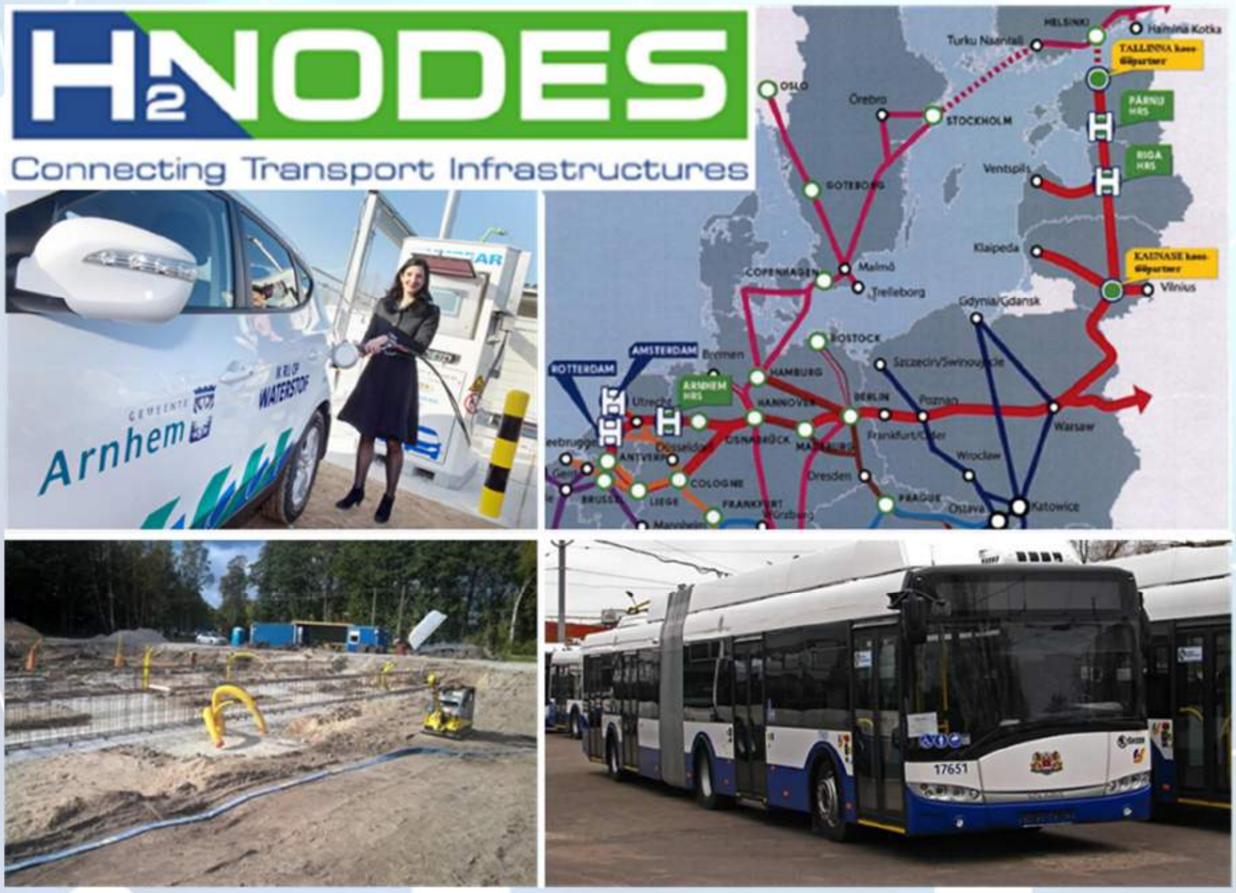
Milestones H2NODES
Milestone 19
Procurement of additional fuel cell electric vehicles



Milestone 19 Report

Date: 21 October 2020

Author(s): Trezors: Dainis Bošs, Aivars Starikovs, Jānis Fricsons, Ilvars Sirmais.

Infram: Robert van Hoof

This report was published on behalf of Rijkswaterstaat (part of the Dutch Ministry of Infrastructure and Water Management) for the Connecting Europe Facility project H2Nodes.

Co-financed by the Connecting Europe Facility of the European Union

Rijkswaterstaat
Ministry of Infrastructure and Water Management

Table of Contents

1. Introduction

The H2Nodes Action contributes to the evolution of a European hydrogen refuelling station (HRS) network by mobilizing local demand and value chains, with a focus on the deployment of public transport vehicles powered by fuel cells. It includes real-life trials of HRS development in combination with the deployment of fuel cell public transport buses in Arnhem, Riga and Pärnu. This action aims at ensuring continuity and growth of these new HRS sites and rising numbers of FCEVs (Fuel cell electric vehicles) along the TEN-T corridors[1].

This Milestone report is about the obvious first step towards reaching the long-term goals: using the H2Nodes experiences as both a basis and a source of information that can be used by public car and bus fleet owners to include the consideration and valuation of fuel cell vehicles in their procurement procedures and processes. It refers to the desired setting where fuel cell vehicles have a good chance of becoming the preferred option, based on their specific merits and their overall cost compared to available alternatives.

In order to make this Milestone as relevant as possible for a wide range of actors involved in the procurement of public fleets, this Milestone report:

1) is closely linked to the EU Green Public Procurement goals and policy guidelines;
2) is focused on the specific public service vehicle segments that are included in the H2Nodes real-life trial: public transport buses and passenger cars;
3) differentiates between the various roles public bodies can play with respect to the procurement of public service vehicles.

Ad 1) Green Public Procurement

This report includes an overview of the EU Green Public Procurement (GPP) goals and guidelines with respect to procurement of vehicles deployed to provide works, goods or services commissioned by the public sector and provided by the private sector[2] [3]. The GPP is a voluntary instrument, meaning that Member States and public authorities can determine the extent to which they implement it.

Chapter 2 provides a closer look at the GPP provisions related to transport as well as how the H2Nodes countries Estonia, Latvia and The Netherlands have incorporated these provisions in their national laws, regulations and/or purchasing practices. It specifically focuses on how the actions and regulations are set at these Member-States levels affect the fuel cell electric vehicles (FCEVs) opportunities.

[1] https://www.H2Nodes.eu/
[2] https://ec.europa.eu/info/policies/public-procurement_en
[3] Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles

Ad 2) Public service vehicle segments

There is no single European database that reports new registrations (or volumes of existing fleets) by type of owners. However, by combining different sources of information, a global indication of public service vehicle procurement can be created. Table 1 presents the outcome of this analysis[4]:

Purchasing/renting entity			Public		Private[5]
		Total (× 1,000)	Purchase (× 1,000)	Rental/lease (× 1,000)	Purchase/lease (× 1,000)
Heavy vehicle segment	HDVs	13	9	3	1
	Buses/coaches	13	8	1	4
Light vehicle segment	Passenger cars	70	53	16	1
	LCVs	10	8	1	1

Table 1. Estimated EU-wide average number of purchased public sector vehicles and vehicles deployed in public sector services that fall within the scope of the Clean Vehicle directive.

Chapter 3 describes the FCEV supply side: vehicle characteristics, availability and total cost of ownership developments for the following vehicle types:

- Heavy vehicle segment: buses
  Buses are included in this analysis because the creation of experience with the operation of fuel cell buses is one of the main objectives of the H2Nodes Action. Obviously, this vehicle segment is included in the further analysis with respect to the procurement of additional fuel cell vehicles. Table 1 shows that, measured by the number of vehicles, buses (including coaches) represent more than 90 % of the heavy-vehicle segment.

- Light vehicle segment: passenger cars
  Table 1 shows that the passenger cars dominate the light vehicle segment with a total share of about 90%, measured by the number of vehicles. Therefore, this report includes a specific analysis and assessment of the merits of FCEVs in public purchasing processes that include the delivery of passenger cars.

Chapter 4 describes the FCEV demand side on the level of Europe as a whole, supplemented by the specific experiences of the H2Nodes with respect to the organisation of public transport in general and the purchasing of public transport buses in specific. This is done for the following two distinctive public transport organisation models:

[4] Impact Assessment study for the review of Directive 2009/33 on the Promotion of Clean and Energy-Efficient Road Transport Vehicles Final report – Annexes Study contract no. MOVE/C1/2016-476/SI2.740207

[5] This refers to the private procurement of coaches to be deployed in private settings as well as buses to be deployed in public transport concessions commissioned by public entities and operated by private entities.

- Publicly operated bus transport
  This refers to the situation where a public entity operates the local/regional public transport. The procurement of the vehicles is done through tendering; thus, the public entity is fully in charge of the way the merits of FCEVs are included and valued in the tendering process. Rigas Satiksme is such a public (bus) transport operator. Chapter 4 describes this operator's experiences with vehicle procurement, especially with respect to FCE buses and FCEV trolley buses.

- Privately operated bus transport.
  In this organisation model the public sector role is limited to the outsourcing of public transport services to private operators through the tendering of public transport concession contracts. The actual vehicle purchase is done by the private operator who performs such a public transport concession. The privately operated public transport in Pärnu is described here. The province of Gelderland (where Arnhem is situated) recently commissioning of zero-emission bus transport through public tendering. Chapter 4 describes the overall tendering experiences in general and the position, merits and costs of fuel cell buses in specific.

Chapter 4 does not include an (experience-based) analysis with respect to passenger cars as there are no recent examples yet of public sector parties procuring FCEVs for other than demonstration purposes. The currently commercially available vehicles also don't match the type of passenger car required by most public entities.

Chapter 5 presents a concise summary of the findings and conclusions with respect to the procurement of additional fuel cell vehicles. This information will be furtherly used in ongoing actions with respect to the mobilisation and engagement of local actors in each of the regions (Arnhem, Riga, Pärnu) and also as background information in the Milestone 16, 17 and 18 reports.

2. Green Public Procurement

2.1 Introduction

The transport sector is responsible for about 25% of greenhouse gas emissions in the EU, with road transport accounting for the majority of these emissions. While vehicles have become more fuel-efficient and cleaner, the volume of transport has continued to increase greenhouse gas emissions as well as other emissions that adversely affect human health. There are many ways to reduce the environmental impact of vehicle ownership and use, such as the replacement of vehicles with an internal combustion engine with zero-emission alternatives, and the development of information and communication technology-driven new mobility concepts that do not require individual vehicle ownership.

Green Public Procurement (GPP) is defined in the European Commission’s Communication Public procurement for a better environment as “a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle when compared to goods, services and works with the same primary function that would otherwise be procured.[6] GPP includes the procurement of goods and services which with a sustainability performance that goes (far) beyond the thresholds of the bare minimum of legally allowed supply.

Although GPP is a voluntary instrument, it has a key role to play in the EU's efforts to become a more resource-efficient economy– especially given the importance of public sector spending on goods and services in Europe.[7] With respect to transport, GPP stimulates and assists all involved parties in a public procurement process to make this procurement more sustainable, for example by demanding zero emission vehicles or by favouring vehicles with no or low emission levels in the evaluation of available or offered alternatives.

GPP applies to all phases of a public procurement process.[8] Rules regarding exclusion and selection aim to ensure a minimum level of compliance with environmental law by contractors and sub-contractors. Techniques such as life-cycle costing, specification of sustainable production processes, and use of environmental award criteria are available to help contracting authorities to procure more sustainable transport and/or vehicles than they would have done otherwise.

As said before, GPP is a voluntary instrument, but the Member-State specific targets with respect to the procurement of clean vehicles are mandatory.[9] Table 2 shows the mandatory minimum required percentages of clean vehicles through public procurement per vehicle segment for Estonia, Latvia and

[6] https://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf
[7] https://op.europa.eu/en/publication-detail/-/publication/8c2da441-f63c-11e5-8529-01aa75ed71a1/language-en
[8] https://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf
[9] Ibid.

