"Development of a spatial planning concept for the creation of a network of hydrogen refuelling stations for trucks in the international TEN-T route network in the Vidzeme region (HyTruck)"

The concept of spatial development of hydrogen refuelling stations

Vidzeme planning region

8th of November 2024

Summary

The Vidzeme Planning Region is involved in the Interreg Baltic Sea Region programme project "Developing a transnational network of hydrogen refuelling stations for trucks", which aims to support public authorities in managing the creation of an international network of hydrogen filling stations for trucks in the eastern part of the North Sea-Baltic TEN-T corridor with harmonised international technological standards.

This report is an initiative aimed at researching possible development scenarios of a sustainable transformation in the heavy-duty transport sector across the Baltic region. It focuses on the strategic development of a network of hydrogen refuelling stations (HRS) along the international TEN-T route network on road E67 in Latvia and Estonia. This project is a collaborative effort led by the Vidzeme planning region and EY, addressing the significant challenge of establishing a new, eco-friendly fuel infrastructure where none currently exists.

Research conducted within the scope of the project has identified a lack of both supply and demand for green hydrogen in Latvia, highlighting the necessity for possible government intervention. The market requires stimulation to kickstart the adoption of green hydrogen. The financial viability of hydrogen compared to diesel is also under scrutiny as currently hydrogen-powered trucks are much more expensive in their life cycle than their electric and diesel counterparts.

Stakeholder engagement is a cornerstone of the HyTruck project, involving key entities such as the Ministry of Transport, Ministry of Climate and Energy, Latvian hydrogen association, regional energy and transport companies. The insights gained from these discussions have been instrumental in strategic planning, emphasizing the need for government support in the initial stages of HRS development due to the lack of private sector investment cases.

The study identifies Salaspils as potentially the most suitable location for Latvia's first AFIR-compliant HRS, given its heavy truck traffic and strategic positioning. This choice aligns with EU mandates and leverages Salaspils' proximity to major transportation routes, including the TEN-T network. Pärnu is recommended as another HRS location in Estonia to comply with EU regulations and to strengthen the hydrogen infrastructure along the E67 corridor.

The HyTruck Spatial Planning Toolkit, a digital tool, has been utilized to enhance the site selection process for HRS locations. It uses criteria such as proximity to gas stations, urban nodes, and transportation networks to identify potential sites. While the toolkit offers valuable infrastructure mapping, it requires further refinement to achieve comprehensive functionality.

Given the uncertainties surrounding costs, market readiness, and infrastructure challenges, the report advocates for a phased approach to HRS development. It suggests starting with smaller-scale stations and considering road tanker delivery of hydrogen to mitigate investment risks and costs.

The success of the HyTruck project depends on regular updates and assessments to stay in sync with the dynamic landscape of renewable energy technologies and the emerging hydrogen market. Ensuring that transnational coordination policies align with infrastructure development is crucial for establishing a solid hydrogen economy in the Baltic region, which will support sustainability and economic growth in accordance with EU goals.

Version history

Table 1. Version history.

Nr.	Version	Description	Date	Authors
1.	1.0.	Submitted version of the document for the Client's comments	09/10/2024	EY
2.	2.0	Final submission	08/11/2024	EY

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Terms and abbreviations

Table 2 Terms and abbreviations

Abbreviation	Description
AFIR	Alternative Fuels Infrastructure Regulation
CAPEX	Capital expenditure
CHP	Combined Heat and Power
CNG	Compressed natural gas
EU	European Union
EUR	Euro
EHB	European hydrogen bank
FCEV	Fuel-cell electric vehicle
GW	Gigawatts
HRS	Hydrogen refuelling station/s
km	Kilometres
mm	Millimetres
RES	Renewable energy station
RFNBO	Renewable fuels of non-biological origin
SIA	Limited liability company
TEN-T	Trans-European Transport Network
TSO	Transmission system operator
VAS	State owned joint stock company

1. Introduction

This deliverable has been prepared in accordance with the agreement signed on April 9, 2024, on the development of a spatial planning concept for the creation of a network of hydrogen filling stations (HRS) for trucks in the international TEN-T route network in the Vidzeme region (HyTruck) a part of the Vidzeme planning region project "Developing a transnational network of hydrogen refuelling stations for trucks".

The purpose of this document is to prepare the spatial development concept of the HRS by examining key insights and providing recommendations for its advancement. First, it provides key insights and conclusions on the prerequisites for HRS development, including legal framework, and supply scenarios for green hydrogen. It also analyses stakeholder engagement activities, summarizing the findings and positions gained through these interactions. The report then discusses the development of HRS in neighbouring territories of the Vidzeme region, focusing on the usability of existing and planned HRS for long-distance freight transport. Following this, the document presents the concept of spatial development for HRS, outlining suitable sites and offering strategic recommendations for future development, including follow-up actions, risk mitigation, and planning requirements. Finally, the report evaluates a digital spatial planning tool for HRS, assessing its effectiveness and suggesting improvements.

This report is structured in five sections:

- Key insights and conclusions on the prerequisites for the development of the HRS;
- Main takeaways from stakeholder engagement activities;
- Finding and conclusions on the development of HRS in the neighbouring territories of the Vidzeme region;
- The concept of spatial development of HRS;
- Evaluation of the digital HRS spatial planning tool.

The outcome of this report is in the form of recommendations for the development of the HRS including necessary follow-up actions, the main risks identified, key stakeholders involved, regulatory measures and potential financing solutions.

2. Key insights and conclusions on the prerequisites for the development of HRS

This section will provide overview of the main foundations that should be taken into account before initiating the development of HRS:

- Regulatory framework;
- Green hydrogen demand;
- Green hydrogen supply;
- Most suitable locations for developing HRS.

Currently, there is no supply of green hydrogen in the Vidzeme planning region or anywhere in Latvia. The first large-scale green hydrogen manufacturing facility is not expected to open until 2029, and it will be located in Liepāja, more than 200 kilometres away from the E67 route and the Vidzeme planning region. Additionally, there is no current demand for green hydrogen in Latvia, further complicating the development of HRS and the relevant infrastructure. The absence of both supply and demand creates significant challenges for the establishment of HRS in the region, as there is no immediate market to justify the investment or operation of these facilities.

Given these circumstances, it is unsurprising that there are currently no existing or planned HRS in the Vidzeme planning region. For future development of HRS, several key factors need to be considered. Compliance with European Union regulations and guidelines is essential. This includes the strategic placement of HRS on urban nodes and in multimodal hubs, which would allow different types of transport to utilize the hydrogen refuelling facilities. Furthermore, EU guidelines stipulate that HRS should not be located more than 200 kilometres apart and within 10 kilometres of the TEN-T core road network to ensure coverage and accessibility.

In addition to regulatory requirements, an evaluation of freight transport traffic flows on the main state roads is crucial for identifying optimal locations for HRS. Understanding these traffic patterns will help in determining the most strategic and effective sites for future hydrogen infrastructure.

