Interreg
North-West Europe
HECTOR
European Regional Development Fund

EUROPEAN UNION

Preparing for a Trial Deployment of Hydrogen Fuel Cell Waste Trucks

How to Specify, Procure, and Deploy Hydrogen Fuel Cell Waste Trucks

Summary

Introduction

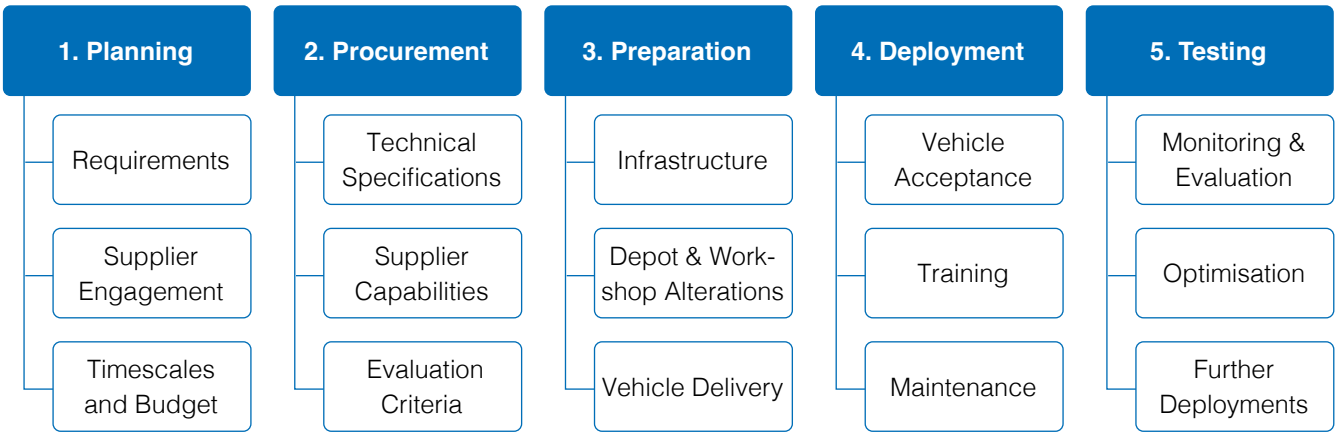
The purpose of this document is to help fleet operators to specify, procure and deploy their first fuel cell waste trucks by sharing the experience and learnings from a pan-European research and vehicle trial project.

The Hydrogen Waste Collection Vehicles in Europe (HECTOR) project aimed to demonstrate that fuel cell waste trucks can provide an effective solution to reduce road transport emissions. The project deployed and tested fuel cell waste trucks in seven pilot sites across North West Europe. Project partners collected information and data throughout the project phases including vehicle specification and procurement, training, maintenance, and real-world operational performance. This information was collated by Cenex – a not-for-profit research and technology organisation (RTO) based in the UK – and used to prepare this guidance.

This handbook is for organisations which have already decided that they want to trial or deploy an H2RCV. If you need assistance working out if hydrogen suits your fleet, please speak to other fleets using hydrogen vehicles or seek specialist technical support.

Fleet Guidance

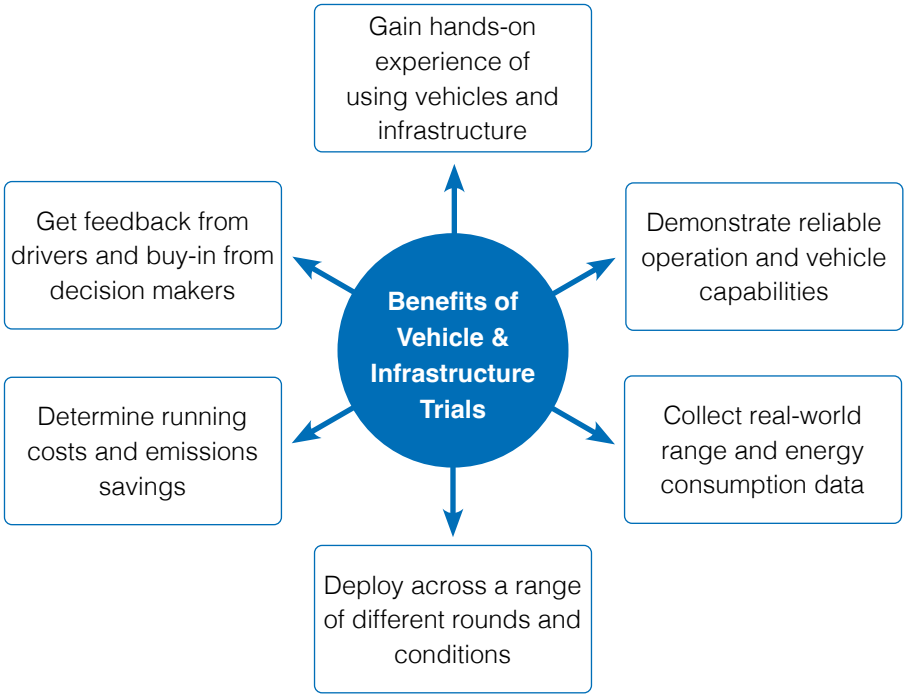
FCEV deployment requires an ongoing cycle of defining requirements, deploying vehicles, and testing and evaluating their performance to optimise operations and allow refinement of the technical specifications for the next generation of vehicles and hydrogen refuelling stations (HRS). This process is shown in the diagram below.



The key points from each part of the process are as follows:

- **Planning:** Before procuring fuel cell waste trucks you need to decide which vehicles need replacing, identify how and where the vehicles might be refuelled, and make sure that you have a good understanding of your vehicle requirements, operations, and round characteristics. Develop a set of vehicle and infrastructure requirements. identify and engage with potential suppliers, and determine a realistic budget and timescales.

- **Procurement:** Writing a good procurement specification is critical to ensuring that the vehicles and equipment are fit for purpose and offer value for money. Define output specifications, using learnings from pre-procurement supplier engagement as a guide. Ask potential suppliers for as much detail and supporting evidence as possible. Consider establishing a joint procurement framework with other similar fleets to consolidate orders and increase total market demand.
- **Preparation:** Ensure that refuelling infrastructure is available nearby or is installed and operational at the depot before the vehicles arrive. Upgrade your depot and workshop so you have a safe place to store, inspect, and maintain fuel cell trucks. Monitor the progress of the delivery of fuel cell waste trucks and infrastructure to ensure suppliers meet agreed timescales.
- **Deployment:** Build in time to make sure the trucks and infrastructure are working as intended, so that vehicles can be signed off and accepted into the fleet. Ensure that all staff involved have received training to operate and maintain the vehicles safely.
- **Testing:** Monitor and evaluate the performance of fuel cell waste trucks across a range of representative rounds and conditions. This allows you to optimise your operations to better suit fuel cell vehicles, plan for further vehicle deployments by refining your technical specifications, and develop a long-term strategy for fuel cell waste trucks and hydrogen refuelling stations. The benefits of in-service vehicle testing are shown in the figure below.



Scaling up Deployment

Following the testing phase, you should have enough information to understand the performance capabilities, infrastructure requirements, costs, and emissions savings potential of fuel cell waste trucks. This evidence should be used to produce or update your long-term hydrogen fleet and infrastructure transition plan and be used to refine the business case for funding further trials or future fleet replacement programmes. Depending on the outcomes of the testing phase it also may be necessary to revisit the case for using fuel cell waste trucks as the technology and market maturity improves over time.

Contents

1 Introduction

The purpose of this document is to help fleet operators to specify, procure and deploy their first fuel cell waste trucks by sharing the experience and learnings from a pan-European research and vehicle trial project. It was prepared by Cenex, a not-for-profit research and technology organisation (RTO) based in the UK.

Emissions from road transport continue to rise, causing environmental issues such as climate change and poor air quality that affect us all today, and will continue to do so in the future, unless we act now.

Alternative technologies, including battery electric vehicles, hydrogen fuel cell electric vehicles (FCEV) and internal combustion engines using renewable fuels, are all proven at a range of scales and in a variety of use-cases, but continued development is required to reduce costs and increase scalability.