The Netherlands. Table 3 shows the adjustments in the definition of a “clean vehicle” per vehicle segment.

Country	Vehicle	2025	2030
Estonia	Buses (M3)	31%	43%
	HDVs (N2;N3)	7%	9%
	LDVs	23%	23%
Latvia	Buses (M3)	35%	50%
	HDVs (N2;N3)	8%	9%
	LDVs	22%	22%
The Netherlands	Buses (M3)	45%	65%
	HDVs (N2;N3)	10%	15%
	LDVs	39%	39%

Table 2. The clean vehicle targets defined as the minimum percentage of clean vehicles in the aggregate public procurement across a Member State. HDV = Heavy Duty Vehicle; LDV= Light Duty Vehicle.

The revised Directive defines a "clean vehicle" as follows:

Clean Vehicles	2025	2026
LDVs	<50g/km CO_2	0 g/km CO_2

Table 3. Definition of a clean Light Duty Vehicle (LDV) according to the Clean Vehicle Directive

Clean heavy-duty vehicle: any truck or bus using one of the following alternative fuels: hydrogen, battery electric (including plug-in hybrids), natural gas (both CNG and LNG, including bio-methane), liquid biofuels, synthetic and paraffinic fuels, LPG.[10]

As result, the Clean Vehicle Directive implementation will result in an increasing number of zero emission vehicles being procured by the public sector as well as the number of zero emission vehicles being deployed in transport commissioned by the public sector.

The following sections provide further details on green vehicle procurement in Latvia, Estonia and The Netherlands.

[10] https://ec.europa.eu/transport/themes/urban/clean-vehicles-directive_en

2.2 Latvia

The Public procurement law of Latvia determines the group of products, services and construction works[11] s where the application of green public procurement requirements, set by the Cabinet of Ministers of Latvia is mandatory. In all other cases of public procurement, contracting authorities shall at least give preference to products and services that meet these green public procurement requirements. This can for example be incorporated in the technical specifications, tender evaluation criteria and conditions for the performance).

The Green Public Procurement in Latvia may be used in order to procure alternative fuelled vehicles. Currently, the Green Public Procurement aspects are not mandatory for the vehicle procurements in Latvia. It is under preparation by the legislator that the Clean Vehicle directive thresholds will be included in the amendment of the national procurement law. With this amendment, the Green Public procurement of vehicles will become mandatory in Latvia in near term.

The requirements are set in terms of CO_2 thresholds per vehicle type. Table 4 shows the current threshold levels.

Vehicle type	CO_2 (g/km)
Mini	110
Small	120
Compact	130
Average	150
Large	170
Exclusive	270
Off-road	210
N1 I class	150
N1 II & III Class	220

Table 4. CO_2 threshold of Green Procurement guidelines of Latvia:

These requirements are translated into criteria per vehicle type.

For light duty vehicles: The vehicles must be at least EURO 6 in relation with the Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007.

For public transportation vehicles: Newly procured buses should be at least EURO 6. Given the average 10-year depreciation period of public transport buses, EURO 5 is currently the minimum threshold on the level of existing bus fleets.

[11] Public Procurement law of Latvia

The EURO 6 requirement is set as a minimum threshold. Public entities are encouraged to procure vehicles with lower CO_2 emission levels than this threshold by favouring alternative fuel vehicles (bio-fuels, BEVs, FCEVs, and hybrids). This can for example be done through a value-based procurement approach, which includes:

- mechanisms that set lower emission levels than EURO 6 as a minimum threshold in the procurement standards;
- mechanisms that improve the competitive position of suppliers of vehicles with emission levels lower than the minimum threshold with extra quality points for this extra value.

This means that extra value should be easily balanced and evaluated against the possible higher price. As for evaluation criteria in public procurements, the suggestion includes providing additional scoring marks for the proposals that are offering alternative fuel vehicles (Bio-fuel, BEV, FCEV, Hybrid solutions) and are offering vehicles with the lowest CO_2 emissions and noise emissions.

This may change when (near) zero emission becomes the new minimum threshold, also for the portion of vehicles that for example require longer driving ranges or short refuelling times. In order to ensure a level playing field for both BEVs and FCEVs the hydrogen refuelling infrastructure net in Latvia must be established as well as a network for BEV charging.

On 2019 the Intercity bus public transport service procurement was announced in Latvia. The procurement was divided in a number of. Each lot had set of criteria for various requirements, including the earlier mentioned green public procurement requirements, set by the Cabinet of Ministers of Latvia. The overall scoring was composed a set of financial and a set of technical sub scores. Suppliers that offered zero-emission-free buses (electric buses powered by fuel cell of battery)[12] received additional points:

Description	Rating scale in points
at least 10% of all buses are emission-free buses and they will be in service from 2021 onwards.	5
at least 10% of all buses are emission-free buses and they will be in service not later than 2025.	3
at least 10% of all buses are emission-free buses and they will be in service not later than 2028.	2

Table 5. Evaluation criteria for emission free buses in Intercity public transport services procurement of Latvia.

Procurement methods including incentives for public transport companies to deploy as many zero-emission buses as soon as possible are not yet in used in the tendering of intercity bus services. This specific transport requires the deployment of coaches. It is currently unclear when this bus type will

[12] http://www.atd.lv/lv/par-tiesību-piešķiršanu-sabiedriskā-transporta-pakalpojumu-sniegšanai-ar-autobusiem-reģionālās-2

become available. In the meantime, actions such as the CoacHyFied Action have been approved. The CoacHyFied action will seek the opportunity to introduce the intercity FCE-bus introduction in the EU market. Due to the limited availability of zero-emission coaches and due to the fact that coaches only play a limited role in public transport, coaches are not included in the scope of Clean Vehicle Directive.

The green public procurement requirements have not led to the purchase of FCEVs by public entities. The reason for this is that, in addition to the previously mentioned high prices of FCEVs compared to other (near) zero-emission vehicles, FCE passenger vehicles are not yet available in Latvia. The HRS development strategy is currently mainly focused on the public transport market. This development has just started, with the Rigas Satiksme HRS, commissioned as recent as 2020, being the first.

2.3 Estonia

The Estonia Public procurement Act promotes social consideration, innovation and sustainability with respect to public procurement.[13] Public road vehicle procurement must include provisions that take the energy and environmental impact over the entire service life of the vehicle into account. Additionally, public authorities have the possibility to purchase good on a predetermined fixed prices basis, and to assess competitive bid solely based on qualitative, environmental or social criteria. The promotion of energy efficiency in public procurements is based on the Energy Sector Organisation Act. Section 6 of the Act establishes the obligation for the central government to purchase only products, services and buildings that are highly energy efficient. More specific requirements are established with the Regulation “Energy efficiency requirements for the products, services and buildings purchased by the central government”[14]

Regulations with respect to the purchase of sustainable vehicles by the Estonian central government regulations focus mainly on the tyres the vehicles, and not the powertrain or fuel type. The central government shall only purchase tires that comply with the highest fuel efficiency class as defined in Regulation (EC) No 1222/2009 of the European Parliament and of the Council on labelling of tires with respect to fuel efficiency and other essential parameters (OJ L 342, 22.12.2009, pp. 46-58). In addition, via sharing best practices, the Ministry of Economic Affairs and Communications encourages all regional and local public sector institutions to follow the example of the central government and purchase only the products, services and buildings that are highly energy efficient.[15]

Between 2012 and 2014, Estonia built up a nationwide network of fast-charger stations in the framework of the Electro-Mobility Program. However, the number of registered new alternative fuel vehicles declined significantly between 2014 and 2015 after abolition of a support scheme demonstrating that without direct support, the transition to low and zero emission vehicles is unlikely.

[13] https://www.riigiteataja.ee/en/eli/ee/Riigikogu/act/513072020002/consolide
[14] https://www.riigiteataja.ee/akt/110032017016
[15] https://ec.europa.eu/energy/sites/ener/files/documents/ec_courtesy_translation_ee_necp.pdf

The Electro-Mobility Program helped to introduce slightly more than 1000 cars into circulation[16] The public authorities in Estonia could be the first movers to deploy alternatively fuelled. The fact that Green Public procurement provisions - other than tyres - are not well developed could also lead to a lagging share of low and zero emission vehicles in the public fleets.

	2021/8- 2025	2026-2030
Buses (M3)	31%	43%
HDVs (N2; N3)	7%	9%
LDVs	23,1%	23,1%

Table 6. Clean Vehicle Directive minimum vehicle procurement targets for Estonia17.

Taking that into account the thresholds of Clean vehicle directive, till 2030 proportion of zero-emission vehicle deployment compared to ICE vehicles is expected to increase. However, with respect to the public sector, this highly depends on the development of green procurement criteria to be included in public purchasing regulations and guidelines.

2.4 The Netherlands

Green Public Procurement with respect to regional public transport in The Netherlands is included and furtherly detailed in:

- The Administrative Agreement Zero Emission Bus Transport[18]. In this agreement all regional Public Transport Authorities committed to include the following sustainability aspects in the public procurement of public bus transport:
  - requirement: the entire public transport bus fleet is 100% zero-emission as from 2030;
  - requirement: each newly added public transport bus is 100% zero-emission as from 2025;
  - public bus transport operators are challenged to and rewarded for committing to the deployment of buses with lower emission levels compared to the emission levels based on a fleet that exactly meets the abovementioned requirements.
- The Administrative Agreement Zero Emission Special Purpose Public Transport (voluntarily signed by a number of municipalities that commission special purpose public transport) and the Covenant Zero Emission Special Purpose Public Transport (voluntarily signed by transport operators, industry associations and umbrella-organisations) include the

[16] http://www.baltic-course.com/eng/analytics/?doc=142676
[17] Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles
[18] BestuursakkoordZero Emissie Regionaal Openbaar Vervoer Per Bus, Amsterdam, 15 April 2016

commitment to 100% zero-emission special purpose public transport as from 2025[19]. The commitments of both the administrative agreement and the covenant are on a best-effort basis; there are no penalties in case the target is not achieved. One of the secondary goals is the gathering and sharing of knowledge with respect to zero-emission transport and the elimination of barriers to the implementation of zero-emission transport.

The remainder of Green Public Procurements is included as a theme within the framework for Sustainable Public Procurement (SPP)[20]. Other themes are: social conditions in global supply chains, social return on investment (SROI), procurement of biobased products, circular procurement, public procurement of innovation (PPI) and opportunities for SMEs (Small and medium enterprises).

GPP involves preventing or minimising any negative impact on the environment, or making a positive contribution to the environment, for instance through the creation of natural values. Six distinct topics have been identified in the environmental criteria documents drawn up by the government as a guide for purchasers: Energy and climate, Materials and raw materials, Water and soil, Quality of life (disruption, air and noise), Natural environment, biodiversity and space, Health and welfare (working conditions, human health, animal welfare).

Detailed environmental criteria documents have been drawn up for product groups that are commonly purchased by government bodies and that have a significant environmental impact (such as company cars or work clothing). As a public procurer, these environmental criteria documents will help to ensure that your procurement activities are environmentally friendly. They include both minimum requirements and award criteria. Suppliers must meet the minimum requirements to be eligible for a contract. Based on the award criteria, suppliers can be encouraged to further improve their environmental performance. Implementation of the minimum requirements contained in the environmental criteria documents is mandatory for all government procurements. Other government bodies have indicated that they will implement the minimum requirements set out in the environmental criteria documents, as standard, by 2015.

