertinent to FCB procurement. PTO personnel who are frequently involved in bus procurement may be tempted to insert their detailed technology experience and knowledge into tender documents. However, performance outcome requirements such as range, fuel economy, reliability and spare part replacement times are more useful.

A cluster coordination initiative was supported by the FCH JU. This was designed to aggregate demand for FCBs and to develop approaches to Joint Procurement in five geographic clusters, to achieve cost reductions via standardisation and economies of scale. As illustrated in Figure 3-1, 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.

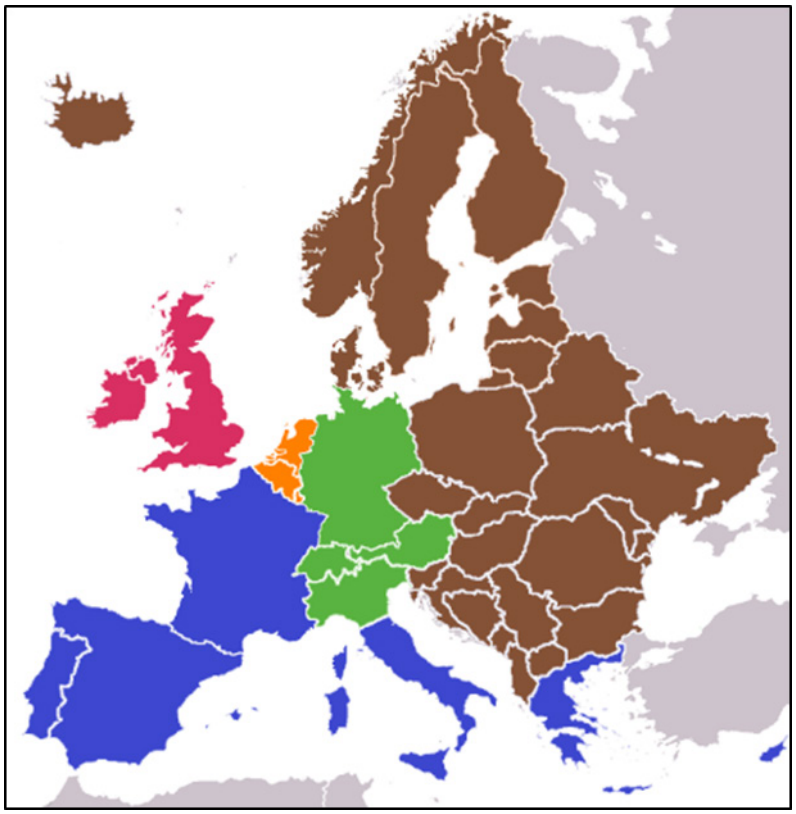

Figure 3-1: Map of the five geographic clusters to advance FCB deployment.
The cluster coordination initiative was designed to aggregate demand for fuel cell buses and to develop approaches to joint procurement.

As part of JIVE, the German speaking cluster (with four sites) and the UK/Ireland cluster (three sites) each published a joint tender.

The latter was successful and resulted in a framework agreement with two bus manufacturers to provide vehicles on a call-off basis, with a common specification and the option to tailor buses according to local needs. This framework is live for five years from 2018 and can also be used by sites from other countries to order their FCBs. However comments from the participant sites, particularly London – the lead site – suggest that the process was very involved and led to considerable additional administration costs to the sites, which at least partly offset the lower price per vehicle that was achieved.

The joint tender by four members of the German speaking cluster was partially successful. Only two of the sites, the Cologne region and Wuppertal, just some 50 kilometres apart from each other, received an offer and proceeded on the basis of the original

tender. They finally placed an order for 40 vehicles, the largest single order for FCBs to date. The other two sites then tendered individually.

A reference for the cluster activities can be found in Table 3-5. There was also some cooperation with respect to procuring HRSs but this did not result in any joint tendering.

Again, the advantages and disadvantages of different approaches and different supply arrangements should be considered in the context of any long-term plans for FCBs and other vehicles in the region.

Table 3-4: Procurement of FCBs – Challenges and Best Practice Solutions.