2.1. Legal framework of the HRS and the framework of planning documents

For hydrogen to be categorized green it must comply with these 3 principles[1]:

- Additionality;
- Temporal correlation;
- Geographic correlation.

The additionality principle means that the renewable energy facility used to produce hydrogen must have started operations no more than 36 months before the hydrogen plant and generally should not have received any operational or investment subsidies, with certain exceptions and a transitional period extending until 2028.

The temporal correlation includes conditions that the hydrogen production must be temporally matched (the same one-hour) with the production of the renewable electricity from which the hydrogen is produced.

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[1] Source: https://www.loyensloeff.com/insights/news--events/news/eu-rules-for-the-classification-of-renewable-hydrogen/

The geographic correlation mandates that the renewable energy facility and the hydrogen plant should ideally be located within the same bidding zone or in an offshore bidding zone that is connected to a bidding zone, if applicable.

2.1.1. Existing local regulatory and planning documents

Transport development guidelines 2021-2027[2]

One of the tasks of the Latvian transport development guidelines implementation plan is the use of alternative fuel, including hydrogen, which also includes infrastructure development.

The guidelines states that the priority is to develop renewable hydrogen (green hydrogen), produced mainly by wind and solar energy. However, in the short to medium term, other forms of low-carbon hydrogen could be needed to rapidly reduce emissions and support the development of a viable market. The connection will also be made with the Sustainable and Smart Mobility Strategy.

To be precise, the Transport Development Guidelines 2027 included a plan to conduct a study on the various scenarios for hydrogen fuel use in Latvia. This study aims to identify the most cost-effective solutions for supplying renewable hydrogen in the transport sector. It will also assess the most appropriate methods of hydrogen production, as well as the best options for filling stations and delivery methods, all while taking into account the EU policies in this area until the end of 2027. In perspective, it is expected that by 2035 there will be three hydrogen filling stations in Latvia.

Latvia's National energy and climate plan 2021-2030 (updated in 2024)

In its current energy and climate plan, Latvia considers hydrogen as a 'future alternative fuel to replace petroleum products' in the transport sector. The plan includes, among the potential priority areas, innovative solutions for renewable technologies like the production and use of hydrogen, developing an action plan for the deployment of hydrogen infrastructure, while also taking actions to set up adequate market conditions for the use of hydrogen. In Latvian National energy and climate plan the goal for the share of renewable fuels from non-biological origin (RFNBO) in transport is 1% by 2030, which aligns with the requirements set out in EU Directive 2018/2001[3]. However, there is no defined goal for planned amount of hydrogen produced in Latvia.[4,5]

Recently, on June 12th, Latvian Ministry of climate and energy released an updated edition of Latvian National energy and climate plan[6]. Regarding hydrogen, the new edition of the plan forecasted that in 2030, RFNBO, in this case - hydrogen, proportion in transport sector will be 0,00002% in base scenario and 0,6% in target scenario. The base case scenario percentage translates to around just 70 kg of Hydrogen fuel used, while the 0,6% would require around 2 000 tons of Hydrogen fuel. To reach the target scenario, there should be at least 5 HRS working at capacity of 1 000kg per day by 2030. This indicates that

[2] Source: https://likumi.lv/ta/id/327053-par-transporta-attistibas-pamatnostadnem-2021-2027-gadam
[3] Source, European Commission: https://commission.europa.eu/document/download/da1d0e60-31a6-45a0-a498-cce8ebaa8567_en?filename=Latvia%20-%20Draft%20updated%20NECP%202021-2030%20EN.pdf
[4] Source, EU Commission: https://energy.ec.europa.eu/system/files/2021-01/staff_working_document_assessment_necp_latvia_en_0.pdf
[5] Source, EU Commission: https://energy.ec.europa.eu/system/files/2020-04/lv_final_necp_main_en_0.pdf
[6] Source, State Chancellery: https://tapportals.mk.gov.lv/public_participation/ea329982-7d73-4318-b9ad-f209ab1937b8

hydrogen use in Latvian transport sector currently may fall below the required level and, in the nearest future, it may be difficult to reach these goals.

***Latvia's Transport Energy Law*[7]**

The law aims to promote a safe transportation energy cycle for health and the environment, supporting sustainable economic development and emission reductions. It outlines compliance requirements, responsible parties, oversight institutions, sanctions, and allows for detailed condition establishment. The bill was recognized by the Parliament on July 8th, 2024 and the Economic and Agrarian Commission for Environment and Regional Policy was deemed to be the responsible commission for the bill[8]. It will mandate Latvia to create a development planning document according to the specifications outlined in Regulation (EU) 2023/1804[9]. Additionally, the law vows to implement various other articles from Regulation (EU) 2023/1084, among which is the necessity for deployment of HRS refuelling stations along the TEN-T network and in multimodal hubs.

Rules from the Cabinet of Ministers no. 78 "Requirements for electric vehicle charging, natural gas filling, hydrogen filling and shore power supply facilities"

Regulation from the Cabinet of Ministers determines requirements for[10]:

- HRS technical equipment (ISO standards),
- Information that should be provided at the station,
- Information that should be provided to the relevant authorities (VAS "Latvijas valsts ceļi").

***Estonian Hydrogen Roadmap*[11]**

The Estonian Hydrogen Roadmap (2023), a vision document outlining Estonia's path towards integrating hydrogen technologies, was adopted in February 2023 and is subject to review at least every three years. Currently, Estonia has no commercial hydrogen production or consumption, but aims to establish a green hydrogen value chain based on renewable energy. Key performance indicators include increasing renewable energy generation capacity, particularly offshore wind energy (projected to reach 3 GW by 2030) and establishing 3 to 5 hydrogen refuelling stations by 2030, each with a daily capacity of 2 tonnes. Green hydrogen production potential is estimated between 2,000 and 40,000 tonnes per year. To support development, EUR 67 million has been allocated for hydrogen technologies and EUR 49 million for its introduction by the Estonian State. Legislative material regarding hydrogen refuelling stations and production equipment is absent, with plans to establish a comprehensive legal framework by 2030.

2.1.2. Existing EU regulation and planning documents

The most important and relevant regulation from EU for the development of HRS is Alternative Fuels Infrastructure Regulation.[12]

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[7] Source: https://tapportals.mk.gov.lv/legal_acts/042cde65-37a0-4e35-a005-109648ea5037
[8] Source: https://titania.saeima.lv/LIVS14/saeimalivs14.nsf/webSasaiste?OpenView&restricttocategory=660/Lp14
[9] Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1804
[10] Source: https://likumi.lv/ta/id/297090-prasibas-elektrotransportlidzeklu-uzlades-dabasgazes-uzpildes-udenraza-uzpildes-un-krasta-elektropadeves-iekartam
[11] Source: https://kliimaministeerium.ee/sites/default/files/documents/2023-07/Estonian%20hydrogen%20roadmap%20ENG.pdf

Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure[13]

The Regulation, effective from 13 April 2024, repeals Directive 2014/94/EU. It introduces mandatory minimum targets for the deployment of publicly accessible HRS for road vehicles, marking a shift towards a more ambitious and coordinated approach across Member States.