The SPP includes the description of best practices, model procurement documents and other comprehensive information specifically prepared specifically for public purchasers. SPP focuses on the environmental and social impact of procurement as well as the price of the products, services or works in question. SPP support the many different ways and phases of public procurement, by having relevant procurement documents and tools available that support the 1) prescription of minimum sustainability requirements, 2) encouragement of receiving products or services that exceed the minimum sustainability requirements and 3) invitation of the market to come up with sustainable solutions on a concrete product or service level. With respect to the green public procurement of vehicles or transport services, especially prescription and encouragement categories are relevant. The aspects and criteria with respect to the specification of requirements and the reward of sustainable

[19] https://zeroemissiedoelgroepenvervoer.nl
[20] Sustainable "Public Procurement This is how it's done!", PIANOo – The central contact point for sustainable public procurement

products and services exceeding the minimum requirements are included in a practical toolbox that can be used to accelerate and improve green procurement.

Within the transport and transportation section the toolbox provides practical guidelines and references in the following categories:

- international business travel;
- contract transport;
- service cars
- transport services.

The toolbox guidelines and references cover a wide field where potential criteria and rewards with respect to sustainability apply, such Euro emission standards, the use of alternative fuels, the availability of tyre pressure monitoring, cruise control, start/stop systems, noise emission, rolling resistance, lubricants and even water use for wash.

Figure 1 includes an example of one of the toolbox aspects that will lead to at least the consideration and possibly a preference for the deployment of fuel cell vehicles: a differentiated reward system for the deployment of various alternative fuel vehicles. enables the supplier to balance sustainability with price.

The final goal of public procurement is to come procure vehicles and services that may include aspects that include aspects where FCEVs may hold the better cards, but only if these aspects are recognised as providing overall extra value, also when the total costs of ownership are included. In some cases, such as garbage trucks FCEVs deliver the best overall mix of performance and price. In other segments, such as passenger cars and vans the limited availability of vehicles in various versions and models. As soon as fuel cell vehicles become more widely available at competitive TCO-levels, the sophisticated valuation of all vehicle characteristics which are considered to be of social, environmental and financial importance will result in substantiated preference for FCEVs in those cases and for those uses where the specific performance of FCEVs, such as the relatively long driving range and short refuelling time create demonstrably added value to the public services where they will be deployed.

GC A higher rating will be assigned when vehicles with alternative fuels/drive systems are used

Add +

Materials Energy Health

hide full item

If the vehicles to be used for the performance of the contract are designed to run on one of the alternative fuel types or drive systems given below, this component will be rated as follows:

	Percentage of use Year of commencement	Percentage of use Year of commencement X	Fuel/drive system	Rating	Score						
Alternative fuels	X%	X%	CNG/LNG	X	X						
Alternative fuels	X%	X%	Biofuels (in accordance with NTA8080)	X	X						
Alternative fuels	X%	X%	Green gas (BNG/LBG)	X	X						
Zero-emission vehicles	X%	X%	Hydrogen	X	X	Zero-emission vehicles	X%	X%	Electric	X	X
Plug-in hybrids	X%	X%	Petrol-electric/diesel-electric	X	X						
	X%	X%	Total		X						

Explanation

The award criterion can be designed in such a way that only the year of commencement is considered. It may be left up to the tenderer to choose when to use a particular vehicle type by including an entry field for different contract years (see table). The tenderer is responsible for proving that the vehicles offered are actually being used. The contracting authority must be able to test this by means of spot checks, for example, through access to the tenderer's fleet management system.

Verification

The tenderer may be asked to specify these properties in the vehicle technical data to be provided. Information such as the drive system can be looked up on the RDW website by entering the registration number of the vehicle.

Permalink

Figure 1. Toolbox example (evaluation of the deployment of alternative fuel vehicles).

3. FCEV supply side: OEM's and vehicle characteristics

3.1 Introduction

The achievement of the goal of this Milestone is that in the Arnhem, Riga an Pärnu area, and subsequently in the whole EU, more FCEVs will be procured by public sector fleet owners depends predominantly on the availability of FCEVs for various public services and their total cost of ownership (TCO) compared to especially BEVs. AT this moment BEVs and FCEVs are the only vehicle with zero-emission (tailpipe) emission. This chapter presents an outline of available vehicles, market developments and TCO-levels. This will be done for the vehicle types that were included in the H2Nodes real life trial: FCE-buses, "HyTrolleybuses" and FC+E-passenger vehicles. The result will however be EU-wide useful, as chapter 1 showed that public transport buses are a dominant vehicle type withing the heavy-duty vehicle segment and that passenger cars are widely used by the public sector in Europe.

Section 3.2 details the supply side of FCE-buses; section 3.3 does this for FCE-passenger cars.

3.2 Buses

3.2.1 Market development

OEMs are mainly producing FCE-buses for city public transport. A number of FCE-bus deployment stimulation programmes such as Jive & JIVE2, CHIC, 3Emotion are focused on scaling up the market, and bringing FCEV-bus costs down to a level comparable to that of diesel buses. Table 7`shows the number of alternative fuel buses in the EU in 2018-2020 [21].

	2018	2019	2020
PHEV	472	485	496
BEV	1,449	3,418	3,855
CNG	18,485	19,761	22,806
LPG	35	2	2
FCEV	38	41	66

Table 7. Number of alternative fuel buses in Europe.

Currently, most alternative fuel buses in the EU are CNG buses. The Member-State with the largest number of newly registered FCE-buses in 2020 are Germany and Latvia with 10 units each[22]. As for Latvia, the 10 units are trolleybuses that are equipped with fuel cell & hydrogen Auxiliary power unit (APU) and are deployed within the Action H2Nodes.

[21] https://www.eafo.eu/vehicles-and-fleet/m1
[22] https://www.eafo.eu/vehicles-and-fleet/m2-m3

FCE-buses are available in the EU market in different compositions: double-deckers, articulated-buses and 12m/18m units. Main OEM FCE-Bus units and their characteristics are listed below.

OEM	Model	Characteristics
CaetonoBus	H2.City gold[23]	Range: 400km Length 10,7m /12 m Passenger capacity 64 (10,7m unit) / 87 (12m unit). Refuelling time: <9min H2 capacity:37,5kg; Consumption: n/a
Mercedes-Bez/ EvoBus	Citaro FuelCELL Hybrid[24]	Range:594 Length: 12m Passenger capacity: 74 Refuelling time: n/a H2 capacity:35kg, Consumption 11-13kg/h2 per 100km
Safra	Businova H2 Fuel Cell[25]	Range:300 Length: 12m Passenger capacity: n/a Refuelling time: n/a H2 capacity:28kg, Consumption: n/a
Solaris Bus & Coach	Solaris Urbino 12 hydrogen[26]	Range:350 Length: 12m Passenger capacity: 37+1 Refuelling time: n/a H2 capacity: 5x312l, Consumption: n/a
	Trolleybus Solaris Trolino 18,75 H2.	Range: up to 150km (using Fuel Cell APU) Length: 18m Passenger capacity: 44 seated, 135 in total Refuelling time: 10 minutes H2 capacity: 18kg, Consumption: tbc.
Ursus Bus	URSUS CS12FCEB[27]	Range:450 Length: 12m Passenger capacity: 28 Refuelling time: n/a H2 capacity: 33kg, Consumption: n/a
VanHool	A330 Fuel Cell Bus[28] [29]	Range:350 Length: 12m Passenger capacity: 34+2 Refuelling time: n/a H2 capacity: 38,2kg, Consumption: n/a
VanHool	Exqui.city 18 Fuel Cell (BRT)[30] [31] [32] [33]	Range:300 Length: 18m Passenger capacity: 42+4 Refuelling time: n/a H2 capacity: 40kg, Consumption: n/a

Table 8. List of FCE-bus OEMs.

There are multiple FCE-bus manufacturers in the EU, some of which already produce several models. This is an important condition to achieve the ambition to develop a competitive market with affordable vehicle prices, comparable to current diesel buses.

3.2.2 TCO-development of FCEV buses

The procurement of public transport buses or the procurement of public transport services that include the provision of the required buses is done on a best value for money basis. The total costs of the order (the vehicle or the transport service) usually account for 80-90% in the overall evaluation of the bids. Quality factors (extra quality in addition to the minimum quality standards) account for the remaining 10-20%. It is therefore crucial for a supplier of buses of bus transport to be able to offer a competitive TCO.

With respect to the abovementioned factors fuel cell buses today are generally not yet cost competitive enough compared to the BEV and ICE alternatives, but they have the potential to break-even within 3-4 years and eventually reach lower TCO-levels.

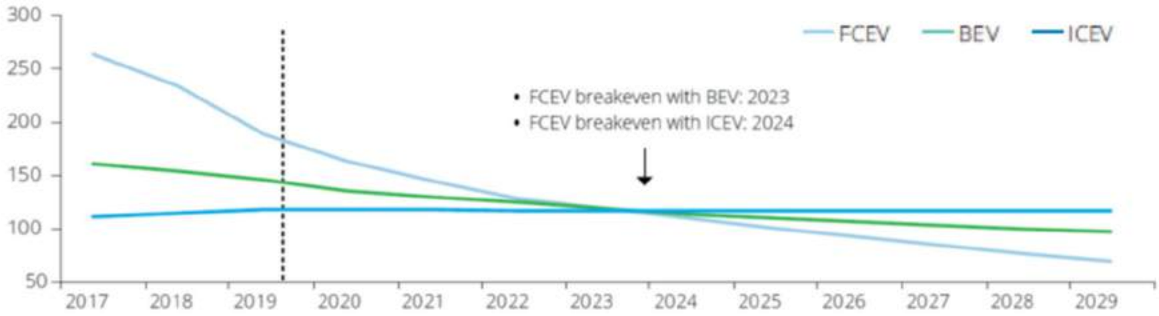
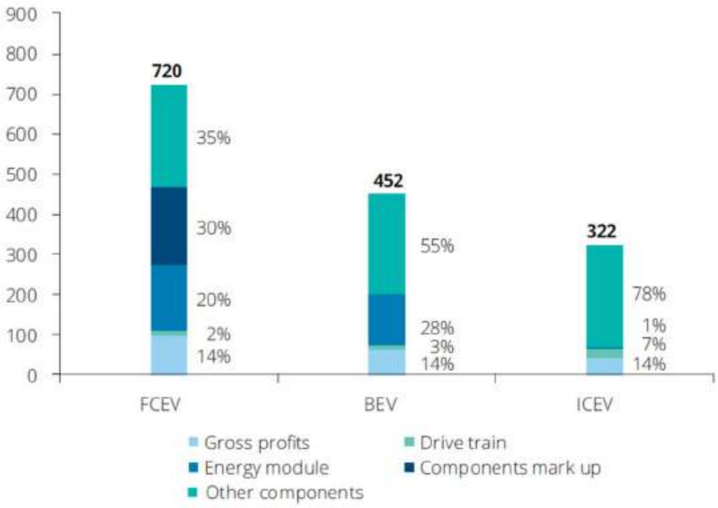


Figure 2. TCO outlook in Europe (USD/100 km) [34]

Generally, the TCO of fuel cell buses is currently not competitive enough as the TCO of BEV buses is about 20% lower and the TCO of ICE buses is about 35% lower than fuel cell buses. The most important factor that explains the current TCO difference between FCEV buses and BEV buses is the purchase price of the vehicle.



