Milestones H2NODES

Milestone 9

HRS expansion along the TEN-T North Sea Baltic Core Network Corridor

Milestone 9 Report

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Introduction

H2Nodes: focus on upscaling of hydrogen refuelling capacity

This Milestone Report is part of Activity 2 of the H2Nodes Act. This Activity is about the upscaling Hydrogen Refuelling Stations (HRSs) on a local, regional, national and international scale.

The Milestone 10, 11 and 12 reports focus on upscaling opportunities for the H2Nodes HRSs in Riga, Arnhem and Pärnu. This Milestone 9 report is a joint report of the HRS Riga, HRS Arnhem and HRS Pärnu project organisations about the expansion of HRSs along the North Sea – Baltic Corridor (in this report also indicated as the NS-B Corridor.

The North Sea – Baltic corridor

The NS-B Corridor is one of the 8 Trans-European Transport corridors and goes through 8 EU Member-States: Belgium, the Netherlands and Germany, extending through central Germany and Poland and Lithuania. Then it turns north into Latvia, Estonia and Finland, where it connects to the Scandinavian-Mediterranean corridor.

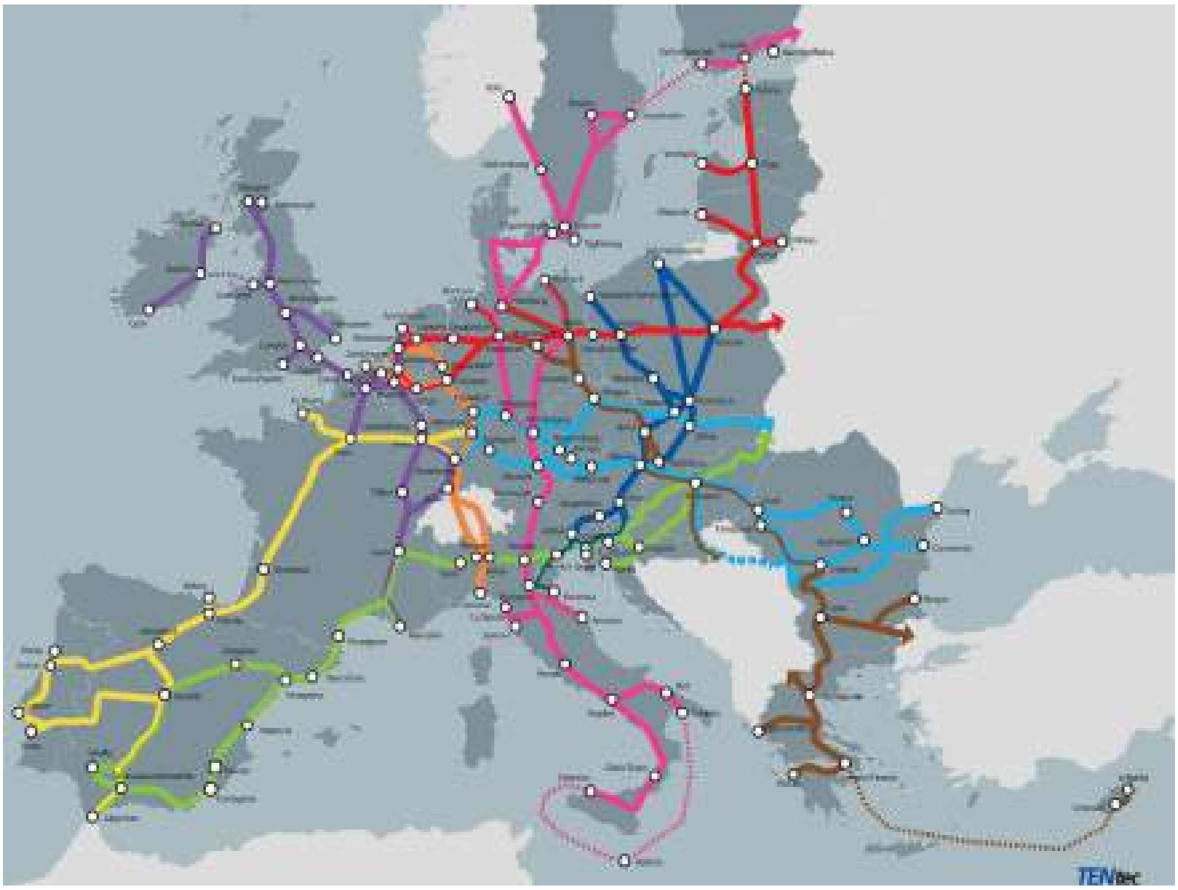

Figure 1. TEN-T Corridors (source: TENtec), with the NS-B Corridor indicated by the red line

It passes through the following major European transport nodes:

Belgium	Brussels Antwerp
The Netherlands	Rotterdam Amsterdam
Germany	Bremen Hannover Hamburg Berlin
Poland	Poznań Łódź Warszawa
Lithuania	Vilnius Klaipeda
Latvia	Ventspils Riga
Estonia	Tallinn
Finland	Helsinki

The corridor development is focused on the improvement of inland waterways, maritime, rail and road transport. The main challenges of the Corridor are[1]:

- the existing technical condition and performance divergences in transport infrastructure between the eastern and western parts of the Corridor;
- the different traffic patterns with strong traffic in the western end of the Corridor which lessens towards the eastern part of the Corridor;
- the development of the interconnectivity and multimodality of key urban nodes located at the junction with other Corridors;
- the creation of new traffic flows in north-south direction feeding in the well-established East-West transport flows.

Additionally, there are projects with respect to the development and deployment of HRS. The lessons learned within the H2Nodes Act are a major source of information for the establishment of hydrogen nodes along the core network corridors

Milestone content

The Milestone 9 description in the H2Nodes Grant Agreement includes the following two focus points:

[1] The mentioned challenges are taken from the report “CEF Support to North Sea-Baltic Corridor”, Innovation and Networks Executive Agency, February 2018.

1. The deployment of existing contacts in neighbouring cities, regions and countries to work on further expansion of the corridor. The associated partners Kauno Autobusai and Tallinna Linnatranspordi are specifically mentioned.
2. The drafting of a report on plans for expansion with more HRS along the NS-B Corridor.

The H2Nodes project partners added some additional focus points to the content of this Milestone 9 Report. The reason for this is that, considering some of the H2Nodes experiences and learning points, the two focus points alone do not necessarily secure the development of a network or increase its economic potential to live up to long distance cross-border travel patterns within road transport..

The relevant experiences and learning points are:

- The expansion of HRS capacity does not always mean that this capacity is publicly available. For example: At this moment most public transport bus operators have dedicated facilities for the refuelling of their fleets, located at their bus depots. Given the similarity between the refuelling of diesel busses with diesel and the refuelling of fuel cell busses with hydrogen, it is expected that bus operators hold on to the currently common situation of having such facilities exclusively available for bus refuelling. This is the reason why some major manufacturers of refuelling systems work on "fully integrated" refuelling solutions.[2] The publicly accessible H2Nodes HRSs are exceptions to this general refuelling practice among public transport operators. They fit the period where both Fuel Cell Electric (FCE) busses and the refuelling facilities are tested on a relatively small scale. Thus, upscaling of refuelling capacity within the public transport sector may only serve hydrogen-fuelled long distance travel in the early upscaling phase. In this phase test-HRSs are publicly accessible, though their locations are not tailored to long-distance traveling. The group of early adopters of FCEVs is well aware of this and accepts the fact that HRS-coverage is minimal and that HRS locations may often be not on-route, requiring driving additional distances and spending extra time for a refill. The value of this "early-stage"-HRS capacity diminishes as:
    a) it is expected that public transport operators that scale up to a whole fleet of FCE busses will build non-publicly available refuelling facilities; and
    b) it is expected that the willingness among motorists to refuel at remote locations will diminish because "early" and "late majority" FCEV driver groups will lack the willingness to spend extra time of drive additional distances to refuel[3].
- The market focus for HRS development is closely related to developments in the FCEV market.
  HRS upscaling in an international context was already foreseen in 2015 when each EU Member-State presented its implementation plan for the accelerated transition to the use of low-emission vehicles. The most important reason why overall only a fraction of the target number of 700 bar HRS was actually built, is that the hydrogen demand side did not develop

[2] Hydrogen Fuelling for Fuel Cell Bus Fleets, European version, Ballard, June 2019

[3] This is in line with the characterisation of groups adopting new technology (Diffusion of Innovations, Everett Rogers, 1995)where individuals adopting new developments in later stage tend to be more conservative.

as expected, due to limited FCEV supply and the availability of cheaper low-emission alternatives, such as CNG. The result of having a refuelling network in place for a market that develops at a slower rate than expected, is HRS under-utilisation. In financial terms this underutilisation causes a level of initial losses beyond what would be commercially acceptable, especially given the dependency on some major Original Equipment Manufacturers (OEMs) to avail FCEVs in various vehicle segments at competitive prices. For most OEMs the focus on the FCEV-segment result from an overall strategy that includes the allocation of available production capacity to internal combustion engine (ICE) vehicles, hybrids (HEVs), battery electric vehicles (BEVs) and FCEVs. In Europe hybrids (both plug-in and non plug-in) are selling at significantly higher rates than predicted[4]. Hybrids offer the consumer affordable cars that comply with tightening emissions regulations while offering without driving range restraints. Hybrids offer OEMs an opportunity to continue the monetisation of mature combustion engine technology.[5] On a worldwide level, hybrid sales are projected to keep growing until they peak in 2027[6].

- The expansion of HRS locations needs to be in line with the specific refuelling demands of targeted user groups. With EU environmental policies becoming more strict, road transport will shift to the deployment of zero-emission vehicles, either BEVs of FCEVs. Volkswagen had already declared its commitment to BEVs in 2019[7] while other major OEMs such as Daimler and Honda put their fuel-cell program for passenger vehicles on hold as the production of passenger FCEVs is about double the expense of an equivalent BEV[8].
  OEMs such as Daimler and Volvo I continue to work on fuel-cell systems for heavy-duty vehicles. The rationale is that a fuel-cell powertrain is better suited to large trucks, where large battery packs could be too heavy. If this strategic focus is adopted by other OEMs, the upscaling of HRS capacity is more likely to follow a path similar to the recent upscaling of liquefied natural gas (LNG) filling stations, as LNG is promoted as a transition fuel that combines low emission levels with total cost of ownership levels comparable to diesel trucks.

Milestone report content and set-up

This report focuses on the expansion of HRSs on the NS-B Corridor against the background of the abovementioned experiences and learning points. It identifies the part of the corridor where HRS coverage is critical and it puts overall HRS coverage within the context of demand-side developments and risks. The H2Nodes experiences and lessons learned are not only of use for neighbouring regions and cities, but for basically every city, region or country where the upscaling of HRS is a challenge.

The potential of HRS-expansion regarding the associated partners Kauno Autobusai and Tallinna Linnatranspordi are not included in this Milestone report, but will be captured in separate reports.

[5] “Hybrids are Quietly Selling Fast Than Fully Electric Cars”, River Davis, Bloomberg, December 2020
[6] Full Hybrid Electric Vehicle Markers 2021-2041, IDTechEx market report, November 2020
[7] “Deutsche Autoknzerne zoffen sic hum denTank”, Markus Balser, Michael Bauchnüller, Suddeutsche Zeitung, 21 October 2020
[8] “Daimler end hydrogen car development because it’s too costly”, Electrek, 22 April 2020

This Milestone report consists of two parts. Part I describes the developments with respect to hydrogen for transport on a per-country basis, including the following topics:

- An introduction including general information about the country's position on the NS-B Corridor as well as other transport corridors, its road network, vehicle fleet and other information that draws the context for HRS upscaling from an international point of view.
- The path towards zero-emission mobility including set targets for cleaner vehicles and their refuelling infrastructure as well as achieved results. It includes a specific outlook for the upscaling of FCEVs as well as HRSs.
- The most recently available HRS development plans. This includes an overview of the existing HRSs as well as the planned HRSs including location aspects.

Part II is written from the NS-B Corridor point of view, and:

- identifies to which extent the existing and planned national HRSs contribute to an international HRS network required for cross-border transport along the NS-B Corridor and if there are any potentially missing links.
- gives an overview of how the lessons learned in the H2Nodes project can contribute to establish an HRS network that offers both sufficient refuelling options for its potential users and sufficient income for its operators.

PART I
Developments per country on the NS-B Corridor

1. Belgium

1.1 General country characteristics and policy framework

Together with The Netherlands, Belgium is on the most western part of the NS-B Corridor. Belgium is also one of the starting points of the Rhine-Alpine Corridor and is located centrally on the North Sea – Mediterranean Corridor. Belgium has 11 455 519 inhabitants[9]. In 2018 the total number of registered road vehicles was 6 850 490 units.[10] The overall length of motorways in Belgium is 1 763km.[11] The main nodes are Antwerp and Brussels.

The implementation of alternative fuels in Belgium is for the most part implemented within the policy frameworks of the three federations of which Belgium is composed.

The Flemish Region remains firmly committed to alternative fuels for transport through the implementation of the Flemish Clean Power for Transport Action Plan, which was approved at the end of 2015. The Action Plan aims to bring about a shift from traditional combustion engines to vehicles running on alternative fuels (battery electric, plug-in hybrid, CNG and hydrogen). The objectives and measures under this Action Plan were included in the National Policy Framework, which was submitted in November 2016 in accordance with the Alternative Fuels Infrastructure Directive (AFID).

The Walloon Government that took up office on 13 September 2019 emphasized various aspects of mobility in its regional policy statement (RPS), primarily reducing the need for mobility and the modal shift, as well as stressing the importance of fuel switching. More broadly, Wallonia will integrate the process which has already begun of phasing out ICE vehicles. In a transitional phase, the Government will support an ambitious plan to establish electric charging points and compressed natural gas (CNG) and liquefied natural gas (LNG) stations, evenly distributed across Wallonia. It will promote vehicles powered by natural gas, electricity and hydrogen and hybrid vehicles. Wallonia will support local authorities through central procurement to help them green their vehicle fleets and machinery.

The policy statement of the new Brussels Government (2019-2024) included phasing- out diesel vehicles by 2030 at the latest and petrol and LPG vehicles by 2035, a measure which has also been included in Good Move. This phasing-out will be structured as a continuation of the Low-Emission Zone (LEZ), which has been in force since 1 January 2018 for the entire territory of the Brussels

[9] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[10] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[11] Eurostat 2018.data https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en

Capital Region and which has currently established access criteria up to and including 2025. The Government's aim here is to promote the development of light, low-carbon and shared vehicles. An impact study of the phasing-out of ICE vehicles was launched at the end of 2019, and provides elements for refinement of the regional strategy on alternative vehicles (electric, hybrid, CNG and hydrogen), taking into account the impact and development of each technology.

1.2 Towards zero emission mobility

1.2.1 Targets and achievements

The National Implementation Plan for the implementation of hydrogen for mobility in Belgium dates from 2015. Figure 2 shows the set targets as well as the delivered performance.

