PORT OF TALLINN
The Port of Good News

Hydrogen strategy

discovering the road towards a new green value proposition

Colofon

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1. Introduction

1.1. The need for a hydrogen strategy

As the energy transition from polluting, fossil fuels towards clean, renewable fuels and feedstocks is taking form, countries and businesses across the globe must adjust their policies and actions accordingly. New value chains are created, old ones are becoming obsolete. The prices of solar and wind energy are decreasing rapidly with every new generation of more effective techniques. Traditional oil and gas companies on the other hand face increasing scrutiny and (potential) CO_2 and environmental taxes from the (inter)national government and community. It is therefore clear that our energy systems are changing, and players in the field would be wise to join in that transition. That is why Port of Tallinn is looking into the possibilities for setting up a hydrogen value chain in Estonia, to produce hydrogen from green energy, and to use that hydrogen as a feedstock or in industries and places where electrification is either too difficult or too expensive.

To set up an entire new economy, a solid strategy is needed. The goals of this H_2 strategy are:

1. Exploring the scope of a future proof business model
2. Ensuring the transition to clean energy sources
3. Obtaining a strategic position in international value chains
4. Preventing the 'last-mover' position

1.2. The scope

The challenge we see before us for Port of Tallinn will not be to achieve climate neutrality in 2030, but to be a net producer of green hydrogen for logistics, transport and export, thus developing a new Estonian value proposition for the (northwest) European market and building a commercially attractive and future proof economic ecosystem.

In this Hydrogen Strategy outline, we first present a vision for the route via which steps the value chain should be set up and worked out. This entails commercial, technical, logistical and governance actions that should be taken to make the value chain a reality. Then, we define the role and place for the Port of Tallinn in this network. Finely, a timeline is given in which the action agenda for 2020-2050 is presented, as well as the next steps for the coming period.

2. Route

2.1. Commercial Value chain

i. Volumes of Green Energy and Hydrogen

Estonia Energy Demand in 2030

The national goal for renewable energy consumed, set in the 2030 National Energy Development Plan (ENMAK 2030), is that renewable energy should be at least 50% of final energy consumption in 2030 (~16 TWh of 32-33 TWh). To achieve this goal, not only must Estonia upscale its renewable electricity production, but the country also has an energy saving objective of 14.7 TWh for the period 2020-2030. In another plan, Estonia's 2030 National Energy and Climate Plan (NECP 2030), the common EU format and methodology are being used, and hence a different renewable energy target (42%) is set than that from the ENMAK 2030. The difference is that the NECP 2030 sets out the renewable energy targets towards the gross final consumption of energy, while the targets in ENMAK 2030 are for final energy consumption. The gross final consumption of energy (38 TWh) is higher than the final energy consumption (32-33 TWh) as it also contains the own consumption of the production equipment of electricity and heating and the energy network losses. In our report, we use the NECP figures.

Renewable energy consumption in 2030 will be ~16 TWh according to both NECP and ENMAK 2030. From the 16 TWh renewables, 4.3 TWh will be renewable electricity, 11TWh renewable heat and 0.7 TWh for transport.

Energy Demand Estonia	**2018**	**2030**
Renewable electricity	1.8 TWh	4.3 TWh
Renewable heat	9.5 TWh	11 TWh
Transport from Renewables	0.03 TWh	0.7 TWh
Fossil energy	20.4 – 21.4 TWh	16 - 17 TWh
Total Energy Demand	**32 - 33 TWh**	**32 - 33 TWh***

* These are ENMAK figures instead of NECP

Offshore wind

As of 2019, a total capacity of 2.5 GW from offshore wind farm applications in Estonia has been applied for and a further total capacity of 5GW might be realized in the future.[1] The total possible capacity for offshore wind is 7.5 GW according to the NECP, an equivalent to approximately 28 TWh per year. A study commissioned by the Fuel Cells and Hydrogen Joint Undertaking (FCK JU) in close cooperation with the EU Commission – DG Energy, showed that the potential for renewable energy exceeds the 7.5 GW, since there is more potential for on- and offshore wind.[2] Another study referenced in the NECP confirms this. After realizing the total capacity of wind farms this would leave excess energy of about 11-12 TWh. About half of this excess energy can be stored for periods of lesser energy production; the other half is eligible for hydrogen production.

[1] National Energy and Climate Plan Estonia (2018)
[2] National Energy and Climate Plan Estonia (2018)

Solar energy
Until now, in Estonia solar energy has been used for electricity generation mainly in small-scale solutions. However, it is possible to upscale its potential in onshore and offshore solar parks (Note: off-shore solar parks are challenging, due to the cold Estonian climate) Solar panels are expected to deliver 415 MW of green *electricity* to the grid in 2030 (but already 500+ MW is installed in 2021), and new and reconstructed buildings add an estimated solar electricity production capacity of up to 21 MW annually.[3] However, total solar *energy* production in 2050 is expected to be only 1% of the total energy demand, compared to 33% for wind energy. Whether solar energy production can play a significant role in hydrogen production, is therefore yet unclear.