[23] https://caetanobus.pt/en/esta-ai-o-h2-city-gold-o-novo-autocarro-caetano-a-hidrogenio/
[24] https://www.fuelcellbuses.eu/wiki/concept-fuel-cell-buses/1213-meter-buses-fuel-cell-buses
[25] http://www.businova.com/en/range/hydrogen.html
[26] https://www.solarisbus.com
[27] https://ursusbus.com/en/buses/ursus-cs12fceb/
[28] https://www.greencarcongress.com/2018/03/20180301-vanhool.html
[29] https://www.vanhool.be/en/public-transport/agamma/hybrid-fuel-cell
[30] https://www.vanhool.be/en/public-transport/exquicity-brt/fuel-cell
[31] https://fuelcellbuses.eu/sites/default/files/documents/CHIC_publication_final_0.pdf
[32] https://www.venturasystems.com/en-4-234/van-hool-towards-a-fuel-cell-future.html
[33] https://www.vanhool.be/en/public-transport/exquicity-brt/fuel-cell
[34] Fueling the Future of Mobility Hydrogen and fuel cell solutions for transportatio, Deloitte, Ballard, 7 January 2020

Figure 3. 2019 Purchase price for a bus in Europe breakdown (USD/vehicle) [35]

The most important factors that are expected to contribute to the decreasing TCO-level of FCEV buses are:

- a lower FCEV purchasing price leading to lower depreciation costs as a result of a decline of the fuel cell system price of around 60% in the period 2019-2029;
- lower operational costs as a result of lower hydrogen prices and HRS costs.

The European JIVE initiatives are of significant importance to achieve these cost reduction goals. The overall objective of the JIVE initiatives is to advance the commercialization of fuel cell buses through large-scale deployment of vehicles and infrastructure so that by the end of the project, fuel cell buses are commercially viable for bus operators to include in their fleets without subsidy. These initiatives will deploy nearly 300 fuel cell buses in 22 cities across Europe by the early 2020s.[36]

In countries that have policies in place to increase taxes on diesel prices, the TCO of fuel cell buses is expected to become lower that ICE buses at around 2024, both as a result of the decreasing TCO of fuel cell buses and the increasing TCO of ICE buses. This is for example the case in the United Kingdom. There are not indications that this will also happen in Latvia, Estonia and The Netherlands.

3.2.3 Total Cost of Operation

The general TCO-levels presented in the previous section are usually a good indicator the potential of a product to gain a substantial market share. In certain cases, fuel buses may already be the better purchasing option compared to battery electric buses. TCO (Total costs of ownership) calculations are generally vehicle based, thus independent from the type of transportation service it will be deployed for and independent from the specific area where that transport service is delivered.

For bus operators the cost of their fleet is only one of many cost components. They will consider the Total Cost of Operations which is the cost of the public transport they offer. It is likely that in the following cases public transport operators may now prefer FCE-buses to battery electric buses in the following cases:

- On certain long-distance routes with no recharging infrastructure where the public transport requires either the deployment of multiple battery electric buses or only one FCE-bus.

- On certain long-distance route where a battery-electric bus can only recharge at a slow facility, taking a substantial amount of time and a paid waiting driver – where a fuel cell bus either does not need refuelling, or can refuel in about 10 mins.

Thus, with respect to the procurement of (additional vehicles), the following considerations apply:

[35] Fueling the Future of Mobility Hydrogen and fuel cell solutions for transportatio, Deloitte, Ballard, 7 January 2020
[36] https://www.fuelcellbuses.eu/projects/jive

- For the operator: not only calculate on the basis of TCO per vehicle, but for example of the total cost of operating a certain bus service. This includes cost factors other than the TCO of one vehicle, such as the number of vehicles required to operate the transport service, the salary cost of the bus driver, as well as for example the cost of risks mitigating measures, such as redundant vehicles or refuelling infrastructure in case of default;
- In all cases where the driving range or refuelling time are the reason to switch to FCEV buses: require guarantees from the selected OEMs to secure that actual performance is in line with expected performance.

3.2.4 Experiences with FCE bus operations in the H2Nodes Arnhem project

As part of the H2Nodes Arnhem project, operator Keolis/Syntus operated 2 fuel cell buses. As the opening of HRS Arnhem (also part of the H2nodes project) was delayed until July 2019, the fuel cell buses refuelled at a temporary HyGear HRS, also situated in Arnhem.

In March 2020 an interim report[37] was released about the experiences of the deployment of 2 fuel cell buses in regular public transport service. The following conclusions and experiences are relevant with respect to the procurement of (more) fuel cell buses and their deployment in public transport operations.

Passenger transport
The deployment the 2 fuel cell buses in regular public transport was easy, as the transport timetable based on diesel buses did not require any adjustments; the driving range and refuelling time of both buses were good enough to operate them in existing timetables. The refuelling experiences are generally positive, but vary with respect to the two refuelling facilities that were used. The temporary HyGear refuelling facility had an excellent performance, while the newly built facility was not always available, due to technical start-up issues. The passenger transport as such was never impacted as Syntus had diesel buses available as back-up.
The drivers are very satisfied with the fuel cell bus driving characteristics. Especially the fast acceleration was appreciated, especially during service at rush hours.

Fuel consumption
The fuel consumption equals an average of 6.1 kg/100km. This is significantly more efficient than the average, about 40% more efficient than the average fuel consumption reported by the High V.LO-Cityproject[38], and about 50% more fuel efficient than the comparable Citaro FuelCELL Hybrid (which has an average fuel consumption of 11-13 kg/100km, see table 8). It must be noted however that the fuel cell consumption rate varied with the use of additional electricity required for on board facilities. For one of the two buses an electric heater was required during winter months. This resulted

[37] "Hydrogen buses on the Veluwe - Interim report of the deployment of 2 hydrogen buses for passenger transport at Keolis, September 2018 – March 2020", 7 April 2020
[38] https://www.fuelcellbuses.eu/projects/high-vlo-city

in a 40% higher fuel consumption. The other bus used the heat from the fuel cell system, and did not require any additional heating.

Refuelling
As the Pitpoint-HRS Arnhem was delayed until July 2019 (opening), the buses were refuelled at a temporary HR, operated by HyGear. Both the temporary and the PitPoint-HRS are not centrally located in the Veluwe public bus transport concession area. Normally a refill takes about 30 minutes. However, given the peripheral location of the HRS, 80 minutes had to be added for the trip to and from the HRS.
The Hygear temporary HRS had an excellent performance with an uptime of nearly 100%. In July 2019 the buses switched to the new Pitpoint-HRS. This new HRS had compressor issues during the months after its opening which even made refuelling impossible in some cases. The routes that the fuel cell buses were scheduled for, had to be taken over by replacement buses.
Refuelling of both FCEV passenger cars and buses can cause interference in the sense that the refuelling time is longer if due to a recent previous refuelling the compression is limited.

Conclusion
The fuel cell buses are excellent zero emission replacements for diesel buses, with driving ranges of about 400 kilometres. The fuel cell buses were also reliable enough to be able to compete with diesel buses and proved to be about 40% more fuel efficient than average.
However, the Syntus experiences also show that the single dependence on an HRS operated by an external operator can come with for the bus operator uncontrollable risk of not being able to refuel and thus not being able to deliver the bus services as guaranteed in the concession agreement. It is unlikely that bus operators would accept such a risk, without additional demands for additional (back-up) HRS capacity or an exemption from payment reductions by the PTA, if such refuelling issues have a direct impact on their ability to comply with the agreed public transport service levels.

3.3 Passenger vehicles

3.3.1 Market development

In 2018, alternative fuel cars, including hybrid cars, only made up a small portion of the total European passenger car fleet; among newly registered passenger cars the number alternative fuel cars are low compared to the total[39].

According to available data, in 2020, the total number of alternatives fuel cars reaches slight uptake compared to previous years[40].

[39] https://ec.europa.eu/eurostat/statistics-explained/pdfscache/25886.pdf
[40] https://www.eafo.eu/vehicles-and-fleet/m1

	2018	2019m	Mid 2020
PHEV	108,197	140,422	143,765
BEV	131,939	246,787	152,543
CNG	65,835	68,851	24,195
LPG	161,938	180,057	41,555
FCEV	193	479	234

Table 12.Newly registered road vehicles in the EU in 2018, 2019 and the first half year of 2020

The previous table indicates that the share of cars with alternative fuels in the total new registrations increased from 2018 to 2020 in Europe. One of the reasons behind this is the variety of national government incentives to stimulate the share of cars with lower emissions, and the timing of when these incentives are introduced. These incentives include e.g. tax reductions, subsidies or specific privileges such as access to lanes reserved for public transport, free parking, etc. Another driver is the growing number and variety of alternative fuel passenger cars at more affordable price levels.[41] Additionally, the growth in availability of the necessary alternative fuels refuelling infrastructure affects the overall deployment of different vehicles.

The availability to refuel the FCEVs directly impact the FCEV deployment within the countries. Clean Vehicle directive does not affect the passenger vehicle deployment; thus, the hydrogen refuelling infrastructure development could secure that more passenger fuel cell electric vehicles (FCEVs) will be deployed within the next years. Within this report, the available units introduced in EU market are specified that are available for the users. The Hydrogen refuelling infrastructure is a critical part for the FCEV deployment and for the FCEV supplier in order to observe the opportunity to introduce the specific FCEV in the country. This outlines the aspect that more FCEV vehicles are deployed and also are available only countries whereas more Hydrogen refuelling stations are deployed. The FCEV deployment can be achieved only if the HRS infrastructure is implemented, therefore different EU co-funded actions with the scope to deploy FCEVs and HRS in the same location where implemented in the last years. These actions i.e. H2Nodes provided the opportunity to deploy the HRS in a country where the FCEV OEMs have not introduced their vehicles in the national market (i.e. Latvia, Estonia). Additionally, to that public entities can act as launching customers for FCEV passenger vehicle deployment.

[41] https://www.eafo.eu/vehicles-and-fleet/m1#

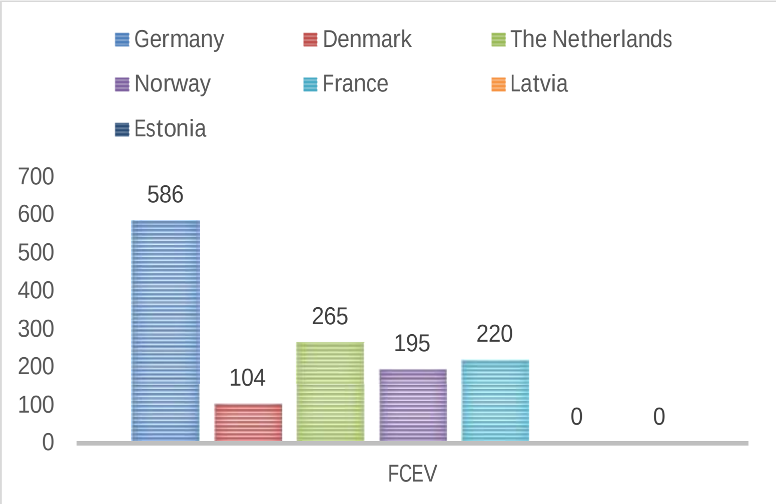


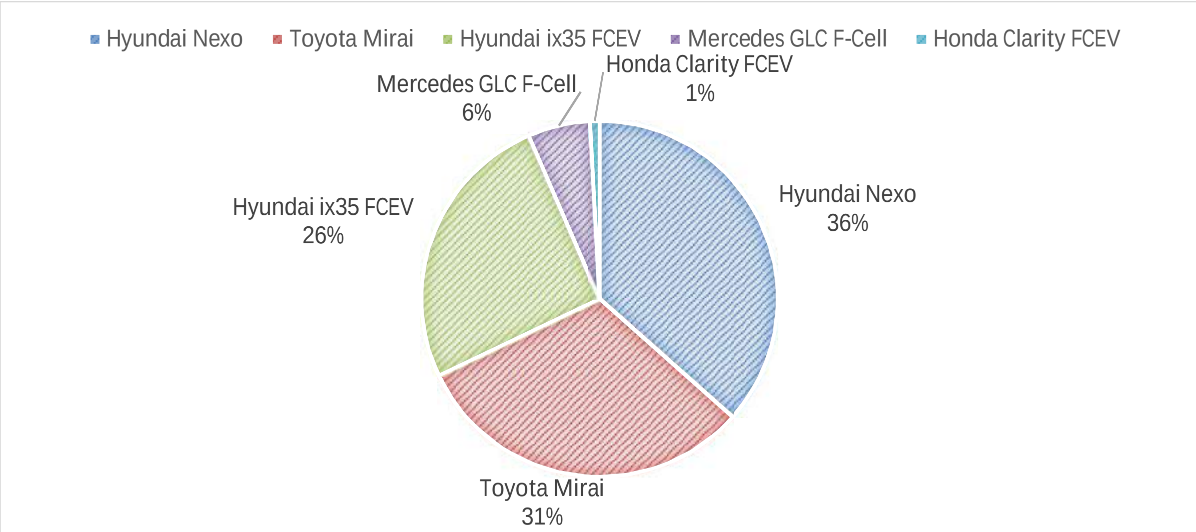
Figure 4. Total number of FCE passenger vehicles European countries (Q2 2020)