The Hydrogen Waste Collection Vehicles in Europe (HECTOR) project aimed to demonstrate that fuel cell waste trucks can provide an effective solution to reduce road transport emissions. The project deployed and tested fuel cell waste trucks in seven pilot sites across North West Europe:

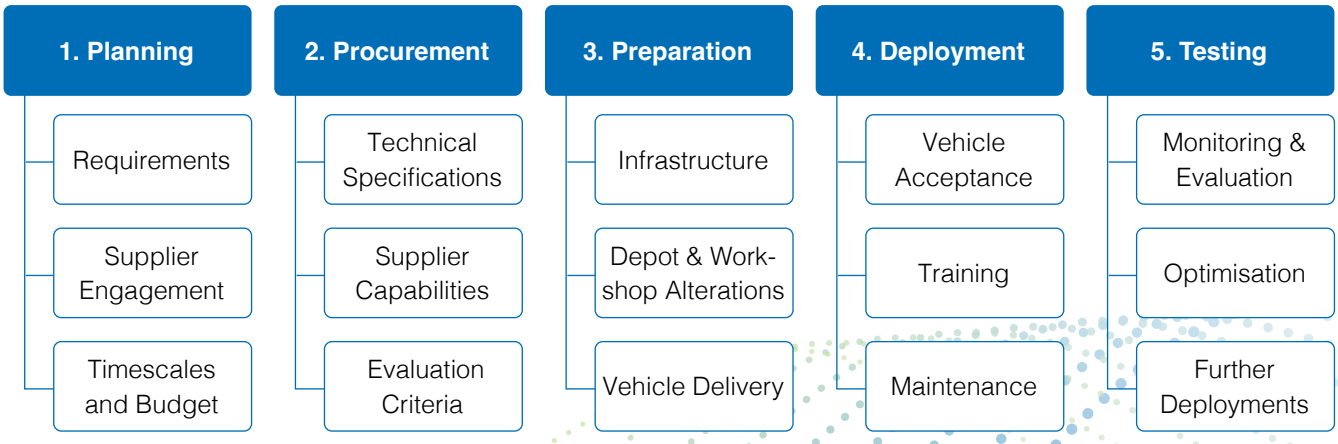
- Aberdeen (Scotland)
- Groningen (Netherlands)
- Arnhem (Netherlands)
- Duisburg (Germany)
- Herten (Germany)
- Touraine Vallee de l'Indre (France)
- Brussels (Belgium)

FCEVs are seen by some as a potential solution to decarbonise road transport. However, at the time of writing they are still in the research and development phase with few fuel cell waste trucks deployed across Europe.

The HECTOR project introduced fuel cell waste trucks into a wide range of fleets, covering different vehicle configurations and waste collection methods, and a range of operating environments from city centres to rural areas. By demonstrating fuel cell waste trucks under normal operating conditions, the project aimed to lay the foundations for upscaling and deploying fuel cell waste trucks within these fleets.

The purpose of this document is to help other fleet operators to specify, procure and deploy their first fuel cell waste trucks by sharing the experience and learnings of the HECTOR project partners. This document is primarily aimed at fleet, waste, facilities, and procurement managers involved in the procurement of new-to-market fuel cell waste vehicles. The HECTOR project partners collected information and data throughout the project phases including vehicle specification and procurement, training, maintenance, and real-world operational performance. This information was collated by Cenex and used to prepare this guidance. We have designed this handbook for organisations who have already assessed their zero and low-emission vehicle technology options and decided that they want to trial or deploy an H2RCV. If you need assistance working out if hydrogen suits your fleet, please speak to other fleets using hydrogen vehicles or seek specialist technical support before using this handbook. This document can therefore be used as the starting point for your own planning and preparations.

FCEV deployment requires an ongoing cycle of defining requirements, deploying vehicles, and testing and evaluating their performance to optimise operations and allow refinement of the technical specifications for the next generation of vehicles and hydrogen refuelling stations (HRS). This process is shown in the diagram below.



Case Study

Collaborative Working

In 2019, three European projects (HECTOR, Revive, and Life n Grab Hy) had deployed hydrogen-powered waste trucks.

- Interreg North West Europe partly funded the HECTOR project. HECTOR aimed to demonstrate that fuel cell waste trucks provided an effective solution to reduce emissions from road transport in North West Europe. The project deployed seven trucks at pilot sites across four European countries.
- The fuel cell and hydrogen joint undertaking (FCH JU) partly funded the Revive project. Revive developed and validated the technology necessary for the operating conditions of refuse trucks. The technology was tested by deploying 15 fuel cell refuse trucks across eight sites in three European countries.
- The EU-LIFE programme partly funded the LIFE' N Grab HY! project. LIFE' N Grab HY! addressed the critical issues of fuel cell garbage trucks and tested the vehicles under various operating conditions at ten sites across Europe.

All three projects aimed to show that fuel cell waste trucks offered a low-carbon, non-polluting, and quieter alternative to conventional diesel trucks. The projects signed a letter of cooperation to share and collect lessons learned and experiences across each project. The projects cooperated on creating awareness for fuel cell vehicles in waste collection through organising events, disseminating project materials and outputs, and sharing lessons learned and experiences from real-life operational conditions to help inform fleet operators, suppliers, and policymakers. The experiences shared helped inform this handbook.

2 Planning

Before procuring fuel cell waste trucks you need to decide which vehicles need replacing, identify how and where the vehicles might be refuelled, and make sure that you have a good understanding of your vehicle requirements, operations, and round characteristics.

In the detailed planning phase, you should produce an approved set of vehicle and infrastructure requirements, identify, and engage with potential suppliers, and then determine a realistic budget and timescales that can be approved by senior management before proceeding to the procurement phase.

2.1 Requirements

Once you have decided which vehicle(s) you intend to replace you should gather detailed information about their requirements, round characteristics, and refuelling patterns to ensure that potential suppliers can specify fuel cell waste trucks and HRS that are going to be fit for purpose throughout their operation.

2.1.1 Vehicle Requirements

Vehicle functional requirements should be captured from the waste manager, fleet manager, and fleet specification engineers. This information can then be used to specify the powertrain of the fuel cell truck (fuel cell system, electric motor, transmission, and power-take off) and the energy storage capacity required to meet the duty cycle requirements (number and pressure of hydrogen tanks, battery capacity and charging capabilities – if required).

This should cover the minimum requirements for the vehicle to be able to undertake its duties:

- **What is the vehicle going to be used for** – these requirements will be similar to a diesel vehicle including the axle configuration (4x2, 6x2, mid lift, mid / rear steer etc.), the maximum external dimensions, the body configuration (loader type, single or twin body, payload weight and volume for each compartment), and the bin lifting equipment specifications (number and type of bins).
- **How must the vehicle perform** – including the maximum speed required, acceleration, maximum gradient, and any additional power requirements from the ancillary equipment.
- **What are the round characteristics and intensity factors** – unlike a diesel vehicle a fuel cell waste truck will need optimising to suite the requirements of the application and duty cycle.

The table below shows an example of the characteristics of four rounds operated by Aberdeen City Council.

	WB3		MR2		BB1		BB2	
	Med	Max	Med	Max	Med	Max	Med	Max
Distance (miles)	35	50	29	40	27	48	28	53
Waste Collected (tonnes)	7.6	11.4	9.0	22.3	7.9	19.9	7.8	13.7
Number of Bins on Round	975	1,179	935	1,160	262	313	233	270
Operating Hours (hours:mins)	7:48	10:32	7:11	8:03	7:38	8:33	7:21	9:01
Elevation Gain (metres)	229	286	315	382	284	292	313	340
Diesel Fuel Consumption (litres)	46	60	48	75	42	66	45	60

Depending on your fleet and waste management systems it may be possible to get all or most of this data from a single source (like a round performance summary table) but if this is not the case this data can also be gathered from a combination of other sources like vehicle telematics summary reports, weighbridge records, route sheets, and fuel records.

Vehicle Requirements Recommendations

- Use best available data to summarise your key vehicle requirements and round characteristics.
- Specify your vehicle requirements for the most demanding day and make sure that you also consider the potential impacts of external factors such as ambient temperature, distance to HRS, traffic conditions, and battery and fuel cell system degradation over time.
- Select rounds and routes that maximise the chance of success but also provide the most benefits in terms of learnings and emissions savings.

2.1.2 Hydrogen Refuelling Requirements

To successfully deploy any FCEV, it is necessary to first plan how and where the vehicle will be refuelled, because building a permanent HRS can take up to two years from planning to commissioning.

Most of the HECTOR partners utilised pre-existing HRS operated by third party station providers.

If building a new HRS, it is necessary to understand:

- **The daily hydrogen demand** – generally the higher the hydrogen demand the lower the price of hydrogen dispensed per kg. Our experience in the HECTOR project is that one truck could use up to one full tank per day, which equates to approximately 15-20 kg. This is highly dependent on route characteristics, volume of waste collected, and other operating conditions.
- **The pressure at which the vehicle will refuel** – the waste trucks within the HECTOR project are mostly specified to refuel at 350 bar but can also be specified to 700 bar if required.
- **The type of contract offered and the resulting price of hydrogen** – for example will it be a 'take or pay' agreement for a minimum quantity of hydrogen or will it be pay at pump.
- **The timescales for commissioning the station** – to ensure that it occurs prior to the delivery of the vehicles.

2.2 Supplier Engagement

It is essential to communicate detailed requirements to potential suppliers before procurement to understand whether your project is feasible and to gather accurate information on the likely availability, specifications, performance, costs, implementation timescales, and risks of deploying fuel cell waste trucks.