EU Hydrogen demand
The European Hydrogen Roadmap has two scenarios for the development of demand for Hydrogen in Europe, which are a Business-as-usual and an Ambitious scenario. The development of the demand for hydrogen in Europe, compared with total energy demand, is expected to be as follows:

EU Hydrogen demand	**2015**	**2030**	**2050**
BAU	325 TWh	481 TWh	780 TWh
% Total Energy Demand	2%	4%	8%
Ambitious	-	665 TWh	2251 TWh
% Total Energy Demand	-	6%	24%

In short, hydrogen demand is high - and current hydrogen projects are not sufficient to fill that demand.[4] As Estonia's potential for green energy is high, the country might also look into possibilities for converting that green energy into hydrogen.

ii. Price of green hydrogen
Current local production prices of Green Hydrogen (retrieved from electrolysis of water) are €4 - 6/kg.[5] IRENA expects that hydrogen will be competitive with blue hydrogen in the next three to five years, when produced under the best circumstances (e.g. wind and solar potential). The Hydrogen council states that within five to ten years (2025-2030) green hydrogen prices could drop to approximately $1 - 1.50/kg in optimal locations and roughly $2 - 3/kg under average conditions. Estonia is expected to be in the second category. There is a lot of potential for wind and solar, but for solar this potential is only half of locations like Australia and Portugal[6].

iii. Potential off takers
Hydrogen production in Estonia can serve multiple goals. The different options are the following:

1. Transportation
2. Industry (feedstock)
3. Energy Storage
4. Heating for buildings

[3] NECP 2030
[4] European Hydrogen Roadmap, European Commission (2019)
[5] European Hydrogen Roadmap, European Commission (2019)
[6] Solar Potential: https://globalsolaratlas.info/map?c=37.439974,-62.929688,2

5. Export

Transportation

The Estonian Energy and Climate plan has set targets for the use of electric transport and generation of 1st and 2nd generation biofuels. Biofuels by definition are fuels that are generated from biological material, a concept that has recently been narrowed down to renewable sources of carbon.

First-generation biofuels include ethanol and biodiesel and are directly related to a type of biomass that is often edible, like sugarcane or corn. These biofuels are expected to be phased out from 2025 on. Second-generation biofuels are defined as fuels produced from a wide array of feedstocks, especially -but not limited to- non-edible lignocellulosic biomass. These biofuels will ultimately account for about 35% of renewable energy used in transportation. The last is electric transport which will account for about 65% of the total renewable energy mix in Estonian transportation in 2030. Hydrogen can play a direct role in the transport sector as well as in making Methanol and / or Ammonia which can be used as a fuel. It can also be used for sustainable aviation fuels (SAF) to decarbonize aviation in Estonia.

In short, the essence of the role of hydrogen in the transport sector is: it can either be used 1) as a direct energy carrier for public and heavy duty transport and ferries, or 2) as a component of advanced fuels (green Methanol, Ammonia) for heavy transport and cargo shipping.

Industry

Industry could make use of hydrogen as a source for very high temperature heating or as a direct feedstock, but opportunities for this are limited. There is not a lot of industry in Estonia and only about 20% of it uses of natural gas as an energy source. However, since this part of the industry can rely on the existing methane infrastructure, for those companies it is an option to use hydrogen to decarbonize their processes in the long run. As the marginal price of natural gas is still quite low (because of a low excise tax and little or no CO_2 taxation), we see hydrogen as a feedstock for Estonian Industry as a pathway for the future, when it becomes competitive.

Energy Storage

Using hydrogen as a buffer for the electricity grid might become a realistic option in the future. This would be an attractive solution for times when an abundance of green electricity is produced, and the grid is not able to absorb that volume. By using electrolysers to absorb the excess of energy, storing it and reconverting It to energy when there is a shortage of green electricity, the grid is stabilized. However, this approach would require huge hydrogen buffers and there are substantial energy losses to be calculated. That is why we do not expect this route to be viable in the near future.

Heating for buildings (through gas grid)

Using hydrogen purely as a source of heat by burning it may well be considered the least valuable way of using hydrogen, especially when the desired temperature is relatively low (as is the case in heating for buildings). When green hydrogen is available in abundance, this may become a viable option, but we do not expect this to be the case before 2040. With one remark: in local mini grids where energy production and use are combined, hydrogen might become an interesting solution on the small scale.

Export

As stated before, the market for green hydrogen, especially in the Dutch and German industrial ecosystems, will increase to numbers that are hard to imagine. Even converting all of the possible green energy production in Estonia to hydrogen or e-fuels and exporting it will hardly fill a substantial gap in the market demand. Worldwide, a number of countries are focusing on the produce and export of green hydrogen (Morocco, Portugal, Chile and others). Estonia, when using its potential for green energy production, may well become a player in this new economy. The transport of green hydrogen may take place in direct form (cryogenic) in the future, when technology is further matured. In the short run, transport via hydrogen carriers (e-fuels Ammonia, Methanol and SAF and Liquid Organic Hydrogen Carriers (LOHC)) can be considered. Those options are further explained in paragraph 2.2.

iv. Investment capacity

As of 2021, producing green hydrogen in a cost competitive way related to standard hydrogen is simply not possible. Investments will have to be made in the start up of the hydrogen value chain that will hardly be commercially viable. At the same time, not investing will put the Estonian economy a step back compared to other (Baltic and other) countries that currently do invest. And the EU recognizes this initial investment valley. In order to close this gap, several funds are being designed for EU countries to 'kickstart' the hydrogen economy. In the '100 climate neutral cities by 2030' plans in Horizon Europe, the baseline for a city to become carbon neutral is set at 10.000 EUR per person.