Challenges	Best Practice Solutions
1. Developing Tender Documents	
• Design and specification of tender document: Lack of mutually recognised guidelines for technical specifications for FCBs (standardisation); e.g. concerning fuel consumption • Joint Procurement: Specifying the buses so that they meet the requirements of all the partners/sites involved • Project Compliance Requirements (where part of a third party funded project) • Sticking to Tender Laws while procuring a new technology in an immature market environment	• Put responsibility into the hands of the PTO to undertake the purchase through normal purchasing arrangements. They have both leverage with suppliers and understanding of their own operating requirements • Preferably work in with a PTO's investment cycle and be prepared to support them with information and advice on where to source information about the new technology • Consider using an existing framework for Joint Procurement from an experienced site as a template/starting point for defining e.g. bus specifications, order process and terms & conditions • Negotiation and communication with suppliers is critical throughout the tender process; due to lack of experience in this area, the purchaser is reliant on the suppliers to validate assumptions and provide input as to the most efficient way to procure the FCB, particularly with respect to the supporting services (maintenance & training) In the event of starting a Joint Procurement with another site(s) with a similar context and requirements: • Partners need willingness to compromise on common bus specifications. • Appoint a single coordinator for discussions and later on negotiations with suppliers. • Using a contract framework to be used by the joint tenderers is 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 • It is critical to develop a framework that is scalable and allows for all interested cities to use it, as it provides suppliers with a level of security over the volume of buses to be procured despite the non-committal nature of a framework

Table 3-4: Procurement of FCBs – Challenges and Best Practice Solutions (continued).

2. Selecting Supplier	
• Lack of Competition/Supply: Manufacturers unresponsive to tender (buses/tenders of under ten vehicles seem to struggle attracting interest); purchaser at a disadvantage; delivery time negotiations can be difficult; • Matching proposal specifications with tender specifications: Technology offered not meeting expectations; e.g. buses equipped with a combination of fuel cell and battery with insufficient power to cope with operation in a hilly environment • Suppliers offering different prices in different locations for similar sized orders, because of factors related to the bus specifications, including liabilities, warranty and damages. • Maintenance costs can increase significantly after around the third year of operation, due to increasing replacement/refurbishment costs of some components. • Evaluating responses requires expertise in H_2/fuel cell technology	• Communication and flexibility to negotiate with suppliers are critical throughout the tender process • Negotiate add-ons once manufacturers have placed bids • Some manufacturers more able/willing, to lower prices in response to scale. • Source expertise on the innovative aspects of the technology – experienced sites may be able to assist with this
3. Developing Contracts	
• Lack of Competition/Supply: Price negotiation; delivery time negotiation; suppliers' side can dictate the negotiations / conditions • Lack experience in procuring FCBs: Technical and legal details • Joint Procurement: Contract needs to allow for multitude of variations on the service offering which increased risk to suppliers; multiple stages of review required prior to suppliers accepting the framework and call off terms / agreeing roles and responsibilities in terms of risk • Fuel Cells: Reassurance needed that stacks will last	• Absolute clarity between all parties on outcomes wanted and compliance with tender / contract details especially where there are sub-contractors involved • Specify maintenance: set expectations, define contracts, assign responsibilities (PTA/PTO/supplier); a full maintenance contract in the early years can be helpful for the PTO

Table 3-5: Procurement – Useful Resources.