By 31 December 2030, Latvia must ensure publicly accessible HRS with a minimum cumulative capacity of 1 tonne per day, equipped with at least a 700bar dispenser, are deployed along the TEN-T core network with a maximum distance of 200 km between them. These stations must be designed to serve both light-duty and heavy-duty vehicles.

HRS deployed along the TEN-T road network must be located directly on the network or within 10 km driving distance from the nearest exit. Latvia must also ensure at least one HRS is deployed in each urban node by 31 December 2030. An urban node as defined by Regulation (EU) 1315/2013 is an area where the transport infrastructure of TEN-T, such as ports, airports, railway stations, logistic platforms and freight terminals located in and around an urban area, is connected with other parts of that infrastructure for regional and local traffic[14].

The Regulation encourages locating these stations within multimodal hubs to facilitate hydrogen supply to other transport modes like rail and inland shipping.

The Regulation acknowledges specific circumstances were implementing the HRS deployment targets might be challenging. Latvia may apply for derogations in cases where:

- **Low Traffic Volumes:** Along TEN-T core network roads with less than 2 000 heavy-duty vehicles per day, and where deployment costs are disproportionate to benefits, Latvia can request to reduce the HRS capacity by up to 50%, provided the maximum distance and dispenser pressure requirements are met.
- **Disproportionate Costs:** Due to the specific circumstances of outermost regions, Latvia can request derogation from the deployment targets if costs are disproportionate to benefits.

Latvia must develop and submit a draft national policy framework for alternative fuels, including HRS, by 31 December 2024. This framework should outline targets, policies, measures, and a clear trajectory for achieving the 2030 HRS deployment target, including an indicative target for 2027. Latvia must also submit national progress reports every two years, starting 31 December 2027.

The Regulation mandates the Commission to review its provisions by 31 December 2026 and every five years thereafter. This review will consider market and technological developments, including the potential need for revising the capacity requirements for HRS and introducing targets for liquid hydrogen refuelling infrastructure.

2.2. Supply of green hydrogen: current situation and future scenarios

2.2.1. Hydrogen supply options and their feasibility

[12] Source: https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en
[13] Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1804
[14] Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2013.348.01.0001.01.ENG

The three main ways of supplying hydrogen to HRS is:

- Hydrogen supply via pipeline;
- Hydrogen supply via road tanker;
- Hydrogen production in the vicinity of HRS.

At the moment, hydrogen production in vicinity of HRS seems to be the most likely option in the region. For instance, existing HRS in Riga (operated by Rigas Satiksme) and planned HRS in Tallin will produce hydrogen in the vicinity of HRS. Nevertheless, supply via road tanker could also be a viable option for initial HRS in the Baltics, because of lower initial investment, therefore reducing the risk of being financial burden for the developer.

Summary of advantages and disadvantages of hydrogen supply options available in Table 3 below.

Table 3 Hydrogen supply options. Source: EY analysis

Supply method	Advantages	Disadvantages	Feasibility
Production in vicinity	‣ Low operating cost ‣ Local flexible load potential ‣ Low emissions ‣ Established technology	‣ Local RES may be more expensive and less effective than RES in other regions ‣ High investment cost ‣ Difficulties balancing hydrogen supply and demand	High
Supply via pipeline	‣ Low energy losses ‣ Reliable supply ‣ Low hydrogen prices ‣ Established technology	‣ Hydrogen pipeline network in Latvia not yet developed ‣ Lengthy construction time ‣ High investment makes it unattractive for low hydrogen demand	Low
Supply via road tanker	‣ Established technology ‣ Easy to implement ‣ Low HRS CAPEX	‣ Small transporting volume of hydrogen per 1 truck	Medium

2.2.2. Companies that are planning to produce hydrogen in Latvia and Estonia

Currently there are no large-scale green hydrogen production in Latvia or Estonia. The most prominent green hydrogen manufacturing facility development projects are in Liepāja, Latvia and in Tallin, Estonia.

At the moment, green hydrogen production plans in Latvia and Estonia are not favourable for supply of green hydrogen to the HRS on the road E67 (ViaBaltica). There are no plans on developing green hydrogen production plants near road E67 in Latvia. Moreover, existing planned green hydrogen manufacturing sites is large (CIS Liepāja and Purplegreen) and it is unlikely that they would be interested in supplying hydrogen to HRS.

SIA "CIS Liepāja"

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SIA "CIS Liepāja" is planning to open Latvia's first commercial green hydrogen manufacturing plant. The company was founded by entrepreneurs from Latvia and the Nordic countries, with the leading partner being the Norwegian company "Clean Industrial Solutions Holding," which has experience in hydrogen production. Liepāja as a location for green hydrogen production was chosen for its port, which facilitates hydrogen export, and the proximity to planned offshore and onshore wind farms, ensuring a consistent supply of renewable energy. The production of hydrogen is scheduled to begin in 2029, with an estimated annual output of 150,000 tons of green hydrogen. Given the substantial production volume, it is anticipated that most of the hydrogen will be exported.[15]

Theoretically, it would be possible to supply green hydrogen to HRS in Vidzeme planning region and on road E67 via road trucks from the manufacturing site in Liepāja, however Liepāja is more than 200 kilometres away from Vidzeme planning region, which complicates logistics of green hydrogen supply. Moreover, hydrogen production will only begin in 2029. First green hydrogen HRS in Latvia will likely be built before 2029, therefore Liepāja cannot provide green hydrogen supply to the first HRS that will be built.

Utilitas OU

Estonia's largest renewable energy producer, Utilitas, is set to construct the country's first green hydrogen production facility in Tallinn by the end of 2024. The hydrogen produced will be utilized in the transportation sector, being available at two hydrogen refuelling stations in Tallinn. Initially, hydrogen will produce only for two of the first HRS in Tallin, however by 2026, Utilitas plans to double its green hydrogen production capacity with further investment.[16]

Although in their website Utilitas claims that they will be producing green hydrogen that will likely not be the case all year round. Their new electrolyzer will be connected to nearby CHP plant that will secure steady supply of electricity when there will not be enough supply of renewable electrical energy. This will probably happen in winter, when solar power stations will have lower energy output.[17] In result, due to unsteady supply of green hydrogen and overall low production capacity of green hydrogen, Utilitas hydrogen manufacturing plant is not suitable for green hydrogen supply to all HRS in Latvia and Estonia.

2.3. Conclusions of the analysis of the suitability of the location of the HRS

As hydrogen supply and demand is not yet certain, the main criteria for selection of suitable locations became truck traffic volume, complying with relevant EU regulations, and proximity to major urban and transport nodes.