Although it can be time consuming to engage with potential suppliers before procurement there are several benefits to doing so for both the buyer and the supplier:

- You can openly discuss your requirements with potential suppliers and establish whether suitable fuel cell waste trucks and hydrogen refuelling infrastructure are available.
- Engaging with a wide range of potential suppliers increases awareness of any resulting procurement and encourages competition which should mean that you have more choice of suppliers and vehicles.
- You can use the information gathered from potential suppliers to make informed decisions, write technical specifications, and set a realistic budget and timescale.
- Potential suppliers get a better understanding of your requirements and can decide how best to meet these needs, which encourages suppliers to provide innovative solutions to meet your specific challenges.

Engagement can be undertaken via webinars, face to face meetings or interviews, questionnaires and/or surveys, workshops, or supplier days.

Pre-market engagement must comply with procurement legislation and regulations. Avoid the risk of giving a supplier a competitive advantage by being open and transparent, maintaining commercial confidentiality, keeping a record of discussions, and ensuring that the process is fair and equal to all suppliers[1].

1 How to carry out early market engagement successfully – Procurement Essentials - CCS (crowncommercial.gov.uk)

Partner Case Study

WBD, Duisburg (Germany)

The team at Duisburg worked closely with their vehicle supplier prior to placing an order to assess their operations and analyse their routes and weights collected to allow them to tailor the fuel cell system and tank sizes to meet their needs. The 27 tonne FAUN BLUEPOWER vehicle was deployed in the fleet in May 2021 and has been in daily operation on residual waste collection routes within Duisburg. The truck typically empties over 900 bins a day which can be up to 20 tonnes over a 90 km route. To date the truck has driven over 30,000 km with zero emissions from the tailpipe.

Supplier Engagement Recommendations

- Identify and consult with internal stakeholders and document their requirements for vehicles, sites, and refuelling infrastructure.
- Undertake market research to identify potential vehicle, body and equipment, infrastructure, and fuel suppliers.
- Brief potential suppliers on your project objectives, specific requirements, and the process and timescales for suppliers to respond with the required information.
- Issue a formal request for information or expression of interest document.
- Ask potential suppliers about their track record and speak to other waste fleet operators about their own experiences of deploying fuel cell waste trucks (or other similar vehicles).
- Review responses, ask clarification questions, and score responses on key criteria to help make strategic decisions and to refine your internal business case.
- Decide whether your project is technically feasible and whether to proceed to the procurement phase or not.
- Incorporate feedback from potential suppliers and refine your requirements.

2.3 Timescales and Budget

This section provides an overview of the timescales and potential costs for the deployment of fuel cell waste trucks based on the experiences of the HECTOR project partners.

The delivery timescales and costs provided in this handbook are indicative. Costs vary greatly depending on factors including the vehicle and body configuration, product maturity, degree of competition between vehicle suppliers, and the supply chain complexity for vehicle and infrastructure components. It is the responsibility of the buyer to get accurate quotes before procuring fuel cell waste trucks or any associated infrastructure / depot alterations.

The fuel cell waste trucks used in the HECTOR project were supplied by low volume vehicle converters using a conventional diesel truck chassis with a fuel cell electric powertrain and fitted with specialist waste collection bodies and equipment.

The waste trucks in the HECTOR project were manufactured and quoted for between 2019 and 2020. The timescales and costs quoted here may reduce over time if the product and market maturity for fuel cell waste trucks increases.

Partner Case Study

Prezero, Arnhem (Netherlands)

Prezero identified that including drivers and frontline staff in the project is essential. Consulting with operational staff to help develop your specifications and inform discussions with suppliers will ensure that the vehicle fits users' needs. They can provide insight into the truck's day-to-day operations. For example, some drivers felt uncomfortable driving a FCEV truck on roads with a higher speed limit due to the lower engine power. You can pick up issues before specification by going on ride-a-longs on the routes or speaking to drivers.

2.3.1 Implementation Timescales

The table below shows an indicative timescale for each phase described in this handbook.

Phase	Task and Approximate Timescale
Planning	3-6 months for supplier engagement, detailed project planning, and business case.
Procurement	Varies significantly depending on public procurement processes.
Preparation (can be done in parallel)	3-6 months for depot and workshop alterations. 6-12 months for a temporary HRS (e.g. mobile or tube trailer); or 24 months for a new HRS including electrolyser. 9-24 months for vehicle build, homologation, and delivery.
Deployment	Allow 3 months minimum to ensure reliable operation before signing off the vehicle (could take up to 12 months in total).
Testing	3-12 months after initial deployment phase.
Operation	Standard lease / rental period for a fuel cell waste truck (5 years). Expected operational lifespan for a fuel cell waste truck (10 years).

Except for the procurement process, timescales are mainly determined by vehicle lead times and the time it takes to plan for and build an HRS if required.

2.3.2 Capital and Revenue Costs

The table below shows estimated capital and operational costs for deploying fuel cell waste trucks. It assumes that an HRS is available nearby or that a new HRS could be financed by a third-party provider with costs included in a fixed (per kilogram) hydrogen price.

Item	Approximate Cost (2019 to 2023)
Capital Costs	
Fuel Cell Waste Truck Purchase	€630.000 to €750.000 (3 times more expensive than diesel) or €6.500 to €11,500 per month to lease for five years.
Depot Alterations	€25.000 to €50.000
Maintenance Technician Training	€3.000 per technician
Driver Training	€1.000 per driver
Operational Costs	
Hydrogen Fuel Costs	~€15 per kg (€300 per 20kg tank for 120 to 240 km)
Maintenance Costs	€7.000 to €10.000 per year (truck only)

3 Procurement

Procurement of a fuel cell waste truck is more complicated and time consuming than for an equivalent diesel vehicle. As such, writing a good procurement specification is critical to ensuring that the vehicles and equipment are fit for purpose and offer good value for money.

The section summarises best practice for writing technical specifications for fuel cell waste trucks, assessing supplier capabilities, and deciding the evaluation criteria and weightings for each aspect of the responses from potential suppliers.

3.1 Technical Specifications

Include the following sections in your specification for fuel cell waste trucks and associated hydrogen refuelling infrastructure:

1. **Vehicle and Refuelling Requirements** – what does the vehicle need to do?
2. **Telemetry Systems** – what data needs to be collected from the vehicle and HRS?
3. **Delivery Timescales** – when must it be delivered and what steps are involved?
4. **Training** – what training is required for drivers, loaders, and maintenance technicians?
5. **Aftersales Support & Account Management** – how you expect issues be dealt with?
6. **Warranty** – what are your expectations for warranty periods and conditions?

Ensure that suppliers provide a detailed response to demonstrate how they will comply with regulatory requirements and standards, particularly those relating to type approval, controlling explosive atmospheres (hydrogen is a flammable gas so you need to ensure that there is sufficient ventilation, detection, and minimised potential sources of ignition), and transport and storage of compressed hydrogen (if applicable).

3.1.1 Vehicle and Refuelling Requirements

Write your specification by defining the required performance of the vehicle and refuelling infrastructure, rather than specifying how your requirements will be met.

An example technical specification for a fuel cell waste truck is summarised below.:

- Operating range without refuelling of up to 80 km (during collections).
- Up to 1,200 bins a day (180 litre bins at an average of 10 kg of waste each).
- Maximum single payload of 10,000 kg.
- Top speed of 90 km/h (56 mph).
- Refuelling time of no more than 20 minutes at a maximum of 350 / 700 bar.
- Operational for 5 days a week, 52 weeks a year, for 7 years (1,820 stop start cycles)
- Able to operate in ambient temperatures of -10°C to 30°C with cabin temperature set to 18°C.
- The vehicle should be able to fulfil these requirements without needing to refuel and with a safety margin of at least 20% of fuel remaining in the tank.

The specification should include a list of accepted evidence for vehicle performance figures. This could include independently monitored in-service trials, reports from a third party such as a testing house, or simulation software such as the Vehicle Energy Consumption Tool (VECTO) Municipal Utility Cycle[2].

Telemetry systems – telemetry systems with automated reporting capabilities should be fitted to vehicles and HRS to provide daily or journey summary data on the usage, performance, and energy consumption of fuel cell waste trucks. More information about data requirements can be found in the Monitoring and Evaluation Section of this handbook.

2 Vehicle Energy Consumption calculation TOol - VECTO (europa.eu)

3.2 Supplier Capabilities

Request detailed information about delivery timescales, what training will be provided and when, and what level of aftersales service will be provided. Service requirements should cover how quickly technical issues will be resolved, what measures will be in place to ensure the fleet can continue to operate, and warranty levels for each subsystem (e.g. vehicle, body, fuel cell system, battery, and refuelling equipment).

Delivery timescales – request a detailed delivery plan before placing an order and set a realistic deadline for the delivery of vehicles and infrastructure. Assess lead times quoted by potential suppliers to make sure they meet your requirements and decide whether to include any penalties for late delivery (such as providing replacement vehicles or equipment, or covering any costs incurred due to delays).