The total number of FCE-passenger vehicles in EU only reaches 1,348 units (2020 Q2). Considering the increase of FCE- passenger vehicle ongoing deployment in different projects, the total estimate could reach >2,000 units by the end of 2020. As for the FCEVs only three OEMs have introduced FCE passenger vehicles on the EU market. Only the major manufacturers Toyota, Hyundai and Daimler have experience with FCEV production in series.

OEM	Model	Characteristics	Available in EU
Hyundai	Nexo	Range: 666km[42] H2 capacity:6,343kg[43]	Available
	Ix35 FCEV	Range:594[44] H2 capacity:5,64kg[45]	Replaced by Hyundai Nexo
Toyota	Mirai	Range:500[46] H2 capacity:5kg [47]	Available
Daimler (Mercedes-Benz)	GLC F-cell	Range:400km on H2/ +50km on Battery[48] H2 capacity:4,4kg[49]	Available

Table 9. FCE-passenger vehicles available in EU.

Figure 5 shows the market share per FCEV model. The pioneers Toyota and Hyundai still dominate the FCE passenger vehicle market.



[42] https://h2.live/en/wasserstoffautos/hyundai-nexo
[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] https://h2.live/en/wasserstoffautos/toyota-mirai
[47] Ibid.
[48] https://www.daimler.com/products/passenger-cars/mercedes-benz/glc-f-cell.html
[49] https://www.daimler.com/products/passenger-cars/mercedes-benz/glc-f-cell.html

Figure 5. Breakdown of FCEV vehicles per model, 2020.

Other OEMs such as BMW and The Volkswagen Group announced the production of FCEV passenger vehicles.

BMW in cooperation with Toyota developed the BMW 5-series GT Fuel Cell Electric Vehicle prototype back in 2015. According to available information the BMW range would reach 500km[50]. However, it is currently not clear if and if yes when the BMW 5-series GT Fuel Cell Electric will find its way to the market.

The Volkswagen Group entered into a fuel-cell development program with Ballard Power Systems in 2013 to advance the automaker’s “HyMotion” (for Hydrogen Motion) technology. In 2016, Audi assumed the lead role in the effort, which is now scheduled to continue until summer 2022.[51]

3.3.2 TCO-development of FCEV passenger cars

As described in chapter 1, GPP is an important tool to achieve environmental policy goals relating to climate change, resource use and sustainable consumption and production. The public sector sets the goals and standards for vehicles emission reduction, but is also responsible for the procurement of vehicles and/or services that include transport. Public authorities also serve as an example of good practice with respect to for example the deployment of low/zero-emission vehicles in public service fleets.

The Latvian, Estonian and Dutch contracting authorities must take into account environmental impacts of publicly purchased vehicles. Sustainable factors such as vehicle CO2-emissions are taken into account. In most cases the purchasing decision of a vehicle or transport service is based on a trade-off between the extent to which such a vehicle exceeds the minimum sustainability requirements versus its cost during the period that such is vehicle is in service.

Public sectors fleet managers have the difficult task of making decisions between conflicting goals such as using efficiently the taxpayers’ money and green procurement goals. FCEVs and BEVs are both zero-emission (tailpipe) electric vehicles with differences in refuelling /charging times, driving range and total cost of ownership.

A 2019 study about a comparison of hydrogen and battery electric vehicles states the following[52]:

The TCO of BEVs is largely determined by the cost of the battery, in the case of FCEVs the fuel cell costs are dominant. At this moment, the TCO of an FCEV is higher than the TCO of a BEV. However,

[50] https://newatlas.com/hydrogen-fuel-cell-bmw-5-series-gt-prototype/38290/
[51] https://store.wardsintelligence.com/Media/Wards/Products/WAFUELC.pdf
[52] “Soft-linking of a behavioral model for transport with energy system costoptimization applied to hydrogen in EU”, Blancoa, Gómez Vilchezc,Nijsb, Thielc, Faaij, Renewable and Sustainable Energy Reviews 115, Eselvier 2019

both are expected to decrease. BEV batteries could reach a cost between 50 and 75€/kWh by 2040, while fuel cell cost could be reduced from 233€/kW to an ultimate cost of 25€/kW. While the most affordable BEVs in the C segment are being sold for around 30–35 k€ (plus VAT), FCEV sales are currently dominated by a single model in the D segment at prices higher than 80k€. Both powertrains currently have limitations: driving range and charging time are the main issues for BEVs, while fuel cell cost and lower efficiency are issues for FCEVs.

Figure 6 shows the forecast of the TCO difference between FCEVs and BEVs in various vehicle segments.

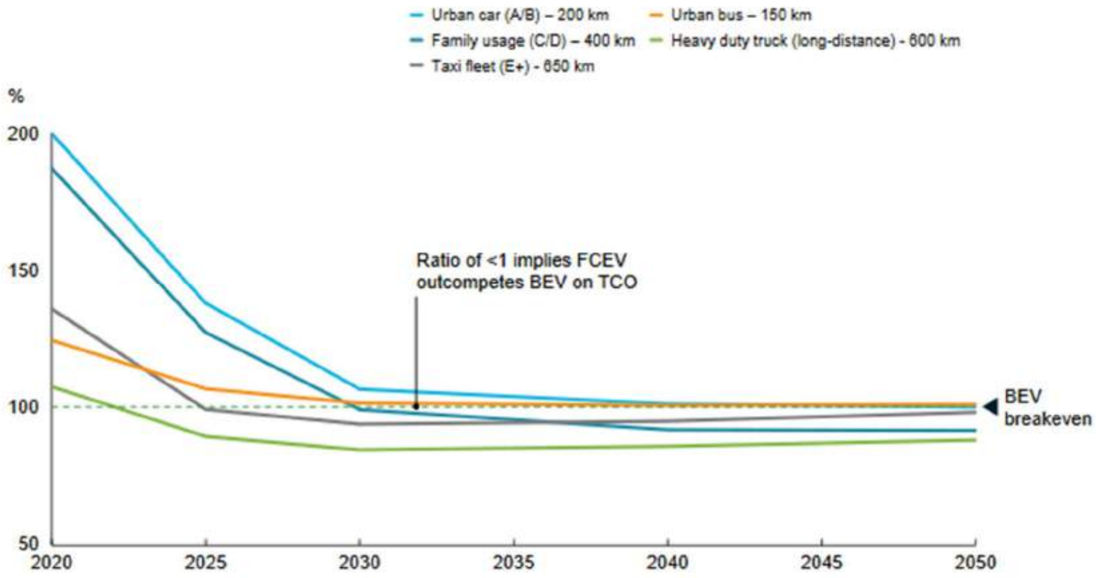


Figure 6. TCO ratio between FCEV/BEV vehicles[53]

The TCO difference between FCEVs and BEVs is currently more significant for passenger cars compared to the heavy-duty vehicle segment. As from 2030 the TCO of FCEV passenger cars is expected to at levels similar to BEVs.

With reference to the best value for money approach included in most green public procurement frameworks, this implies that the better performance of FCEVs with respect to driving range end refuelling time must be valued at a level that at least equals the TCO gap. However, the mobility needs of most of the public entities are well within the driving range of the BEVs currently in the market, without requiring charging during the daily service.[54] This basically means that in the next 10 years FCEV passenger cars generally are not expected to be the preferred zero emission public

[53] "Path to hydrogen competitiveness A cost perspective", Hydrogen Council, 20 januari 2020
[54] "Romeo Danielis1, Mariangela Scorrano, Marco Giansoldati, Stefano Alessandrini, "The Economic Case for Electric Vehicles in Public Sector Fleet", World Electric Vehicle Journal, 10 March 2020

service vehicles compared to BEVs. A recent statement of the city or Rotterdam in its hydrogen vision document illustrates the outcome this analysis: “Rotterdam will not use hydrogen for heating homes (residual heat is a more suitable alternative) or passenger cars and light commercial vehicles. Electricity is considered to be a more sustainable and cheaper alternative for this.”[55].

Finally, apart from the forecasted general TCO of FCEVs compared to BEVs, the availability of vehicles in the relevant segments is an even more important issue on the short term. For example, in The Netherlands, the Hyundai Nexo currently sells at EUR 83K (including 21% VAT) and the Toyota Mirai sells at EUR 80K (including 21% VAT). Municipalities such as Utrecht, Arnhem, Zaltbommel and Lelystad all procured Nissan Leaf vehicles. This vehicle sells at EUR 34K (including 21% VAT).

[55] Gemeentelijke visie op waterstof, gemeente Rotterdam, 21 juli 2020

4. FCEV Public Sector demand side: direct & indirect procurement

4.1 Introduction

Within the EU, there are several ways to organise public transport with buses. The two main models are[56]:

1) Operator Model.
The Public Transport Authority (PTA) procures and owns the buses. They can be then operated by the PTA (in this case PTA and operator are the same) or by a private public transport operator (PTO). The PTA procures buses from the market according to the EU regulation on procurement[57]. While the general rules of the procurement directives allow for green public procurement on a voluntary base, the European Clean Vehicles Directive (2009/33/EC) requires life-cycle costing (LCC) as a mandatory criterion to be included in the selection criteria for purchasing public transport service vehicles.

2) Concession Model.
The PTA tenders out he operation of the bus transport concession according to the EU procurement regulation[58]. The concessionaire provides both the buses as well as the transport service. As the total concession was tendered, the procurement of buses by the operator is not subject to EU public procurement regulation. The public transport tender can be technology neutral (with specifications for low/zero emissions and low noise levels), but it could also specify the use of a given technology. The level of detail of transport requirements varies among PTAs. Tenders are awarded to the tenderers whose bid produces the best value for money. The costs of the concession for the PTA are however the most substantial award factors, with an 80-90% share in the overall evaluation.[59]

The following sections describe the experiences from two H2Nodes partners with bus fleet procurement and management in relation to the organisation of public transport.

Section 4.2 describes situation for Riga, where public bus transport is organised in accordance with the operator model.