Consequently, as the demand and supply of green hydrogen is non-existent, the development of HRS in Vidzeme planning region on the main state roads A2 and A3 is not considered. Currently, the only suitable place for developing first green hydrogen refuelling station in Latvia is on road E67 (Via Baltica).

The AFIR[18] directive mandates a minimum of one HRS for every 200 kilometres in both directions on the TEN-T core network, promoting hydrogen infrastructure development. It is possible to cover entire part of Via Baltica in Latvia with only 1 HRS (on Riga bypass road

[15] Source, LSM: https://www.lsm.lv/raksts/zinas/ekonomika/09.04.2024-liepaja-plano-attistit-latvija-pirmo-udenraza-razotni.a549767/
[16]Source, Utilitas: https://www.utilitas.ee/en/utilitas-is-building-a-green-hydrogen-production-unit-in-tallinn/
[17] Stakeholder interview.
[18] Source, EU Commission: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1804

near Salaspils). This would be possible if the nearest HRS would be in Pärnu, Estonia (~190km) and in Panevėžys, Lithuania (~160km).

2.3.1. Analysis of the locations in Latvia

For Latvia, 3 potential locations of HRS were considered:

- Port of Riga;
- Riga bypass road near Salaspils;
- Skulte Infrastructure Maintenance Facility.

To determine the most suitable HRS location in Latvia, a multifactor analysis was performed. Multifactor analysis available in Table 4 below.

Table 4 Multifactor analysis for determining most suitable HRS location in Latvia.

Location	TEN-T within 10km	Daily truck traffic count	1 520mm tracks	1 435mm tracks (planned)	Land transport hub	Port
Riga Port (3)	No	N/A	Yes	No	Yes	Yes
Skulte (1)	Yes	2 652	Yes	Yes	No	No
Salaspils (2)	Yes	4 906	Yes	Yes	Yes[19]	No

Based on this analysis, Salaspils Intermodal Freight Terminal location is most suitable location as it has the largest truck traffic, the station would be within the required 10km distance from a highway included in the TEN-T network and has 1 520mm and planned 1 435mm train tracks nearby. Additionally, by placing HRS on Riga bypass road near Salaspils, multiple requirements from AFIR regulation would be satisfied, such as that there would be HRS at an important transport node and that there would be HRS every 200km on road E67. Locations on the map displayed in Figure 1[20].

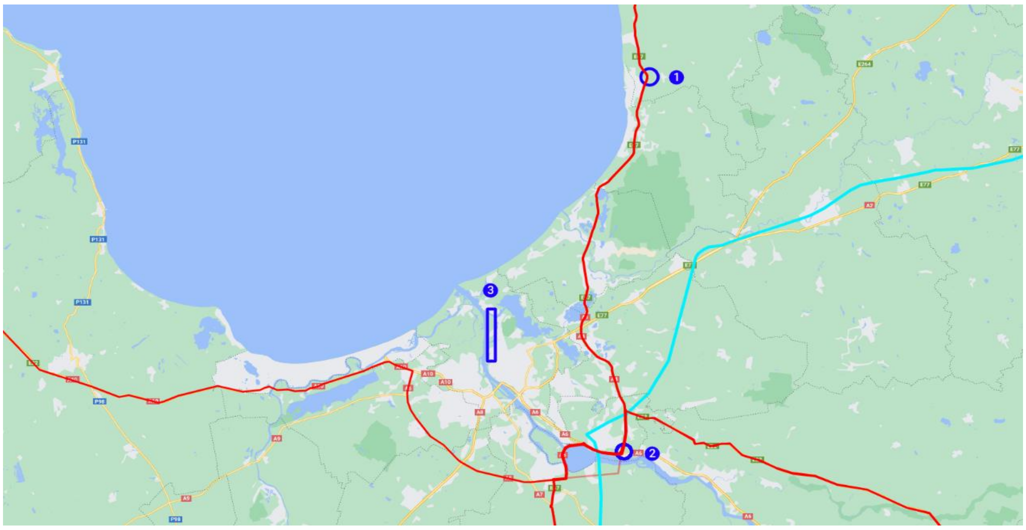

Figure 1 Current natural gas pipeline (hydrogen pipeline will be built next to it) and possible HRS locations analyzed in multifactor analysis

2.3.2. Analysis of locations on the road E67 (*Via Baltica*)

[19] Salaspils Intermodal Freight Terminal is planned to be constructed with the construction of Rail Baltica

[20] Source: https://www.h2inframap.eu/ and https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home (accessed 16.10.2024). Base of map: https://www.google.com/maps/

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The establishment of HRS along the E67 route, commonly referred to as the Via Baltica, is vital for advancing the shift to zero-emission transportation in the wider Baltic region. Being a component of the Trans-European Transport Network (TEN-T), it is crucial that the deployment of HRS adheres to EU regulations, which require a maximum distance of 200 km between stations, particularly on cross-border road segments.

In summary, the planned HRS network along route E67 in Latvia and Estonia will feature stations in Tallinn, Pärnu, and Riga. This station placement not only complies with EU regulations concerning the spacing between stations but also takes advantage of the strategic locations and infrastructure of these cities, promoting the efficient and sustainable establishment of hydrogen refuelling infrastructure in the area.

More detailed information about analysis of suitable location available in section 5. (Concept of spatial development) of this report.

2.4. Results of the HRS potential customers analysis

Currently, there are no potential customers identified- there is no entity identified in Latvia that has announced publicly that they will be purchasing hydrogen-powered vehicles in the next three years.

As part of our investigation into the potential adoption of hydrogen-powered freight transport in Latvia, we reached out to a range of companies whose everyday operations include road freight transport. These included some of the largest national road freight transport providers as well as regional companies specializing in niche sectors, such as timber transportation. The objective was to determine their interest and commitment in transitioning to hydrogen-powered freight transport.

From the responses received, it was evident that none of the companies currently have plans to adopt hydrogen-powered vehicles in the near future. While most fleet managers were aware of hydrogen as an alternative fuel source and the existence of hydrogen-powered trucks, several key concerns were highlighted:

- **Lack of Availability**: One of the primary issues raised was the unavailability of hydrogen-powered trucks in the Latvian market. The absence of supply limits the potential for these companies to consider hydrogen as a feasible option.
- **Cost-Effectiveness**: Another pressing concern for these logistics providers is the cost-effectiveness of their fleet operations. Given the current market conditions, the fleet managers indicated that hydrogen-powered vehicles do not present a financially viable alternative to the traditional diesel or CNG options. The high initial costs associated with hydrogen vehicles, coupled with uncertainties about operational costs and resale value, currently make it an unattractive option.