At this moment it is hard to precisely figure out what exact investment is needed in Estonia and what should or should not be included in the scope. Above mentioned number can be used as a starting reference. The main question here is: Do Estonian companies and government realize that to be competitive they will have to invest in the hydrogen economy anyway?

v. Economic development chances

Transport and Logistics are pillars of the Estonian economy. Furthermore, the oil shale industry still has a strong position. As government decided to end the use of oil shale in 2035, we see a few challenges coming together:

1. Shale oil is ending, Estonia needs a new international value proposition;
2. International players in transport and logistics are all aiming for more sustainable fuels;
3. Estonia has the potential to be a net exporter of hydrogen derived products like fuels.

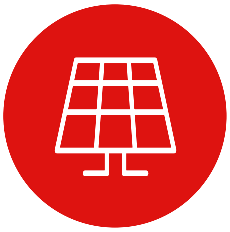
This is of course a very short and bluntly put, but it is the essence of the economic development chance Estonia could bring to fruition. The sustainable fuels market is close to the core pillars of the Estonian economy and could replace an economic (fossil) sector. This means that the Estonian economy has to position itself between the countries who want to be the front runners in the hydrogen economy. That will attract the first-of-its-kind projects and facilities, will get Estonia into the learning curve of the hydrogen economy and attract new industries to the economy.

2.2. Logistic and Technical Hydrogen Value Chain

*i. Renewable energy **production***

To produce green hydrogen, you need enough green energy. As of yet, the government of Estonia is still considering all possible options for renewable energy: solar, (offshore) wind and biomass. Hydropower capacity is left out of scope, as its potential is already being harnessed.[7]

As already explained in paragraph 2.1, the total possible capacity for offshore wind in Estonia is at least 7.5 GW, an equivalent to approximately 28 TWh per year. For onshore wind, total potential is 300 MW in Eastern Estonia and 850 MW in Western Estonia, thus adding another GW in energy production.[8] More than 4 GW of wind farms on and offshore are now in the development stage in Estonia. The furthest developed is a project by Enefit Green, on the border of and in corporation with Latvia. Wind energy is expected to cover up to a third of the country's power demand in 2050.[9]



Until now, solar energy has been used for electricity generation mainly in small-scale solutions. However, it is possible to upscale its potential in onshore and offshore solar parks. Solar panels are expected to deliver 415 MW of green electricity in 2030, and about 1% of total power demand in 2050. This potential could be expanded by involving citizens and local initiatives. For instance, by using the potential of new and reconstructed buildings, Estonia could add an estimated solar electricity production capacity of up to 21 MW annually. The potential of local cooperative electricity generation with solar panels amounts to 30 GWh/year. Whether solar energy production can play a significant role in hydrogen production, is yet unclear.

In 2017, around 11 TWh of total energy consumption (32 TWh) in Estonia came from renewable sources. Around 80% of that renewable energy was derived from burning biomass, and mainly used for heating purposes. This percentage is going to decrease, as there are many solar and wind projects coming up, while the amount of biomass used for energy production is not expected to change. However, including biomass in the energy mix can help regulate the intermittent capacities of solar and wind energy. Furthermore, if biomass is used for gasification (thus producing syngas, which contains hydrogen as well and can be used as a sustainable fuels base) instead of burning it, it could deliver far more value.

*ii. Energy **transportation and storage***

For the transportation of energy, adequate transmission lines and a substantial grid network are essential. Currently, in Estonia the grid isn't equipped to large quantities of (green) electricity. Updating the grid will be costly, especially old city areas like that of Tallinn. Therefore, Port of Tallinn should keep in mind that the transport of green energy towards the electrolyser location needs to be viable and affordable and adjust potential locations of energy and hydrogen production to this.

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[7] ENMAK 2030
[8] NCEP 2030
[9] ENMAK 2030

Green electricity production is dependent on the weather, and therefore intermittent in nature. Therefore, there are periods with either shortages or excess of energy. This can be solved in two ways:

1. Battery storage. By storing excess energy in batteries, either at the energy plant or near the hydrogen site, a buffer is made for times when little energy is produced. Battery technology is still expensive, but new, more cost-effective versions are developed every year.
2. Grid connection. Via the grid, one can buy energy from the grid when production is low and sell it when production is too high. That way, any fluctuation can be absorbed. However, grid energy is not all green, so clear agreements must be made with the grid provider concerning certificates of origin. Furthermore, connecting to the grid can be very expensive, especially in build areas, and is therefore not always cost effective. A good option might therefore be to develop an own dedicated line and connect that to the national grid at some point, e.g., in the harbour area.

