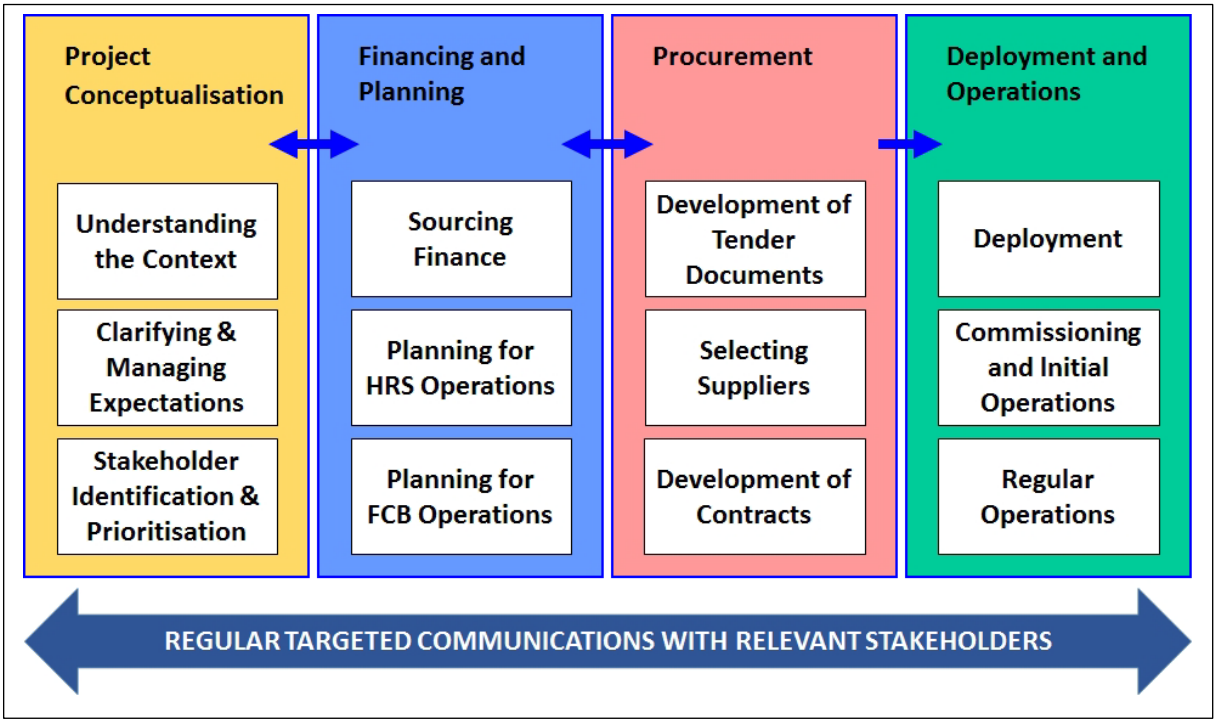
Section 5: Bringing it all Together – A Case Study in Best Practice

The Context

The year is 2021 and in European City X the local council has decided that due to the twin imperatives of improving air quality and meeting EU CO_2 emission standards and allied policies, public transport buses would need to move to fully emission free alternatives from 2023 onwards. As part of the region's decision to develop a hydrogen-based energy system, the local administration decided to acquire Fuel Cell Buses (FCBs). These decisions had strong and widespread political and community support.

It was decided to implement the FCB project along a continuum of stages as follows:



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 renewable energy, the relevance to local industry and to national and supra-national 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 renewable 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.; pooling hydrogen demand with other (large) consumers to achieve better prices)

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 including a spectrum of political actors, 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 dialoguing with interested PTOs.
- 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 PTOs 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.

FCBs were compared with BEBs and internal combustion engines (diesel and natural gas). The intent was to make the case for FCBs outright, on the grounds of cost, operations and synergies with other regional hydrogen use options.

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 their selected 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 at a fixed price.

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 fleet of cars, refuse collection trucks etc. 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 (within one kilometre of the bus depot) 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

4. Deployment and Operations Stage

Deployment

Once the procurement contracts were signed, the project leader focus turned preparatory activities that need to be undertaken before operating FCBs can commence. A timeline for delivery of the buses and the availability of refuelling had

been agreed as part of the contract. Some buffer was built into the timelines to manage any delays and also the expectations of all stakeholders.

Due to high demand the FCBs were not projected to be delivered for 12 months. The HRS was contracted to come online ahead of the buses to allow for a slow ramp up of the equipment.

HRS

A "hydrogen as a service"[1] supplier had been chosen for the HRS and a location site already identified prior to selecting the supplier. Site preparation work began as soon as possible. The site was close to, but not on the bus depot where the FCBs would be located. This was to facilitate refuelling in the timeframe acceptable to the PTO. The HRS also allowed for the possibility of scale up and for refuelling of other types of FC vehicles (cars, waste trucks etc.).

Bus Depot

Upgrade of the bus depot also needed to occur to both prepare maintenance arrangements and parking space so that e.g. safety requirements were adhered to. This included configuring the depot so that the FCBs and their battery electric and diesel counterparts in the fleet did not interfere with each other. A lot of the thinking work on this had been done by the project leader with the PTO at the Planning and Financing Stage, again with an eye to future needs for a fully zero emission fleet. The PTO had been provided with a grant to undertake this extra work and controlled the contracts to make it happen.