Training – define what training suppliers should provide for drivers, loaders, and maintenance technicians. Consider whether you want one-off training at the start, refresher training, or a 'train the trainer' program. More information about training plans can be found in the Training Section of this handbook.

Aftersales Support and Account Management – assess what level of support is required, covering servicing, maintenance, and repairs (including the availability of spare parts); timescales for responding to and resolving issues, breakdown and recovery, and options for replacement vehicles if needed. This information should be captured in a Service Level Agreement with contractual obligations for vehicle and service availability.

Warranty – assess the duration, conditions, and exclusions of warranties offered and make sure they cover the vehicle, body and lifting equipment, fuel cell system, battery, and electric drivetrain. As an example, to be eligible for the Office for Zero Emission Vehicles purchase grants in the UK fuel cell trucks must have a minimum warranty period of 3 years or 60,000 miles (96,500 km) for the vehicle, battery, fuel cell, and electric drive train, and the fuel cell stack must maintain at least 90% of its rated voltage for the initial five years (over which time a plug-in battery is also expected to have at least 70% of its initial rated storage capacity). These conditions conform to the requirements of Directive 1999/44/EC[3] but you should specify your own warranty conditions to meet your specific requirements.

Ask suppliers to provide evidence of their experience of delivering similar products and services. This could include case studies or testimonials from other customers or project partners.

3.3 Evaluation Criteria

Evaluation of suppliers' responses should focus on the technical parts of their submissions, their experience and track record, and in a mature supply chain their costs.

You should confirm that the proposed vehicles and infrastructure comply with your technical specifications and that bidders have provided sufficient evidence to demonstrate that the vehicles will be safe and fit for purpose.

Evaluate whether the supplier can deliver the vehicle to your required timescales, the support that will be offered during the commissioning phase, and the proposed approach to dealing with issues during ongoing operation.

As an example, you could evaluate tender responses on the following criteria to emphasise the need for suppliers that will work in partnership with you to deliver the best outcomes: 70% quality (30% aftersales support and account management, 20% delivery, 20% warranty), 30% cost, and a check of overall compliance with the specification (pass / fail).

Procurement Recommendations

- Consider which requirements are essential and which are desirable.
- Define output specifications, using learnings from pre-procurement supplier engagement as a guide.
- Ask potential suppliers for as much detail and supporting evidence as possible.
- Specify what training is required from the supplier.
- Specify automated data collection and reporting systems wherever possible.
- Consider establishing a joint procurement framework with other similar fleets to consolidate orders and increase total market demand.

3 Plug-in van and truck grant: meeting the warranty criterion - GOV.UK (www.gov.uk)

4 Preparation

There are three aspects to consider when preparing for the deployment of fuel cell waste trucks:

1. Firstly, you need to make sure that the required hydrogen refuelling infrastructure is either already available nearby or is fully installed and operational at the depot before the vehicles arrive.
2. Secondly, you might need to make alterations to your depot and workshop to make sure that you have a safe place to store, inspect, and maintain fuel cell trucks during operation (and that staff are appropriately trained to do so).
3. And lastly, you must monitor the progress of the delivery of fuel cell waste trucks (and infrastructure) within the overall programme timescales as they are specialist vehicles that undergo a multi-stage build that must be tested and certified to the required standards in the country that they will be built and deployed in.

4.1 Infrastructure

If the trucks will be refuelled from a public HRS, you may have to negotiate a fuel supply contract depending on the access arrangements (for example a take or pay, or exclusive use offtake agreement for a minimum quantify of hydrogen each day).

If hydrogen will be dispensed or produced at the depot, then the following preparations could be required depending on the solution provided:

Hydrogen production and dispensing on site (large demand at 350 and 700 bar):

- Lease agreement and a large footprint required for electrolysers, hydrogen storage, compressors, and dispensers.
- A large grid connection for an electrolyser to produce hydrogen on site (approximately 50 kWh is required for each 1 kg of hydrogen produced).
- Adequate water supply and water purification for the proposed hydrogen production scale (approximately 10 litres of water required for each 1 kg of hydrogen produced).
- Planning permission and compliance with relevant safety standards. The HyTrEc2 report[4] "Hydrogen Transport Legislation and Standards in the NSR" outlines the regulatory principles for the installation of HRS. .
- A power purchase agreement or direct connection to a source of renewable electricity.

Hydrogen dispensing on site supplied by a tube trailer (medium demand at 350 bar):

- Site power supply and planning permission for dispensing equipment only.
- A nearby source of green hydrogen that can be transported to the site.

Mobile refueller (small to medium demand at 350 bar):

- Space for one or more 20-to-40-foot containers with a single phase power supply.
- Relevant safety and risk assessments.
- A nearby source of green hydrogen that can fill the mobile refueller.

Hydrogen must be produced from renewable energy (so-called 'green' hydrogen) to provide zero greenhouse gas emissions at the point of use. For a short duration vehicle trial, it may be acceptable to use hydrogen produced from fossil fuels, as the purpose of the trial is to provide familiarity with hydrogen vehicles and infrastructure, and increase knowledge within the participating organisation.

Cost-efficient supply and distribution of hydrogen is only achieved when large volumes of fuel are being consumed[5]. Small scale hydrogen technology demonstration projects may find it more cost-effective to co-locate the electrolyser (hydrogen production) at the refuelling station. The use of renewably sourced electricity will result in the onsite generation of 'green' hydrogen with no associated greenhouse gas emissions.

4 Hydrogen Transport Legislation and Standards in the NSR , 2021

5 Business case and Economic Modelling for Green Hydrogen Production, 2022

Partner Case Study

Groningen (The Netherlands)

Groningen was one of the first European cities to deploy hydrogen refuelling infrastructure. HRS development has been ongoing since 2017. The first station has been upgraded, and now consists of an electrolyser, solar panels, and cascade storage. The solar panels ensure green hydrogen production. The cascade storage enables faster refuelling. The station has one dispenser with capacity for 19 FCEV passenger cars per day. More recently constructed HRS have multiple dispensers and far higher throughput of hydrogen.

4.2 Depot and Workshop Alterations

It may be necessary to upgrade your depot and/or workshop to safely store and maintain fuel cell waste trucks. Fleets should engage an expert organisation to audit your depot. The auditor should review the risk associated with operating and maintaining hydrogen vehicles within the depot, particularly concerning electrical safety, hydrogen gas detection and ventilation, and reducing any potential ignition sources.

There are currently no dedicated national hydrogen technology regulations or standards that specifically address hydrogen fuelling at fleet depots. However, a variety of European regulations and directives do apply.

A list of items that operators may need to consider is in Appendix B. Check your national regulations and seek expert advice before carrying out any works.

Most HECTOR partners already had their own facility to store fuel cell trucks. In certain circumstances, adjustments were needed to make the storage facility suitable for hydrogen trucks. Examples of these changes included:

- Installing safety signs and signals, fire extinguishers, and ventilation systems in the ceiling.
- Installing hydrogen sensors to open gates or ventilation systems.
- Securing safe distances in case of fire from the surrounding areas.
- Creating dedicated parking spaces for vehicles that also require electric charging infrastructure, in addition to access to a HRS.

The estimated costs of making the necessary changes to the storage facilities varied considerably within the project, ranging from €25.000 to €50.000 per depot. These changes could take from three to six months to complete.

Workshops must also adapt to high voltage working practices. When working with any high voltage powertrains (fuel cell or battery) several new working practices must be adopted by technicians.

Depot and Workshop Alterations Recommendations

- Any adjustments must comply with national and local regulations.
- Good practice for compressed and flammable gases must be followed.
- Good practice for high voltage systems must followed, specifically to eliminate accidental short circuits and spark creation.
- Manual handling policies for heavy loads must be in place and enforced.
- Frost protection points should be installed for overnight storage.
- In case of indoor storage automatic ventilation systems should be installed.
- For parking hydrogen vehicles outdoors, the above-mentioned safety procedures might not apply. Check your local legislation for more information.

4.3 Vehicle Delivery

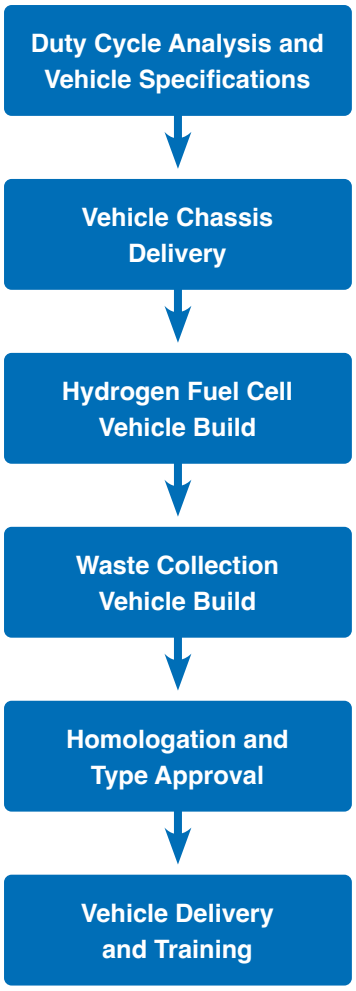
During the procurement process the lead contractor (e.g. the vehicle supplier) should be required to provide a detailed and realistic project plan for the delivery of the fuel cell trucks. This should identify interdependencies with any other suppliers involved in the project and also show the timescales and sequence for each individual phase.