Resources	Where to find the Resources
Talking to FCB and HRS suppliers and question them on their product specifications and experiences	For lists of suppliers see: https://fuelcellbuses.eu/suppliers or search the membership list of: https://www.hydrogeneurope.eu/directory/industry If possible, visit their factory and use your performance criteria to question them on performance.
Talking to and/or visiting demonstration sites with operating FCBs and HRSs	For JIVE sites see Figure 0-1 and/or: https://www.fuelcellbuses.eu/projects/jive, https://www.fuelcellbuses.eu/projects/jive2 and/or https://fuelcellbuses.eu/ Currently (December 2019) the most experienced active sites are Aberdeen, Bolzano, Cologne and London. The authors of this report can provide personal introductions, see their e-mail addresses on page 2.
Reports from JIVE/JIVE 2 and from other ongoing and from completed projects, including CHIC and NewBusFuel	On https://fuelcellbuses.eu/publications for example: • Operators' guide to fuel cell bus deployment (JIVE 2) Documents with collation of training materials for staff involved in bus operation, for HRS users and for first responders will become available in mid-2021
Particular reports on planning for HRSs	On https://fuelcellbuses.eu/publications for example: • Recommendations for hydrogen infrastructure in subsequent projects (CHIC) On http://newbusfuel.eu/publications/ for example: • Guidance document on large scale hydrogen bus refuelling • Strategies to ensure adequate redundancy • Agreed definition of availability for bus depot fuelling stations and recommendations
Particular reports on planning for FCBs	On https://fuelcellbuses.eu/publications for example: • Lessons learnt from joint procurement of fuel cell buses (JIVE) • Final report on the strategies for joint procurement of fuel cell buses (Report for the FCH JU) On http://newbusfuel.eu/publications/: • Common bus operator requirements for future tendering processes (focus: links/interdependencies FCBs/HRSs)

4 Bringing it all Together: Case Study in Best Practice

It is difficult to put together a summary of a series of Best Practice suggestions for deploying this new technology. What do you re-mention – what do you leave out? By its very nature, Best Practice cannot be shortened to a few summary paragraphs.

Therefore, in the place of a summary/conclusion, this chapter provides a Case Study of what a Best Practice demonstration project might look like. The 'perfect world' scenario is based on a range of 'real-world' examples and the experience and imagination of the authors. It brings together in a narrative many of the key Best Practice recommendations gathered from JIVE/JIVE 2 project partners and knowledgeable others. This is an 'ideal' scenario and should be interpreted as such, serving only as a vehicle to highlight approaches that work.

If there is one piece of wisdom that does transcend all practices, it would be that all contexts are different, so the advice that you find in this case study and in other resources needs to be considered in the light of your own project and its specific circumstances. Having said that, there is some good advice here for every situation.

The Context

The year is 2018 and in European City X the local administration has issued an edict that improving air quality was the highest priority and that public transport buses would need to move to emission free alternatives from 2021 onwards. Because of the currently limited range of BEBs, the local administration decided to acquire FCBs. These decisions had strong and widespread political and community support.

1. Project Conceptualisation Stage

The Mayor of the City (a highly respected former national politician with deep political networks) tasked the CEO of the PTA to make this happen. The CEO appointed an experienced senior member of staff as project leader to source funding and implement a programme to deliver the outcome. The project leader had significant experience in transport policy and working with teams to deliver projects. She established a dedicated Project Team of three full time workers consisting of herself, a technical person with a good understanding of bus technology, some knowledge of alternative energy technologies and good networks and linkages with PTOs operating in the city, and a legal expert in the area of tendering and contracts.

A Project Steering Committee was also set up consisting of the Mayor, the CEO of the PTA, the Chief Operating Officer of the PTA, a senior financial officer tasked with supporting the project, a senior engineering staff member and a senior marketing person in the PTA. The project leader asked for and gained their commitment to attend regular briefings in the early months of the project.

Understanding the Context / Clarifying Expectations

The Project Team started with developing a vision that set the project within the context of the city's regional and national forward strategic plans. This included strategic use of sources of energy, the relevance to local industry and to national and supranational requirements to meet clean air and climate change targets. Examples of what was considered included:

- A thorough explanation of the policy environment driving the decision to invest in new clean technologies
- A consideration of the energy system (stationary and transport) and how the introduction of the new energy might be leveraged in this setting (e.g. H_2 as a buffer for intermittent renewable energy)

- The chance to create synergies with local/regional/cross-regional industry (manufacturers; gas suppliers etc.; by-product H_2 from chemical plants etc.)

The vision developed was complemented with a description of outcomes/benefits that might be expected to be derived from the new technology. These were updated as the project developed (e.g. from business case analysis).

Stakeholder Identification and Support

In parallel, key stakeholders in the community and their areas of interest were identified. Significant among these was a local PTO that showed interest in being part of the project.

A Stakeholder Map was drafted and kept up-to-date during the following Stages, and a first Communication Plan was developed and implemented.