iii. Hydrogen production

There are different possible electrolysis technologies, each with their own (dis)advantages. The main options currently in the market, are the Alkaline and PEM technologies, as they have already reached commercial scale. Alkaline has the highest efficiency and durability and the lowest cost of CAPEX, but PEM has the advantage that it doesn't require a minimum load (useful in case of green, fluctuating energy), it is more flexible and faster and operating pressure can be lower.[10]

As an input for the production of H_2, one first of all needs enough green electricity. That includes back-up power in the form of grid connection and/or batteries. Furthermore, clean water is needed. A demineralization water plant is necessary in order to provide enough qualitative water. After the H_2 has been produced, it can temporarily be stored in a buffer, or directly be transported to the carrier reactor, either via pipeline or via truck. Because of the costs and risks of this, it's advisable to make this distance as short as possible.

iv. Hydrogen transportation, carriers and storage

Transporting hydrogen in its pure form can either be done via pipeline, or via truck or rails. Pipelines for hydrogen are a costly investment, as a 1-inch pipeline can cost up to 1 million euros per kilometer, and hydrogen pipelines need to be at least 10 inches to ensure high enough pressure and throughput. Therefore, hydrogen pipelines are initially mostly applicable for short-distance transport of high amounts of hydrogen, for instance between electrolyser and carrier plant. Of course, when natural gas pipelines are already in place and available, the switch to H_2 pipelines is much better financeable. Road or rail transport of hydrogen is often done in liquid form via cryogenic tanks, since a liquid hydrogen can hold substantially more hydrogen than a pressurized gas tank.

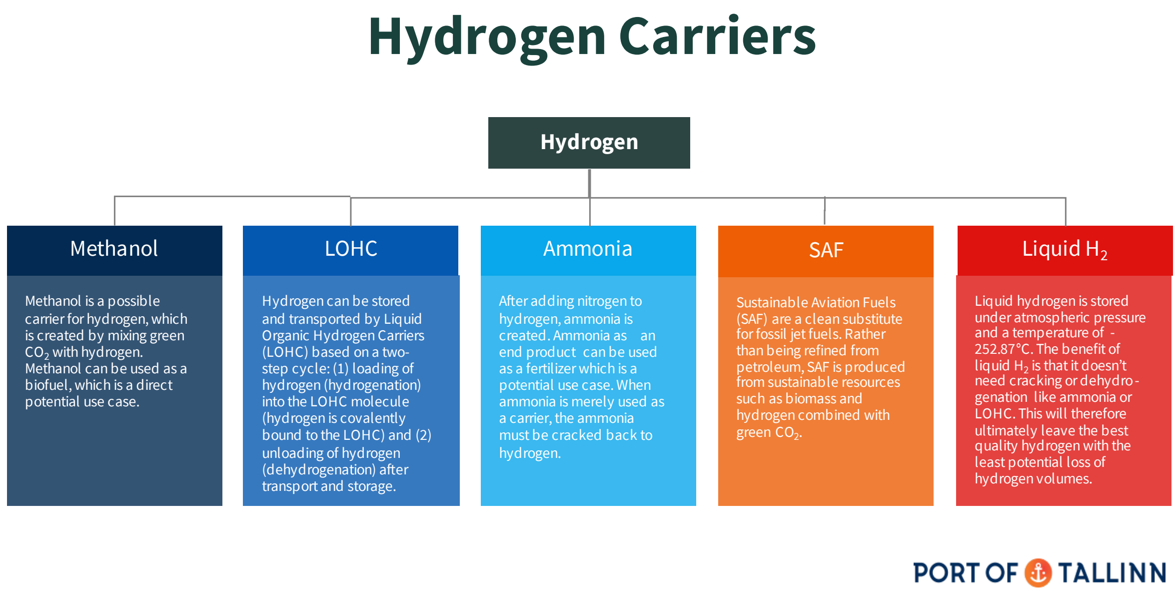
Another option to transport hydrogen, is to convert it into a carrier that is easier and/or cheaper to handle. There are five main carrier options for hydrogen: methanol, LOHC, ammonia, SAFs and liquid hydrogen.

1. Methanol (CH_4O). Methanol is created by mixing green CO_2 with hydrogen. Methanol can be used as a biofuel, which is a direct potential use case for methanol. Furthermore, after

[10] IEA, 2019

cracking methanol back to hydrogen it has a feedstock grade quality, and therefore can be used as an industry feedstock as well. However, methanol as a carrier is technically still less feasible than ammonia and LOHC and a lot of green CO_2 is needed to turn the hydrogen into methanol. There might be a unique Estonian value proposition in this route as an abundance of green CO_2 is available, as opposed to many other countries. In the Netherlands, BioMCN is one of the groundbreaking investors in this field.