3. Stakeholder engagement activities

During the project, we engaged with a diverse group of Latvian and Estonian stakeholders, gaining valuable insights into hydrogen infrastructure technologies and potential locations for future HRS. These discussions deepened our understanding of regional considerations and provided critical perspectives on aligning proposed developments with strategic objectives for sustainable growth.

3.1. Stakeholder introductory call

In the beginning of this project, stakeholder introductory meeting was held. The main stakeholders interested in development of HRS were invited:

- Ministry of Transport
- Ministry of Climate and Energy
- Latvian hydrogen association
- AS Latvenergo – state owned energy company
- Latvian State Roads
- Regional truck delivery company – SIA SAHO

In the meeting, the main stakeholders were introduced to the purpose of the report and exchanged views and experience on HRS infrastructure development in Latvia. Summary of the main insights from the stakeholder introductory meeting available in Table 5 below.

Table 5 Main insights from the stakeholder introductory meeting

Issue discussed	Opinions expressed	Recommendations and objections
Financial viability of hydrogen trucks	For freight transport companies, it is crucial to have established HRS network to consider buying hydrogen-powered trucks, additionally it is important that hydrogen is financially comparable to existing fuels. Currently, these types of trucks are too expensive.	It seems that government involvement will be crucial for the development of hydrogen transport ecosystem – subsidies, no road tax, etc.
Hydrogen supply	At the moment, Baltic hydrogen corridor is being developed. There will potentially be a pipeline next to existing gas TSO network that will connect Baltics to the rest of the EU. It is important to locate connection points in hydrogen TSO system.	Research the possibilities on supplying hydrogen to HRS via pipelines. Look at all the possibilities of hydrogen supply, find the most cost-effective solution.
Impact of Rail Baltica	How is Rail Baltica going to impact road freight transport market?	Rail Baltica may cannibalize some of the existing road freight flows.
Development of local hydrogen-powered truck fleet	It is difficult to evaluate hydrogen demand for trucks in transit, therefore a strong local demand is needed to kickstart hydrogen ecosystem.	Research local freight transport truck market and infrastructure. Is there a potential for hydrogen-powered trucks? Cost analysis for different types of tracks on 1 km.
Diesel Truck engine retrofitting for hydrogen fuel	Hard to accomplish – legislative and technical barriers.	To be checked, however it is unlikely that this will be the solution.
Smaller scale freight transport trucks	Smaller scale freight transport trucks could be adopted for hydrogen, therefore driving local demand.	Local transport amounts are constant year to year. It is possible to do some calculations on potential local hydrogen demand.
Public transport		Explore options for adopting hydrogen-powered buses for long-range travel.

3.2. Engagement with different stakeholders

To further broaden our understanding and validate existing findings, additional stakeholder meetings were organized.

MP industries

During our meeting with MP Industries, we delved into the cost structure of the hydrogen value chain and the challenges impeding the growth of hydrogen infrastructure and the hydrogen economy in Latvia. The representative from MP Industries pointed out the importance of addressing infrastructure challenges, including the development of hydrogen production facilities, storage, and distribution networks. Additionally, the need for strategic investments in research and development were emphasized, as well as acquiring financing from EU and local government.

Estonian hydrogen association

During our meeting with the Estonian Hydrogen Association, we received valuable details on the development of hydrogen transport infrastructure in Tallinn. Additionally, the association validated existing data regarding hydrogen infrastructure costs, such as hydrogen transportation and the cost of hydrogen-powered vehicles. This information is essential for assessing the economic viability of hydrogen projects and making informed investment decisions in the Baltic region.

Tartu university

In the meeting with Tartu university researchers, we mainly discussed advantages/disadvantages and how to improve the digital HRS spatial planning tool they had developed for HyTruck project. Additionally, we were able to validate our data about existing hydrogen infrastructure in Estonia.

Ministry of Transport

Ministry of Transport has pointed out that suggested location of HRS development in Salaspils will not be directly on the road E67 in the future as it is now. That is because there will be a new multi-purpose bridge (for cars and trains) over river Daugava under Rail Baltica project. The new bridge will connect national roads A4 and A5 in a faster and more efficient way. In result, road E67 would no longer go through Salaspils and therefore HRS would lose some of its potential clients. It is possible that bridge will not be built until 2030, which is the deadline for complying with AFIR regulations in regard with HRS.

3.3. Summary of key findings, conclusions and common positions gained during stakeholder involvement

- **Economic Feasibility:** Hydrogen vehicles, even considering their entire lifecycle, remain significantly more expensive than diesel and electric vehicles. This disinterest companies in transport sector who would potentially be interested in adopting hydrogen-powered trucks.

- **Infrastructure Challenges:** The transportation of hydrogen presents a significant hurdle, highlighting the need for on-site production near HRS. Existing and planned HRS in Latvia and Estonia will produce green hydrogen in the vicinity of the station.

- **Market Immaturity:** The transportation sector currently lacks a well-developed market for hydrogen, limiting its commercial viability. Simply saying, there is no demand and supply in the market for green hydrogen in transportation sector.

- **Production Constraints:** Producing green hydrogen consistently throughout the year poses technical and logistical challenges. As green hydrogen should be produced from renewable energy, which in the Baltics is either wind or solar energy. It's hard to secure direct access to wind energy for small scale electrolysers. In the winter, solar energy production reduces significantly. In result both of these renewable energy production technologies are not suitable for small scale electrolysers in the Baltics. For example, electrolyzer in Tallin, managed by Utilitas will be connected to nearby CHP plant, which will secure steady energy supply in case of lack of energy from renewable sources.

- **Investīciju uncertainty:** The development of initial HRS is likely to require public sector intervention due to the current market conditions, where a compelling business case for private investors in the green hydrogen use in transportation sector is not yet established.

4. Main findings and conclusions on the development of HRS in the neighbouring territories of the Vidzeme region

This section examines the existing and planned HRS in the neighbouring territories of the Vidzeme region, focusing on their development and potential impact. A key aspect of this analysis is assessing the suitability of these HRS for supporting freight truck traffic. By evaluating current and future HRS locations, this section provides insights into how these facilities could meet the needs of long-distance transport and contribute to regional hydrogen infrastructure.