Section 4.3. describes situation for Pärnu county, where public bus transport operator is organized in accordance with the Regional authority.

[56] Public procurement of sustainable urban mobility measures, European Commission, June 2019
[57] Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles
[58] EU Directive 2014/23/EU
[59] Didier van de Velde, Competition in Public TransportAn Exploratory Research in Institutional Frameworks in the Public Transport Sector, TU Delft, November 2019

Section 4.4 describes a recently tender of public bus transport commissioned by the province of Gelderland, who organizes public bus transport in accordance with the concession model.

4.2 Riga Case, performed by the public body

Public transport operations in Riga are operated by RM LLC “Rigas Satiksme” (hereafter “Rigas Satiksme”). The municipality of Riga has full ownership of Rigas Satiksme, to which is has granted the exclusive rights to perform the public transport operations in Riga, based on Regulation[60] EC No.1370/2007. This regulation allows competent authorities to directly provide public passenger transport to secure – among other things – safer and higher quality service levels at lower prices compared to fully private operations. In this public transport organisation model, public authorities compensate public service operators for costs incurred and/or grant exclusive public transport rights in return for the discharge of public service obligations.[61]

As a publicly-held company, Rigas Satiksme directly receives the exclusive public transport right for the Riga without any prior competitive tendering procedure. In General, Rigas Satiksme is acting as a ‘internal operator’ that means a legally distinct entity over which a competent local authority (Riga Municipality), exercises control similar to that exercised over its own departments.

Rigas Satiksme is also the owner of the vehicle fleet and performs fleet management, including vehicle maintenance and replacement. The Clean Vehicle Directive and the Latvian green procurement suggestions will imply significant changes with respect to the replacement of the Rigas Satiksme fleet. Currently there are no mandatory low-/zero-emission thresholds for vehicle replacements. There are only minimum target requirements with respect to the portion of the fleet that has to meet more stringent emission standards, while allowing time for the adjustment of public procurement processes and market preparations. Moreover, the target for the buses procured in those reference periods to be fulfilled through the procurement of zero-emission buses strengthens the commitment to decarbonization of the transport sector in Latvia. It should be noted that trolley buses are considered to be zero-emission buses, provided that they run only on electricity or that they use only a zero-emission powertrain when they are not connected to the grid, otherwise they will not be regarded as zero-emission, but still as clean vehicles.[62]

On 2011, the Rigas Satiksme and Riga Municipality concluded that the public transport operation agreement would also include emission standards for the deployed public transport fleet, both the

[60] REGULATION (EC) No 1370/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2007 on public passenger transport services by rail and by road and repealing Council Regulations (EEC) Nos 1191/69 and 1107/70

[61] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32007R1370&from=LV

[62] Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles (Text with EEA relevance.)

existing fleet as well as fleet replacement. This includes different types of vehicles and exploitation periods: trolleybuses 12 years, M3 category buses 10 years and M2 category buses 5 years. This aspect must be considered by Rigas Satiksme in preparation of new procurements for vehicle units to deploy low-emission or zero-emission vehicles such as fuel cell electric or battery electric units.

Emission aspects must be incorporated into procurement procedures. As result, the public service contract requires Rigas Satiksme to comply with the Clean Vehicle directive by securing a fleet composition and emission level that meets the prescribed standards.

Within the Action H2Nodes 10 Trolleybuses with fuel cell & hydrogen APU systems were deployed. The preparation of the technical specification required the evaluation of the existing routes, comparison of existing vehicles and even usage of different alternative fuelled public transport vehicles.

4.2.1 Development of technical specification

In 2010 Rigas Satiksme tested a CNG bus “Mercedes Benz Citaro CNG”[63] in order to evaluate the possibility to deploy a number of CNG buses for public transport operations. The “Mercedes Benz Citaro CNG” was a 12m unit with total passenger capacity of 86 (35 seated). The average CNG consumption per 100km reached 37,6kg that resulted as 16% economic benefits compered to diesel powered buses used on the same route. On 2016 Rigas Satiksme tested a BEV bus, Solaris Urbino 12 electric. The different powertrain tests resulted as a need to look forward to FCEV usage in public transport operations. The CNG bus option did not provide the opportunity to solve the greenhouse gas emission level reduction in the city, while BEV charging times and range restrictions affected the bus unit availability due to the length of different routes. A 100% BE bus fleet would require a larger fleet to secure daily public transport operations.

Rigas Satiksme is responsible for the procurement of 10 Trolleybuses that are equipped with fuel cell and hydrogen systems[64]. Originally the procurement of 10 additional FCE-buses was planned (funded outside the H2Nodes action). The Riga HRS and HyTrolleybuses were funded by loan from European Investment Bank. The loan originally also was meant to fund the 10 FCE-buses in connection with the projects JIVE and JIVE2. However, the offered price from the suppliers where not feasible in order to introduce FCE-buses in 2017. As result, Rigas Satiksme withdrew its rights to procure 10 FCE-buses within the JIVE and JIVE 2 projects.

The open tender procedure was used due to the actual situation in the market and that only few FC bus OEMs are capable of developing a Trolleybus with fuel cell and hydrogen system.

The technical characteristics of the vehicle unit was aligned with the already used Trolleybuses in Riga. There were just a few minor changes necessary because of the fuel cell and hydrogen APU.

---

[63] https://www.rigassatiksme.lv/lv/aktualitates/Rigas-satiksme-13-autobusu-marsruta-testes-autobusu-kas-tiek-darbinats-ar-dabas-gazi-68/

[64] https://www.rigassatiksme.lv/lv/par-mums/iepirkumi/sarunu-procedura-par-ar-udenradi-darbinamu-transportlidzeklu-piegadi/

Taking into account the practice of CNG bus usage and BEV bus usage it was set that the FCEV units must secure same characteristics as ICE powered buses or existing trolleybuses with APU. Those 211 reference trolleybuses include units that are equipped with diesel APU, that are used in cases of malfunction of the catenary wire system or in routes where the system is not yet established. By route evaluation it was identified that there exist some of these routes where the bus route is extended only for a couple of kilometres to reach the suburbs of Riga, thus the catenary system is not deployed in those areas and a Trolleybus with APU could be used.

Public transport route system in Riga is developed in 1980 and some routes may be outdated and ready for alteration. The Hytrolleybus concept creates a possibility to consolidate the routes and, in some occasions, with possibilities to reduce the transport fleet. Evaluation of the existing diesel bus and trolleybus routes shows that in some cases it is possible to replace diesel buses with Hytrolleybuses.

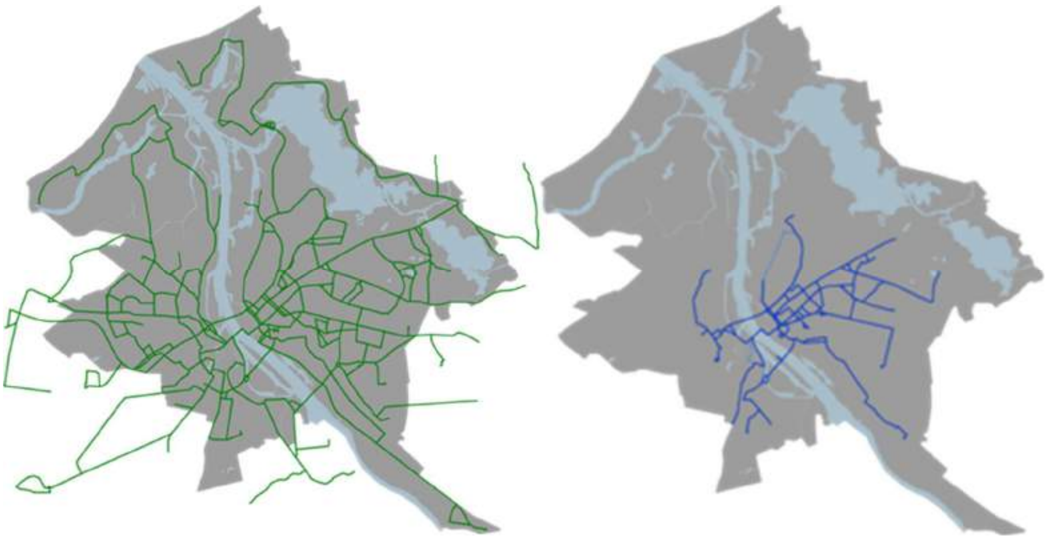


Figure 7 Bus routes (left) and Trolleybus routes (right) in Riga

Additionally, trolleybuses APUs are useful in cases of power outages as in such cases buses can continue their operations where they otherwise would have stopped. As trolleybuses also operate in the old part of Riga city, the emissions of diesel APU raised a problem. High buildings and narrow streets prevented the dispersion of produced emissions (such as particles), resulting in low air quality.

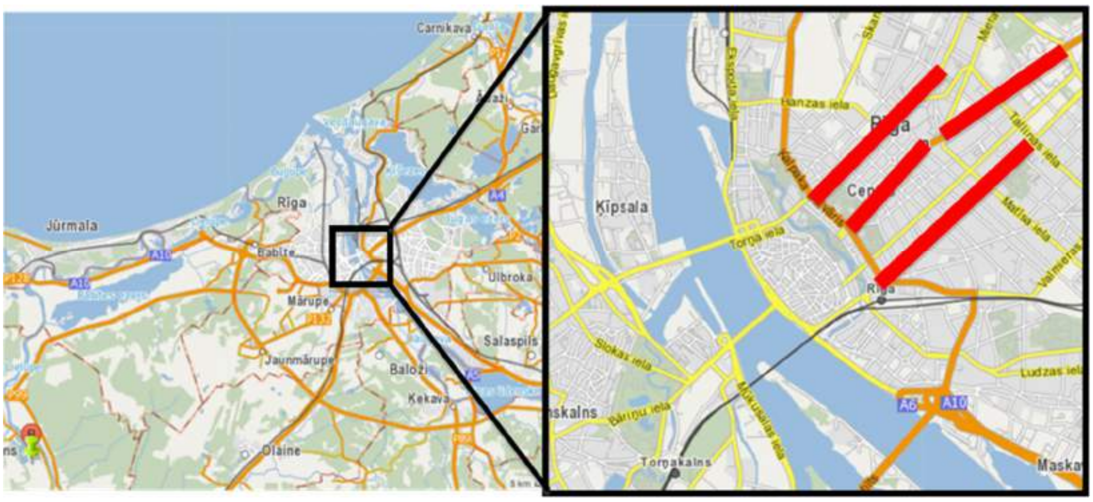


Figure 8. Canyon streets in Riga.

The new HyTrolleybus units had to be compatible with the already existing trolleybus catenary wire system in Riga and the overall construction had to be aligned with safety requirements.[65] As for the chassis the requirements included a low-floor articulated vehicle unit, as all new vehicles for public transport usage are mainly made with accessibility for the passengers with reduced mobility.

According to the technical specification, the dimensions of the HyTrolleybuses were similar to the existing trolleybuses:

- Length – 18,75m (-4%)
- Width – 2,55m.
- Height – 3,60m (including the equipment that is mounted on the roof).

[65] Regulation No 107 of the Economic Commission for Europe of the United Nations (UNECE) – Uniform provisions concerning the approval of category M2 or M3 vehicles with regard to their general construction (2015/992) annex 12. Additional Safety prescriptions for trolleybuses.

Figure 9. Rigas Satiksme HyTrolleybus.