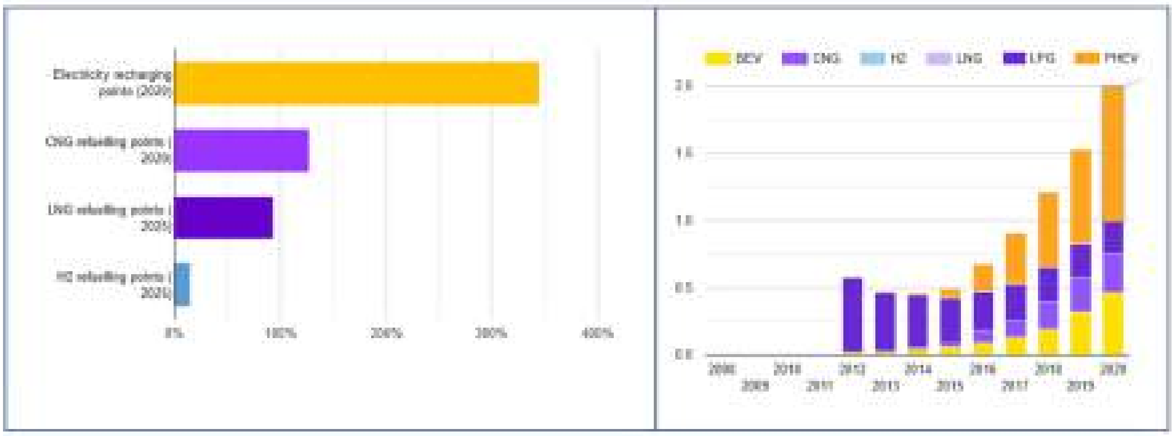

Figure 2. Infrastructure as % of National Policy Framework targets and share of low emission vehicles in total fleet (source: European Alternative Fuels Observatory)

The two existing HRSs in Belgium are both situated in the Brussels region: Halle (700 bar) and Zaventem/Brussel (350 and 700 bar).

FCEV Deployment

The goal set at that time included a total 1.000 FCEVs being operative. This goal has not been achieved as the number of FCEVs currently is 26 FCEVs (2019)[12]. Figure 2 shows that within the low and zero emission segment vehicles other than FCEVs were preferred as sustainable alternatives to ICE vehicles.

HRS Development

The goals set at that time included a total of 25 HRS to be developed in the period 2015-2020. These goals have not been achieved as currently 2 public HRSs are operational (2020)[13]. Figure 2 shows

[12] European Alternative Fuels Observatory
[13] European Alternative Fuels Observatory

that within the low and zero emission segment vehicles other than FCEVs were preferred as sustainable alternatives to ICE vehicles.

1.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

It may be expected that the number of FCEVs will increase as a result of both positive and negative incentives. Positive incentive include tax discount and other benefits, such as[14]:

- In Flanders, zero-emission vehicles are exempted from vehicle registration taxes, natural gas and plug-in hybrid vehicles are exempted until 2020. In Wallonia and the Brussels Capital Region there is a minimum BIV of EUR 61,50.
- In Flanders, zero-emission vehicles are exempted from annual circulation taxes, natural gas and plug-in hybrid vehicles are exempted until 2020. In Wallonia and the Brussels Capital Region, for 100 % electric vehicles, the “circulation tax” is EUR 83,56 (minimum tariff). This tax can anywhere between the minimum tariff and EUR 4.957,= for new vehicle with a high cylinder volume.
- In Flanders there was a purchase subsidy available since January 2016, but this has ended in 2020. The subsidy used to be: EUR 4.000 purchase subsidy for a Battery Electric Vehicles and Fuel Cell Electric Vehicle. Only applicable for passenger vehicles (M1) and vans (N1). Since August 2017 also applicable for private lease cars and car sharing. Subsidy available until end of 2019. Subsidy of EUR 4.000 for vehicles < EUR 31.000, EUR 31 < EUR 41.000 a subsidy of EUR 3.500, EUR 41 < EUR 61.000 a subsidy of EUR 2.500 and above EUR 61.000 a subsidy of EUR 2.000.
- A percentage 75% from Cost of charging can be deducted from Income Tax. In the Brussels Capital Region micro and small companies who need to replace a diesel van due to the Brussels' LEZ, may receive a purchase subsidy for a non-diesel van for 20% of the purchase price (max 3000 €).

The negative incentives which for example for the Brussels Capital Region will ban on the highest-polluting diesel an petrol vehicles in the period 2020-2025 and a total ban on ICE vehicles as from 2035.

Stimulation of hydrogen for mobility

The development of hydrogen for mobility in Belgium is embedded in a Benelux (Belgium, The Netherlands and Luxembourg) approach. At this moment only the Flanders region has a specific focus on FCEV deployment and HRS development, with a lead position for the knowledge platform WaterstofNet[15]. The main components of the WaterstofNet strategy are (CEF-funder) HRS developments, and the deployment of at least 10 FCEVs per initial HRS. Furthermore Waterstofnet acts as a centre of knowledge, providing both public and private actors with information about FCEVs

[14] Derived from the National Policy Framework as availed to the European Alternative Fuels Observatory
[15] www.waterstofnet.eu

as zero-emission alternatives to ICE vehicles. It also provides the Flemish government with policy advise with respect to hydrogen for mobility. In 2020 WaterstofNet purchased a mobile HRS so that the use and refuelling of FCEVs can be demonstrated at various places in the region.

1.3 HRS development plans

In addition to the two existing HRss, 5 HRS are planned, funded an have permits in place. The first ones to be actually developed are

- The location Wilrijk in the Antwerp region. This project is, part of the Hydrogen Region 2.0 project[16] will be operational in 2020. It has a 350 and 700 bar refuelling facility.
- The location Luik/Liège, to be operated by the airport authority as part of the H2Benelux programme.
- The locations Leuven and Gent, also part of the H2Benelux programme.

The H2Benelux programme[17], funded by CEF, has the overall objective to accelerate the market development of hydrogen as a fuel for road transport. It is part of a global project aiming to fully develop a hydrogen refuelling network in the Benelux interconnected with the network of bordering Member States on a Trans-European Perspective, including the NS-B Corridor.

Figure 3. Existing and planned HRS in Belgium (source: WaterstofNet)

With a basic refuelling infrastructure in place in 2021, the next challenge will be to get the utilisation level up or, in other words, to secure a market of vehicles that fill up. Figure 2 showed that few FCEVs have been sold so far, because of limited FCEV availability and competition from low-emission alternatives such as CNG and LNG vehicles. About 98% of Belgium's national fleet consists of ICE

[16] http://hyer.eu/events/waterstofregio-2-0-hydrogen-region-2-0/
[17] https://h2benelux.eu/

vehicles. BEVs and FCEVs are currently the only 100% zero-emission alternatives to ICE vehicles. With a basic refuelling infrastructure for FCEVs in place, this means that the actual upscaling of hydrogen fuelled vehicles will be predominantly be determined by market factors, such as vehicle availability and costs.

Additionally, within the context of the H2Share project[18], Waterstofnet has procured a mobile refuelling installation. The main goal of this mobile HRS is to facilitate short-term regional demonstration activities and is not intended to increase HRS capacity.

1.4 Conclusion

All of the existing and planned HRSs in Belgium are developed within the framework of European grant programmes. The number of FCEVs is too ow to provide HRS operators with the level of income from refuelling that covers the HRS investment and operation costs.

Compared to The Netherlands and Germany Belgium has achieved a larger portion of its original HRS development targets. This is not the result of a better HRS development performance in Belgium, but rather of a lower 2025 HRS ambition compared to its neighboring countries. Taking the existing HRSs and the planned and committed ones in consideration it can be concluded that the Belgium HRS network plans provide a basic HRS coverage for both domestic and NS-B Corridor FCEV mobility:

- Both Belgian nodes Brussels and Antwerp will both have at least 2 HRSs;
- International NS-B Corridor connectivity is secured as:
    - the distance between the Brussels HRSs and the Liege HRS is 100km;
    - the distance between the Brussels HRSs and the Cologne (Germany) HRSs is 220 km;
    - the distance between the Antwerp HRS and the Rotterdam (The Netherlands) HRS is 100 km.

The focus on demonstration projects in combination with financial incentives for zero-emission vehicles contributes to the potential upscaling of FCEV-mobility but does not anticipate on steep upscaling curves, thus avoiding the risk of building HRS that may remain under-utilised.

[18] http://www.nweurope.eu/h2share

2. The Netherlands

2.1 General country characteristics and policy framework

Together with Belgium, The Netherlands is on the most western part of the NS-B Corridor. The Netherlands is also one of the starting points of the Rhine-Alpine Corridor and is located centrally on the North Sea – Mediterranean Corridor. The Netherlands has 17 282 163 inhabitants[19]. In 2018 the total number of registered road vehicles was 9 657 214 units.[20] The overall length of motorways in The Netherlands is 3 055km.[21] The main nodes are Rotterdam and Amsterdam.

The National Climate Agreement is the overall policy framework for CO2-reduction, including the implementation of alternative fuels. It is an agreement between government, industry and other stakeholders in 2019[22]. It included targets for hydrogen for mobility, with as key targets upscaling, cost reduction and innovation. The Dutch government has set out its national strategy on hydrogen and corresponding policy agenda in its letter dated March 2020[23].

Hydrogen production opportunities are predominantly seen in the field of green hydrogen production through large scale electrolysis. This hydrogen can be used in the chemical industry, mobility, heating of buildings and can also serve as seasonal storage of electricity produced by wind turbines and solar panels.

2.2 Towards zero emission mobility

2.2.1 Targets and achievements

Figure 4 shows the refuelling infrastructure put in place in 2020 compared to the National Policy Framework ambitions in 2016. It shows a pattern similar to Belgium: Most infrastructure goals from back then have been achieved, except for the HRS goals. This is for the most part explained by the limited number of fuel cell vehicles compared to the total Dutch vehicle fleet.

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[19] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[20] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[21] Eurostat 2018.data https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en
[22] Nationaal Klimaatakkoord, https://www.klimaatakkoord.nl/
[23] Kamerbrief Kabinetsvisie Waterstof, 30 March 2020

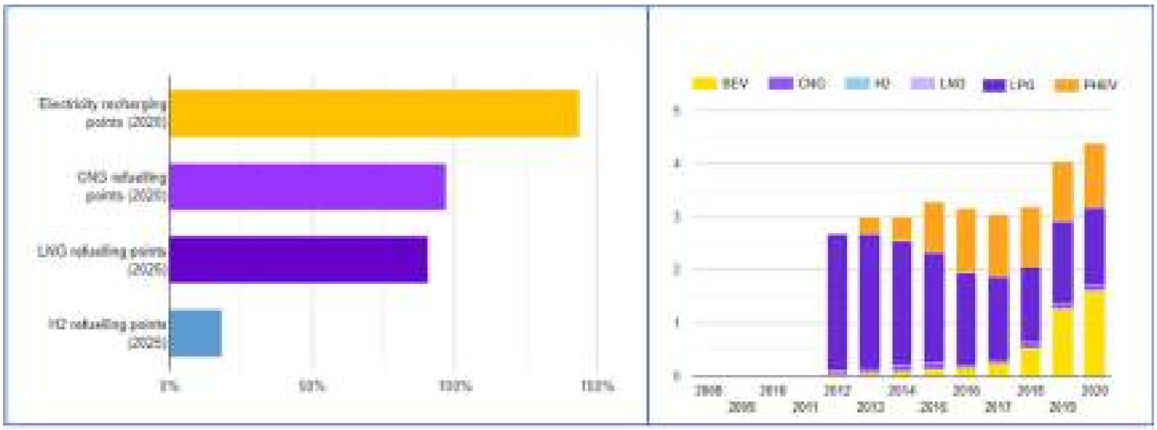

Figure 4. Infrastructure as % of National Policy Framework targets and share of low emission vehicles in total fleet (source: European Alternative Fuels Observatory)

Figure 4 shows the various low and zero emission fuels currently used. LNG was promoted as a transition fuel for heavy duty trucks, but the long term goal of the National Climate Agreement (NCA) is that also those vehicles move towards zero emission. The NCA regards hydrogen as a potential zero emission replacement for diesel trucks as well as LNG-trucks.

Figure 4 also shows that currently about 4% of the Dutch fleet is low or zero emission and about 2,5% is totally zero emission. In other words, many users of ICE vehicles still have to decide which zero emission alternative they prefer, given the ambitions of the National Climate Agreement.

FCEV Deployment

There are currently about 277 FCEVs in the Netherlands.

HRS Development

The currently available publicly accessible HRSs in The Netherlands are:

- Amsterdam/Schiphol (2020)
- Rotterdam/Rhoon (2014)
- Helmond (2013)
- Arnhem (2020)
- The Hague (2020)

2.2.2 Hydrogen vehicles and infrastructure development outlook

The highlights of the NCA are:

- As from 2025 all newly bought vans and trucks entering zero-emission zones have to be zero emission (tailpipe). As from 2030 all vans and trucks have to be zero-emission in these zones. Zero-emission zones are foreseen for the 30-40 largest municipalities.
- As from 2030 only zero emission passenger cars will be sold.
- The entire public transport fleet is zero emission as from 2030.

The specific 2025 targets regarding hydrogen for mobility are:

- 15.000 FCEV cars
- 3.000 FCEV heavy duty vehicles
- 50 HRSs

The 2030 target is: 300.000 FCEV cars.

General stimulation of low-/zero-emission vehicles

The NCA includes an incentive package to stimulate a switch from and ICE vehicle to a BEV or FCEV at an earlier moment than required. These incentives include[24]:

- Zero emission cars are exempt from paying registration tax. For other cars the system is progressive, with different levels of CO2 emissions that pay different amounts of registration tax.
- No road tax for BEVs and FCEVs.
- A lower taxation rate (8% versus 22% of the vehicle purchasing price) is applied to the private use of a company, up to a maximum purchasing price of EUR 45 000 for BEVs and currently no maximum for FCEVs.
- Tax deductible investments: The Netherlands has a system of facilitating investments in clean technology, by making these investments partially deductible from corporate and income taxes. Zero emission and plug-in hybrid (and not with a diesel engine) cars are on the list of deductible investments, as are the accompanying charging points.
- Since July 2020, the Netherlands has opened a purchase subsidy for private persons. For 2020 and 2021, the subsidy amounts for electric passenger cars that meet the conditions are:
    - Used electric passenger car purchase or private lease: EUR 2.000
    - New electric passenger car for sale or private lease: EUR 4.000

  This subsidy only applies to vehicles with a list price lower than EUR 45.000. This means that FCEVs currently don't qualify for this facility, as their list prices are well above the threshold value.

Stimulation of hydrogen for mobility

Hydrogen for mobility is specifically stimulated by the following provisions:

- The absence of a maximum purchasing price as basis for a reduces vehicle tax rate.