2. LOHC. Hydrogen can be stored and transported by Liquid Organic Hydrogen Carriers (LOHC) based on a two-step cycle: (1) loading of hydrogen (hydrogenation) into the LOHC molecule (hydrogen is covalently bound to the LOHC) and (2) unloading of hydrogen (dehydrogenation) after transport and storage. The benefits of LOHC are that it can be dehydrogenated centrally as well as locally and is transported easy and safe. Furthermore, after dehydrogenation a feedstock grade H2 remains. Through LOHC the hydrogen can be used as industry feedstock and for mobility and heavy-duty transport. In the field of LOHC, VOPAK has a very strong knowledge base.
3. Ammonia (NH_3). After adding nitrogen (N) to hydrogen, ammonia is created. Ammonia as end product can be used as a fertilizer which is a potential use case. When ammonia is merely used as a carrier, the ammonia has to be cracked back to hydrogen. After cracking, a fuel grade H_2 will remain. Fuel grade H_2 has two use cases, which are high temperature heat and power. After cracking the ammonia to H_2 the purity is 99.5%, which is good enough for these use cases. To use hydrogen as an industry feedstock or as a fuel for the mobility and transport sector, a feedstock grade H_2 is needed. This can be done through purification of the fuel grade H2, but the TRL for this purification step is too immature. Therefore, this currently is not an option and possible use case. In this field the Dutch firm Proton Ventures is one of the frontrunners.
4. Another route to directly use hydrogen derived products, is the production of sustainable aviation fuels (SAF). As these fuels are being introduced to the market right now (initiated in the Netherlands) and the aviation sector is rapidly increasing the ambition regarding SAF, this might be an interesting market for Estonia, especially since the required green carbon molecules for SAF are available in abundance. SAF production however requires a huge amount of knowledge and subsequent investments that will have to be attracted from parties like SkyNRG and Shell. Both have a strong basis on SAF in the Netherlands. Germany has a great appetite for SAF as well. Besides parties interested in SAF opportunities to decarbonize, Porsche announced to invest 32 million into a synthetic fuel project in Chile.
5. Liquid H_2. Hydrogen can also be made liquid under atmospheric pressure and a temperature of -252.87°C and therefore needs to be stored in isolated tanks. The benefit of liquid hydrogen is that it doesn't need cracking, purification or dehydrogenation like ammonia of LOHC. This will therefore ultimately leave the best quality hydrogen with the least potential loss of hydrogen volumes. The challenge is that the technology to make liquid hydrogen is in a too low TRL. Therefore, this is not considered as a carrier option in the short term. It might be in scope as a carrier option for the long run because of the above-mentioned benefits.



Buffering hydrogen

After production of hydrogen, it often needs to be stored first, before it is transported to its final destination. Especially in the case of converting hydrogen into a carrier, this buffer capacity is important. The carriers are produced using a reactor, and downtime of this reactor causes major costs and safety risks. However, buffers large enough to cover all potential downtime of the reactor are huge, and therefore expensive. Thus, it is important that the size of Renewable Energy production, hydrogen production, carrier production and buffers are optimized in an integral model, to ensure the lowest costs possible.

2.3. Governance Value chain

i. Legislation

Estonian Legislation
Estonia is preparing an institutional framework for the usage and production of hydrogen. The ministry of Environment has set up a 'Hydrogen Working Group', which will develop a hydrogen roadmap for Estonia. This working group will also analyze the deployment of hydrogen and fuel cells applications in the Estonian energy system, with a focus on transportation. As seen in the National Energy & Climate Plan, decarbonizing the transport sector has a strong focus within the plans. Estonia is already working together with its neighboring countries in the Baltics in terms of electricity and gas systems and this is still relevant for setting up a hydrogen infrastructure. Through its neighboring countries the energy infrastructure connects to the rest of the EU network. Estonia could participate in dedicated hydrogen related research and facilitate the implementation of pilot and demonstration projects in the area of sector coupling based on hydrogen technologies.

As the Estonian hydrogen roadmap is still in development not a lot can be said about future legislations. However, in the National Energy & Climate Plan a lot measures are mentioned to decrease emissions. The following might impact hydrogen:

Measures in the transport sector:
- TR1 - Increasing the share of biofuels in the transport sector
- TR3 - The promotion of sustainable driving
- TR5 - The development of convenient and modern public transport

The implementation of the following additional measures is still under discussion:
- TR10 - Additional activities for the development of convenient and modern public transport.
- TR11 - Establishment of mileage-based road usage fees for heavy-duty vehicles
- TR14 - Electrification of railways.
- TR15 - Electrification of ferries.
- TR16 Transition to public transport powered by biomethane and electricity

EU Strategies and Legislation
The EU legislative landscape for hydrogen supply chains is based on strategies that are supported by legislation. An assessment is made from the applicable strategies and legislation and its goals, objectives and specific measures. The strategies and legislation that are most relevant to strategy of Port of Tallinn are mentioned below. A detailed overview can be found in the appendices.

Applicable Strategies
- Energy System Integration Strategy
- European Hydrogen Strategy
- Smart and Sustainable Mobility Strategy
- Industrial Strategy & Clean Steel Strategy

Applicable Legislation
- Renewable Energy Directive (II)
- Energy Taxation Directive
- TEN-E
- TEN-T

Estonian Taxation
To be further investigated in a next phase.

EU Taxation
The import, distribution and use of H_2 for different purposes is subject to taxation in the EU. Three taxes might be applicable: Import Tax, Excises and Energy Tax. The application and rate of different taxes depend on the product imported and the end use. Most of these will become relevant when involving exporting parties or other countries.

ii. Subsidies

Estonian Subsidy Schemes
As the Estonian Hydrogen Roadmap is still under development a lot is still unknown in how the Estonian government will kickstart the hydrogen economy. There is a subsidy scheme which grants a € 5.000.000, - subsidy to a partnership of companies willing to invest in a hydrogen pilot project. This study aims at being non-competitive and can grant another € 50.000.000, - to successful pilot projects.