Important points to note from the story:

1. Advantage: Highly influential political support;
   Risk: Political climates can change quickly and dramatically;
   Solution: Make a robust case that appeals across the political field and to other key community stakeholders
2. Appoint experienced, dedicated project staff with a good spread of existing experience and skills needed for this project
3. Develop a broader vision for the project
4. Identify stakeholders early, co-opt all the important players and establish mechanism for regular stakeholder communication

2. Financing and Planning Stage

With the project vision in place, the Project Team undertook an intensive period of familiarisation with all aspects of the task ahead. This included:

- Enhancing their understanding of all aspects of bus operations in their city, including tender and funding cycles, and dialogue with the PTO, that had volunteered to be the FCB operator for the project, commenced.
- Reviewing reports from past and ongoing FCB demonstration projects

- Visiting other cities that had already gone down the route of FCB acquisition
- Meeting with suppliers selling FCBs and suppliers of HRSs and/or hydrogen, and conducting a more formal RFI process to test the market
- Engaging an expert to develop a list of possible funding sources to cover the additional costs incurred by the new technology together with advice on the best 'fit for purpose' to approach
- Tasking marketing & communications support with developing a targeted and detailed Communication Plan based on the refined Stakeholder Map and in line with each Stages of the project.

This information was fed back to the Project Steering Committee in the regular briefings. Concerns/issues raised by the Steering Committee were rigorously addressed.

Further important points to note from the story:

5. Spread the information gathering net wide enough; importantly include suppliers and experienced cities; potentially use a RFI process
6. Speak to PTO early to provide them with information and to understand their perspectives; directly involve them with scoping out their requirements
7. Undertake dedicated work to find possible additional funding sources
8. Maintain political and community support by attending to issues raised

Work also commenced on the business case for the FCBs. The PTA's finance staff were fed information gathered in the early planning stages. This business case was developed using conservative estimates for costs and, where costs were uncertain, to assume the upper end of the range. This was to reduce risk of budget 'surprises' at a later date.

The Project Team understood that covering the likely additional costs of the new technology when compared with diesel buses was essential to getting buy-in from the PTO. As a commercial enterprise, the PTO would be looking to de-risk the process of moving away from what they know and expect support from the PTA to do so. This de-risking process included an assured H_2 fuel supply.

As part of this process, other cities with experience in FCB acquisition were approached again, to help advise on various business case aspects. The time horizon for the business case was built around the typical 10 – 15 years replacement cycle for diesel buses. The business case covered CAPEX and OPEX, including 'beyond project' costs to be expected arise after the co-funded demonstration phase. It provided comparative cases with diesel, diesel electric and battery electric buses.

Calculating the Additional Costs

CAPEX: The relative lack of competition among FCB and HRS suppliers, and therefore likely higher costs, was included in the cost estimation decision process.

OPEX: The volume of H_2 required was to be augmented by assuming conversion of city administration's car fleet to fuel cell vehicles which could assist in securing a lower price for the H_2 through higher volumes. However, this had to be balanced against any resulting increased CAPEX. FCB and HRS maintenance costs were estimated taking the same conservative approach described above.

While the CAPEX and OPEX calculations (and therefore the TCO), took account of the likely direct financial costs to the PTO and the PTA, to present a more profound case the broader community benefits of moving to zero emission buses were also considered. These included financial savings from reduced human health costs from fossil fuel emissions, as well as improved public amenity from reduced noise, more comfort and public approval, in terms of a Life-Cycle costing approach. The project team knew these would provide a good argument for asking for additional funds if necessary or, in the future, cheaper loans from government (or their funding/financing organisations) for whom health costs are a large budget item.

Covering the additional costs

Following costing calculations and the funding research being finalised, proposals were submitted to cover the additional costs from sources outside the usual bus fleet and infrastructure investment programmes. Funding requests were audited for conflicting requirements between different funding bodies, and with private-public rules in mind.

Once all planning – technology, communications, financing outcomes - were in place and funds approval obtained, a decision was made to go ahead with procurement.