- A special subsidy available for the development of HRS, with co-funding up to 50% of the initial investments[25]

2.3 HRS development plans

Figure 5 shows the currently operational HRS in The Netherland as well as the planned ones. The National Climate Agreement foresees a growth of FCE passenger vehicles to 15.000 in 2025 and 50

[24] https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/financi%C3%ABle-ondersteuning
[25] https://mijn.rvo.nl/demonstratieregeling-klimaattechnologieen-en-innovaties-in-transport

HRSs to refuel them. The number of FCE passenger cars could further grow to a level of 300.000 in 2030. Furthermore hydrogen is regarded as a feasible zero-emission alternative for heavy-duty vehicles.

Figure 5. Existing and to be developed public HRSs in The Netherlands[26]

From the confrontation of the current HRS coverage with the ambitions mentioned in the NCA one could conclude the total of existing and planned HRSs is significantly lower than the 50 mentioned in the NCA.

The transition to zero-emission mobility has a high level of insecurity about how the market will be divided between BEVs and FCEVs and possibly future available other zero emission alternatives. Within the passenger car segment the BEV dominates the zero-emission segment but that domination cannot be extrapolated to the entire market as it represents a small portion of the total Dutch fleet and includes a specific group that decided to switch voluntarily to a zero-emission vehicle.

The NCA reflects the ambition with respect to HRS coverage, based on assumptions regarding the growth of the FCEV segment. However it is up to the OEMs and vehicle owners/users what the BEV/FCEV tradeoff will look like. With redundant HRSs available in the west (Amsterdam and Rotterdam area), center (Utrecht) and east (Arnhem) of The Netherlands it can be concluded that a basic refuelling infrastructure is in place from the NS-B Corridor point of view.

- The distance between HRS Amsterdam and HRS Arnhem is 100km
- The distance between HRS Rotterdam and HRS Antwerp is 100 km
- The distance between HRS Arnhem and the multiple HRSs in the German Ruhr industrial area is 130 km.

Further upscaling can be done when FCEV segments actually show growth. The risk of a rapid upscaling of refuelling facilities far ahead of the FCEV market growth is that HRS will remain

[26] [26] source: H2 Platform The Netherlands

underutilised for periods that are too long and consequently start-up losses that are too big to cover with private funds alone.

2.4 Conclusion

From the NS-B Corridor point of view The Netherlands has a basic network of publicly accessible HRSs in place. These HRSs are all co-funded by national and EU grant money. The policy instruments are focused on the enforcement of the deployment of zero-emission vehicles and the further upscaling of hydrogen mobility is for the most part determined by market factors, especially the availability and price levels of FCEVs compared to BEVs. HRS Arnhem is the gateway to the well-developed HRS network in Germany. Furthermore, the following aspects are important regarding further expansion of capacity:

- The need for HRS redundancy to control the risk of range anxiety, which is important to secure the availability of refuelling capacity, also in case a specific HRS is temporarily not available.
- A possible shift from focus on passenger vehicles to heavy-duty vehicles, given the fact that some major OEMs such as Volkswagen and Daimler concentrate on the production of BEVs in the passenger car segment. Given the specific vehicle characteristics and use in the heavy duty segments, hydrogen vehicles are expected to be more cost-efficient than BEVs.

The NS-B Corridor nodes Rotterdam and Amsterdam have one HRS each. There are concrete plans for the development of additional HRSs that further strengthen the reliability of refuelling options.

3. Germany

3.1 General country characteristics and policy framework

Germany is located on several transport corridors: the NS-B Corridor, the Scandinavian-Mediterranean Corridor, The Rhine-Alpine Corridor, the Rhine-Danube Corridor, the Orient-East-Mediterranean Corridor and the Atlantic Corridor. Germany has 83 019 213 inhabitants[27]. In 2018 the total number of registered road vehicles was 52 886 030 units[28]. The overall length of motorways in Germany is 13 009km[29]. The main NS-B Corridor nodes are Bremen, Hannover, Hamburg and Berlin.

Germany is the leading nation with respect to the development of hydrogen refuelling facilities. A total of about 90 HRS are currently in operation. HRS development is not executed as a stand-alone development, but is embedded in a overall National Hydrogen Strategy that includes each part of the value chain, from its production to its consumption in various fields of application.

The German Hydrogen Strategy is one of the pillars of the overall German Energiewende, a term used for the change in energy policy in 2011 including a planned shift from central energy production from fossil fuels to a more decentralized energy production from renewable sources.

The German approach is all-inclusive in the sense that each segment of the energy transition strategy is accompanied by a governance model and the availability of public funding options. This thorough approach finds it origin in Germany’s position as an industrial nation and it ambition to use the energy transition to strengthen its competitive position, by developing sustainable energy systems not only to be utilised in Germany but to also become export products.

3.2 Towards zero emission mobility

3.2.1 Targets and achievements

Figure 6 shows the German 2020 performance on the targets that were set in 2016 for the transition to low emission vehicles and their refuelling infrastructure.

[27] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[28] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[29] Eurostat 2018.data https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en

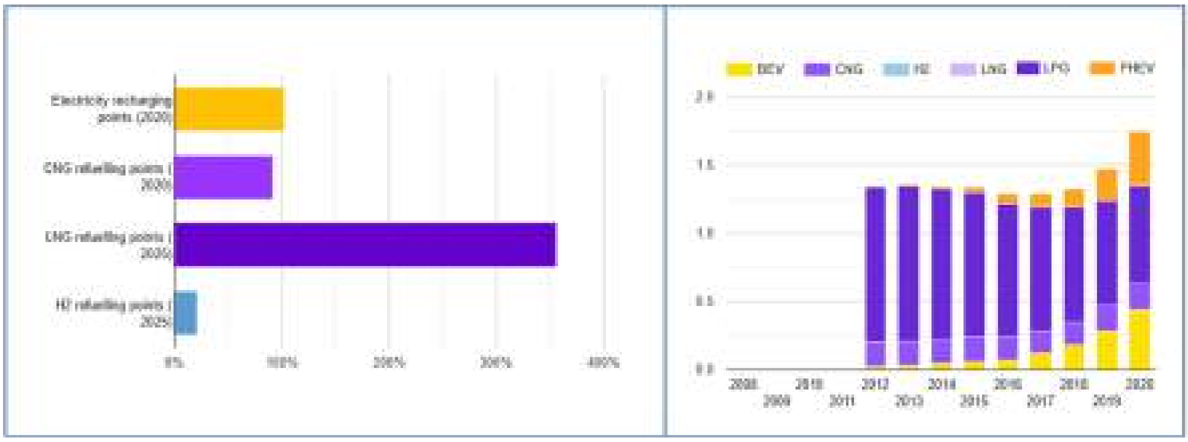

Figure 6. Infrastructure as % of National Policy Framework targets and share of low emission vehicles in total fleet (source: European Alternative Fuels Observatory)

This data presented in this figure are quite similar to the data presented by The Netherlands and Belgium. However, the following aspects should be considered:

- The over-performance on LNG refuelling infrastructure is not the result of a large number of built filling stations, but rather of a relative low ambition level of 5 LNG filling stations.
- The under-performance on Hydrogen refuelling infrastructure is not the result of a low number of built filling stations (50 in 2019; 100 in 2020), but rather of a relative high 2030 ambition level of 400 HRSs.

FCEV Deployment

There are currently 386 FCEVs deployed in Germany, most of them in the passenger car segment.

HRS Development

The about 90 HRSs are predominantly developed for the refuelling of passenger cars. The basic network for 700 bar refuelling will grow to 100 in Q1 2021, able to serve more than 6 million motorists[30]. Six hydrogen stations already offer 350 bar refuelling facilities for commercial vehicles. In line with the updated 2020 national hydrogen strategy additional hydrogen stations will be set up primarily where demand for commercial vehicles is expected in the short term and where a public filling station would make sense for a growing network of filling stations for passenger cars as well. pe here

3.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

The following incentives are put in place to stimulate zero-emission mobility:

[30] Source: H2 Mobility

- Purchase Benefits: Per June 2020, for electric vehicles up to a net list price of up to € 40.000, the environmental bonus is increased.
    - For purely electric and fuel-cell vehicles the total bonus (federal share + manufacturer share) is € 9.000 and for plug-in hybrid and range-extended electric vehicles it's € 6.750.
    - For electric vehicles with a net list price between € 40.000 and € 65.000, the total bonus for purely electric and fuel-cell vehicles is € 8.000 and for plug-in hybrid and range-extended electric vehicles it's € 5.625.
    - In addition, criteria for the latter also include a maximum emission value of 50g of CO_2/km or an electrical range of at least 40km. This range requirement applies until 31 December 2021, subsequently it will be increased to 60km. From 1 January 2025 it will increase to 80km.

  The regulation does not only apply to new cars but also to cars not older than 12 months and whose mileage does not exceed 15.000 km. Used purely electric and fuel-cell vehicles receive a bonus of € 5.000. For plug-in hybrid and range-extended electric vehicles, the bonus is € 3.750.

- Vehicle ownership: For initial registrations from 1 January 2016 until 31 December 2025, there is a tax exemption of 10 years for electric vehicles (purely electric or fuel-cell vehicles, not hybrid vehicles). After the exemption, the car tax will amount to 50% of €11.25 (up to 2,000kg), €12.02 (up to 3,000kg) or €12.78 (up to 3,500kg) for each 100cc or part thereof.

- Company Tax Benefits: The private use of a company car is treated as taxable income in Germany and normally measured at a flat monthly rate of 1% of the vehicle's gross list price. However, the preferential tax treatment for electric vehicles and plug-in hybrids introduced in 2018 and initially limited to three years is extended in two stages until 2030: From 2022 to 2024, only electric and hybrid vehicles with a minimum range of 60 km or a maximum CO_2 emission of 50 g/km with a purely electric drive will benefit; in the period from 2025 to 2030, the required purely electric minimum range will increase to 80 km. Purely electric cars with a gross list price of a maximum of 60,000 Euros (increased from € 40.000 to € 60.000 in June 2020) will receive greater support, with only a quarter of the monetary advantage being taxed (0.25%). The increased list price means more models qualify for the lower taxation. The tax exemption for the free recharging of electric vehicles and plug-in hybrids in the employer’s company was also extended until 2030.

Stimulation of hydrogen for mobility

In a wide range of sectors – such as local public bus transport, -duty road transport (trucks), commercial vehicles or logistics (such as delivery vehicles and forklifts) the introduction of fuel cell vehicles is regarded as a sustainable solution in addition to battery-powered electric mobility.

The development of hydrogen and fuel cell technology is largely funded by the National Innovation Programme (NIP) and the Energy and Climate Fund (ECF). ECT funding is also available for investments in hydrogen-powered vehicles (light and heavy-duty vehicles, buses, trains, inland and coastal navigation, car fleets).[31]

Funding for the construction of a demand-based refuelling infrastructure for vehicles, including heavy-duty road haulage vehicles, public transport vehicles and in local passenger rail services. In total and for all alternative technologies combined, EUR 3,4 billion in grants for the construction of a refuelling and charging infrastructure is made available from the Energy and Climate Fund (ECF) for the period 2020-2030. Under its 2030 Climate Programme, the Federal Government wants to develop concepts for the construction of HRS for commercial vehicles.

3.3 HRS development plans

In Germany, H2 Mobility is responsible for establishing a nationwide hydrogen infrastructure in Germany. H2 Mobility is a partnership of Air Liquide, Daimler, Linde, OMV, Shell and TOTAL. It is funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) as part of the National Innovation Programme (NIP) and from the European Commission in the Hydrogen Mobility Europe project, which receives funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU, grant agreement no. 671438). The FCH JU is supported by the European Union Framework Programme for Research and Innovation (Horizon 2020), Hydrogen Europe and the Hydrogen Europe Research Association.

This updated strategy can be seen as the answer of the German government to the changes in FCEV market developments. Major German OEMs such as Volkswagen and Daimler have publicly announced to exclusively focus on the development of BEVs for the passenger car market. However, FCEVs are still regarded as the best zero-emission alternative for heavier vehicles / long haul vehicles.

[31] https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf?__blob=publicationFile&v=14

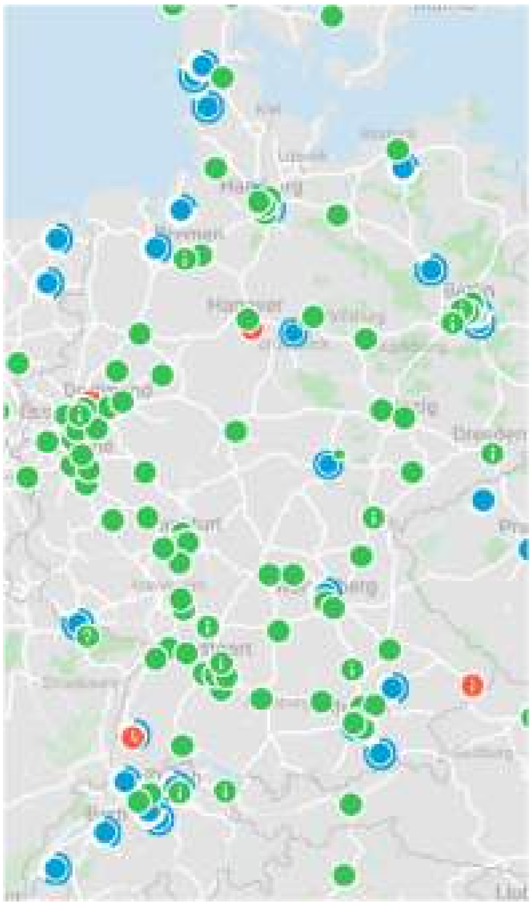

Figure 7. HRSs in Germany (November 2020)

By the end of 2020, Germany will have completed its basic network of 700 bar HRSs. These are situated in the Metropolitan areas Hamburg, Berlin, Rhine-Ruhr, Frankfurt, Nuremberg, Stuttgart and Munich and along the connecting roads and motorways. They are all situated within a 100km driving range from each other.

3.4 Conclusion

Germany currently has the highest HRS density of all EU Member-States. The development and operation is carried out by H2Mobility, a private partnership, predominantly funded by public sources, especially sources from the German federal government. The availability of these public sources must be seen against the background of Germany's industrial economy in general and automotive industry in particular. The German government's strategy is directed at its goal to at least maintain the market position of German OEMs and preferably strengthen them. Investment in fuel cell technology and refuelling capacity for vehicles is regarded as an investment in Germany's economy rather than an expenditure to comply with emission reduction goals.

In the recently published national hydrogen strategy the German government announces the continuation of funding for the development and utilisation of hydrogen-based technologies and facilities in a wide field of application, including transport. However, this new hydrogen strategy also includes some adjustments with respect to HRS development goals. The original H2 Mobility goal was to have about 400 HRSs in operation at the end of 2023. With the new hydrogen strategy in place, this fixed goal has been replaced by a more flexible approach for future developments. At the end of 2020 Germany will have about 100 HRSs with 700 bar refuelling facilities.

The refuelling facilities are concentrated in urban areas, so that all German nodes are equipped with several HRSs.