EU Subsidy Schemes
Many subsidy schemes are available for EU parties pursuing hydrogen projects, in all parts of the supply chain. Most are focused on subsidizing (CAPEX) of EU entities. In support of the energy transition and reaching EU climate goals, the EU has developed proprietary subsidy schemes. Besides EU subsidy schemes, regional and local subsidy schemes might be available.

Fund	Description
Estonian subsidy scheme	Granting a € 5.000.000, - subsidy to a partnership of companies willing to invest in a H_2 pilot project. Can grant another € 50.000.000, - to successful pilot projects.
IPCEI	Supports innovative projects involving more than one Member State (e.g. Latvia); project can be aided up to 100% of the funding gap on the basis of a large set of eligible costs.
ECH2A	Launched on 8 July 2020. Aims to install 40GW of electrolyser capacity by 2030 in Europe.
Innovation Fund	Funding programme for the demonstration of innovative low-carbon technologies; €10 billion to invest up to 2030.
Cohesion Fund	Aims to reduce economic and social disparities within the EU and to promote sustainable development, e.a. use of renewable energy.
European Regional Development Fund	Aims to reduce economic and social disparities within the EU and focuses on investments in several key priority areas, e.g. R&D and low-carbon economy.
Horizon Europe	Running from 2021-2017. Strategic plan including innovation support (e.a. for H_2) not yet available.
Ocean Fund	European Investment Bank fund investing in companies that build resilience in coastal ecosystems.
FuelEU Maritime	Aims to increase the use of sustainable alternative fuels in European shipping and ports.

iii. Partner network

In building a value chain, having a good partner network is essential. In the following tables, all Estonian public and private H_2 stakeholders are listed, including their potential role in the value chain. In green those who have already taken steps / have launched activities on green H_2.

Private stakeholders	Business field	Potential role
Elcogen AS:	Manufacturer of solid oxide cells and stacks; fuel cell technology	Producer of Hydrogen-based products
Enefit Green:	Renewable energy company, subsidiary of Eesti Energeia	Producer of green energy and hydrogen
Estiko AS:	Producer of energy, package materials	Producer of green energy
Fortum:	Finnish energy company	Producer of green energy
Skeleton Technologies:	Ultracapacitor-based energy storage	Storage of green energy
Alexela Logistics AS:	Energy, metal and property development company	Logistics, off-taker
Linde:	Engineering and gas company	Technology provider, logistics
HHLA TK Estonia AS:	Operator of a multi-function terminal and facility for container handling	Off-taker, …
Elektrilevi:	Network operator	Logistics
Elering:	National transmission system operator for electricity and natural gas	Logistics
Liwathon E.O.S.:	Oil products terminal operator	Logistics, off-taker
Lux Express:	Bus transport	Off-taker
Operail:	Railway logistics company	Off-taker, producer of Hydrogen-based products
PowerUp Fuel Cells:	Developer of H_2 fuel cell electric generators	Producer of Hydrogen-based products
SKYCORP OÜ:	Hydrogen Fuel Cell Unmanned Aerial Systems developer	Producer of Hydrogen-based products
Tallink Grupp AS:	Shipping company: ferries, ropax ships	Off-taker
Terminal Oil:	Oil terminal company	Logistics, off-taker
PAKRI Smart Industrial City:	Greentech Manufacturing centre	Technology provider
Estonian Hydrogen Association:	Aims to accelerate H_2 by building awareness, assisting municipalities, policy feedback etc.	Accelerator of the green H_2 industry

Public stakeholders	Potential role
Hiiumaa Island	Legislative, Off-taker for ferry industry
Association of Estonian Cities and Rural Municipalities	Legislative
Union of Harju County Municipalities	Legislative
Keila City Government	Legislative
Rakvere City Government	Legislative
Tartu City Government	Legislative
Tartu Regional Energy Agency	Advisor
National Institute of Chemical Physics and Biophysics	Knowledge development
Stockholm Environment Institute (SEI) Tallinn	Knowledge development
Tallinn University of Technology	Knowledge development
University of Tartu, Institute of Chemistry	Knowledge development

On the technical level, Tartu University, Elcogen, SKYCORP and PowerUp are actively working with hydrogen on a daily basis. Various entities like Port of Tallinn, Estiko, Operail, Tartu & Keila are looking at opportunities to start working with hydrogen. Eesti Energeia and Elering have done some prefeasibility studies as well, to investigate potential H_2 projects.

As mentioned earlier, the Estonian government has set up a hydrogen working group, which has the aim of analyzing the opportunities for implementing hydrogen and fuel element technology in Estonia to achieve the country's climate targets. Estonia is also part of the Hydrogen Initiative from the European Commission. As mentioned above, Estonia has launched a pilot project support scheme in Q1 this year. This support scheme of 5 million euros is focusing on the whole value chain for hydrogen and is expected to be upscaled to 50 million euros via the Resilience Recovery Fund, which will come into effect next summer. Other than this, hydrogen is mentioned in climate plans and other documents of course, but no other real activities are taking place yet. Estonia as of yet doesn't have a national Hydrogen strategy; although a study on hydrogen is carried out by Civitta to be completed in May 2021.