Some suppliers might be able to provide a complete vehicle build from start to finish, but it is also possible that up to three suppliers could be involved in the process of building and delivery a complete vehicle (a vehicle supplier, a specialist fuel cell systems integrator / conversion specialist, and a body / equipment supplier). Additionally, these parties will also need to engage with the fleet operator throughout the project and potentially infrastructure suppliers to ensure that everything is ready before the vehicle is deployed.

In our experience a realistic timescale for vehicle delivery could be up to 9 to 24 months from finalising the vehicle specifications to deployment of the vehicle depending on critical path activities such as the lead times for ordering and delivering the chassis, and the complexity of the homologation process.

From procurement to vehicle delivery, you need to monitor progress at each phase and ensure that all suppliers are on track to meet your overall project timescales.

The figure below shows an indicative project plan for a first of its kind fuel cell waste truck.



Partner Case Study

Touraine Vallee de l'Indre
(France)

Deploying a novel vehicle can present issues when it comes to regulation and legal requirements. It is important to understand the implications of national law on purchasing a vehicle. The HECTOR project experienced this when one partner experienced challenges with the French certification process because it was a bespoke vehicle. This caused some delays and shows the complication in trialling unique vehicles. Ultimately due to the unresolved licence issue, Zöller & SEMAT decided to exchange the FAUN BLUEPOWER truck for a new vehicle, which is now Certificate of Conformity homologated and licenced in France.

"We've operated the hydrogen garbage truck for several months now, and we're proud to be able to give our first feedback to other territories.

This equipment is a real added value for us, both from an environmental point of view (zero greenhouse gas emissions) and in terms of improving the quality of life in the area and the quality of working life for collection team members (silent equipment, more pleasant and ergonomic driving).

If we had to do it all over again, we'd make the same choices!"

Alain ESNAULT, Vice-President of CCTVI

Partner Case Study

AGR, Herten (Germany)

AGR developed a good working relationship with their trucks supplier, E-Trucks Europe, throughout the project. They had regular check-ins with the supplier while waiting for the truck and accompanied the truck build and delivery process. Once the vehicle arrived on site, E-Truck employees went out with the drivers for the first few weeks to make sure things went well. Then after some issues, staff also accompanied the driver once a week every week. AGR gave themselves plenty of time to resolve problems before officially signing the truck off over a year later. They understood that a big part of training is needed to help staff to be patient and deal with problems when there is an issue.

5 Deployment

During the initial deployment phase, it is important to build in some time to make sure that the fuel cell waste truck and hydrogen refuelling station are working as intended and that any issues are resolved so that the vehicle can be formally signed off and accepted into the fleet. You should also ensure that all staff involved have received the right amount of training to operate and maintain the vehicles safely.

5.1 Vehicle Acceptance

Before deployment all staff involved should be briefed to get their buy in, establish what is required from them during the initial deployment, and let them know what to do if there are any issues with the vehicle or HRS. Fleets that have successfully deployed FCEVs have often appointed someone to 'champion' the project. This person could be an enthusiastic and engaged manager, supervisor, or driver.

Set realistic expectations that there could be challenges associated with deploying a new technology. At the same time, ensure staff understand the potential benefits of deploying FCEVs. Deploying new technology is often an iterative process. A single vehicle deployed for a short period can provide valuable learning. The lessons learnt in the first deployment should be taken and used as a foundation for a subsequent, larger, deployment (two or three vehicles for a year, for example). At each iteration, the knowledge, processes, skills, and confidence in the technology improves over time.

As specified during the procurement process, vehicle and infrastructure suppliers should be involved in this stage and be available to resolve issues. They should provide ongoing advice and guidance to operational crews to ensure they are getting the most out of the vehicles.

Most of the HECTOR project partners implemented a testing phase at the start of the truck operations, and some had diesel vehicles on standby to cover any arising issues. This testing phase can take longer than expected so it is important to include significant contingency in plans and budgets to address technical issues and maintain service continuity for the public.

Vehicle Acceptance Recommendations

- Staff should be briefed by the project lead and suppliers before the vehicle is delivered to make sure that they know what is expected of them.
- For at least the first three to six months vehicles should be deployed on fixed rounds with a dedicated crew to minimise variation.
- Fleets should only formally sign off the vehicle (and any subsequent orders) once it has achieved a certain level of quality and operational availability, for example as part of a service level agreement with the supplier.

5.2 Training

Most manufacturers offer some form of training on hydrogen vehicles for the drivers and the maintenance technicians; however, this is not formalised and differs by manufacturer. Within the HECTOR project, the level of training varied across the partnership. An example training plan is shown below.

- Early intervention by inviting drivers to meet with the manufacturer to get to know the vehicles before delivery;
- Short introductory training followed by more in-depth training once the trucks were delivered;
- Instructors from the manufacturer remained on site at the start of operations and followed the trucks in their vehicles to support training as drivers used the trucks on actual routes.
- Provide additional training on general hydrogen safety and refuelling as described earlier in this document.

A range of training organisations have begun to offer dedicated hydrogen vehicle training. Typically, this training falls into one of two types: electric vehicle maintenance and servicing training with additional

information on hydrogen (most suitable for fuel cell vehicles) and internal combustion engine training with additional adaptions from compressed natural gas and liquefied petroleum gas-based courses (most suitable for hydrogen ICE and dual fuel engines).

For example, UK based training providers offer IMI certified, NVQ, “City & Guilds”, and post-graduate certification training in a wide variety of hydrogen vehicle topics.

One example course[6] offered the following content (other courses and training providers are available):

Training Recommendations

- Clarify what training is provided by the manufacturer and when at the procurement stage.
- Ensure that any training provided adheres to legislation and is regularly reviewed in line with industry standards.
- Provide drivers with appropriate refuelling training prior to starting operations and provide refresher training at regular intervals to prevent misuse of the vehicles or refuelling station.
- Ensure training is provided to any new member of staff prior to working on, driving, or refuelling a fuel cell vehicle.
- It is good practice to “train the trainer” by having an expert trainer teach internal employees to become trainers themselves. These internal trainers can now train others within the organisation to the same standards using what they have learned.

6 Hydrogen Vehicles Technician

5.3 Maintenance

Ensure that workshop technicians are trained to safely undertake routine inspections and maintenance on the vehicle and body. Based on the experience of the HECTOR project partners it is better to use a specialist provider for maintenance of the fuel cell system, electric drivetrain, and hydrogen storage tanks.

Training Case Study

Kiwa Hydrogen Vehicle Technician Training

The training is based on the Dutch guideline PGS26 for CNG & LNG vehicles, adapted to hydrogen vehicles. The training focuses on basic knowledge about hydrogen production, infrastructure, and the use of hydrogen in vehicles, building equipment, agricultural equipment etc., and is intended for anyone interested in hydrogen-powered vehicles. The course is aimed at vehicle engineers, vehicle mechanics, fleet managers, service station staff, and anyone who is interested in hydrogen for vehicles.

Partner Case Study

Aberdeen City Council

(Aberdeen, Scotland)

With the use of a diagnostic laptop and trained staff, Aberdeen hope to minimise the down time of the vehicle, by no longer waiting on the availability of third-party maintenance. Aberdeen is able to contact the manufacturer directly with the information supplied by the diagnostics system, who can remotely log into the vehicle if required. Aberdeen has several mechanics who underwent previous training on other hydrogen vehicles and familiarisation training on HECTOR and have already undertaken repairs on the vehicle. The repairs take place in the designated hydrogen area of the workshop which had previously been adapted, by installing warning sensors, along with anti-static floor covering and new lighting in that area.

"Aberdeen has been working for more than ten years to position itself as a leading city in bringing hydrogen technology to market, and schemes like the HECTOR project have an important role to play. To meet our target of becoming a net zero city, it's vital that we move towards using cleaner and greener energy, so we are pleased to have the HECTOR truck as part of our fleet, complimenting the hydrogen and clean energy projects happening in our city."

Councillor Ian Yuill
Aberdeen City Council Co-leader

"Waste Service are willing to trial and introduce alternative fuel vehicles into its Fleet. Hector complements our existing hybrid hydrogen/diesel refuse collection vehicles."