As the number of fuel cell vehicles is relatively small (386 fuel cell cars in June 2020). Now that Germany's carmakers have largely decided on strategies favouring battery electric cars[32], a rapid further upscaling of HRS would lead to a network of predominantly underutilised HRSs. Instead, the 100 HRSs in place are considered to be enough of a basic refuelling network for 700 bar vehicles. The development of new HRSs will be in line with the national hydrogen strategy where the focus for fuel cell vehicles is shifting towards commercial vehicles and heavy duty vehicles. Such vehicles currently require 350 bar refuelling facilities. Additional 700 bar HRS will be developed if required to facilitate existing demand.

The German promptness with respect to HRS development not only serves German national interests, but also international interest by having a basic HRS network in place for 700 bar vehicles. The German hydrogen strategy includes a shift in focus towards vehicles with a 350 bar tank. As substantial amounts of government funding are available for hydrogen infrastructure including refuelling stations, it may be expected that a Germany will also soon have a basic network for 350 bar refuelling in place.

[32] Wasserstoffautos sind aktuell kaum gefragt“, Lukas Bay , Handelsblatt 18 June 2019

4. Poland

4.1 General country characteristics and policy framework

Poland is a essential link in the North Sea- Baltic Sea TEN-T core network corridor. The population of Poland is 37 972 812 inhabitants[33]. In 2018 the total number of registered road vehicles was 27 513 544 units.[34] The overall length of motorways in Poland is 1637km.[35]

The North Sea-Baltic Sea and the Baltic Adriatic TEN-T core networks are crossing Poland. As within the Action H2NODES the evaluation must be performed for the North-Sea-Baltic Sea TEN-T Core network corridor, the main Nodes to point out are Warsaw, Łódź and Poznan.

Poland is one of the largest hydrogen producers in Europe. Poland produces 14% of overall EU hydrogen demand. The produced hydrogen is mainly used for industry applications and not as alternative fuel for mobility. The main alternative fuel implementation policy documents are the National Alternative fuel implementation plan and the NECP 2030.

4.2 Towards zero emission mobility

4.2.1 Targets and achievements

The alternative vehicle fleet in Poland mainly consists of BEVs, CNG and LPG vehicles. Currently an absence of FCEV deployment as well as Refuelling infrastructure can be seen. This aspect has raised since the Poland National fuel implementation plan did not include hydrogen Refuelling infrastructure deployment in perspective. The Poland Alternative fuel implementation plan only included evaluation of Electricity recharging points, CNG refuelling points and LNG Refuelling points that were mainly foreseen for heavy-duty vehicles.[36] Figure 8 shows the national alternative fuel infrastructure put in place in 2020 compared to National Policy framework (Alternative fuel implementation plan) ambitions.

[33] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[34] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[35] Eurostat 2018.data
https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en
[36] Member state fitches https://ec.europa.eu/transport/sites/transport/files/2017-11-08-mobility-package-two/ms-fiches.pdf

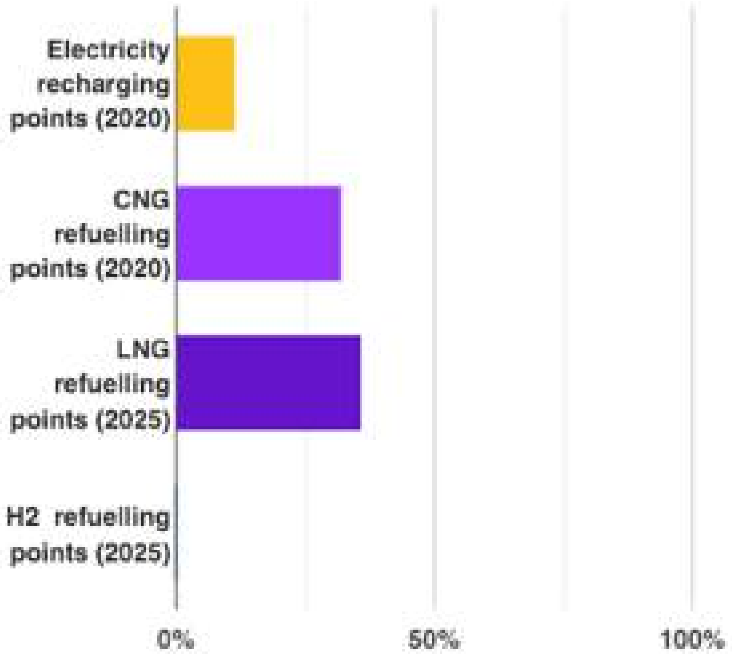

Figure 8. Infrastructure as % of National Policy Framework targets of Poland (source: European Alternative Fuels Observatory)

It shows a pattern different to other Western Europe countries. The alternative fuel infrastructure deployment plans are not fulfilled till the 2020. In relation to hydrogen, the HRS were not included in the NPF targets and the hydrogen was not set as mandatory fuel.

The NPF states that about 70 000 and about 1 million electric vehicles will be registered in Poland in 2020 and 2025. Till 2020 only 2000 BEVs are registered in Poland.

AF Fleet percentage of total Fleet M1 (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
0,02%	0,02%	0	0	14,54%	0,02%	14,60%

Table 1. Percentage of alternative fuel vehicles in M1 fleet. (source: European Alternative Fuels Observatory).

Table 1 indicates the lack of alternative fueled vehicle deployment. The increase of BEV deployment can be seen as in 2020 September alone 380 BEV M1 category vehicles were registered in Poland. The LPG share is slowly decreasing as the number of newly registered LPG vehicles (figure 9) has dropped since 2017.

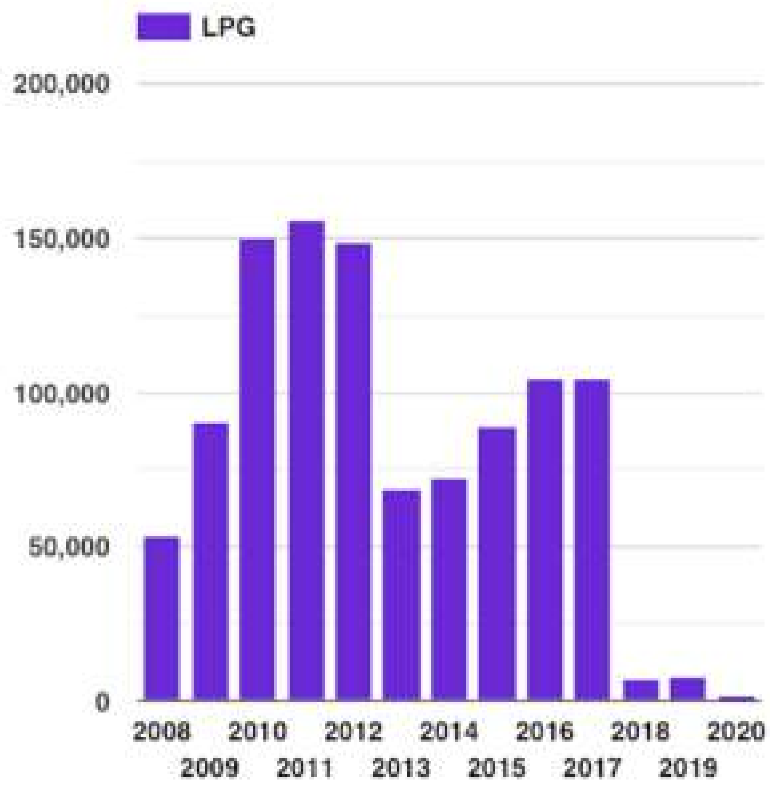

Figure 9. Number of new LPG M1 category vehicle registrations in Poland M1 fleet. (source: European Alternative Fuels Observatory).

FCEV Deployment

There is no information about deployed FCEVs in Poland.

HRS Development

No HRS were included in the NPF targets. The lack of hydrogen as alternative fuel vision in near-term strategy will affect the overall hydrogen Refuelling infrastructure deployment in Poland. Currently a new pilot project for HRS deployment is ongoing in Poland.

4.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

The NECP 2030 plan includes description of measures on security of supply, in particular for electricity. The NECP 2030 includes the need to diversify sources of gas and invest in

- LNG and new pipelines sourcing gas from other sources than the East;
- Maintenance of domestic gas production;
- the Baltic gas pipeline;
- Promotion of alternative transport fuels. (Decarbonized gases such as biogas and renewable hydrogen are not mentioned in this context).

The NECP 2030 highlights Poland's great potential in the hydrogen economy and refers to the upcoming Hydrogen Technology Development Programme, where hydrogen generation, transport, storage, distribution and end-use are addressed. As one of the future aims for Poland is to evaluate the possibility in injecting hydrogen into the natural gas network to produce synthetic methane. The NECP 2030 directly does not mentions HRS deployment but support priorities for national research and promotion the use hydrogen as an alternative fuel in the transport sector is included.[37]

Also, within the NECP the ambition of BEV vehicle deployment is decreased to 50 000 and around one million vehicles in 2020 and 2025 respectively.[38] Significant subsidy mechanisms are needed in order to achieve the target.

Stimulation of hydrogen for mobility

By the end of 2020, the Ministry of the Climate intends to publish the Polish Hydrogen Strategy for 2030, with perspective until 2040. It will be a key strategic document for the development of hydrogen in Poland. The aim of this strategy is to build hydrogen installations with a total capacity of 2-4 GW.[39] It is foreseen that the plan will also provide grounds for obtaining EU structural funds as part of the new financial framework[40]

The Polish government has established a well-financed Low Emission Transportation Fund[41], which supports matters connected with the generation and use of alternative fuels in general. The Low Emission Transportation fund policy includes hydrogen as alternative fuel. Its planned that the Low Emission Transportation Fund will be replaced with the National Fund for Environmental Protection and Water Management.[42]

4.3 HRS development plans

There are no existing HRS in Poland. Few HRS with both 700bar and 350bar dispensers are planned. Three of them are approved. A number of local companies have started the development process of HRS deployment. These include the state-owned energy companies PKN ORLEN, PGNiG and LOTOS, who are planning to develop a network of hydrogen vehicle Refuelling stations by 2021. PKN ORLEN's first HRS is foreseen to be in operation in 2021.[43] The current situation foresees that a total number of 8 HRS will be deployed in different cities: 2 HRS in Gdansk, 1 HRS in Gdynia, 1 HRS in Jastrzębie-Zdrój, 1 HRS in Łomża, 1 HRS in Poznan and 2 HRS in Warsaw.

[37] Assessment of the final national energy and climate plan of Poland
[38] Europe alternative fuel observatory https://www.eafo.eu/content/poland
[39] Current state of hydrogen projects in Poland (CMS Expert Guide to Hydrogen)
[40] Poland is joining the European Hydrogen Economy (Marek Foltynowicz CEEP report Q2 2020)
[41] The Low-Emission Transport Fund https://www.iea.org/policies/12223-the-low-emission-transport-fund
[42] National Fund for Environmental Protection and Water Management http://nfosigw.gov.pl/en/
[43] Current state of hydrogen projects in Poland (CMS Expert Guide to Hydrogen)

Figure 10. Ambition of HRSs in Poland[44]

The tender for the construction of a test hydrogen station at Pradzynski was announced. It is foreseen that the hydrogen station will be in operation from 2021. The hydrogen production will be done via water electrolysis with a 40kg of H_2 capacity per day. The intended amount will allow to refuel around 5 FCEVs per day. Both dispensers 350bar and 700bar will be mounted.[45] The second HRS from PGNiG located in Warsaw (Hydratank project)[46]

The city of Gdynia and Grupa Lotos S.a. expressed their willingness to cooperate on the development of hydrogen buses. Grupa Lotos S.a. plans to build a hydrogen purification installation to a purity of 99.999%, which will allow it to be used for propulsion purposes. The vehicles will be refueled in Gdańsk. Gdynia is planning to implement hydrogen vehicles in the coming years. It is not known yet whether they will be buses or trolleybuses with range extension by hydrogen. In Gdańsk the RM LLC Rigas Satiksme HyTrolleybuses were tested.[47]

[44] Pure H2 Hydrogen Purifying Unit and Filling Infrastructure https://trimis.ec.europa.eu/project/hydrogen-purifying-unit-and-filling-infrastructure#tab-partners
[45] Stacja tankowania wodoru w Warszawie od PGNiG http://gashd.eu/2019/10/26/stacja-tankowania-wodoru-w-warszawie-od-pgnig/
[46]Stacja tankowania wodoru w Warszawie od PGNiG http://gashd.eu/2019/10/26/stacja-tankowania-wodoru-w-warszawie-od-pgnig/
[47] Stacja tankowania wodoru w Warszawie od PGNiG http://gashd.eu/2019/10/26/stacja-tankowania-wodoru-w-warszawie-od-pgnig/

Currently, MPK Łomża has a photovoltaic installation with a capacity of 28.6 kW. There are plans to extend it by 300 kW. The city plans to build roofed charging points with electricity in selected locations. To balance the system, energy storage would be necessary. This possibility is offered by the production of hydrogen in the electrolysis plant. The intention of MPK Łomża is to set up a hydrogen station at the depot and to refuel 20 FCE-buses.[48]

Figure 11. The hydrogen Refuelling point would be built at the depot at ul. Spokojna 9 in Łomża.

One of the largest conventional fuel retailers Grupa Lotos S.a. is currently participating in EU Co-funded project “PURE H2”. The overall objective of the PURE H2 is to eliminate or reduce the impact of the currently existing barriers and to develop the market for hydrogen as a transport fuel in Poland. These obstacles include:

- insufficient supply of hydrogen intended for the use in fuel cells;
- insufficient purity of hydrogen as well as non-existing market;
- lack of hydrogen Refuelling infrastructure.

The PURE H2 is a pilot project in Poland and aims to construct a Hydrogen Purification Unit to produce 160 kg/h of hydrogen with associated hydrogen compression, storage and a Refuelling station in Gdansk, for the purpose of filling personal vehicles, buses and tube trailers together with the acquisition of two tube trailers with a capacity of at least 4 000 Nm3 (+/- 320kg) of hydrogen each. The Action also includes the construction of a public HRS at an existing fuel station located along the TEN-T core network in Warsaw, for the purpose of filling passenger vehicles and buses.[49]

[48] Stacja tankowania wodoru w Warszawie od PGNiG http://gashd.eu/2019/10/26/stacja-tankowania-wodoru-w-warszawie-od-pgnig/

The oil company PKN ORLEN S.A. intends to develop[50] a hydrogen hub in Włocławek with the use of hydrogen as a chlorine production biproduct. Once the HRS is deployed, the purified hydrogen will be used by city buses. A similar hydrogen purification plant with the necessary infrastructure will be built in Płock and in Silesia region[51]. Note that none of the cities mentioned in this paragraph are located on the North Sea-Baltic Sea core network corridor.

Some cities are planning to buy hydrogen buses for public transport (Gdynia, Gdańsk, Wejherowo, Tczew, Konin, Piła, Poznań, Kraków etc. Plans for hydrogen availability are developed by coal mining company Jastrzębska Spółka Węglowa[52], which intends to launch the production of hydrogen from coke-oven gas.