As indicated by some of the stakeholders, the main parties that are currently missing in Estonia and that are vital to accelerate this new industry, are:

- Technology partners, e.g. electrolyser system manufacturers, fuel cell solutions, technology hubs;
- Commercial partners, e.g. local train/bus/lorry operators;
- Consultants with experience in performing a feasibility study for hydrogen project, including how to optimally operate the electrolyser in a day-ahead electricity market and offering auxiliary grid services.
- Investors. As Estonia is a small country with big ambitions, (international) investments and subsidies are more than welcome to accelerate the value chain.

iv. Public opinion

Hydrogen as an energy carrier, a fuel or a feedstock is a new economy and not well known in Estonia. As there are some possible societal questions regarding safety and the like, it will be important to introduce the hydrogen economy in Estonia while investing in societal understanding and acceptance. That means that developing projects that relate to the public (public transport, ferries e.g.) with a strong communicative aspect are essential to further the integration of the hydrogen economy in Estonia.

3. Role Port of Tallinn

3.1. Place in the network

As the biggest port organization in Estonia, Port of Tallinn (PoT) is divided in four different industrial port locations. Through its four main activities, which are ferry connections, cruise ships and cargo shipping, and developing attractive real estate and industrial parks in harbour areas, PoT aims to become the most innovative port on the shores of the Baltic Sea, and to develop the competitiveness of Estonia as a maritime country.

Subsidiaries of Port of Tallinn, with at least 51% ownership, are:

- TS Laevad, a ferry operator between islands Saaremaa and Hiiumaa and the mainland;
- TS Shipping, an icebreaking and maritime support services provider;
- Green Marine, an environmental services provider for ports and ships. Also coordinates waste management services.

In 2019, 1744 cargo ships, 345 cruise ships and 5,766 passenger ships entered the harbors of the Port. All this traffic and shipping requires a lot of energy; energy that is currently produced from fossil sources. If the Port is to be sustainable in the future, it will need to switch to greener sources of energy. Also, if the organizations based in the harbor, such as oil terminals and logistics companies, aim to play a role in the future international energy system, they will need to transfer to sustainable business operations; a daunting task where the input of the Port is badly needed in order to ensure the right infrastructure and other provisions.

3.2. Role to fulfill

We have identified five roles the Port should fulfill to make the hydrogen value chain a reality:

Port of Tallinn already is moving towards *kickstarting the hydrogen value chain* in Estonia, by developing this hydrogen strategy. Of course, setting up a strategy only doesn't do the trick, but by following up on the strategy with next steps, hydrogen will get feet on the ground in Estonia. To make that truly work, the port should *facilitate collaboration within the port area*, on the entire value chain, from production of green electricity and hydrogen to transport, storage and shipment of the final product(s) abroad and Inland. This leads to the Port *being the infrastructural hydrogen backbone*, as Port of Tallinn should realize a hydrogen infrastructure in the port area, together with a logistics company specialized in either pipes or trucks/trains. Also, the Port should start operating its own internal logistics and ferries on hydrogen. By taking this active role in the hydrogen chain, PoT can ensure a renowned place in the international hydrogen industry, and become a Baltic Hydrogen Hub.

Potential: As PoT owns large pieces of land that have yet to be developed, it could very well take its place in the value chain as a land owner for the H_2 plant. In the figure below, the main development areas in the Muuga and Paldiski South Harbour are shown. Of course, the best possible locations will have to be determined through thorough research by the Port into the possible development areas.


Industrial & Logistics Parks
Muuga & Paldiski South Harbour Industrial and Logistics Parks
Next to terminals and quays
Great connections – sea, rail, main roads
Location in free zone in Muuga Harbour
Located on international trade routes, the Port of Tallinn Industrial and Logistics Parks are ideal hubs for warehousing and distribution service providers as well as commodities producers.
Operating next to modern terminals enables to reduce transportation costs significantly and add value by using commodities handled in the harbour as an input to production.
Muuga Industrial Park
Located in the largest and deepest cargo port in Estonia
Distance from Tallinn 17 km
Industrial park area 76 ha
Plot areas: total 58 ha plots 0.3–21 ha
Development area
Industrial Park area 76 ha
41
portoftallinn.com/muuga-industrial-park
Important stopover point for regular Ro-Ro lines to Western Europe and Scandinavia
Distance from Tallinn 45 km
Paldiski South Harbour Industrial Park
Industrial park area 34 ha
Plot areas 1,5–15 ha
Industrial Park area 23 ha
Industrial Park area 11 ha
portoftallinn.com/paldiski-industrial-park
42

3.3. Synthesis

Transport and Logistics are key pillars of the Estonian economy. By gradually replacing the oil shale industry with a new international value proposition on hydrogen, Estonian economy aims for the future and Port of Tallinn is at the center of this transition. By kickstarting the transition on using hydrogen for internal logistics, scaling up to public transport and ferries and scaling massively to international ferries and export of (hydrogen derived) fuels, the Estonian value proposition may come to fruition. The potential for the production of green electricity is there, and maybe even more so the availability of green carbon for fuels. The market is there, countries in North West Europe and the Baltics are heavily investing in hydrogen strategies and the Dutch market has the knowledge to accelerate the Estonian transition. From a ton-scale in 2023 to a kiloton scale around 2025 and 100 kiloton scale around 2030, Estonia is in tempo with market developments.