Route Checking

Having been an integral partner in the project, the PTO had also already identified the inaugural routes for their new buses. These were to be 'long run' routes ideally suited to FCBs with their range and flexibility. Two buses were to be dedicated to the "Clean Air" zone in the heart of the City to give the new technology good visibility. Methodical

[1] In this model, the FCBs simply turn up at the HRS and are refuelled. The PTO does not have responsibility for any of the refuelling infrastructure other than contracting and determining location.

checking of these routes now commenced in order to identify any unanticipated hazards for the somewhat taller (FC equipment on the roof) and heavier buses. This check would be repeated just prior to the buses coming into operations.

Awareness Raising and Training

The PTO and the PTA also worked together to schedule awareness raising and training for all the different groups of people coming into contact with the buses. These included:

- Maintenance technicians
- Drivers
- Refuelling/Cleaning staff
- All depot staff – with particular emphasis on safety
- First responders (Emergency Services)
- General Public

Refresher training was scheduled for those most involved to pick up on new employees. In the case of the latter two groups, advance awareness raising had been in place since the Planning and Financing Stage was completed and the procurement process had commenced.

As part of the contract, the bus supplier had agreed to a "Train the Trainer" arrangement where initial training was undertaken by the supplier and would be taken over by the PTO over a period time. Full documentation would be provided to the local trainers and a staff member of the bus supplier would remain available to the local people for support for an additional year as part of the contract.

Commissioning and Initial Operations

Despite every effort to synchronise the commissioning of buses and the HRS, the latter was delayed due to permitting issues. Back up refuelling arrangements (a temporary "mobile" refueller) had already been planned and were swung into action to coincide with the arrival of the first FCBs. As part of preparation of the community for the

introduction of the FCBs, a press release featuring photos of the new buses was released.

FCB Commissioning and Testing

Bus acceptance testing was carried out close to the intended depot and included the range of topography over which the bus would run. Some standard components were found to be faulty and quickly remedied by an on-site technician from the bus supplier using the onsite stock of spare parts. The time taken for these checks was longer than for a typical diesel bus, but this had already been factored into the planned start date of operations, as had the necessary training of drivers and technicians.

A “fire onboard a bus” simulation exercise was carried out involving the City first responders and relevant depot staff including drivers.

Bus data delivery systems specified by the contract were tested and found to be adequate to the needs of the PTO. The bus and HRS supplier were contractually obliged to resolve any inconsistencies in readouts and were able to successfully achieve this to meet the needs of PTO.

As part of a feedback system to their production line, the bus manufacturer retained their technician at site for a pre-specified period to give immediate feedback on identified faults.

HRS Commissioning and Testing

Despite the delays with the refueller already experienced, the project leader ensured that the HRS supplier followed the planned slow ramp up once it was ready to commence operations. This allowed identification and resolution of faults as they arose and gave an indication of where future issues may arise, informing what additional spare parts may need to be kept in storage locally. Hydrogen quality to the nozzle was tested as were H_2 pre-cooling and redundancy systems. The supplier’s onsite technician was able to handle all issues within the contract-specified half day timeframe.

During this ramp up period, FCB refuelling staff were also trained in understanding the system and their role in it and the HRS alarm system was tested through a simulation exercise.

Refuelling times were verified and found to be adequate with the pre-cooling in place.

Regular Operations

Having done a slow and methodical ramp up of buses and the HRS, the buses went into regular operations in a seamless fashion. The PTO had plans in place for back up diesel buses to be available should the FCBs have operational problems. These were accessed a couple of times due to driver concerns about dashboard messages suggesting malfunction of an FCB. All were found to be software issues and remedies without major loss of availability. The speed of fault resolution was partly due to a contractual arrangement on timely communications between a well-trained local technician and an "on call" technician at the bus manufacturer.

The City administration took the opportunity of the arrival of the buses to hold a public event to welcome the buses and to raise awareness about their benefits at a local and wider level.

Drivers, technicians, PTO administrations and the public were surveyed after a period of 6 months to gauge level of acceptance. Results indicated there was a high degree of satisfaction with the quiet and smoother ride among the public and with the ease of handling among the drivers. The PTO administration were highly satisfied with the fuel efficiency, the reliability and the reception of the buses by the public.

The HRS was not as reliable as the buses and suffered numerous shutdowns during the first 6 months period. These situations were mitigated greatly by the contractual backup hydrogen delivery service.

Further important points to note from the story:

20. Rigorous planning (including contingency planning) and contractual comprehensiveness will avoid or mitigate most of the typical challenges experienced in the Deployment and Operations phase
21. Unexpected challenges will be easier to handle by building buffer into your timeline for starting operations. You must expect delays
22. Have back-ups in place: both for the buses and for the HRS. While buses are very reliable by the standard of new technology, they will likely have teething issues as will the HRS
23. **Good Training and Maintenance = SAFE Operations**
24. Leverage the buses for showing the public you will be meeting European emission standards. It will encourage the use of public transport and be a source of pride for the municipality and region.