In City of Konin the Zepak S.A. have developed plans to produce bio-hydrogen. The intended action includes hydrogen production and compression to 350bars that could afterwards be transported to HRS.[53]

In total, currently plans are approved for 3 HRS (2 within Pure H2 action located in Warsaw and Gdansk and 1 in Pradzynski).

4.4 Conclusion

According to available data, the national wide hydrogen development plans are currently under preparation and centralized support may be available with EU support. Local actors are currently developing plans for hydrogen availability. The lack of hydrogen promotion as alternative fuel affected hydrogen Refuelling infrastructure deployment in Poland on the North Sea-Baltic Sea corridor. The produced amounts of hydrogen in Poland are enough to secure the necessary hydrogen for the first Refuelling stations. The deployment plans from local actors already include a number of HRS to be deployed in Poland. It is foreseen that HRS will be deployed on North Sea-Baltic Sea corridor node Warsaw. Plans for HRS in Poznan are not confirmed and no information about HRS deployment plans in Lodz are available. The first HRS deployment in Poland will be via the PURE H2 pilot project and could open the pathway for hydrogen Refuelling infrastructure deployment.

[50] Poland's PKN Orlen to start making hydrogen fuel https://bbj.hu/region/polands-pkn-orlen-to-start-making-hydrogen-fuel-ceo-says_189426
[51] Poland is joining the European Hydrogen Economy (Marek Foltynowicz CEEP report Q2 2020)
[52] Jastrzębska Spółka Węglowa S.A. https://www.jsw.pl/
[53] ZE PAK purchases first hydrogen fueling stations for cars and buses – implements green strategy https://www.zepak.com.pl/en/about-us/press-office/news/11643-ze-pak-purchases-first-hydrogen-fueling-stations-for-cars-and-buses-implements-green-strategy.html

5. Lithuania

5.1 General country characteristics and policy framework

Lithuania has no plans for the use of hydrogen as an alternative fuel. The subsidy mechanisms are developed for BEVs and could be used for FCEV deployment. The population of Lithuania is 2 784 184 inhabitants[54] and the registered vehicles in 2018 reached 1 574 435[55]. The overall length of motorways in Lithuania is 324km.[56] The North-Sea-Baltic Sea core network corridor crosses Lithuania. The Lithuanian nodes on the North-sea-Baltic Sea core network corridor are Vilnius and Kaunas. The main alternative fuel implementation policy documents are the National Alternative fuel implementation plan (NPF) and the NECP 2030.

5.2 Towards zero emission mobility

5.2.1 Targets and achievements

Till 2020 Lithuania has fulfilled only the NPF plans for BEV charging points. The NPF included evaluation of CNG, LNG and electricity infrastructure deployment for vehicles. Evaluation of HRS deployment was not included and therefore a possibility that the same issue as in Poland will arise, as lack of planned HRS will affect the hydrogen availability in the near-term.

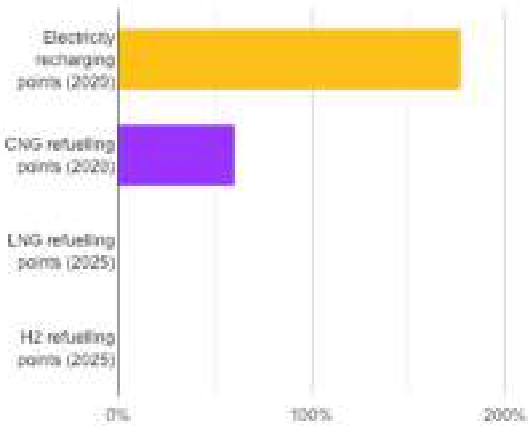

Figure 12. Infrastructure as % of National Policy Framework targets (source: European Alternative Fuels Observatory)

According to available data, Lithuania has currently 177 charging points for BEVs and only 6 of planned 10 CNG Refuelling stations are in operation.

[54] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[55] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[56] Eurostat 2018.data
https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en

AF Fleet percentage of total Fleet M1 (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
0,20%	0,00%	0	0	10,88%	0,17%	11,25%

Table 2 Percentage of alternative fuel vehicles in M1 fleet. (source: European Alternative Fuels Observatory).

Table 2 Percentage of alternative fuel vehicles in M1 fleet. (source: European Alternative Fuels Observatory).Table 2indicates the alternative fuel percentage of total Lithuanian M1 vehicle fleet. In total there are 1 780 BEV, 97 000 LPG and 1 539 PHEV vehicles registered in Lithuania.[57]

The deployed CNG Refuelling stations are currently serving around 300 CNG buses that are used for public transportation in Lithuania.

FCEV Deployment

There are no FCEVs deployed in Lithuania.

HRS Development

There are no HRS deployed in Lithuania.

5.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

The NECP 2030 includes that Lithuania's priorities include the digitalization of industry, industrial transformation towards a circular economy and further integration of its national industries into European strategic value chains. The most relevant strategic value chains are:

- batteries;
- interconnected, clean and self-contained vehicles;
- low carbon industry and hydrogen technologies and systems.[58]

The new targets of NECP includes that for 2025 the annual newly registered BEVs will reach 10% of the total fleet of M1 class and 50% by 2030. In order to push for BEV deployment, the primary electric vehicle charging infrastructure will be deployed in Municipalities with more than 25 000 inhabitants and newly constructed and reconstructed residential and non-residential buildings incl. gas stations, railway stations etc.

The subsidy mechanisms are already developed in Lithuania for zero emission vehicles. From April 2020, subsidy for an individual purchase of BEV which is not older than 5 years is 2 000 EUR for used

[57] Europe Alternative Fuel observatory https://www.eafo.eu/uploads/temp_chart_/data-export-191120.pdf?now=1605769605666
[58] Assessment of the final national energy and climate plan of Lithuania

vehicle and 4 000 EUR for new vehicle. Additional 1 000 EUR will be paid out for scrapping the old polluting vehicle. Additionally for electric vehicles and vehicles where emissions do not exceed 130 g/km CO2 are exempted from the vehicle registration tax.

NECP 2030 foresees potential in hydrogen usage in rail applications. The Lithuanian road transport sector is still heavily dependent on fossil fuels, like in the rest of the EU. Hydrogen is one of the solutions that can be deployed to decarbonize this sector. In Lithuania, heavy-duty vehicles and vans represent 41% of the energy demand in road transport, which means that there is significant potential for hydrogen deployment.[59]

Stimulation of hydrogen for mobility

Currently there are no information about development of hydrogen road map, that would provide a support for hydrogen technologies deployment in Lithuania.

On 30th November 2020 the Ministry of Energy of the Republic of Lithuania launched Lithuanian hydrogen energy platform, where majority of hydrogen-interested parties will join to encourage development of hydrogen economy in Lithuania.[60]

5.3 HRS development plans

Currently there is no information about approved HRS that have received all the necessary permits. The Alternative fuel implementation plan of Lithuania and NECP 2030 does not include hydrogen as alternative fuel. The NECP mentions hydrogen as promising fuel for the future thus, there are no publicly announced HRS deployment plans in Lithuania.

HRS and FCE-bus deployment for Kauno Autobusai, a public transport operator in Kaunas will be evaluated within Action H2NODES.

Regionally the Company SG Dujos has been engaged in exploration of alternative fuels. Currently hydrogen is blended into natural gas and filled in Scania CNG buses. The total number of 23 buses powered by hydrogen-natural gas blend are used in Telšiai, Ukmerge and Marijampolė. The annual consumption is around 0,5 million cubic meters of HCNG.[61]

5.4 Conclusion

In Lithuania the main focus is to deploy BE vehicles and the charging infrastructure. Hydrogen is not foreseen as potential fuel in Lithuania in the near-term. The Alternative fuel implementation plan of Lithuania only foreseen electric charging and CNG Refuelling infrastructure deployment. The Lithuanian hydrogen energy platform will develop hydrogen related regulations, thus currently the lack of overall hydrogen strategy will significantly impact the potential hydrogen Refuelling

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[59] Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans
[60] Ministry of Energy of the Republic of Lithuania – Hydrogen platform https://enmin.lrv.lt/en/news/hydrogen-platform-being-developed-in-lithuania-to-promote-advanced-energy-technologies
[61] SG dujos.

infrastructure deployment in Lithuania and could result as a missing link to connect the North Sea – Baltic sea network corridor.

6. Latvia

6.1 General country characteristics and policy framework

Latvia is the first country with a HRS in Eastern Europe. The HRS is deployed within the Action H2NODES and is owned by Rigas Municipality Public transport operator RM LLC Rigas Satiksme. The population of Latvia is 1 919 968 inhabitants[62] and in total 806 801 vehicles are in operation[63]. The main alternative fuel implementation policy documents are the National Alternative fuel implementation plan and the NECP 2030. The North-Sea-Baltic Sea TEN-T Core network corridor crosses Latvia and the main nodes on the corridor are Riga and Ventspils (comprehensive network).

6.2 Towards zero emission mobility

6.2.1 Targets and achievements

The Alternative fuel infrastructure implementation plan of Latvia (NPF) was accepted on April 2017. Only the BEV charging infrastructure goals are reached till 2020. The Latvian Alternative fuel infrastructure implementation Plan admits that the absence of a national policy plan has jeopardized the use of natural gas and hydrogen in transport. The NPF does not provide future estimates thereof. Although it includes assessment of hydrogen as alternative fuel, the hydrogen is not set as a mandatory fuel.

Currently in Latvia there are 238 public BEV charging points, 3 CNG Refuelling stations, 1 HRS.

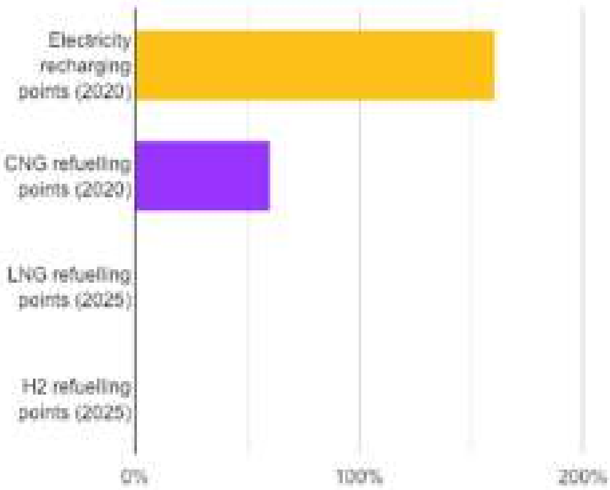

Figure 13. Infrastructure as % of National Policy Framework targets (source: European Alternative Fuels Observatory)

Figure 13 provides insight that deployment of publicly accessible electricity charging points have extended the NPF plans. As mentioned previously, the hydrogen Refuelling infrastructure was not part of NPF. The NPF target for CNG Refuelling stations was 5.

[62] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[63] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en

AF Fleet percentage of total Fleet M1 (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
0,11%	0	0	0	6,87%	0,02%	7%

Table 3. Percentage of alternative fuel vehicles in M1 fleet. (source: European Alternative Fuels Observatory).

Table 3 estimates the total alternative fuel M1 category vehicles. Additionally, there are small number of CNG vehicles registered in Latvia. There is a lack of hydrogen passenger vehicles despite the Refuelling infrastructure being deployed and in operation.

FCEV Deployment

The Latvian alternative fuel implementation plan expects that the purchase price of 'green' vehicles will remain higher than that of conventional vehicles. However, the government of Latvia considers it has "few instruments available to influence this". Notwithstanding, the Alternative fuel implementation plan mentions the possibility of financial support between 2018 and 2020 to reduce the current 7,000 EUR financial differential between internal combustion engine vehicles and EVs on sale in Latvia. Three levels of support were under discussion: 7,000 EUR for 2018, 5,000 EUR for 2019 and 3,000 EUR for 2020.[64] Thus none of options were approved and implemented. Currently there is no support for electric-vehicle owners other than tax reduction.

The FCE-vehicles are foreseen as electric vehicles and therefore FCE-passenger vehicles are able to use public transport lines. Additionally, FCE-vehicles are excluded for circulation tax[65] and (if equipped with specific license plate) can park for free in Riga and Liepāja. The current data shows that in Latvia total number of electric vehicles in Latvia is 1049, of which (1031 – M1 category and 18 N2 category). [66] Currently the only FCE-vehicles that are registered in Latvia are 10 HyTrolleybuses owned by RM LLC Rigas Satiksme.

HRS Development

No support for HRS deployment was available.

6.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

The NECP of Latvia includes hydrogen for mobility and energy applications at R&D level. The priority is to achieve innovative solutions in the field of renewable energy technologies and for the production

[64] Member state fiches https://ec.europa.eu/transport/sites/transport/files/2017-11-08-mobility-package-two/ms-fiches.pdf
[65] Transportlīdzekļa ekspluatācijas nodokļa un uzņēmumu vieglo transportlīdzekļu nodokļa likums. Latvijas Vēstnesis, 206, 30.12.2010. https://likumi.lv/doc.php?id=223536
[66] CSDD elekrotransportlīdzekļi http://etransports.lv/index.php/arhivs/elektrotransportlidzekli

and use of biomethane, hydrogen and advanced biofuels.[67] The second R&D initiative includes aspects of smart mobility, such as alternative fuels and biofuels - hydrogen, biogas, electric propulsion and energy recovery technologies, automated transport and intelligent transport systems, solutions for the introduction and development of electromobility, resource efficiency and decarbonization-oriented transport and mobility, incl. multimodal, system, planning and design.[68]

Stimulation of hydrogen for mobility

The NECP includes obligation to develop regulation that would allow EU structural funds and other funding divert to development of Electric vehicle charging points as well as other alternative (prioritizing hydrogen) fuel infrastructure implementation from 2021.

Overall, the main aspect of transport future is firstly related to improve the energy efficiency. The first steps are foreseen as transition from fossil fuels to electricity, biofuels (incl. bio-methane), CNG/LNG. The introduction of hydrogen as an alternative fuel according to NECP 2030 is foreseen further into the future.

6.3 HRS development plans

Only one HRS has received all the permits and in operation. The HRS planning in Latvia is fragmented as no overall state-wide strategy is developed. The main drivers are actors with large public transport fleets such as RM LLC Rigas Satiksme and LLC “Jelgavas Autobusu parks”. The RM LLC Rigas Satiksme is the owner of the first HRS in Latvia.

The Alternative fuel implementation plan includes a possible map of HRS points but no further indications about actual deployment can be found. The map included 18 HRS in Latvia that would be enough to establish a nationwide hydrogen Refuelling network. Note that the map included in the Alternative fuel implementation plan is a recommendation from Latvian Hydrogen association.