Further important points to note from the story:

9. Continue to seek support from experienced others
10. Ensure conservative cost estimates, address additional funding requirements and the need to de-risk in order to achieve PTO buy-in
11. When seeking funding for additional costs, be aware there can be conflicting requirements
12. Plan for going over budget and over time
13. Consider undertaking a Life Cycle Costing exercise
14. Respond to short deadlines by running concurrent activities

3. Procurement Stage

HRS and FCB tenders were dealt with separately. Expert groups were formed with membership being specific to the technology. One expert group (mainly drawn from the PTA) would manage the HRS tender, and the other (led by the PTO) would manage the FCB tender process. Some overlap in personnel was built in. The timing of the calls was designed to try and have both FCBs and HRS commissioned at the same time, but was also consistent with the investment cycle of PTA/PTO to take advantage of existing and proven procurement processes and to work in with city's budgeting arrangements.

To address potential reservations by local authorities lacking experiences, an early professional safety assessment for the HRS and the bus maintenance facility was arranged and the outcomes fed into the tender documents.

Developing the HRS Tender

The HRS tender, including H_2 supply, was run by the PTA. PTA staff had had the opportunity to gain their expertise during the project planning process and had already determined the location of the HRS in consultation with the PTO.

The tender document emphasised outcomes wanted rather than specifying inputs. Requirements for daily dispensing capacity, modularity and scalability, precision of H_2

metering, H_2 quality (purity), backup supply, and Green H_2 supply in the short to medium term were addressed. Potential suppliers were encouraged to be innovative and given thorough briefings consistent with procurement regulations.

Tenderers were strongly encouraged to visit the proposed HRS location.

Developing the FCB Tender

The PTO was in the process of purchasing new buses and the procurement of FCBs was added into their normal tendering arrangement. However, they indicated that they could have purchased the FCBs as a specific, one off tender arrangement if the PTA had required.

The PTO was able to use their existing bus tender template as a base and integrate into it the outcomes-based performance criteria for the FCBs. To define these criteria, they had spoken to experienced cities, researched publicly available performance data on the technology and tested draft criteria with potential suppliers through an RFI.

Selecting & Contracting Suppliers

Prices offered were higher than wanted for the HRS. The final price was negotiated with the preferred supplier during the contracting process. In relation to the H_2 supply, the PTA was able to offer a guaranteed length of contract with break clauses. Issues to do with ownership, responsibilities, guarantees & warranties and the coverage of 3rd party suppliers were all addressed in the development of the contract. The PTA guaranteed the PTO a H_2 fuel price resulting in fuel costs per kilometre driven that are equivalent to using diesel.

The limited FCB supplier market yielded only two proposals. The PTO remained flexible in negotiating the FCB price with the preferred supplier, leveraging possible alternative maintenance and training arrangements and possible future purchases to deliver an acceptable price. Due to additional funds available from the PTA for the introduction of the new technology, the PTO was comfortable that their commercial operations were not at risk.

Further important points to note from the story:

15. Run tenders in parallel but not necessarily by the same organisation
16. Tenders should concentrate on outcomes wanted; include scalability as appropriate
17. Purchasers should remain flexible in order to meet cost limits
18. Ownership of assets and responsibilities should be made explicit in the contract
19. An early professional safety assessment of HRS and bus maintenance facility provides comfort to local authorities and supports the tenderers

This is where this 'ideal' FCB acquisition story ends for now. The Stage of Deployment and Operations will be addressed in the future, based on the experiences of the JIVE/JIVE 2 project sites as their FCBs come on line.

5 Issues to be Addressed to Support Future FCB Deployment

The gathering of Best Practice information from the participants in the JIVE and JIVE 2 projects has produced a number of insights and suggestions on resolving issues relevant to supporting an easier uptake of FCBs. These may also be useful in speeding up the pathway to full commercialisation of FCBs. Tackling these issues could be considered for action by the FCH JU and other European public and private sector groups and organisations, as well as by stakeholders at the national level. In some cases, suggestions are made on how to address these matters. The recently revised CVD with its mandatory targets for procuring zero emission buses adds weight to the need to address these 'meta' issues sooner rather than later.

Further Growing and Better Supplying the Demand

1. While there have been some new manufacturers entering the FCB market recently, this market is still considered far from mature. There are still few FCB suppliers, and some of them are relatively small bus suppliers with limited financial resources. Many of the larger European manufacturers are not yet active in the FCB market. The result is that there is limited competition among FCB bidders.