Port of Tallinn can be the central node in the hydrogen hub (as suggested by government) as a kickstarter, a facilitator for its partners and the provider of a backbone.

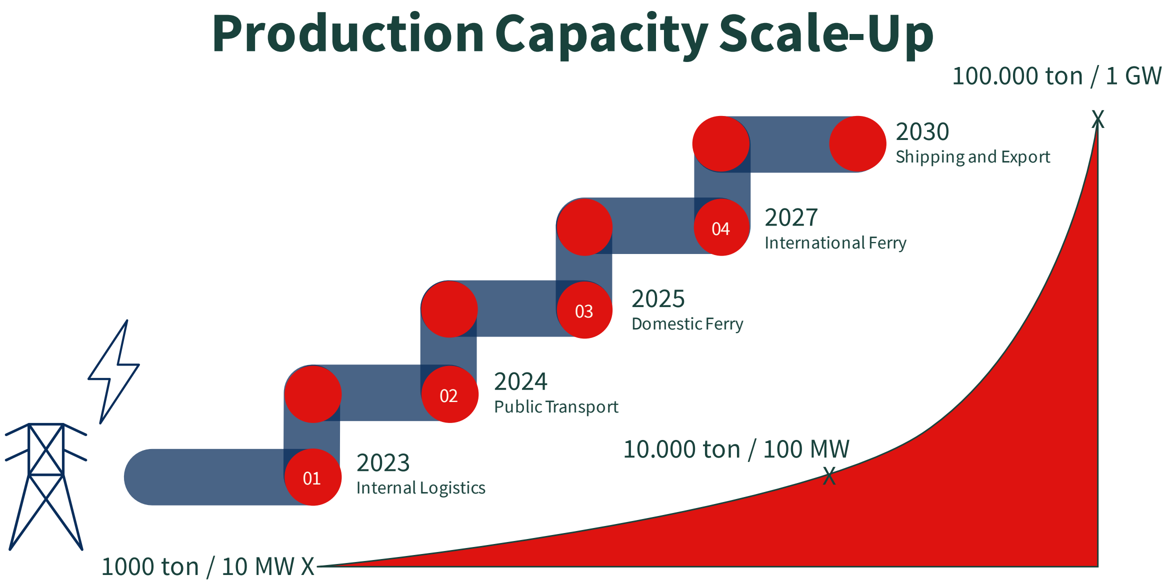
3.4. Value proposition Port of Tallinn

The value proposition for Port of Tallinn can be summarized in the following points:

1. Estonia has a huge potential for the production of green energy through mainly offshore wind and secondary onshore wind, solar and biomass (gasification).
2. That potential can be used for (heavy) duty mobility and ferry industry in the short term, export in the medium term and other use cases in the long term.
3. Port of Tallinn may well play the role of a central node in this new ecosystem for the production and use of hydrogen.
4. Partners in business (ferries, logistics, energy) are willing to move but will need a central facilitating organization, the role Port of Tallinn is equipped for.
5. This will take heavy investments in the coming years, but we see several subsidy structures to be used and a commercial potential before 2030.
6. The factual steppingstones of this ecosystem would be:
    a. Internal logistics (trucks, heavy lifting) on hydrogen by 2023
    b. Providing hydrogen for Public transport (busses and possible trains) by 2024
    c. Providing hydrogen for domestic ferry industry by 2025
    d. Providing hydrogen for international ferry industry by 2027
    e. Providing hydrogen for shipping and export by 2030
7. This would imply production capacity:
    a. Magnitude of tons capacity from decentralized green production by 2023
    b. Magnitude of kilotons capacity from renewable sources by 2025
    c. Magnitude of 100 kilotons capacity from offshore wind and other renewables by 2030

4. Timeline

4.1. Agenda 2020-2030



4.2. Next steps

We recommend taking the following steps to carry out this agenda:

1. Acquire adhesion statements from industry partners (Q1 2021)
2. Gain agreement and mandate from board Port of Tallinn (Q1 2021)
3. Present the strategy including adhesion statements to government (Q1 2021)
4. Organize webinar on Dutch-Estonian cooperation opportunities (Q2 2021)
5. Acquire a subsidy specialist for EU subsidies (Q2 2021)
6. Map the internal logistics and potential for hydrogen transition (Q2 2021)
7. Dialogue with regional government on hydrogen for public transport (Q3 2021)
8. Further investigate projects for domestic ferry projects (Q3 2021)
9. Organize hydrogen event between Netherlands and Estonia (Q3 2021)
10. Further develop the strategy combined with a technical partner like TNO (2021)
11. Map the stakeholder network and each position in the value chain (2021)