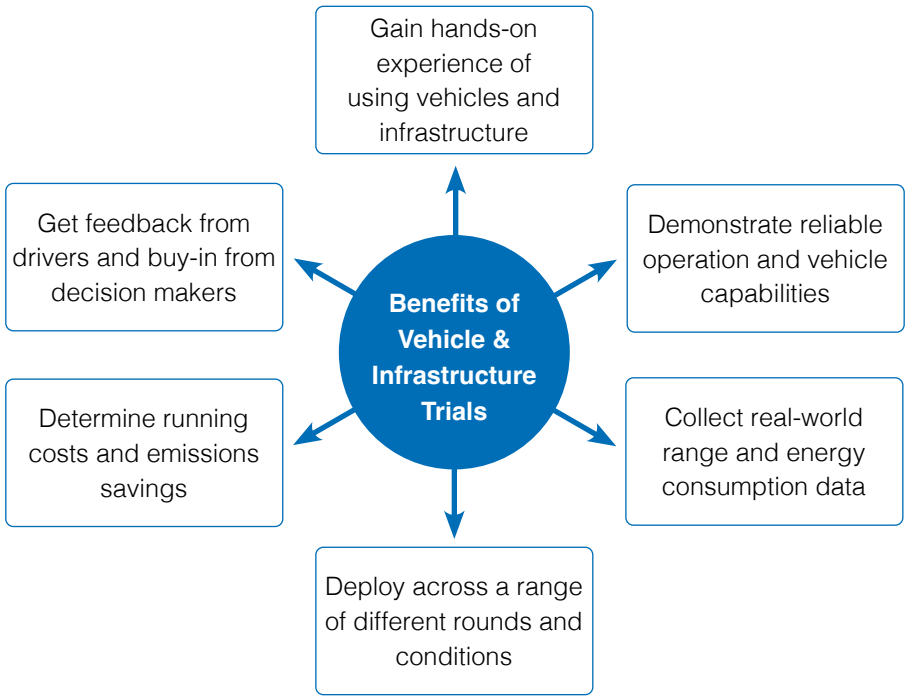
Paul McPherson
Waste Collection Service Manager

6 Testing

Monitoring and evaluating the performance of fuel cell waste trucks across a range of representative rounds and conditions is recommended so you can:

- **Optimise your operations** to better suit fuel cell vehicles.
- **Plan for further vehicle deployments** by refining your technical specifications.
- **Develop a long-term strategy** for fuel cell waste trucks and hydrogen refuelling stations.

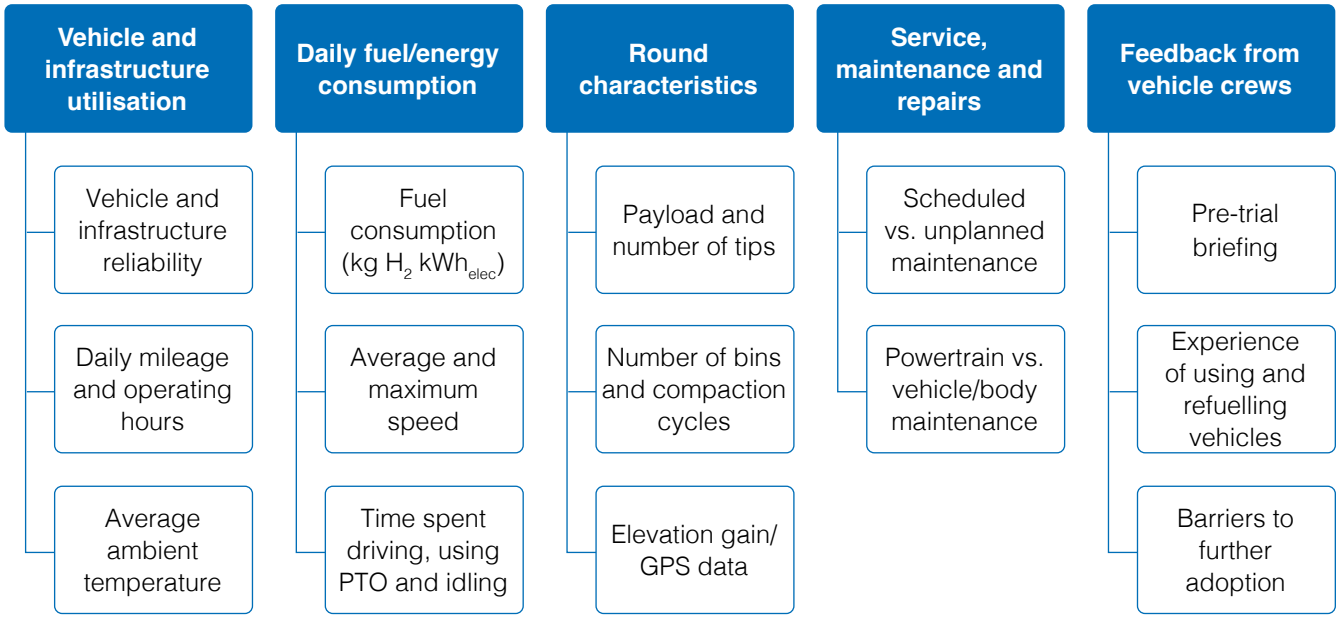
The benefits of in-service vehicle testing are shown in the figure below.



6.1 Monitoring and Evaluation

It is essential that fuel cell vehicles, waste collection systems, and HRS are all specified with the right data collection systems to measure the daily hydrogen / energy consumption and all the variables that can impact energy consumption.

Specify that suppliers provide monthly update reports or access to an online reporting dashboard that can provide the following data on a day-to-day or journey by journey basis (e.g. ignition on to ignition off):



Monitoring and Evaluation Recommendations

- Specify automated data collection and reporting systems during procurement. This should include data from vehicle telematics systems (including the fuel cell system and electric vehicle powertrain), waste management software, and hydrogen refuelling station.
- Consider what rounds and routes the fuel cell waste truck will operate on during the procurement phase. Select a suitable diesel baseline vehicle for comparison purposes.
- As a minimum the vehicle should be monitored for 9 months covering summer and winter months to understand the impacts of ambient temperature, heating and air conditioning, and road conditions on hydrogen consumption. Include busier collection periods such as public holidays to understand the impact of payload and number of tips on hydrogen fuel consumption.
- Assign roles and responsibilities for data collection and specify how frequently and in what format data should be submitted in.
- Make sure that vehicle data is reported on a daily or journey basis and consider refuelling with hydrogen every day rather than on demand to improve accuracy.
- Aim to get the most out of the vehicle by testing it on several representative rounds and make sure that the vehicle is well utilised (both in terms of operational days but also distance and amount of work done). This will maximise the learnings from the initial deployment and provide the best emissions savings / value for public money.

6.2 Optimisation

Following the initial deployment, you should have a better idea about whether fuel cell waste trucks meet your requirements and what can be optimised to improve performance or better accommodate the vehicles into your operations.

Examples include:

- **Optimising technical specifications** – it may be desirable to over-specify the first vehicles to ensure that they are fit for purpose then refine and optimise specifications for fleet-wide deployment to reduce costs. Optimise vehicles to perform better or consume less energy (e.g. by optimising motor power, gear ratios, fuel cell system, control strategy, or body and bin lift settings) or optimising the energy storage capacity to better meet the requirements of the rounds (e.g. optimisation of the hydrogen fuel tank capacity or refuelling pressure and optimisation of the battery).
- **Optimising rounds and operations** – conversely it might be possible to deploy more fuel cell waste trucks by also optimising the rounds and operations to better match the performance of the vehicles. This could include making operational changes such as incorporating refuelling into planned downtime or improving round design to better accommodate refuelling into planned routes. Alternatively, it might become clear during the testing that there are more suitable rounds to deploy the vehicle(s) on in which case they would just need redeploying.

6.3 Further Deployments

Following the testing phase, you should now have enough information to understand the performance capabilities, infrastructure requirements, costs, and emissions savings potential of fuel cell waste trucks.

This evidence should be used to produce or update your long-term hydrogen fleet and infrastructure transition plan and be used to refine the business case for funding further trials or future fleet replacement programmes.

Depending on the outcomes of the testing phase it also may be necessary to revisit the case for using fuel cell waste trucks as the technology and market maturity improves over time.

7 Further Information

The guidance provided in this document can support fleets to make informed decisions about the procurement and deployment of FCEV waste trucks.

For more information see the following online resources:

- **Cenex:** information and case studies on low emission vehicle trials and deployment: Cenex | Low Emission Vehicle Research & Consultancy
- **HECTOR:** more details on the HECTOR project HECTOR - Hydrogen waste collection vehicles in North West Europe | Interreg NWE (nweurope.eu)
- **Aberdeen City Council:** overview of activity in Aberdeen to demonstrate FCEVs Projects H2 Aberdeen | Aberdeen City Council


Ik rijd
op waterstof
Interreg
North-West Europe
HECTOR
pre
zero
E-TRUCKS EUROPE
27-BTD-9


Ik rijd
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North-West Europe
HECTOR

8 Appendix A:
Checklist for Depot Alterations for Fuel Cell Vehicles

Infrastructure & Equipment

The following list is an example of the types of infrastructure and equipment that may need to be considered when retrofitting a depot for hydrogen vehicles. However, the extent of works required will depend on the individual depot, whether maintenance will be carried out there, the number of vehicles and volume of hydrogen.