[67] Nacionālais Enerģētikas un Klimata Plāns Latvia. https://em.gov.lv/lv/nozares_politika/nacionalais_energetikas_un_klimata_plans/
[68] Nacionālais Enerģētikas un Klimata Plāns Latvia. https://em.gov.lv/lv/nozares_politika/nacionalais_energetikas_un_klimata_plans/

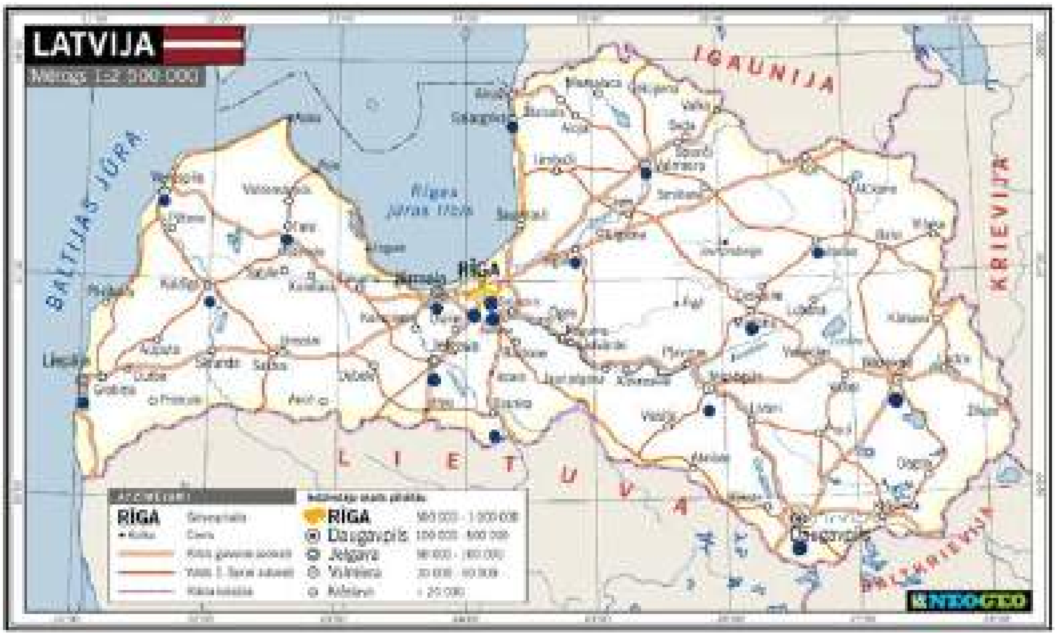

Figure 14. Foreseen HRS map of Latvia[69]

RM LLC Rigas Satiksme HRS is located in Riga, Vienības Gatve 6 next to 2nd Trolleybus depot. The HRS was deployed within the Action H2NODES.[70]

Figure 15. Riga Hydrogen production and refuelling station

[69] Ministru kabineta 2017. gada 25. aprīļa rīkojums Nr. 202 "Par Alternatīvo degvielu attīstības plānu 2017.–2020. gadam". https://likumi.lv/ta/en/en/id/290393-on-alternative-fuels-development-plan-20172020
[70] Rigas Satiksme. https://www.rigassatiksme.lv/lv/aktualitates/nodota-ekspluatacija-baltija-pirma-udenraza-uzpildes-stacija/

Riga HRS specification:

Capacity	300kg/day
Dispensing pressure	350/700bar
Source of hydrogen	steam-methane reformation
Publicly accessible	yes
Payment method	credit card.

The development of local policy documents resulted in deployment of the Riga HRS. The policy documents were mainly developed by Rigas Satiksme, and Riga City Council, as they are the first movers of hydrogen mobility in Latvia. The development of these documents and HRS was established within publicly funded projects (i.e. EU co-funded).:

- "Commercialization Strategy of Hydrogen Fuel Cell Buses in Europe NewBusFuel". Engineering solutions for a HRS of city public transport depot;
- "HiT2-Corridors" - corridors of hydrogen infrastructure for transport;
- "H2Nodes" establishment of hydrogen as transport Refuelling infrastructure within the framework of TEN-T main network corridor North SEA - BALTIC. Within the project "H2Nodes".

Additionally, The Riga City Council is taking steps to address the challenges of both decarbonization and lowering of air pollution arising from transport in and around the city. Part of this is the development of hydrogen as transport fuel, with a Hydrogen technologies advisory board established since September 2013.

In 2016 the first initiative to create a Zero-Emission center in Riga were established. The initiative included 3 scenarios to decrease the overall emissions in Riga. One of the scenarios was to develop a “low emission zone” in the Riga City Centre. This initiative would forbid vehicles with emission class lower than “EURO 3” to drive in the Centre. However, no further development of the initiative has taken place since 2016.

Other regional activities and planning of HRS are ongoing. The Jelgava City council has concluded a memorandum of understanding with LLC “Fortum Latvia” on the possibility to evaluate hydrogen production and usage in Jelgava City. According to the publicly available information this evaluation will also include an evaluation of FCE-vehicle usage for public transport operations in Jelgava.[71] The longest public transport route in city of Jelgava is 290 kilometers, (average 180-190 kilometers). This means that the FCE-buses would not have to be refueled during the day, as is the case with BE-

[71] Jelgava City Council. https://www.jelgava.lv/lv/jaunumi/zinas/jelgava-izmegina-ar-udenradi-darbinamu-auto/

buses. [72] Only the announcements of evaluation are available and no indications about the source of hydrogen production, HRS capacity etc. is publicly available.

6.4 Conclusions

Lack of overall hydrogen road-map of Latvia will significantly impact the overall hydrogen as alternative fuel availability in the near term. HRS deployment plans were included in the Alternative fuel implementation plan. The fact that hydrogen was not set as mandatory fuel resulted as the plans will not be achieved. As mentioned above, currently only some independent actors are seeking opportunities to deploy HRS. A state-lead approach and clear support mechanisms would provide the necessary push for this technology.

[72] Jelgava City Council https://www.jelgava.lv/lv/jaunumi/zinas/jelgava-izmegina-ar-udenradi-darbinamu-auto/

7. Estonia

7.1 General country characteristics and policy framework

In Estonia HRS infrastructure will be deployed within the Action H2NODES. Estonia has well developed the CNG usage in public transport operations and currently the Hydrogen road map of Estonia is under development and will be finalized in 2021. The population 1 324 820 inhabitants[73]. The overall length of motorways in Estonia is 154 km[74]. The North-Sea-Baltic Sea TEN-T Core network corridor crosses Estonia and the main nodes on the corridor are Tallinn. The main alternative fuel implementation policy documents are the National Alternative fuel implementation plan and the NECP 2030.

7.2 Towards zero emission mobility

7.2.1 Targets and achievements

Estonia deployed even more alternative fuel infrastructure than set in the national plans. The National Alternative fuel implementation plan of Estonia focuses on increasing the proportion of alternative fuels use in road transport and is seeking to increase the use of renewable energy sources in road transport to 10% of the amount of fuel consumed in 2020. The objective is to be achieved through three types of fuel – liquid biofuels, biomethane and electricity.[75]

Figure 16 shows the deployed alternative fuel infrastructure compared to National Policy framework ambitions.

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[73] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[74] Eurostat 2018.data
https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en
[75] Member state fitches, https://ec.europa.eu/transport/sites/transport/files/2017-11-08-mobility-package-two/ms-fiches.pdf

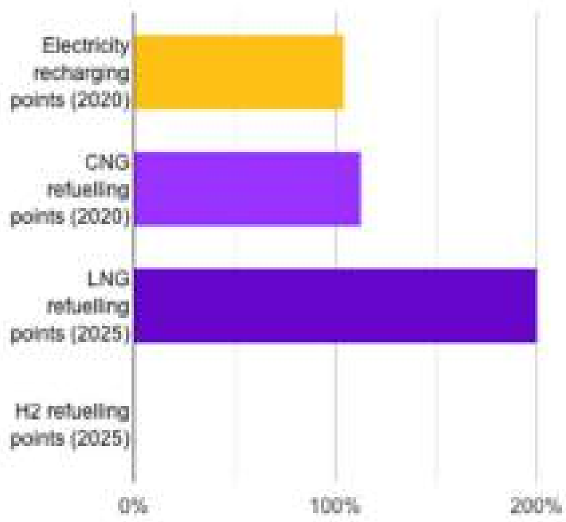

Figure 16. Infrastructure as % of National Policy Framework targets (source: European Alternative Fuels Observatory)

Estonia is one of the countries that have fully fulfilled its set targets for alternative fuel infrastructure. There are 404 BEV charging points, 89 LPG and 20 CNG Refuelling points. The breakdown of the whole Estonia alternative fuel fleet is included in Table 4.

AF vehicles of all categories in Estonia (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
1675	1100	1	0	6210	246	9232

Table 4. Alternative fuel vehicles of Estonia vehicle fleet. (source: European Alternative Fuels Observatory).

The PTO of Tallinn, "Tallinna Linnatranspordi" is already using 100 CNG buses for public transport operations. According to their plans, it is foreseen that till 2025 the number will reach 350 units in Tallinn. Evaluation of "Tallinna Linnatranspordi" possible HRS and FCE-bus fleet will be made within H2NODES action.

FCEV Deployment

As for fuel cell vehicles, there was only 1 vehicle registered in Estonia. The registered vehicle is also used to perform fueling tests of 700bar dispenser at Riga HRS.

HRS Development

The HRS that will be deployed within the Action H2Nodes is also included in the National Alternative fuel implementation plan, thus it is set as a target for 2025. Hydrogen was not seen as mandatory alternative fuel.

7.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

The NECP 2030 only indicates that the conversations about hydrogen opportunities for transport sector are ongoing. No plans about transport related infrastructure are included.[76]

The policy document that suggests the FCEV usage is the Estonian Transport and Mobility Master Plan.[77] It states hydrogen as energy efficient and environmentally friendly fuel, which could be used in buses, on railway, and in shipping.

Estonia has no car tax. The only fuel that is subsidized is biomethane. There is a floating premium from production side and incentives available for purchasing buses for public transport.[78]

Stimulation of hydrogen for mobility

In mid-2020 the agreement for the development of Estonia Hydrogen road-map was concluded. The aim of Estonia Hydrogen road-map is to open the pathway of Estonia towards zero-mobility as currently it is set mainly in the CNG and bio methane direction. It is foreseen that the Estonia Hydrogen road-map will be concluded in mid 2021.

7.3 HRS development plans

Only the HRS intended to be deployed in Pärnu has received the building permit. The HRS would be deployed within the action H2NODES. The location of the approved HRS may change to Tallinn and therefore the permitting process may have to be repeated. In addition to the two existing HRss, 5 HRS are planned, funded an have permits in place. Currently there are no HRS development plans in Estonia. The intended HRS that will be deployed by H2NODES beneficiary Parox Energy OU is still the first confirmed HRS in Estonia that will be deployed.

Regionally the Tallinn Sustainable Energy and Climate Action Plan includes plans to introduce of green hydrogen and hydrogen buses. With regards to the transport sector, the vehicles belonging to the city and providing services in the city will mostly be emission-free. The bus fleet belonging to the city will be switched to gas buses in the first phase and to electric and/or hydrogen buses in the second phase. The local strategy indicates that taxis, rental vehicles and intra-urban freight transport will have shifted 50% to zero-emission vehicles by 2030.[79]

Keila town is interested in being a pilot project for hydrogen technology development and use in Estonia. Keila has an excellent location in terms of infrastructure. Combining nearby onshore wind energy for hydrogen production, Paldiski port with supporting infrastructure and connection with main railway line and gas network. In the industrial sector there are potential opportunities with Harju KEK industrial park.

[76] Estonia 2030 National Energy and Climate plan.
[77] Estonian Transport and Mobility Master Plan. 2020 is in favour of using hydrogen as energy efficient and environmentally friendly fuel, which could be used in buses, on railway, and in shipping.[77]
[78] Alternative Fuel Observatory.
[79] Tallinn Sustainable Energy and Climate Action Plan.

Local public company Estiko Energy is currently building a 75MW solar park and is heavily looking into producing green hydrogen off excess production.[80] Project planning is in motion for a smaller Refuelling station at their warehouse whereas green hydrogen would be produced locally. The produced hydrogen would be used mainly for forklifts. The same location could be used for a public Refuelling station, initially smaller scale to support different types of FCEVs, thus government support is necessary in order to perform actual works.

7.4 Conclusions

The hydrogen infrastructure deployment plans were not included in the National Alternative fuel implementation plan. The construction works of the first and currently only publicly announced HRS are ongoing. The Estonia hydrogen road map is under preparation and will be finalized in mid 2021. The development of hydrogen road map of Estonia would help to assess the hydrogen implementation and role in Estonia.

[80] Estiko Energia OÜ https://www.estiko.ee/ettevotted/estiko-energia-ou

8. Finland

8.1 General country characteristics and policy framework

Finland is the country situated at the end of the TEN-T North-Sea- Baltic sea network corridor with one Node - Helsinki. The population is 5 517 919 inhabitants[81] and the registered vehicles in 2018 reached 4 224 907 units.[82] The overall length of motorways in Finland is 926km.[83] It is also a country where HRS were deployed in 2016, but were then decommissioned due to a lack of fuel cell vehicles. Total dedicated hydrogen production in Finland is estimated to be 140 000–150 000 t/a (4.7–5.0 TWh), and 99 % of the dedicated hydrogen is produced via either steam reforming or partial oxidation of fossil fuels and <1 % is produced via water electrolysis.[84] As a biproduct of the Finnish industries, a quantity of hydrogen is currently produced that would be enough to meet the energy needs of some 10 000 cars.[85] The produced hydrogen is mainly used in oil refining and biofuel production. The main alternative fuel implementation policy documents are the National Alternative fuel implementation plan (NPF), Hydrogen roadmap of Finland and the NECP 2030.

8.2 Towards zero emission mobility

8.2.1 Targets and achievements

The alternative vehicle fleet in Finland mainly consists of BEVs and CNG vehicles. The Finnish NPF focuses on biofuels to meet the near-zero emission transport target by 2050. Low and high blends are planned to be used in different modes of transport, ensuring less fossil oil dependency and less GHG emissions.

The Finland Alternative fuel implementation plan focuses of battery electric recharging and CNG, LNG and H2 Refuelling infrastructure development.

Figure 17. Infrastructure as % of National Policy Framework targets (source: European Alternative Fuels Observatory)Figure 17 shows the national alternative fuel infrastructure put in place in 2020 compared to National Policy framework ambitions.

[81] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[82] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[83] Eurostat 2018.data
https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en
[84] National hydrogen roadmap of Finland https://www.businessfinland.fi/4abb35/globalassets/finnish-customers/02-build-your-network/bioeconomy--cleantech/alykas-energia/bf_national_hydrogen_roadmap_2020.pdf
[85] Alternative transport fuel infrastructure plan of Finland.
https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/80230/Report%205-2017.pdf?sequence=1&isAllowed=y

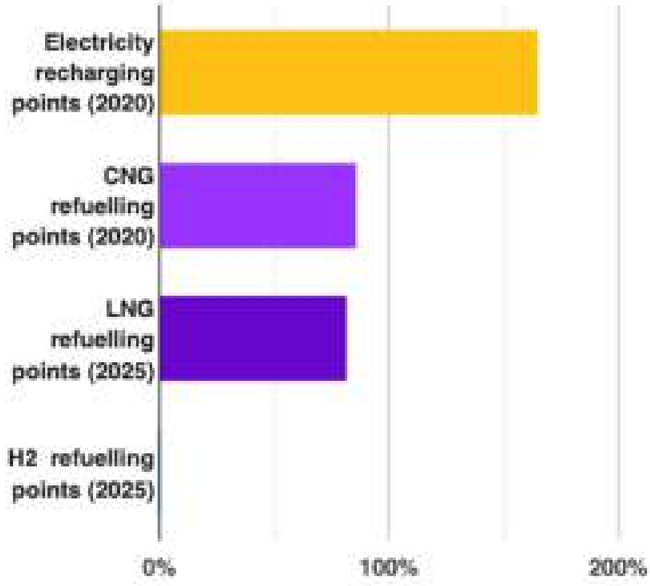

Figure 17. Infrastructure as % of National Policy Framework targets (source: European Alternative Fuels Observatory)

It shows the pattern that deployment of alternative fuel infrastructure is ongoing, however no progress on hydrogen Refuelling infrastructure can be seen. Only the BEV charging infrastructure goals are reached.