One of the main vehicle requirements for the public transport operators is the maximum number of passengers that could be transported with one vehicle unit. For the HyTrolleybus this include a minimum of 135 passenger including36-44 seats, room for 8 persons per square meter standing and special places suitable for wheelchairs. The HyTrolleybus exploitation characteristics that were specified in the technical specification were aligned with the actual operational data of other trolleybuses that already were in operation in Riga:

1. Average route of trolleybus – 17km.
2. Average range between the bus stops – 520m;
3. Average drive speed during the public transport route 16 km/h.

As one of the specific requirements is the potential operation in different whether conditions i.e. -40ºC till +40ºC (relative humidity 98% at +25 C).

Specific conditions related to fuel cell and hydrogen system is the total requested power that would allow the HyTrolleybus to achieve a range of at least 100km without the catenary system. The transmission should be optimally aligned with the drivetrain work conditions in order to achieve the best efficiency between energy/hydrogen consumptions

Table 10 shows the overall noise characteristics that were included. They are similar to other new public transport units.

Mode	Noise	Place of measurement	dB(A)

Parked vehicle (all auxiliary units are turned ON)	In the vehicle interior (1,2m above the floor).	Driver's cab	70
		Passenger cabin	70
	Outside the vehicle (1,2m above the ground and 7,5m away from the vehicle)		65
Vehicle traveling at a speed of 50km/h	In the vehicle interior (1,2m above the floor).	Driver's cab	75
		Passenger cabin	75
	Outside the vehicle (1,2m above the ground and 7,5m away from the vehicle)		80

Table 10. Noise characteristics requested in HyTrolleybus procurement.

To point out, the FCEVs noise emission is lower compared to CNG or other ICE vehicles.

As to reduce maintenance costs it was set that the main units and equipment had to be established in a way that maintenance and operational costs could be kept to a minimum. Considering that multiple similar Hytrolleybus units were procured, the modules should be compatible with other Hytrolleybuses without any additional alignment or processing. Additionally, to secure the long-term reliable HyTrolleybus operations, all spare parts must be available for at least 12 years after the delivery of the HyTrolleybus units.

As the FCEV technology was new for Rigas Satiksme, its employees were trained prior the delivery of the trolleybuses. The training included know how of how to detect malfunction and how to replace parts of the Trolleybus in case of malfunction.

HyTrolleybus will be used in city routes performing public transport operations. The requirement is for each unit to be operational for 12 years with possible range of 70,000km per year without main maintenance issues.

Specific requirements to the hydrogen and fuel cell system included a system that ensures the automatic disconnection of the catenary when the fuel cell system is turned on. The fuel cell system must be installed on the roof of the Hytrolleybus unit and must be secured from heat and other damages that can be caused by other HyTrolleybus moving parts or collisions with other vehicles. Its place of construction must be chosen in such a way that it allows for minimum levels of heat and noise to enter the passenger compartment. In the event of an emergency, the hydrogen fuel supply in the fuel cell unit must be automatically shut down and the system should be switched off . If the bonnet of the fuel cell block is in an open position, the starting of the traction engine must be blocked. Additionally, the metallic components of the hydrogen system have to be connected to the vehicle ground. Collision sensors, hydrogen sensors, smoke sensors, heat exchanger safety systems, hydrogen leakage monitoring systems, ground failure monitoring systems, isolation resistance monitoring systems were all required and delivered.

It is foreseen that Rigas Satiksme will perform HyTrolleybus maintenance after expiration of the warranty period. This will be done at a newly built maintenance centre for FCEVs.

Only Proton Exchange Membrane Fuel Cells, PEMFC can be used in the HyTrolleybuses whereas clean hydrogen could be used.

The passenger compartment of the vehicle had to be separated from the hydrogen system in order to avoid the accumulation of hydrogen gas. It must be ensured that hydrogen leaks from the tank or its accessories never reach the passenger compartment. In order to prevent the accumulation of hydrogen gas, compartments in which electrical equipment is located and where hydrogen gas may appear, must be fitted with fans or a ventilation system. Additionally, the supplier had to provide the complete set of special tools and devices for the diagnosis, maintenance and repair of hydrogen equipment.

Rigas Satiksme demanded a minimum driving range of 100 km for each FCE bus. This provided OEMs with the opportunity to test and evaluate the storage of (a part of) the required amount of hydrogen on the roof of the HyTrolleybus.

Pressure reduction devices shall be fitted in such a way as to ensure that the pressure in the internal container or any other component of the hydrogen module does not exceed the permissible value. The values shall be determined in proportion to the maximum permissible working pressure (MAWP) of the hydrogen system. A safety system for heat exchangers must be installed to detect malfunctioning.

As for hydrogen refuelling, measures must be taken to avoid errors in vehicle refuelling and leakage of hydrogen in the event of re-filling. The refill fitting must be protected against misalignment, including dirt and water. The filling tube must be closed with a non-return valve or with a valve which performs the same function. A pressure gauge must be installed at the filler valve to control the pressure in the system.

The vehicle had to be fitted with an identification device that ensures registration of the vehicle in the service station control system and accounts the filled hydrogen amount.

The delivery-acceptance procedure was performed in two main sections:

1. Prior-delivery tests;
2. After-delivery tests.

This aspect was included and requested in order to receive full test documentation of each HyTrolleybus unit in order to determine if the specific unit meets the specified criteria. The HyTrolleybus road test documents were requested. The goal of these road tests was to check equipment compatibility with the technical requirements. For each HyTrolleybus a test-drive with a range of 100km had to be made. The malfunctions or other aspects that raised during the road tests were documented and the Full vehicle checks had to be repeated after the malfunctions were eliminated.

After the delivery, the Road test in Riga was performed for the HyTrolleybus including 1,000km in full daily operation.

At the moment the Rigas Satiksme HRS ensures refuelling of 10 HyTrolleybuses while being publicly accessible for the private FCEVs. Currently the only FCEVs registered in Latvia are the 10 HyTrolleybuses. Rigas Satiksme foresees the procurement of 10 additional FCE-buses for daily passenger transportation operations. This will also ensure the optimal usage of the existing HRS. Rigas Satiksme sees that FCE-buses also offer driving ranges and refuelling similar to diesel buses, meaning that they can provide conventional public transport services without any loss of performance, operational flexibility or productivity, and with a reduction in noise. Rigas Satiksme sees that independent expertise with in-depth knowledge in hydrogen technologies involvement is required throughout the process from procurement to operations. Currently Rigas Satiksme is preparing the replacement of 400 buses till 2027. The strategy foresees that in the period until 2026 a total of 15 additional FCE-buses will be procured.

4.2.2 Conclusion

The Hytrolleybus technical specification were mainly based on the existing (diesel-APU) trolleybus technical specifications, except for the fuel-specific APU. With respect to the placement of the hydrogen tanks, Rigas Satiksme initially only put the requirements with respect to the bus driving range on the table. The manufacturers translated this functional requirement into practical vehicle components, including the size and position of the hydrogen storage tanks. These preliminary designs were used by Rigas Satiksme to formulate a set of more technical requirements with respect to the tanks. This way, Rigas Satiksme stayed in charge of this important vehicle component which also has an impact on for example passenger safety and security, while it had secured that manufacturers would be able to comply with these demands.

In general, the warranty requirements as well as the usage characteristics was set the same as for units with diesel APU. Taking into account that the supplier managed to secure the requirements, the preparation of FCEV technical specification can be simplified by determining only the drive-cycle characteristics such as range, acceleration et cetera.

The preparation of FCEV technical specification can be simplified by determinising only the drive-cycle characteristics such as range, acceleration, refuelling time etc. The development of Hytrolleybus technical specification was mainly based on the existing trolleybus technical specifications that use diesel APU. The fuel cell and hydrogen system were directly included therefore excluding other alternative fuel APUs for Trolleybus.

4.3 Pärnu case, outsourced by Regional authority

The public transport operations at city level are procured by regional authority MTÜ Pärnumaa Ühistranspordikeskus. The public transport service provider is selected through a competitive procurement process[66] and no environmental aspect was considered or specified as a selection criterion.[67] In the meantime the technical specification outlined that the tenderer must provide at least 13 12m CNG buses in order to comply with the technical specification. Thus, from potential suppliers scope this aspect would be more beneficial if it would be outlined as an additional selection criterion and would be specified as additional points for usage of alternative fuelled buses. The annual mileage on the routes in Pärnu according to the procurement documents are 1,808,130 kilometres (km), of which 1,372,649 are performed by regular buses and 435,481 by articulated buses. As for the articulated buses, these technical specifications did not specify the fuel that should be used in these units.

The public transport agreement allows for the public authority to provide buses to the service provider. This aspect allows the public authority to participate in different CO_2 reduction programmes by procuring low-/zero emission buses. As part of structural support for the implementation of the strategic plan “Increasing the use of alternative fuels in transport” the Cohesion Policy Fund

[66] Pärnu linna bussiliinivedu 2017-2026", viitenumber 168909
[67] https://riigihanked.riik.ee/rhr-web/#/procurement/696520/general-info

supported the retrofit 18 CNG buses to the usage of bio-methane. These buses are provided to SEBE bus, the transport operator that provides the current public transport concessionaire. The estimated annual CO_2 reduction is 9723.9 tonnes.[68]

In other procurement MTÜ Pärnumaa Ühistranspordikeskus required that public transport services on Pärnu county public bus routes had to be provided through the deployment of EURO 6 buses. Buses equipped with the CNG propulsion system must comply with Type 4. The procurement documentation also includes that the price per km is the only aspect that will be evaluated in order to award the procurement and no other environmental aspects where considered.[69]

4.3.1 Conclusion

The lack of different alternative fuel requirements affects the deployment of different powertrain vehicles. The HRS deployment in Párnu would allow the responsible entity to diversify the possible requirements included in the procurement documentation and could encourage suppliers to consider to include FCE-bus operations in their competitive bids for a public transport concession.

4.4 Province of Gelderland case, outsourced by the local government

4.4.1 Introduction

Since the year 1998 urban and regional public transport in The Netherlands is commissioned by regional authorities. Since the year 2000 the commissioning of public transport is done by the competitive tendering of public transport service contracts. This means that e service is tendered and contracted by the regional authorities on the basis of a mostly functionally described set of requirements. This means that for example the frequency of service, comfort levels are described, but not each details of the vehicles to be deployed.

In this section we describe specifically how green procurement is included in the commissioning of public transport by the provinces of Gelderland, Overijssel and Flevoland. These three adjacent provinces concluded that since the majority of regional public transport passenger flows crosses the provincial borders, a joint organization and commissioning of public transport services would be beneficial for the transport authorities, the transport operators and the passengers. Since 2018 these 3 provinces have replaced existing 7 intra-provincial concession areas into 3 major inter-provincial concession areas. These concession areas are described in the Milestone 11 report.[70]

[68] https://pytk.ee/projektid/paernu-linnas-gaasibusside-ueleviimine-biometaani-tarbimisele.html
[69] https://riigihanked.riik.ee/rhr-web/#/procurement/722250/documents/source-document?group=B&documentOldId=12308290
[70] Milestones H2Nodes Milestone 11,HRS Upscaling, 9 July 200

4.4.2 Preparation of the tender documents

The competitive tendering of the first concession started in February 2019. The tender documents were in line with Administrative Agreement Zero Emission Bus transport. This agreement lays down the path to 100% zero-emission public transport bus transport in 2030.

Before drafting the competitive tender documents, Gelderland/Overijssel/Flevoland, drafter the key components of the new concession in a Document on Basic Principles, including the conditions and preferences with respect to the implementation of the abovementioned provisions for zero-emission transport. This document was presented to all municipalities withing the concession area, some adjacent municipalities and regions, a few German regions and public transport operators. The three provinces included some of the remarks and suggestions made by the consulted parties in the final Document on Basic Principles, which was included in the formal tender documentation (Programme of Requirements).