4.1. Existing and planned HRS in the neighbouring territories of the Vidzeme region

SIA "Rīgas Satiksme"

Currently, the only operational HRS in Latvia is owned and managed by SIA "Rīgas satiksme." This station primarily produces hydrogen for public transportation but is also open to external customers. SIA "Rīgas satiksme" has provided comprehensive details about the HRS, including its location, maximum storage capacity, pressure level, and the source and type of hydrogen used. The station was initially established as part of a collaborative project between H2Nodes and SIA "Rīgas satiksme." A notable aspect of this initiative was the introduction of 10 enhanced FCEV trolleybuses, which replaced their backup diesel engines with fuel cell range extenders. The total project cost amounted to 16.1 million EUR, with 50% funded by the European Union. The project was successful, and the "HyTrolley" trolleybuses have been in regular use since 2020. Although there is no specific data on the hydrogen consumption of these trolleybuses, it is estimated that over 11 tons of hydrogen were produced in the first year of operation, serving as a reasonable estimate of usage since there are no other registered FCEVs in Latvia as of 2024. As of summer 2024, there are no other operational HRS in Latvia. [21,22,23]

SIA "Rīgas Satiksme" HRS does not fulfil AFIR regulations on hydrogen refuelling. The station offers grey hydrogen instead of green hydrogen and is more than 10 kilometres

[21] Source: https://www.rigassatiksme.lv/lv/pakalpojumi/udenraza-uzpildes-stacija/
[22] Source: https://www.h2nodes.eu/en/regions/riga.html
[23] Source: https://lvportals.lv/dienaskartiba/326532-rigas-satiksmes-udenraza-stacija-pirma-darbibas-gada-laika-sarazoti-vairak-neka-11-000-kg-udenraza-2021

away from the TEN-T core network road E67. Although the station is built for servicing large vehicles (trolleybuses), it is located near the city centre of Riga, where it is convenient only for public transport and light passenger refuelling, not for large freight transport vehicles. Detailed information about SIA "Rīgas Satiksme" HRS available in Table 6 below.

Table 6 SIA "Rīgas Satiksme" HRS

SIA "Rīgas Satiksme" HRS	
Commissioned/ Planned	2020
Location	Riga, Latvia
Storage capacity	600kg
Pressure level	350bar and 700bar
Type of hydrogen	Gray
Origin of hydrogen	Production in the vicinity
Station operator	SIA "Rīgas Satiksme"

Alexela OU

Together with Estonia's largest renewable energy producer Utilitas, Alexela, plans to establish the country's first green hydrogen production facility in Tallinn by the end of 2024. The hydrogen supplied in Estonia will be entirely green, derived from renewable sources. This green hydrogen will be distributed through HRS located near the Väo energy complex at the Utilitas Tallinn Power Plant, catering to large vehicles, such as trucks and Tallinn's public transport buses. Another HRS in Tallinn will be on the Peterburi tee highway, primarily serving light passenger vehicles. By spring 2026, an additional refuelling station will be developed in Jüri, about 10 kilometres from the centre of Tallinn, as part of an expansion project. Initially, all HRS will be constructed and managed by Alexela.

As the information about precise location, dispenser pressure levels and storage capacity are unknown, it is hard to evaluate station suitability for large freight transport vehicles. Only 1 out of 3 planned stations in Tallin is located within 10 kilometres from TEN-T core road network (the one on Peterburi tee highway HRS). Other two HRS in Tallin are located on/near city bypass road, that likely are suitable locations for road freight vehicle refuelling. Overall, with these 3 stations, initial demand of hydrogen in in the area will be satisfied.

Technical information on the three HRS planned by Alexela OU in Tallinn available in Table 7, Table 8 and Table 9 below. Information on the storage capacities and pressure levels has not been disclosed therefore is indicated as Not Available.

Table 7. Alexela OU HRS 1

Alexela OU HRS 1	
Commissioned/ Planned	10.2024
Location	Utilitas energy complex, Väo, Tallin, Estonia
Storage capacity	N/A
Pressure level	N/A
Type of hydrogen	Green
Origin of hydrogen	Production in the vicinity
Station operator	Alexela OU

Table 8. Alexela OU HRS 2

Alexela OU HRS 2	
Commissioned/ Planned	10.2024
Location	Peterburi tee highway, Tallin, Estonia
Storage capacity	N/A
Pressure level	N/A
Type of hydrogen	Green
Origin of hydrogen	Domestic production supplied by road tanker
Station operator	Alexela OU

Table 9. Alexela OU HRS 3

Alexela OU HRS 3	
Commissioned/ Planned	2026
Location	Jüri, Tallin, Estonia
Storage capacity	N/A
Pressure level	N/A
Type of hydrogen	Green
Origin of hydrogen	Domestic production supplied by road tanker
Station operator	Alexela OU

Currently, existing and planned HRS in Latvia and Estonia does not comply with EU AFIR regulation, therefore, there will be a need for a development of new HRS until 2030.

5. Concept of spatial development of HRS

5.1. Suitable sites for the further development of the HRS

Salaspils

Salaspils has been chosen as the most suitable location for the establishment of a new HRS in Latvia (analysis available in section 2.3.1.). As discussed, the main criteria for selection of suitable locations are truck traffic volume, complying with relevant EU regulations, and proximity to major urban and transport nodes. Salaspils was chosen as a potential HRS site due to its compliance with the AFIR mandate of at least one HRS for every 200km on the TEN-T network, its significant volume of truck traffic and its location near key transportation routes that are part of TEN-T. Specifically, the city is conveniently situated within a 10-kilometer radius of the A6 highway, which is known for its heavy truck traffic and has the highest truck traffic of the considered locations. It is also in close proximity to the A4 highway and the proposed site for a new bridge over the Daugava River, which is part of the Rail Baltica project.

Selected location for development of HRS is land between Zviedru iela 1A and Zviedru iela 1C in Salaspils. There are already in place existing appropriate access and exit road infrastructure, freight truck resting point and 2 gas stations. This existing infrastructure could potentially facilitate the integration of the HRS into the local fuel supply network.

In terms of technical characteristics, the Salaspils location has access to both the 1520mm and the planned 1435mm railway tracks, which aligns with the broader objectives of the

Rail Baltica project to enhance intermodal freight transport. This access underscores the site's capacity to serve as a land transport hub, further justifying its selection for an HRS.

Furthermore, of the potential sites evaluated, HRS in Salaspils was the only one situated close to Latvia's existing natural gas pipeline. Although there are no hydrogen pipelines installed currently, future planning and construction of such a pipeline is expected to follow the existing natural gas pipeline, which would offer a considerable benefit for transportation to the Salaspils terminal and potentially HRS.

The priority selection criteria for the Salaspils HRS site include its high truck traffic volume, compliance with EU regulations, and proximity to major urban and transport nodes. While the Salaspils location is deemed the most beneficial based on these criteria, a comprehensive decision would necessitate a more detailed analysis that considers all of the relevant factors.

Detailed location for HRS development available in Figure 2[24] and Figure 3[25] below.