According to the available data, Finland has the smallest alternative fueled M1 category vehicle fleet share compared to other countries on the North-sea Baltic sea TEN-T corridor.

AF Fleet percentage of total Fleet M1 (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
0,18%	0,33%	0	0	0	0,94%	1,45%

Table 5. Percentage of alternative fuel vehicles in M1 fleet. (source: European Alternative Fuels Observatory).

Table 5 indicates the lack of alternative fueled vehicle deployment. The breakdown of the whole Finland alternative fuel fleet is included in Table 6Error! Reference source not found.

AF vehicles of all categories in Finland (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
6432	11900	0	0	7	33883	52222

Table 6. Alternative fuel vehicles of Finland vehicle fleet. (source: European Alternative Fuels Observatory)

FCEV Deployment

Originally the target of electric vehicles in 2030 is to reach 25 000 units and this includes FCEVs.[86] There were only 1 FCEV registered in Finland from 2015-2019 and the current number of FCE-vehicles in Finland are 0.

HRS Development

The Finnish NPF displays a strong commitment towards hydrogen. The deployment of 19 publicly accessible hydrogen Refuelling points in addition to the two existing ones was planned, ensuring the distance of 300 km between HRS.[87] The aim to deploy additional 19 HRS is set to be achieved by 2030. Note that the two-existing hydrogen Refuelling stations are decommissioned and are no longer in operation. And there is no indication that the 2030 aim will be achieved.

8.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

The NECP 2030 includes only general need to move towards alternative fuel vehicle fleet. In order to achieve the targets, the taxation of fossil fuels must be increased and use of biofuels in road transport (up to 30%) must be achieved. Support mechanisms for alternative fuel must be developed. For road transport the NECP 2030 states that 250 000 electric and 50 000 gas-powered vehicles should be on the Finnish roads till 2030. The plan mentions a roadmap for fossil-free transport to be drafted by the end of 2020, which would present the measures to halve GHG emissions from national transport by 2030 and to achieve net-zero transport emissions by 2045.[88]

As for support mechanisms the direct purchase subsidy for BEVs are of 2 000 EUR are available and valid until November 2021.[89]

Stimulation of hydrogen for mobility

According to available information the roadmap of fossil-free transport is not yet finalized. As Finland already had plans for hydrogen availability in the Alternative fuel implementation plan, the lack of hydrogen deployment has to be highlighted.

[86] Alternative transport fuel infrastructure plan of Finland https://julkaisut.valtioneuvosto.fi/handle/10024/80230
[87] Member state fitches. https://ec.europa.eu/transport/sites/transport/files/2017-11-08-mobility-package-two/ms-fiches.pdf
[88] Assessment of national Energy and Climate Plan of Finland.
[89] European Alternative fuel observatory https://www.eafo.eu/countries/finland/1732/incentives

8.3 HRS development plans

In late 2015, there was one FCEV and two operating HRS in Finland. One of these points was located in Vuosaari port in Helsinki and the other in Voikoski, Southern Savo. Both of these were compliant with the general HRS standards with their fueling pressures of 350 bar and 700 bar.[90]

Figure 18. Hydrogen refuelling infrastructure deployment map from Alternative fuel implementation Plan of Finland[91]

[90] Alternative transport fuel infrastructure plan of Finland https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/80230/Report%205-2017.pdf?sequence=1&isAllowed=y

[91] Alternative transport fuel infrastructure plan of Finland https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/80230/Report%205-2017.pdf?sequence=1&isAllowed=y

The number of HRS in 2030 would be 20, ensuring that the distance between stations would be approximately 300 km, and that each station would serve its area within a radius of 150 km.[92] The deployment of 20 HRS could create a nation-wide hydrogen Refuelling net in Finland.

The Hydrogen road-map of Finland states that the use of hydrogen in FCEVs has not taken such progress that was anticipated ten or even five years ago. The main obstacle was the limited HRS network density, allowing the vehicles to be used in quite limited geographical areas. Furthermore, the current market offering of the industry is restricted just to four different vehicles, and that may not satisfy the needs of the buying customers.[93] Thus the main focus of hydrogen usage in Finland is to use renewable hydrogen in oil refineries. The actual situation indicates that FCEVs will not be deployed if HRS will not be available.

Currently there are no HRS in Finland. The city of Kerava (30km away from Helsinki) is looking forward to test 20 FCE-buses for public transport operations. In order to refuel the buses Public authorities will build a three-hectare solar park to make the electricity needed for the hydrogen production.[94] No timescale of test are available.

Considering that in Finland there were two hydrogen Refuelling points, the lack of fuel cell vehicles and governmental support mechanisms for zero-emission vehicles will impact the hydrogen availability in Finland.

8.4 Conclusions

The hydrogen infrastructure deployment plans were already included in the Alternative fuel implementation plan of Finland and foresee a total number of 20 Refuelling points to be deployed by 2030. Since the approval of alternative fuel infrastructure plan, two existing HRS were closed due to insufficient number of fuel cell vehicles. The lack of fuel cell vehicles and governmental support mechanisms for zero-emission vehicles impacted the hydrogen availability in Finland. Currently the hydrogen is not seen as alternative fuel for the near-term future. The produced hydrogen is and will mainly be used in the oil refineries.

[92] Alternative transport fuel infrastructure plan of Finland https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/80230/Report%205-2017.pdf?sequence=1&isAllowed=y

[93] National hydrogen roadmap of Finland https://www.businessfinland.fi/4abb35/globalassets/finnish-customers/02-build-your-network/bioeconomy--cleantech/alykas-energia/bf_national_hydrogen_roadmap_2020.pdf

[94] Fuel Cell works https://fuelcellsworks.com/news/testing-fuel-cell-buses-in-finland/

9. Sweden

9.1 General country characteristics and policy framework

As a step towards zero net GHG emissions by 2050, a target has been set for the vehicle fleet to be independent of fossil fuels by 2030.[95] In Sweden there are 5 HRS deployed. The population of Sweden is 11 230 185 inhabitants[96] and registered vehicles by 2018 reached 5 558 217[97] units. The total length of motorways in Sweden is 2132km. [98] The production of electricity and heat in Sweden, to a large extent, free from fossil fuels and greenhouse gas (GHG) emissions. The major potential for Sweden to reduce GHG emissions on a national scale is in the transport sector. The North-Sea Baltic Sea TEN-T network core corridor does not cross Sweden mainland. Sweden is part of Scandinavian-Mediterranean TEN-T core network corridor. The description will be included within this report, with Sweden listed as a neighboring country to be considered in the analysis within the Grant Agreement of the Action H2NODES.

9.2 Towards zero emission mobility

9.2.1 Targets and achievements

The Swedish Alternative fuel implementation plan contains neither future estimates for alternative fuels vehicles nor any targets for alternative fuels recharging or Refuelling infrastructure.

The total alternative fuel infrastructure deployment in Sweden is well developed, there are 9511 BEV charging points, 196 CNG, 21 LNG Refuelling points and 5 HRS.

The breakdown of the Sweden alternative fuel fleet is included in Table 7.

AF vehicles of all categories in Sweden (2020)						
BEV	CNG	H2	LNG	LPG	PHEV	TOTAL
47208	43315	46	0	0	107086	197655

Table 7. Alternative fuel vehicles of Sweden fleet. (source: European Alternative Fuels Observatory).

One of the main policy documents for AF vehicle deployment is The Swedish Climate Act[99] that was developed in 2018. It includes targets on reduction of diesel and petrol and obligation to gradually

[95] National Strategies and Plans for Fuel Cells and Infrastructure Implementing Agreement for a Programme of Research, Development and Demonstration on Advanced Fuel Cells https://www.ieafuelcell.com/fileadmin/publications/NatStratandPlansforFuelCellsandInfraStruct_v10.pdf
[96] Eurostat 2019.data. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[97] Eurostat 2018 data https://ec.europa.eu/eurostat/databrowser/view/tran_r_vehst/default/table?lang=en
[98] Eurostat 2018.data https://ec.europa.eu/eurostat/databrowser/view/road_if_motorwa/default/table?lang=en
[99] The Swedish climate act https://www.iea.org/policies/7158-the-swedish-climate-act

increase biofuels blending amounts and recommends that specific regulation for hydrogen as alternative fuel should be developed.

FCEV Deployment

The deployment of alternative fueled cars could be in line with the well-developed support mechanism. Cars and light trucks/buses with emission of max 60g/km (NEDC) that are newly registered from 1st of July 2018 are subject to a “climate bonus” of up to SEK 60 000. Supplementing the users who bought new CNG cars and light trucks/buses are able to receive a bonus of SEK 10 000 independent of the CO2 emission. The highest subsidy is for electric vehicles that can reach up to SEK 60 000. The subsidy for plug-in hybrids (PHEV) with CO2-emission of 70g/km is SEK 10 020. The climate bonus must not exceed 25% of the new car price. Additionally, the public transportation authorities can receive a premium of maximum 20% of the purchase price of the new electric bus. The premium must not be higher than the difference in price of the electric bus and that of the corresponding diesel bus. Plug- in hybrid buses can receive half of the premium amount. Private companies buying new electric buses can receive a premium of 40% on the difference between the price of the electric bus and corresponding diesel bus. [100]

HRS Development

The alternative fuel implementation plan included the target for 5 publicly accessible HRS till 2020.[101] The target is reached as currently there are 5 operating HRS in Sweden.

9.2.2 Hydrogen vehicles and infrastructure development outlook

General stimulation of low-/zero-emission vehicles

It is foreseen that also the potential users of new electric heavy-duty trucks would be eligible for the previously mentioned subsidy mechanism.[102]

Stimulation of hydrogen for mobility

Sweden has no national roadmap for hydrogen and fuel cells, but a number of Government-funded research and demonstration programmes exist to help achieve the national energy goals.[103]

In August 2020 the Government issued a Memorandum, reflecting on the EU’s strategy for an Integrated Energy system and the Hydrogen strategy. The Memorandum was positive to hydrogen

[100] European Alternative fuel observatory https://www.eafo.eu/countries/sweden/1755/incentives
[101] Member state Fitches. https://ec.europa.eu/transport/sites/transport/files/2017-11-08-mobility-package-two/ms-fiches.pdf
[102] European Alternative fuel observatory https://www.eafo.eu/countries/sweden/1755/incentives
[103] National Strategies and Plans for Fuel Cells and Infrastructure Implementing agreement for a Programme of Research, Development and Demonstration on Advanced Fuel Cells https://www.ieafuelcell.com/fileadmin/publications/NatStratandPlansforFuelCellsandInfraStruct_v10.pdf

and supports the EU strategies. In September the Government's budget proposal for 2021 was made. There are three areas with budget for hydrogen applications:

1. The industrial budget – funding for industrial projects;
2. The climate budget – funding to all sorts of applications with CO2-reductions;
3. Infrastructure for electrified heavy vehicles (valid for batteries, hydrogen and electrical roads).

Additionally, to that formations such as the Scandinavian Hydrogen Highway Partnership, whose vision is to make the Scandinavian region one of the first in Europe where hydrogen is commercially available and used in a network of Refuelling stations, helps to achieve the real-life deployment of hydrogen infrastructure.[104]

As the subsidy mechanisms exist the main barriers for hydrogen could be competence and experience, as there is strong focus on biofuels usage and BEV deployment, that is delaying the deployment of hydrogen applications.

9.3 HRS development plans

According to available data, there are currently 5 operating HRS in Sweden. The Refuelling stations are located in Gothenburg, Mariestad, Stockholm (Arlanda Airport), Sandviken and Umeå.

HRS in Umea[105]

HRS in Gothenburg[106]

[104] Scandinavian Hydrogen Highway Partnership. https://www.nordichydrogenpartnership.com/

[105] Fuel cell works. https://fuelcellsworks.com/news/sweden-oazer-ab-opens-hydrogen-fueling-station-in-vasterslatt-in-umea/

[106] Fuel cell works. https://fuelcellsworks.com/news/hynion-acquires-hydrogen-station-in-sweden/

HRS in Mariestad[107]


HRS in Sandviken


HRS in Stockholm (Arlanda Airport)

Figure 19. HRS in Sweden

For HRS development plans The Nordic Hydrogen corridor must be pointed out. It is an EU Co-funded initiative aiming at providing hydrogen transport solutions based in Sweden. The Nordic Hydrogen Corridor includes deployment of FCEVs, hydrogen production and refuelling infrastructure. Within the action 8 new HRS will be deployed. The hydrogen will be produced centralized whereas hydrogen for up to 3 000FCEVs will be produced. The total co-funded number of FCEVs is 100 units. The Nordic Hydrogen corridor is implemented along the Scandinavian-Mediterranean Core Network Corridor. It aims at increasing Hydrogen mobility in Sweden to a level comparable with the neighboring countries and it will contribute to building one large interconnected hydrogen mobility region. Outcomes of the pilot and business models will be studied so as to allow wider roll-out of FCEV and HRS along the main roads of Sweden, the Nordic countries and the whole Scandinavian-Mediterranean corridor.[108]

[107] Fuel Cell works. https://fuelcellsworks.com/news/the-worlds-first-solar-powered-hydrogen-refuelling-station-inaugurated-in-mariestad/
[108] Trimis. Nordic hydroen corridor zero emission transport between capitals https://trimis.ec.europa.eu/project/nordic-hydrogen-corridor-zero-emission-transport-between-capitals-nordic-countries-fuel-cell

In Sweden two municipalities are strong actors in the field of hydrogen applications: Mariestad and Sandviken. In Mariestad the first off-grid solar-powered hydrogen producing and filling station was opened.[109] Sandviken is known for actors in the field of the fuel cell production. The municipality of Sandviken is looking forward to introduce hydrogen buses in city traffic. The municipality declares themselves as largest owner of hydrogen cars per capita in the world.[110]

9.4 Conclusions

Sweden has fulfilled its alternative fuel implementation plan for HRS deployment. Government's budget proposal for 2021 approval would enable more HRS deployment in Sweden. Currently there are only 46 FCEVs in Sweden. The deployment of additional 8 HRS within the Nordic Hydrogen corridor will provide a more available hydrogen Refuelling network in Sweden and would open the possibility to deploy more FCEVs in the regions.