   Only one supplier currently offers an articulated FCB despite many PTOs expressing urgent demand for this type of vehicle.

   Promoting the demand and the type of demand for FCBs to bus manufacturers remains an important and necessary activity.

2. Some calls for tenders, particularly for small numbers of buses, and tenders with complex specifications and options, have not prompted any bids at all. It was hoped that tendering larger bus orders, including by means of Joint Procurement, would stimulate the industry. However, industry has not been quick to respond, and it is possible that the orders are still too small to attract additional manufacturers into the market.

   Future financial support could, as an example, concentrate on:

- large scale FCB implementation through individual site orders of 20 or more FCBs and
- 20+ orders based on Joint Procurement with good support on the national or Cluster level, that bundle individual site demands for smaller numbers of buses. This should be encouraged in regions with little activity up to now, particularly from the EU13 new member states. It will be important to ensure that Joint Procurement arrangements do not become overly complicated e.g. by crossing regulatory frameworks or with different group members requiring a large number of vehicle options/variations.

Ensuring Experience is Better Shared

3. Participants in the JIVE projects say they highly value talking to sites with experience of deploying FCBs as a means of learning. This can come at a cost to these experienced sites when they are approached frequently.

   Providing funding to these experienced sites to compensate them for their work to provide on-going assistance to new entrants might make this learning more accessible to all. These experienced sites could effectively become regional "Centres of Excellence."

4. Written information on the 'how to…' of implementing FCBs, held in a central, online repository, is being used but not as much as would be preferable.

   Information from JIVE participants suggests that two actions might improve the usage of the valuable information that is available:

   - provision of basic information in a range of languages in national/regional online information pools (in addition to the central ones)
   - provision of the information through workshop and training events, in cooperation with experienced sites.

   Currently the UITP is undertaking some of this work as part of their JIVE/JIVE 2 participation. It could also be undertaken by Hydrogen Europe in cooperation with

their National Hydrogen Association members, and/or with locally based consultants, who would have the added benefit of being able to present it in their own language.

5. Some sites seem to have entered projects with little understanding of what they are embarking on.

   A one-day introductory, mandatory workshop before any city or region new to FCBs can submit an application for funding/finance could ensure that there is a basic level of insight and reduce the risk of local projects running into easily foreseeable difficulties.

Providing the Right Frameworks

6. Many of the JIVE/JIVE2 projects sites have struggled to put together cost models with acceptably small levels of uncertainty. While local contexts vary enormously, some general, practical hands-on guidance on costs would likely be very useful.

7. Current sites point to the essential requirement, for the time being, to de-risk the TCO (including the higher CAPEX, FCB maintenance, H_2 fuel costs and staff training) for PTOs, in order to encourage them to come on board with this innovative and yet disruptive technology.

8. Some HRS tenders faced problems and delays. Sometimes this resulted from suppliers having to tailor their equipment to meet demanding local requirements. While PTAs/PTOs have become better at tendering appropriately, standardisation of HRS outcome specifications is urgent. Based on experiences gained in the implementation of the JIVE and other projects, HRS manufacturers should now be able to offer a set of basic models/options that PTOs/PTAs and other potential HRS operators can chose from. It may be worth investigating why this is not happening.

9. A definition for Green H_2 that is widely accepted, or even EU endorsed, is urgently required. Some participants in JIVE projects believe that this definition should also acknowledge that the use of by-product H_2 that would otherwise be vented can be considered Green, or at least clean.

10. Permitting and certification of HRSs and bus maintenance workshops is making progress. However, it can still seriously slow down the implementation process.
11. Finding insurers for FCBs and HRSs is difficult. (Experiences in relation to this will be reported on in the next Best Practice Report.)
12. Many of the above concerns have been successfully addressed on many occasions in close to 20 years of FCB demonstration in Europe. During this time various consultants have gained excellent insights and knowledge which could be accessed to effectively address such challenges. Developing a Register of these consultants and their claimed experience and expertise would be a useful resource for new project participants.