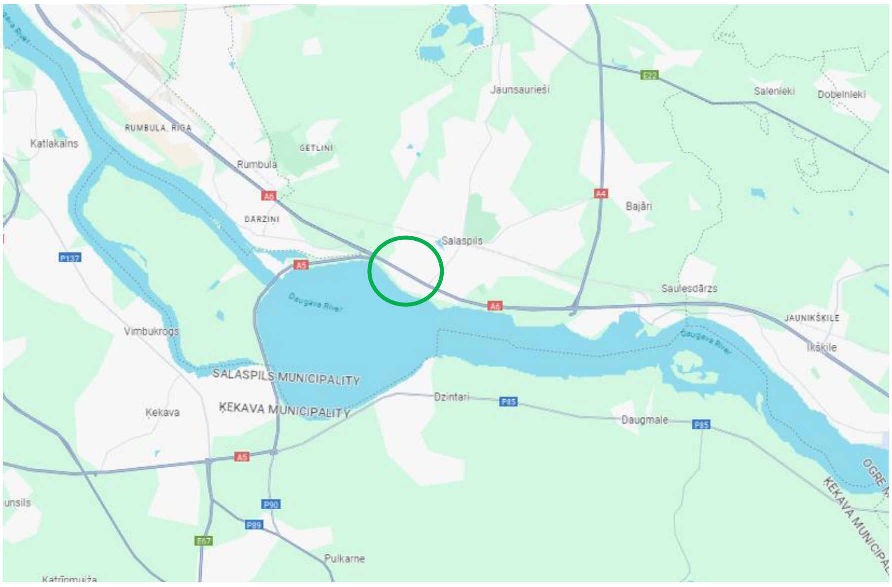


Figure 2 Suggested location of Salaspils HRS.

[25] Source: https://www.kadastrs.lv/graphical_data/show

Figure 3 Suggested location of Salaspils HRS.

Pärnu

As a critical part of the Trans-European Transport Network (TEN-T), the planning of HRS must comply with EU regulations, which mandate a maximum interval of 200 km between stations, particularly on cross-border road sections. Based on the analysis in the previous section, the optimal location for an HRS in Latvia is near Salaspils, along the Riga bypass road. With planned HRS stations in Tallinn, the logical and strategic placement for an additional station is in Pärnu, situated between Tallinn and Riga. An HRS in Pärnu, the largest city on the E67 (Via Baltica) between two urban centres, complies the required 200 km distance between HRS, ensuring an uninterrupted hydrogen supply for vehicles

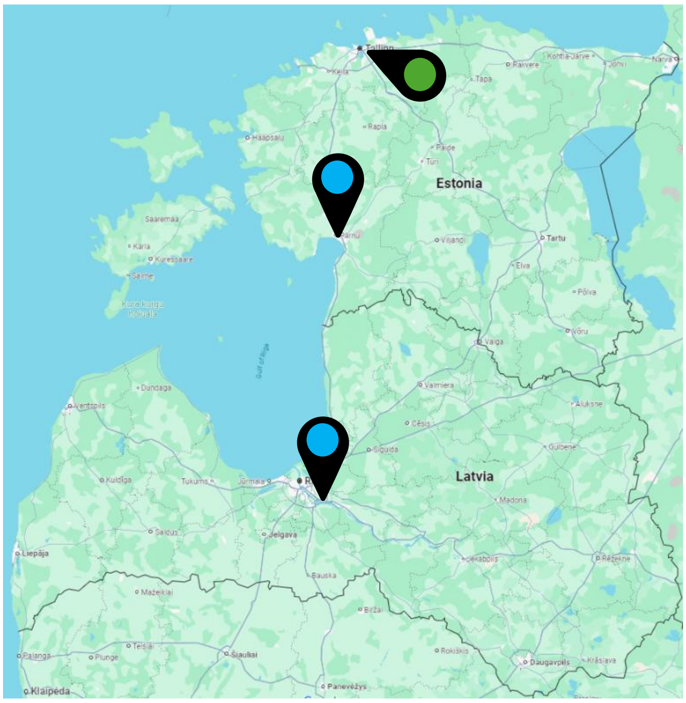


Figure 4. Suggested locations for HRS development (blue) and planned HRS (green) in Latvia and Estonia

Legend

Suggested locations for HRS development

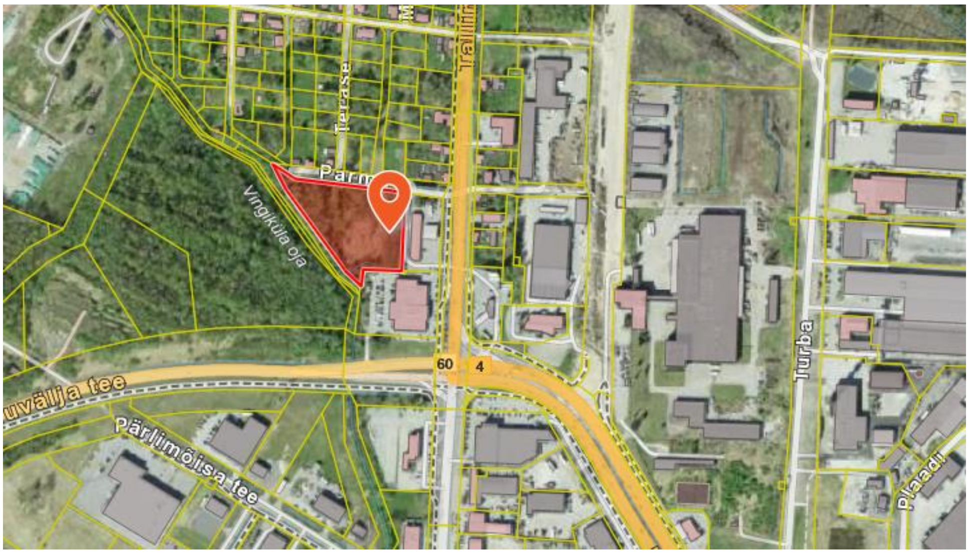
Already planned green H_2 HRS

traveling on this major route (See **Error! Reference source not found.**[26]).

Establishing an HRS in Pärnu not only adheres to EU regulations but also meets the other stated criteria for choosing an HRS site. Pärnu encompasses key transport infrastructure, including ports and train depots, making it an ideal location for an HRS as a significant regional hub. The proposed HRS network along the E67 in Latvia and Estonia will consist of stations in Tallinn, Pärnu, and Riga, ensuring both compliance with EU regulations and the strategic utilization of existing infrastructure. The suggested site for the Pärnu station is on the northern side of the city in Parmu tn 1, an area well-suited for truck traffic due to its proximity to the industrial zone and an exit from the E67 highway. The location is also in close proximity of an existing gas station, further enhancing its convenience and accessibility. See Figure [27] and Figure [28] for reference.

[26] Source: https://www.google.com/maps/
[27] Source: https://www.google.com/maps
[28] Source: https://xgis.maaamet.ee/xgis2/page/app/maainfo

Figure 5 Parmu tn 1



5.2. Conclusions and recommendations for the development of HRS

Taking into account that the demand for hydrogen in transport sector is uncertain, it is recommended to develop 1 HRS in Latvia (Near Salaspils, see section 5.1.) and 1 HRS in Pärnu, Estonia. This development of these new HRS would comply with the existing EU AFIR regulation requirements (see section 2.1.2.).