[109] Fuel cell works. https://fuelcellsworks.com/news/the-worlds-first-solar-powered-hydrogen-refuelling-station-inaugurated-in-mariestad/
[110] Sandviken Pure Power https://sandvikenpurepower.com/in-english/hydrogen.html

PART II
Hydrogen Mobility and Refuelling along the NSB Corridor

1. Hydrogen Mobility and Refuelling along the NSB Corridor

1.1 HRS capacity for cross-border mobility

In chapter 2 the data about HRS availability HRS development plans were provided on a per-country basis. The National Policy Frameworks. Figure 20 shows the target number of HRSs per EU Member-State. Poland, Lithuania and Latvia had not set explicit targets for HRS development.

Figure 20. NPF targets for hydrogen refuelling points for 2025 .[111]

[111] https://ec.europa.eu/transport/sites/transport/files/legislation/swd20190029.pdf

The performed analysis in part I shows that the actual number of developed HRSs is significantly lower compared to the ambitions set in the National Policy Frameworks. Figure 20 includes an overview of the level of attainment in 2019 which demonstrates this.

Table 8 presents an overview of all existing and planned HRSs on the NS-B Corridor. It shows a) an overall underperformance regarding the 2015 plans and b) a clear discrepancy between HRS coverage in the western part of the corridor compared to the eastern part.

Listed HRS				
City	In operation	Planned	Confirmed	Distance from pervious HRS (km)
Finland				
Helsinki	No	Yes	No	N/A
Estonia				
Pärnu (Talinn)	No	Yes	No	220 Pärnu (30 Talinn)
Latvia				
Riga	Yes	Yes	Yes	180/310
Lithuania				
Panevezys	Yes	Yes	Yes	150
Kaunas	Yes	Yes	Yes	100
Poland				
Lomza	No	Yes	No	315
Warszawa	No	Yes	Yes	150
Lodz	No	No	No	130
Poznan	No	Yes	No	200
Germany				
Berlin	Yes	Yes	Yes	280
Potsdam	Yes	Yes	Yes	35
Magdeburg	Yes	Yes	Yes	120
Wolfsburg	Yes	Yes	Yes	90
Braunschweig	Yes	Yes	Yes	40
Hannover	Yes	Yes	Yes	70
Hasbergen	Yes	Yes	Yes	150
Munster	Yes	Yes	Yes	50
Kamen	Yes	Yes	Yes	50
Dortmund	Yes	Yes	Yes	20
Wupptertal	Yes	Yes	Yes	50
Frechen	Yes	Yes	Yes	65
Aachen	Yes	Yes	Yes	60
Hagenow	Yes	Yes	Yes	200 (Berlin)
Hamburg	Yes	Yes	Yes	90
Bremen	Yes	Yes	Yes	130 (Hannover)
Netherlands				
Amsterdam	Yes	Yes	Yes	100
Rotterdam	Yes	Yes	Yes	20
The Hague	Yes	Yes	Yes	60
Arnhem	Yes	Yes	Yes	180 (Hasbergen - Germany)
Belgium				
Brussels	Yes	Yes	Yes	150 (Aachen - Germany)
Antwerp	Yes	Yes	Yes	50
Liege	No	Yes	Yes	55 (Aachen - Germany)

Table 8. Existing and planned HRS including distances

The main reason why (a) some countries did not include HRS development targets in their National Policy Framework and (b) none of the countries that did include HRS targets in their plans actually achieved them is lack of financial/commercial feasibility.

As explained in the introduction, European OEMs that were expected to introduce FCEVs on the European market changed their priorities because of:

- the currently high production costs of FCEVs compared to BEVs;
- a high market demand for HEVs on the passenger vehicle market;
- a preference of light commercial vehicle / van owner for CNG as low-emission fuel, mainly because of the opportunity to deploy CNG vehicles at a lower total cost of ownership compared to diesel.

It should be noted that most Member-States did achieve their targets with respect to EV charging points, CNG and LNG fuel stations.

The workplan of North Sea – Baltic Sea TEN-T core network corridor states that for the provision of alternative fuel sources for road transport, the Corridor has made significant developments and some implementation projects are ongoing for electricity, LPG, LNG or HRS development across the Corridor. However, there are differences between the Member States with regard to the type of alternative fuel provided, network coverage and thus a lack of continuity of service provision for all types of alternative fuel across Corridor borders is expected. [112].

The alternative fuel implementation directive set a necessary average distance between refuelling points for LNG and CNG fuels. For LNG refuelling stations it is 400km, and for CNG 150km.[113] The recommended range characteristics between hydrogen refuelling infrastructure were not included in the Alternative Fuel Infrastructure Directive. The European Commission by assessing the Member state national alternative fuel plans determinate that recommended distance between hydrogen refuelling stations would be “300 km on TEN-T Core network”.[114]

Figure 21 shows the 2020 situation of HRS on the NS-B Corridor.

[112] https://ec.europa.eu/transport/sites/transport/files/4th_nsb_wp.pdf
[113] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32014L0094
[114] https://ec.europa.eu/transport/sites/transport/files/legislation/swd20190029.pdf

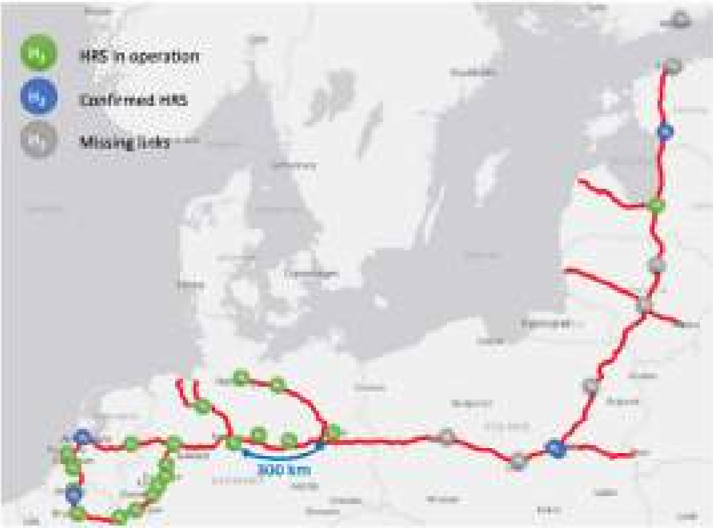

Figure 21. Existing and potential HRS on North Sea-Baltic Sea core TEN-T network corridor.

It shows a discrepancy between the western and eastern part of the corridor. Despite the fact that Belgium, The Netherlands and Germany did not achieve the targeted number of HRSs, from a corridor point of view the infrastructure could be called sufficient and certainly meets the 300 km distance between HRSs standard. The HRS locations vary: some are situated directly at one of the main motorways, some are located in urban centers. Given the fact that fuel cell mobility is still in an early stage of development, the exact locations are of less importance. The main conclusion is that early adopters of FCEV mobility are able to drive cross-border along the western part of the NS-B Corridor.

From the NS-B Corridor point of view, there are clearly missing links in the eastern part of the corridor. As stated in paragraph 4 there are already plans to fill the gaps and secure the hydrogen availability in Poland. So far only the HRS in Warsaw is confirmed and would be deployed within the Action PureH2.[115]. The distance to the nearest HRS in Germany (Berlin) is 572 km.

The uncertainty about possible HRS in Lithuania may directly affect the availability for FCEV user to travel all through Lithuania. From a corridor point of view the number or HRSs in Latvia and Estonia should also increase to provide a solid connection to Finland. The lag in HRS development in Finland has foremost an impact on more regional local transport to the north of the country with low population density. The connection to Sweden is mainly serviced by HRS capacity in Helsinki (assuming a transfer from Turku to Stockholm by ferry).

1.2 Plans to fill in the missing links

As stated in the introduction the expectation with respect to the upscaling of hydrogen fuelled vehicles changed as other sustainable fuels such as CNG (vans), LNG (trucks) and HEVs (cars) turned out out to be the preferred alternatives. However, it should be noted that CNG, LNG and HEV vehicles can only be regarded as transition-within-the-transition vehicles. They all are low-emission vehicles, but none of them are actually zero emission, which means that they are not compliant with the long-term goals of zero-emission mobility in the EU. Given the reservations of some major European OEMs

[115] https://trimis.ec.europa.eu/project/hydrogen-purifying-unit-and-filling-infrastructure

about the potential of fuel cell passenger cars, heavy-duty vehicles could serve as the commercial base for HRS upscaling. In 2020 Daimler Truck, IVECO, OMV and the Volvo Group launched H2Accelerate, with the mass-market roll-out of hydrogen trucks in Europe as a goal[116].

PHASE 1	PHASE 2
ROLLOUT OF FIRST STATIONS AND TRUCKS	EUROPE-WIDE COVERAGE
▪ 100s of trucks ▪ >20 high capacity stations ▪ Proving high capacity station concepts ▪ Selective locations/clusters	▪ Second half of 2020s: Achieve volume manufacture '000's per year ▪ Rapidly reaching > 10,000 trucks ▪ Europe wide coverage of major corridors ▪ High capacity/reliability stations

Figure 22. Goals of H2Accelerate

With respect to FCEV-development, Major OEMs seem to shift focus of fuel cell electric vehicles from passenger cars to light commercial vehicles and eventually heavy duty vehicles as zero-emission alternative for currently used diesel vehicles. BEVs have become the primary focus for the passenger vehicle market. This has also led to a shift in the German position with respect to HRS development. The fact that the German government was prepared to invest in an ambitious HRS development can be seen in the light of creating a domestic market for German OEMs that were expected to introduce FCEVs on the passenger car market from 2015. The strategic re-focus of German OEMs has led to a structural underutilisation of the 100 HRS network, almost all equipped with 700 bar fuel facilities. The most important components of the strategic changes are:

- A shift in development focus from 700 bar to 350 bar (suitable for the refuelling of heavier vehicles such as trucks and busses – as well as passenger cars up to 50% of their capacity)[117].
- A shift from unconditional HRS development to a strategy where further HRS expansion depends on proven market demand.

2. H2Nodes contribution to the expansion of HRSs on the Corridor

From the NS-B Corridor point of view the challenge is to increase the number of HRSs on the eastern part of the corridor, in order to establish a basic network for international fuell cell vehicle traffic. Given the fact that especially the commercial and financial feasibility is considered to be a bottleneck, the focus should be on the elimination of such barriers. The H2Nodes project provide some lessons learned that could contribute.

Lesson 1: Focus on the development of 350 bar HRSs in addition to 700 bar

[116] https://www.volvogroup.com/en-en/news/2020/dec/news-3851298.html
[117] At this moment most heavy-duty vehicles require a 350 bare refuelling facility. It is expected that 700 bar technology will also become available for these vehicle segments within 10 years.

Currently, a 350 bar refuelling facility is required for heavy vehicles such as trucks or busses With 350 bar stations in place, the HRS is positioned to provide an income from the refuelling of vehicle segments where hydrogen is seen as a promising zero-emission alternative for fossil fuels.

Lesson 2: Invest in vehicle-deployment rather than solely on HRS-development
The demand creation / aggregation initiative in Arnhem shows that by availing funds that stimulate the sale and use of FCEVs help to establish an acceptable HRS business case for HRS operators. Deployment of FCEVS provides operator a basis of recurring revenues, which is a far better basis for upscaling than one-off investment grants. It prevents a situation where HRSs remain underutilised, which not only is important from a business case point of view, but also in terms of the role of early HRSs as a show case. Stations that are used make a better impression than stations that remain empty for most of the time.
It is therefore important to develop the first HRSs in areas where such demand-creation initiatives have high chances of success. If these such chances are better at other locations that originally targeted, a location switch should be considered. The Estonia HRS is an example of such a shift. The Pärnu hydrogen Refuelling and production station is yet to be built. The uncertainty about the actual location of the station raised due to lack of public transport operator of Pärnu involvement and decisions to deploy FCEVs. The Pärnu PTO decided to deploy CNG buses for public transport operations as it was cheaper option and the CNG Refuelling station was already deployed in Pärnu. The current situation foresees that the intended Pärnu Hydrogen Refuelling and production station could be deployed in the capital of Estonia Tallinn. The Tallinna linnatranspordi (TLT) has expressed the commitment to deploy FCE-buses in the near future. As result, the hydrogen infrastructure that will be deployed within H2NODES would make a significant impact in Estonia. The lack of FCE-vehicles and commitment of stakeholders in Pärnu could result as hydrogen Refuelling infrastructure deployment without any added value. The risk of hydrogen availability but no usability could impact the further HRS deployment in Estonia as technically the action H2NODES could be fulfilled but the Refuelling would not be possible due to lack of FCEVs.

Lesson 3: Position the first HRS as show cases of technology innovation and various hydrogen production methods as well as providing commercial opportunities
The Latvia HRS was positioned as a show case for HRS development in Eastern Europe. In the preparation stage for the action H2 nodes a number of feasibility studies were made that provided an insight at novel technology such as fuel cell vehicles and hydrogen Refuelling stations. As one of the main achievements can be seen the awareness of the first hydrogen Refuelling and production station in Eastern Europe. A number of stakeholders from Latvia, Sweden, Estonia, Lithuania, Poland have visited the site.
Furthermore, the hydrogen availability in Riga allowed for Toyota Baltic to start the preparation of Toyota Mirai introduction in Latvia and it is foreseen that till the end of 2021 the vehicle will be available for possible customers. Currently the first Toyota Mirai (that is registered in Estonia for Toyota Baltic) is participating in RM LLC Rigas Satiksme HRS Refuelling tests for 700bar dispenser. On 9th of December a webinar was held about sustainable mobility whereas the information about RM LLC Rigas Satiksme 10 HyTrolleybuses and HRS was presented.

Lesson 4: Need for revision of Alternative fuel implementation plans.
The availability to set hydrogen as mandatory fuel in National alternative fuel implementation plans resulted as 3 of the North-Sea Baltic Sea core network corridor countries (Poland, Lithuania, Latvia) have not evaluated the HRS deployment in the near future. The Alternative fuel directive foreseen that the HRSs have to be built till 2025 in Member States who opt for hydrogen. The actual situation with HRS deployment resulted as lack of national plan fulfilment for Belgium and Finland. In both

countries the HRS deployment plans were ambitious. In a resolution adopted in October 2018, the Parliament highlighted the need to accelerate the development of alternative fuel infrastructure. It stressed the connection between the availability of alternatively fuelled vehicles, the deployment of alternative fuels infrastructure and consumer demand for these technologies. The resolution called on the Commission to revise the 2014 Alternative fuel implementation Directive to fill the gaps in the build-up of infrastructure and to replace the system of national plans with more efficient instruments, such as binding and enforceable targets. It also stressed that the scope of the Directive needs to be broadened to cover the TEN-T comprehensive network and urban and regional nodes and called on the Commission to make hydrogen infrastructure deployment mandatory. The inclusion of hydrogen as mandatory fuel and introduction of binding and enforceable targets would enable for all countries to revise the HRS deployment plans and to develop more realistic scenarios.