The Program of Requirements includes[71]:

1) the overall goals of the concession;
2) a definition of the scope of the concession;
3) the required supply of public transport services on A, B and C bus connections (core network routes, non-core routes with substantial transport volumes, minor routes and other types of public transport);
4) bus service infrastructure, such as roads, bus stops and bus charging facilities;
5) bus transport operations including provisions to secure punctuality and alternative transport in case of cancellation of regular service.
6) bus fleet: provisions with respect to technical aspects, sustainability, accessibility, appearance, and comfort;
7) travel information;
8) bus fee collection,
9) personnel;
10) customer service;
11) social safety;
12) gathering of data and monitoring.

Furthermore, tenderers were invited to present a transition plan with actions leading to a sustainability performance that exceeds the minimum requirements. This transition plan was included as a separate component in the overall evaluation of bids, which was presented as follows[72]:

[71] Bijlage 3 Programma van Eisen Concessie IJssel-Vecht, 5 February 2019
[72] Beschrijvend document Aanbesteding Concessie IJssel-Vecht, 5 February 2019

		Maximum score as a % of the total score
G1	Marketing Plan	5%
G2	Alignment of public transport supply and demand	45%
G3	Corporate social responsibility	
G3.1	- Transition to zero emission	20%
G3,2	- Personnel plan	5%
G3.3	- Circularity	3%
G4	Passenger comfort	17%
G5	Development roles	5%

Table 11. Criteria and weights for the evaluation of bids for the Ijssel-Vecht public transport concession.

The price of the concession is fixed. This tender selects the bus operator that offers the most value for this fixed price.

4.4.3 Provisions for zero-emission bus transport

The zero emission requirements are included in the bus fleet and bus service infrastructure sections of the Programme of Requirements. Emission reductions beyond the minimum requirements are rewarded in section G3.1 of the award criteria and score table and account for a substantial 20% weight in the overall evaluation.

The Programme of Requirements includes the framework which describes requirements and preferences with respect to the roadmap towards total zero emission bus transport in 2030. The most important components of this framework are:

- minimum sustainability requirements for a number of specific lines as per start of the concession period (such as: zero-emission buses on a number of city routes, and minimum EURO requirements for other routes);
- all new buses added to the fleet as from 2025 are zero-emission;
- all deployed buses are zero-emission as per 2030;
- the concessionaire is obliged to fully cooperate with demonstration projects, such as fuel cell buses and smart grid centres pilot projects.

Chapter 4 of the Programme of Requirements includes the following provisions with respect to zero-emission buses:

- The PTAs are responsible for the availability of charging facilities for battery electric buses at a number of designated locations.
- The concessionaire is responsible for additionally required charging facilities and should allow bus operators in adjacent concession areas to use these facilities for charging their fleet at cost price.

Tenderers are awarded for offering a transition plan that results in emission reductions beyond the minimum requirements as described in chapter 6 of the Programme of Requirements. The deployment of vehicles per commencement date with lower emission levels than the maximum allowed emission levels, is rewarded with a maximum of 20 points (out of a maximum total of 100 points). The maximum applies if all vehicles are zero-emission per commencement date. The relative score per vehicle type is:

- zero-emission vehicles: 100%;
- Ebus with range extender: 30%;
- Plugin hybrid: 20%;
- Non-plugin-hybrid: 10%;
- EURO VI: 0.

4.4.4 Submitted bids

A total of 4 bids was submitted:

- Arriva (a multinational public transport company headquartered in Sunderland, England, owned by the Deutsche Bahn AG (Germany)).
- Connexxion (Dutch public transport company, daughter company of Transdev – a French-based international private public transport operator).
- EBS (Dutch subsidiary of the Israeli public transport company Egged).
- Keolis Nederland (A subsidiary of the French-based Keolis multinational transportation company).

None of the 4 submitted bids included the deployment of FCEV buses. Keolis (the mother company of Syntus, the operator of the 2 H2Nodes FCEV buses) concluded that FCEV buses are not yet ready for large-scale operations.

Keolis senior executive Richard Bruns concluded the following[73]:

- Keolis could not get sufficient guarantees that 256 buses could be delivered on time.
- The refuelling station was not 100% reliable – with as a consequence last-minute replacements of FCEV buses with diesel buses each time FCEV refuelling was not possible. It is impossible to replace 256 buses in similar cases.
- At this moment, FCEV buses are more expensive than BEV buses.
- The documents provided by the PTAs only mentioned the availability of charging infrastructure – provided by the three provinces. There were no references to facilities for FCEV buses and their funding.
- FCEV buses have the potential to become a competitive alternative, it just needs some extra time.

4.4.5 Conclusion

As stated in section 284.1, regional public bus transport in The Netherlands is for the most part organised through the competitive tendering of regional transport concessions that include both the procurement and deployment of buses used to operate the transport services.

[73] "Waarom Keolis niet voor Hollandse bussen en waterstof koos, maar voor 256 Chinese batterijbussen", De Stentor, 30 January 2020

The regulatory framework for these regional transport concessions are set within the Directive 2014/23/UE on the award of concession contracts, the Directive 2014/24/UE on public procurement and the Directive 2014/25/UE on procurement by entities operating in the water, energy, transport and postal services sectors and repealing. All directives haven been transposed in the National Law of Passenger Transport. One of the relevant aspects of the regulatory framework is that there the public transport is tendered as a service that includes the vehicle required to operate that service. The evaluation of bids includes criteria with respect to the quality aspects of the service offered as well as price. Bus operation companies are not required to procure the required vehicles through public tendering; as the TCO of the bus fleet is part of the bid for the overall transport concession.

The tendering of the IJssel-Vecht bus concession shows that the PTA plays an important role with respect to the type of zero emission bus (BEV or FCEV) that operators will include in their bid. The PTA explicitly mentioned the development of charging facilities for electric vehicles at core locations within the transport network. The tender document did however not include any information with respect to hydrogen refuelling options (there is currently no HRS in the IJssel-Vecht concession area). Even though the requirement was “zero emission”, the tenderers had the impression that the PTA had a preference for BEV-buses and they concluded that with parts of the BEV charging infrastructure paid for by the PTA, BEV buses could be deployed at a significant lower cost level than FCEV buses.

As large scale zero emission public transport comes with the perception of a higher risk with respect to zero-emission buses (compared to diesel buses). Considerations are:

- bus operating personnel has to get used to punctual services with zero emission vehicles, the deployment of both FCEVs and BEVs is considered to be complex, which is reduced by having a fleet of only BEV-buses;
- there are multiple charging points for BEV, compared to probably only 1 HRS for refuelling FCEVs; this makes the operational performances of the entire fleet dependent on 1 refuelling station. That risk is considered to be too high, especially as service level underperformance is penalised by the PTA.
- At the time this the final bids had to be submitted, the TCO of BEVs was lower than the TCO of FCEVs.

Especially with respect to public bus transport concessions that include zero-emission requirements for the entire fleet, the PTAs play an important role to create a level playing field for FCEVs. The deployment of FCEV-buses is more likely if PTAs provide at least information about the refuelling/charging situation for both BEV as FCEV buses. It may be expected that bus operators participating in large-scale public bus transport tenders are very well informed about TCO-levels of both BEVs and FCEVS. As FCEVs are expected to reach TCO-levels similar to BEVS, it may be expected that FCEVs become a serious and perhaps even preferred alternative to BEVs, especially as within this period the risk of HRS availability is reduced, either technically (99,9% uptime) or by creating HRS redundancy.

5. Summary and conclusion

1. The Clean Vehicle Directive a Green Public Procurement (GPP) are an important basis for the promotion of clean mobility solutions in public procurement tenders, providing a solid boost to the demand and further deployment of low- and zero-emission vehicles. The Clean Vehicle Directive prescribes per Member-State the minimum number of clean vehicles as a percentage of the total publicly procured number of vehicles; as well as minimum levels of zero-emission vehicles for the total public fleet. It also defines a clean vehicle in terms of CO_2 emission levels. GPP stimulates the public sector to use its purchasing power to choose environmentally friendly goods, services and works. Even though it is a voluntarily instrument, it will not be ignored as GPP mechanisms will be needed to comply with the Clean vehicle directive's targets.

2. The Netherlands secure compliance with the Clean vehicle directive through direct agreements with public transport authorities with respect to the deployment of zero-emission vehicles in public transport. GPP is promoted by availing a national system of criteria, guidelines and examples that local and regional governments can use to buy (more) sustainable products and services. In Latvia the Clean Vehicle directive targets will be included in the national procurement law. Currently for Latvia and Estonia the Green Public procurement suggestions are not mandatory. Latvia and the Netherlands have strategies that will lead to the deployment of zero-emission public fleets. The lack of details in Estonian recommendations of GPP can be seen as a barrier for FCEV deployment.

3. For the next 5 to 10 years FCEVs are expected to only have a limited role within the public procurement of operations where passenger vehicles are used. Battery electric vehicles deliver comparable performance levels with respect to zero-emission and low noise, in most cases at lower cost levels. A better performance of FCEVs with respect to driving range and refuelling time will only in some cases create additional value for the public entity, given the fact that in most cases the underlying public services do not require longer driving ranges than currently offered by battery electric vehicles. Furthermore, FCEVs are currently not available in many of the relevant vehicle / price segments.

4. The development of Hytrolleybus technical specification was mainly based on the existing trolleybus technical specifications. The fuel cell and hydrogen system were directly included therefore excluding other alternative fuel APUs for Trolleybus. By determination of the necessary range of the APU, the manufacturer was free to evaluate the necessary technological characteristics that would be provided in the tender. The same approach can also be used for FCE-bus procurements.

5. The public transport operations in Pärnu are procured by regional authority MTÜ Pärnumaa Ühistranspordikeskus. Currently the use CNG buses are listed as one of the main requirements in the procurement. The HRS deployment in Pärnu would allow the responsible entity to diversify the possible requirements and allow to either directly request deployment of FCE-buses or specify the supply of alternative fuelled vehicles as additional procurement evaluation criteria.

6. The path towards zero-emission is not only a regulatory matter. Programmes such as H2Nodes are important showcases that allow public transport operators to experience the provision of public transport services with this type of zero emission vehicle including the refuelling of fuel cell buses.

7. The first experiences with the tendering of zero-emission public transport show that public transport operating companies currently prefer battery electric buses to fuel cell electric buses.

However, the conclusion that can be drawn from international market studies and the H2Nodes project is that fuel cell buses have the potential to become the preferred alternative to diesel buses in the very near future. Key considerations are:

- The total cost of ownership of fuel cell buses is expected to reach a level comparable to battery electric buses within a couple of years.
- Fuel cell buses will become competitive even sooner for public transport routes requiring buses with the ability to drive longer ranges without refuelling. Even with the total cost of ownership of the vehicle at higher levels than competitive bus types, the more efficient deployment of public transport staff may already lead to a fuel cell bus preference.
- When commissioning zero-emission public transport, public authorities are advised to maintain a level playing field for battery electric and fuel cell electric buses by including a comparable recharging/refuelling infrastructure.
- Bus operators may initially place fuel cell bus operations in a higher risk category than battery electric buses because of the potential impact of malfunctioning refuelling infrastructure on delivery of the core public transport service. A situation of default at an HRS may affect multiple buses, where the impact of a default situation of a charging facility can be kept to a minimum, given the number of charging units. Backup facilities may be required as a risk mitigation measure.