1. **Hydrogen detection system:** Due to the nature of hydrogen gas (no smell, clear, tasteless and highly flammable) it is important to be able to detect any leaks that may occur. Therefore, it is recommended to install a fixed hydrogen detection system with an alarm throughout the depot and / or workshop.
2. **Hydrogen detectors:** Handheld / portable hydrogen detectors are also recommended for use when carrying out maintenance activities. These can be directed towards the vehicle to detect levels of hydrogen.
3. **Natural air exchange / ventilation:** Air exchange within the depot and / or workshop may need to be improved to ensure that build-up of hydrogen in the event of a leak is minimised. Some vehicles may require a vent hose pipe to be attached when being maintained to safely guide a possible hydrogen leakage to the outside.
4. **Anti-spark floor / grounding:** The workshop floor should discharge static charges as per EN 61340-5-1 (Electrostatics. Protection of electronic devices from electrostatic phenomena) and grounding points and respective cables may be required to be connected to the vehicle during maintenance activities. Depends per country if this is necessary.
5. **Protective clothing:** All maintenance staff should be provided with the appropriate clothing to meet health and safety requirements. For hydrogen vehicles the key things would be non-flammable clothing and shoes to discharge static. Depends per country if this is necessary.

Processes

(depending on country, might not be relevant to some countries)

1. **Risk assessment:** A risk assessment should be developed and approved which assesses the maintenance activities, considering what could go wrong, and deciding on suitable control measures. These control measures should eliminate, reduce or minimise the risks of loss, damage or injury in the depot.
2. **Danger prevention plan:** Explosion prevention is fundamental and procedures outlining how an explosive atmosphere will be avoided is required.
3. **Emergency response plan:** Should be developed in conjunction with the appropriate emergency services e.g. fire, police, ambulance. This plan should outline the procedures to be undertaken in the event of an incident.
4. **Local Fire Service requirements:** the local Fire service should be informed of the vehicles early in the process and be kept informed throughout the project as they may have their own requirements to satisfy. For example, they may want to know where the nearest water connection is or want to review access to the depot. The local Police service may also want to be kept informed.
5. **Safety procedures addressing the secure management of suspected gas leaks:** procedures outlining how any suspected leaks will be dealt with within the depot are essential and will need to be prepared in advance of the vehicles arriving. It is essential for workers to be trained and fully aware of these procedures.
6. **Allowed standard maintenance & repairs:** A list of what maintenance and repairs can be undertaken within the depot and / or workshop must be prepared and approved by the manufacturer and client.
7. **Signalling and signposting:** It is essential to have appropriate signs within the depot which provide warnings on such things as no smoke, fire or sources of ignition within the depot. Signs showing the procedure for handling of hydrogen and the hydrogen systems would also be recommended.
8. **Hydrogen awareness training:** Awareness training should be developed and provided to all staff to encourage buy in however it is important to provide bespoke safety training to employees working in the maintenance depot and bespoke maintenance and repair training for technicians working directly on the vehicles.
9. **Refuelling strategy:** How and where the vehicles will be refuelled with hydrogen should also be considered. Refuelling should not take place within the depot unless in adherence to applicable international and / or local legislation.

Technical Note 1
Early market engagement procurement

Information for Suppliers/ Minimum requirements

Collecting information from the suppliers helps you to build a realistic procurement specification and process and to manage expectations of any trial of new technology. This template sets out the types of information you may want to consider requesting from a suppler. This includes how they will comply with all relevant regulatory requirements and standards, particularly those relating to type approval and transporting and storing compressed hydrogen (if applicable).

Once you have decided which vehicle(s) you intend to replace you should gather detailed information about their requirements, round characteristics, and refuelling patterns to ensure that potential suppliers can specify fuel cell waste trucks and hydrogen refuelling stations that are going to be fit for purpose throughout their operation.

Minimum vehicle requirements for the vehicle to be able to undertake it duties:

- What is the vehicle going to be used for?
- How must the vehicle perform?
- What are the round characteristics and intensity factors?

The template below provides some examples of the type of information you may wish to collect from a supplier. We have two templates one for vehicles and one for infrastructure. Review them alongside your requirements to create your own request for information.

1.1 Request for information template (RFI) (VEHICLES)

The purpose of this request for information (RFI) would be to gather data about product availability, technical specifications, delivery timescales, costs, and implementation considerations in Operational Fleets.

Instructions to sellers

Please return this enquiry reply document with information under section headings corresponding to the heading titles in this enquiry document. Each section has guidance text that you may overwrite or keep as you wish.

There are [number] main elements to this enquiry document. Please state clearly which of the topics you are responding to:

- Element 1
- Element 2

This enquiry document does not constitute a contract to supply, and it is understood that all provided prices are indicative and non-binding.

Summary of Answers

Describe the service, product, or support options that you could provide in delivering low-emission commercial vehicle and infrastructure trials.

- Vehicle types
- Technologies
- Locations that would be of most interest, including product availability or proximity to existing infrastructure and fuel supplies.

Previous experience

Please provide details of company experience regarding hydrogen demonstration projects, including size, location, and a brief description. Any other relevant experience and reference should also be detailed.

Information for Sellers

Specify number of vehicles for each location and the vehicle specification

Additional Notes and Comments

Please use this section to provide any additional comments. Suppliers should also state any assumptions that have been made and the potential impact on the accuracy of the information provided in the RFI.

Capital and Revenue Costs

Please provide a breakdown of the potential costs (Handbook section 2.3.2)

If costs vary by the scale of the trial, please provide a breakdown of costs for several options including key sensitivities such as numbers of vehicles.

- Capital cost:
- Predicted residual value or guaranteed buyback price at the end of the trial:
- Monthly lease / hire cost:
- Service, maintenance, and repair costs:
- Fuel costs:
- User training costs:
- Trial set up costs:
- Other costs (development / integration costs, telematics, project management):
- End of trial options to continue / expand:

Guarantees

The seller shall detail performance and equipment guarantees and warranties provided under this proposal.

Assumptions

The seller should state all assumptions made in the design and costing of the system.

Project management and Schedule

The seller shall detail the arrangement of contracting parties and expertise for this project, including specialist design work, main contractor and specialist subcontractors engaged in the project.

The seller's proposal should include an estimated timing schedule for works, including as a minimum.

- Planning
- Detailed design
- Lead times for key components
- Fabrication and manufacture
- Construction
- Commissioning
- Completion
- Disassembly and 'making good' at the end of the demonstration.

Operation and Maintenance, Warranty and Aftercare

The seller shall include a brief description of Operation and Maintenance (O&M) requirements and have an expected cost per annum for O&M support. These costs should include any replacement parts or site visit for software updates as required. Please provide details on the level of customer service / support you provide (including how long it's provided for and the costs). What are your Service Level Agreements for responding to and resolving any issues with the vehicle?

What warranty offers are available on a conversion for this type of vehicle, and over what duration? Please include costs and a breakdown of the items included.

Do you supply parts from your own stock to support vehicle repairs? If so, for how long and do you have indication of costs?

What is your experience of working with fuel cell waste truck's part suppliers?

Where are your ongoing customer support and spares suppliers located?

1.2 Request for information template (RFI) (INFRASTRUCTURE)

Instructions to sellers

Please return this enquiry reply document with information under section headings corresponding to the heading titles in this enquiry document. Each section has guidance text that you may overwrite or keep as you wish.

There are [number] main elements to this enquiry document. Please state clearly which of the topics you are responding to:

- Element 1
- Element 2

This enquiry document does not constitute a contract to supply, and it is understood that all provided prices are indicative and non-binding.

Summary of Answers

Describe the service, product, or support options that you could provide in delivering low-emission commercial vehicle and infrastructure trials.

- Technologies
- Locations that would be of most interest, including product availability or proximity to existing infrastructure and fuel supplies.

Previous experience

Please provide details of company experience regarding hydrogen demonstration projects, including size, location and a brief description. Any other relevant experience and reference should also be detailed.

Information for Sellers

Include Site information.

Specify Hydrogen delivery or generation

Schedule

The seller's proposal should include an estimated timing schedule for works, including as a minimum.

- Planning
- Detailed design
- Lead times for key components
- Fabrication and manufacture
- Construction
- Commissioning
- Completion
- Disassembly and 'making good' at the end of the demonstration.

Additional Notes and Comments

Please use this section to provide any additional comments. Suppliers should also state any assumptions that have been made and the potential impact on the accuracy of the information provided in the RFI.