As HRS is modular, it is preferred to initially develop considerably small HRS (0,5t/day), to reduce initial investment and risk of not being financially viable. If the demand for hydrogen in transport sector rises, it is relatively simple to expand capacity of HRS by adding more storage units.

To further reduce initial investment and risk, it is an option that initially hydrogen will be supplied to the HRS via road tanker. In this case there would be cost savings on electrolyzer, which can be added to the HRS later, when the demand for green hydrogen in transport sector is more certain.

Vidzeme planning region project "Developing a transnational network of hydrogen refuelling stations for trucks"

As the development of HRS in Latvia is not only mandated by EU AFIR regulation, but also in Latvian national planning documents, such as Transport development guidelines 2021-2027 and Latvia's National energy and climate plan 2021-2030 (see section 2.1.1.), it is likely that public sector involvement might need to be required in the development of initial HRS in Latvia. Ministry of Transport, Ministry of Economy or some local municipality will have to build the first green hydrogen refuelling station as there business case for private investment is uncertain.

The EU Hydrogen observatory has compiled a list of public funding programs and initiatives for hydrogen projects[29], such as Cohesion fund[30] or InvestEU[31]. Many of these financing programmes are targeted toward the supply side to reduce initial production costs and stimulate market uptake.

[29] Source: https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/financial-tools-and-incentives
[30] Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1059
[31] Source: https://single-market-economy.ec.europa.eu/industry/strategy/hydrogen/funding-guide/eu-programmes-funds/investeu_en

6. Evaluation of the digital HRS spatial planning tool

The HyTruck Spatial Planning Toolkit is an advanced mapping tool that helps to plan the placement of HRS for trucks in all HyTruck covered countries in the Baltic Sea Region. The tool has been created using extensive literature review and gathered feedback from stakeholders to determine the factors critical for selecting HRS sites. The toolkit employs the Analytic Hierarchy Process (AHP) to combine 13 criteria into a single suitability score for each grid cell. This score ranges from 0 (not suitable) to 10 (very suitable) and is represented by a colour ranging from red to bright green, colouring each grid cell in the map. The map is divided into hexagon-shaped cells with the size of 1km across. The 13 criteria variables for the suitability score are as follows:

- *modelled_fuel_stations:* Proximity of gas fuel stations.
- *modelled_seashore:* Proximity of Sea from Eurostat.
- *modelled_solar_wind:* Proximity of existing solar and wind farms from GEM.
- *modelled_urban_nodes:* Proximity of the urban nodes from the Ten-T.
- *modelled_water_bodies:* Proximity of water bodies from the European Environment Agency.
- *modelled_gas_pipelines:* Proximity of gas pipelines.
- *modelled_hydrogen_pipelines:* Proximity of hydrogen pipelines expected by 2040.
- *modelled_corridor_points:* Proximity of Ten-T corridor points.
- *modelled_powerlines:* Proximity of industrial power transmission lines from CORINE.
- *modelled_transport_nodes:* Proximity of transport nodes.
- *modelled_residential_areas:* Distance from residential areas.
- *modelled_rest_areas:* Proximity to resting areas from Open Street Map.
- *modelled_slope:* Amount of land incline expressed as value from 0 to 10.

The total suitability score for a selected grid cell is the weighted average of the 13 variable scores. There are default weights given for each criterion, but the model allows to modify the weight of each criterion based on user input, reflecting their relative importance.

In addition, the model allows to add a wide variety of relevant layers on top of the map to evaluate the HRS location with more scrutiny. They are segregated in 6 categories, namely: Overview, EHB, Power, Ten-T, h2live and Modelling. By clicking each layer separately, it is possible to add the locations of fuel stations, resting areas, EHB planned hydrogen pipelines, gas import terminals, planned offshore and onshore wind parks, power lines and powerplants, Ten-T corridors and more, which gives a very comprehensive overview of the hydrogen, power and gas infrastructure in the HyTruck countries. Furthermore, the tool models the hypothetical HRS station locations and hypothetical HRS network service area on the map, along the main Ten-T highways. In Latvia, the hypothetical locations for HRS stations have been given in Rīga (Lucavsala) and near Valmiera.

HRS Planning Tool Conclusions and Shortcomings

The HRS Spatial Planning Toolkit is a very promising prototype with several useful features. It has been created using extensive data collection and accurately displays the current and planned hydrogen infrastructure. There have been major upgrades to the tool since previous versions, with it now considering more suitability criteria and incorporating a vast variety of factors that could affect the HRS location. One of the most useful features is the ability to layer the map with important elements for considering the HRS location like urban nodes, pipelines and wind farms. The tool is still in development phase and is going to be updated, but currently provides a comprehensive overview of the HyTruck landscape. There is a possibility to provide user feedback on bugs, functionality and user interface to help improve the tool in future versions.

Despite the tool being useful for infrastructure overview, it has some shortcomings. It has a layer for segmented road suitability assessment but does not consider truck traffic in different regions or accessibility for trucks bypassing cities, which are important factors for HRS. Additionally, it seems to not consider nature-protected areas, which were included in previous versions. The system is also relatively slow, especially when multiple layers are selected, causing it to lag excessively. Furthermore, its continued operation depends on securing funding for maintenance and hosting, as they state on the webpage.

Digital spatial planning toolkit was used in the possible location analysis; however, the tool had only a supplementary role for location selection. Due to the tool not considering all factors that are relevant to the choice of location, having relatively small resolution in assigning the values and not comprehensively assessing the factors that are included, a more detailed analysis was required to find a suitable HRS location.

Visualization of digital HRS spatial planning tool website available below in Figure and Figure .

Figure 8 Digital HRS spatial planning tool

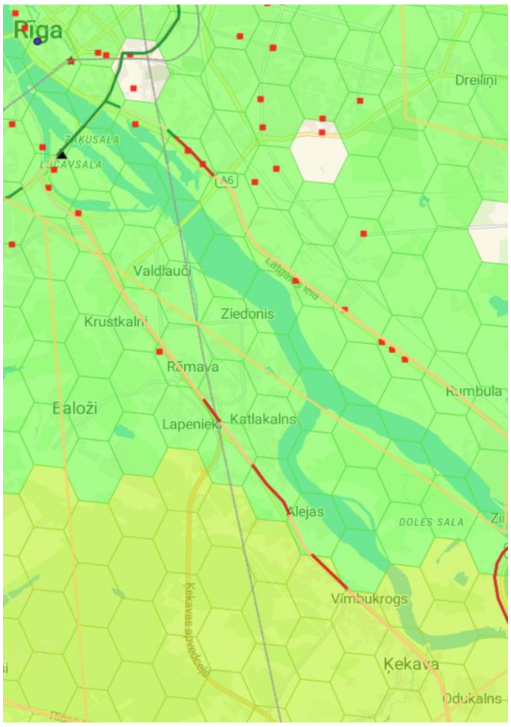


Figure 7 Digital HRS spatial planning tool