Annex A Quantitative Expectations for Performance

Suppliers and customers of FCBs and HRSs have repeatedly stressed the major benefits of technical specifications being described as expected outputs rather than inputs. While this may seem challenging for a new technology, operators are generally very familiar with what services and performance (outputs) they need from their buses. This approach leaves it open for the supplier to recommend their best and most cost effective solution to provide those services. For example, it is recommended to specify a certain amount of hydrogen to be dispensed within the overnight refuelling window and a maximum time to fill per bus, rather than requiring a certain size for the HRS on-site storage.

To help focus JIVE and JIVE 2 project partners on this, and to have them clarify their expectations for performance, they were asked early to quantify these with respect to a set of parameters. This Appendix provides an aggregated overview of their responses.

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

Methodology of evaluation

The responses of the JIVE and JIVE 2 Local Coordinators were evaluated by calculating:

- the lowest and highest values
- the median (the centre of a dataset)

- 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.

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

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 most cases, the spread between the lowest and highest entries is significant and there are marked outlier values with respect to the highest expectations

Table A-1: Quantitative Expectations for the Performance of HRSs and FCBs.

Parameter	Lowest / Median / Highest
1. Availability HRS [%]	90 / **99** / 99.9
2. Availability Buses [%]	80 / **90** / 99.9
3. Cost of hydrogen [€/kg]	4 / **6** / 12
4. Bus operating costs relative to standard fleet [%]	75 / **150** / 400
5. Maximum wait time for Repairs HRS [hours]	0 / **12** / 120
6. Maximum wait time for Repairs FCBs [hours]	2 / **24** / 72
7. Specific fuel consumption [kg/100 km]	8 / **9** / 12
8. Time to fill [minutes]	5 / **10** / 15
9. Fuel cell stack lifetime [hours]	7,000 / **25,000** / 50,000

1. Availability HRS

The expectations range from 90% to 99.9% availability.

The median value is 99%. This is in line with the work programme targets (with down-time 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% on a 24/7 basis would certainly result in extra costs for a very high level of redundancy and maintenance capability.

2. Availability FCBs

The expectations range from 80% to 99.9% availability. Again, median value of 99% is in line with the project targets, which are to reach more than 90% after an initial six-month ramp-up phase. The highest expectations of 99.9% do not appear to be reasonable given that only one site in the previous CHIC project achieved the 85% availability target for that project. Few suppliers would guarantee such a level of availability even for diesel buses.

Achieving the JIVE/JIVE 2 project availability target for the FCBs seems to be more challenging than reaching the project availability target for the HRS.

3. Cost of hydrogen

The median value is 6 €/kg, therefore significantly smaller than the JIVE and JIVE 2 project targets of < 9.0 €/kg hydrogen dispensed (excluding taxes) at the end of the project(s).

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 median is in line with this, but some sites expect much better figures.

5. Maximum wait time for repairs of the HRS

Achieving the median figure of 12 hours will require very good support from the technology suppliers. Wait time for repairs was not analysed in previous projects, but it is clear that 12 hours was not achieved in most cases.

6. Maximum wait time for repairs of the FCBs

Again, achieving the median figure of 24 hours will require good support from the technology suppliers. Wait time for repairs was not analysed in previous projects, but it is clear the median value was not always achieved.

7. Specific fuel consumption

The median figure of 9 kg/100 km is in line with the target of less than 9 kg/100 km for buses of 12 to 13.5 metres length. The feasibility of the median is supported by the fact that 12 m FCBs in CHIC achieved less than 9 kg/100 km and 13.2 m FCBs with three axles in HyTransit 10.7 kg/100 km on average.

8. Time to fill

The JIVE projects have targets for speed of dispensing rather than time to fill. The intention is to refuel faster than 3 kg/minute. Assuming a required range of 330 km/day and the target 9 kg/100 km fuel consumption, close to 30 kg hydrogen would have to be dispensed. At 3 kg/minute this would take 10 minutes and be in line with the median expectations of the sites.

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 > 20,000 operating hours. The median expectation is somewhat higher at 25,000 hours.

A few of the stacks in CHIC buses have already surpassed 20,000 operating hours. The manufacturer of a recently announced fuel cell for heavy duty mobility applications states a stack lifetime > 30,000 hours.

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