We have spilt the next section into Infrastructure and dispensing of hydrogen for vehicles and Hydrogen fuel supply and storage. Depending on your plans for acquiring hydrogen (whether you are purchasing it or intending to make your own on site) you will need to choose different options.

Infrastructure and dispensing

Infrastructure for Zero and Low Emission Vehicles

Please provide as much detail as possible about your proposed infrastructure solution including schematics/ layouts of refuelling options.

- Availability and Maturity
- Product availability / production start date:
- Phase of the product lifecycle (introduction, growth, maturity, decline):
- Number of units sold or in operation:
- Lead times (system and component):
- Infrastructure Specifications
- Mobile, temporary or permanent infrastructure:
- Tank storage capacity and pressure:
- EV charging infrastructure power:
- Nozzle / dispenser / connector types and compatible vehicle types:
- Site Requirements

The seller should submit a design philosophy for the plant, a process flow diagram and a brief description and justification of each process step. Overall dimensions of each major component of the design should be submitted along with the general footprint of the facility. EU standards and regulations shall be adhered to. The seller shall estimate:

- Overall dimensions including any exclusion zones:
- Utility connections required (electricity, water, gas) and demand:
- Fuel delivered by trailer or generated / compressed onsite:
- Recommended number of dispensers:

- Refuelling times / dispensing rate:
- Number of back-to-back refuels / minimum time between refuels:
- Fuel monitoring system and reporting (including leak detection):
- Communication protocols between vehicles and dispenser:
- Outline plans for metering and back-office systems if the system is made available to non-depot staff:
- Training required to dispense hydrogen:
- Contingency planning for dispenser failure:
- Site staff safety training:
- Site staff maintenance training:
- Fuel supplier and source (location):
- Planning permission required:
- Site preparation required:
- Reliability and redundancy:
- Safety systems and emergency shut off:
- Standards / certification:
- Plans for decommissioning and 'making good' at the end of the trial:

Fuel Supply

Onsite hydrogen production

The seller should submit a design philosophy for the plant, a process flow diagram and a brief description and justification of each process step. Overall dimensions of each major component of the design should be submitted, along with the general footprint of the facility.

The design stages should cover as a minimum; maximum hydrogen generation capacity, hydrogen storage capacity, hydrogen storage pressure, compression systems, leak detection systems, emergency cut off systems and safe procedures of work for hydrogen generation.

The submitted design information should detail:

- Power demand
- Water demand
- Pressure vessel type and certifications
- Compression systems
- Approximated gas flow rates (for filling storage vessels)
- Additional power requirements of the system
- Maintenance plans and availability of replacement parts in case of failure (for example, compressor failure)
- If there is a preferred supplier for your system
- Site staff safety training
- Site staff maintenance training

Onsite hydrogen storage

The seller should submit a design philosophy for the plant, a process flow diagram and a brief description and justification of each process step. Overall dimensions of each major component of the design should be submitted along with the general footprint of the facility.

The design stages should cover as a minimum; maximum hydrogen storage capacity, hydrogen storage pressure, leak detection systems, emergency cut off systems and safe procedures of work for refilling storage vessels.

The submitted design information should detail.

- Pressure vessel type and certifications
- Trailer and cage costs
- Compression systems
- Approximated gas flow rates (both for filling storage vessels and dispensing H2 to vehicles)
- Additional power requirements of the system
- Maintenance plans and availability of replacement parts in case of failure (for example, compressor failure)
- If there is a preferred hydrogen supplier for your system
- Site staff safety training
- Site staff maintenance training

Hydrogen Fuel Supply

Please provide details of the proposed fuel supply agreement for relevant renewable fuels, in particular the level of demand and commitment required for a viable supply.

- Refuelling site(s):
- Access and account arrangements:
- Minimum fuel supply contract length:
- Minimum fuel demand / take or pay offtake agreement required:
- Unit fuel price at different volumes:
- RFAS approved supplier:
- Fuel production, import, and distribution locations:
- Environmental impact of fuel production:

Technical Note 2
Trial planning and checklist

Ensuring you have a proper vehicle deployment and trial plan is important to get the full value of testing new technology on your fleet. This template provides a check list for your vehicle trial and deployment planning. It aims to help you think through the different aspects of trialling new vehicles in operational fleets, to maximising learnings and minimise disruption.

1.1 Trial and Deployment Planning

	Development of trial options and comparison of key criteria
Determine which vehicle types to prioritise first	• Calculate fleet fuel consumption and greenhouse gas emissions contribution. • Compare to zero emission vehicle technology availability and maturity. • Consider targets and organisation strategies that may influence your decision. • Identify funding options.
Develop zero emission vehicle trial options	• Document vehicle requirements (range, payload, power take-off etc.) • Identify potential trial locations. • Engage with vehicle, equipment, infrastructure, and fuel suppliers to refine options.
Develop a project plan and set realistic timescales and expectations	• Site plans, prep, infrastructure installation, and vehicle commissioning ahead of the trial. • Finalise vehicle specs. Include timescales for vehicle build, delivery, and acceptance.
Develop a robust trial plan	• Determine the number of vehicles and trial duration. • Select the most suitable diesel baseline vehicles and rounds. • Include different operating areas and conditions for example, seasonal variation. • See tables below for ideas on how trial planning.
Determine data requirements	• Document data collection requirements, roles and responsibilities, data submission format and frequency. • Implement data quality checks and controls. • See Template 3 for more information on data requirements.
Refuelling Infrastructure requirement	• Ensure you have considered your infrastructure requirements and reliability. • Can your current infrastructure handle increase demand? • Are there any operational considerations about location or set up for refuelling infrastructure?
Staff engagement and training	• Ensure that drivers are fully trained and you have considered carefully their assignment to vehicles to ensure this will not confuse any data collection (at least for the duration of the trial monitoring period).
Service, maintenance, and repairs	• How will you manage scheduled and unplanned maintenance? • Do you need to make changes to in-house workshops? • What contingency plans are there for when the vehicle it not operational?

	Development of trial options and comparison of key criteria
Trial Reporting	This can be as simple as a short report or as detailed as a live dashboard. This should include reporting on: • Vehicle and infrastructure reliability. • Energy consumption. • Running costs. • Total cost of ownership. • Greenhouse gas and air quality emissions. • Feedback from crews.
Next steps	You should have a plan for what the outcomes of the trial will inform and next steps once the demonstration is over. • Reassess your options. • Develop a detailed zero emission vehicle fleet and infrastructure plan. • Plan for the vehicle post demonstration.

The vehicle trial plan can be synthesised into the following tables showing the agreed vehicle deployment plan by round type and vehicle registration.

Vehicles are colour coded according to the key below.

Vehicle 1	Vehicle 2	Vehicle 3	Vehicle 4

Round Type	Spring and Autumn			Summer and Winter		
	March	April	May	June	July	August
	September	October	November	December	January	February
Round 1						
Round 2						
Round 3						
Round 4						

In any project it is important to define the roles and responsibilities – below is a table with some key roles that you should ensure are covered prior to deployment:

Roles and responsibilities	
Senior responsible officer (SRO) for vehicle and infrastructure deployment	*Name, job title and email.*
Person responsible for vehicle and infrastructure deployment	*If different. Fleet manager or similar. Name, job title and email.*
Person responsible for ensuring sufficient energy is available for vehicle charging	*If different. Energy manager or similar. Name, job title and email.*
Other key personnel involved	*Names, job titles and emails.*

Technical Note 3
Vehicle and Infrastructure data requirements

When trialling a new vehicle it is important to consider you data collection requirements as early as possible. Listed below are the key types of data that will help you evaluate the success of your trial, you need to considered where you can get this data from, what format it is in and if it is not currently available whether you are able to put in place measures to collect it.

	Development of trial options and comparison of key criteria
Identifying information	• Vehicle registration • Date and time • Route ID • Driver ID
Daily fuel/energy consumption	• Fuel / energy costs • Instances of refuelling – date and time. • kg hydrogen dispensed.
Vehicle performance	• Fuel/Power usage • Daily mileage (miles) • Total amount of waste collected (kg) • Total operating hours (hours and minutes)
Round characteristics	• Round intensity indicator – Compaction cycles – Payload and number of tips – Number of bins collected • Elevation gain • Work type (types of waste collected and type of bins)
Service, maintenance, and repairs	• Scheduled vs. unplanned maintenance • Powertrain vs. vehicle / body maintenance
Notable Deviations	• Such as vehicle settings changed, adverse weather conditions, different route etc.

Example Data Sources

- Manual Driver Record
- Vehicle Telematics
- Odometer Readings (at start and end of shift)
- Instrument Panel (at start and end of shift)
- Trip Computer (reset at start of shift, recorded at end of shift)
- Dispenser data

Our Partners:

Contacts:

If you would like to know more about the HECTOR project:
Follow us on twitter @project_hector
Website: nweurope.eu/hector
Email: somondi@aberdeencity.gov.uk