

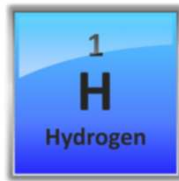


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Vesinik H_2 – mis see on?

PORT OF TALLINN

- kõige väiksema molekulmassiga element
- lõhnatu, värvitu, maitsetu, mittemürgine ja põlev gaas
- 14 x õhust kergem
- kütteväärtus on 33,32 kWh/kg (ületab 3 x bensiini)



	Aine tihedus [kg/m ³]	Energiatihedus [kWh/m ³]
H_2 normaalrõhul (t +20 °C)	0,08376	2,79
H_2 veeldatuna (t -253 °C)	70,85	2361

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Fakte vesinikust

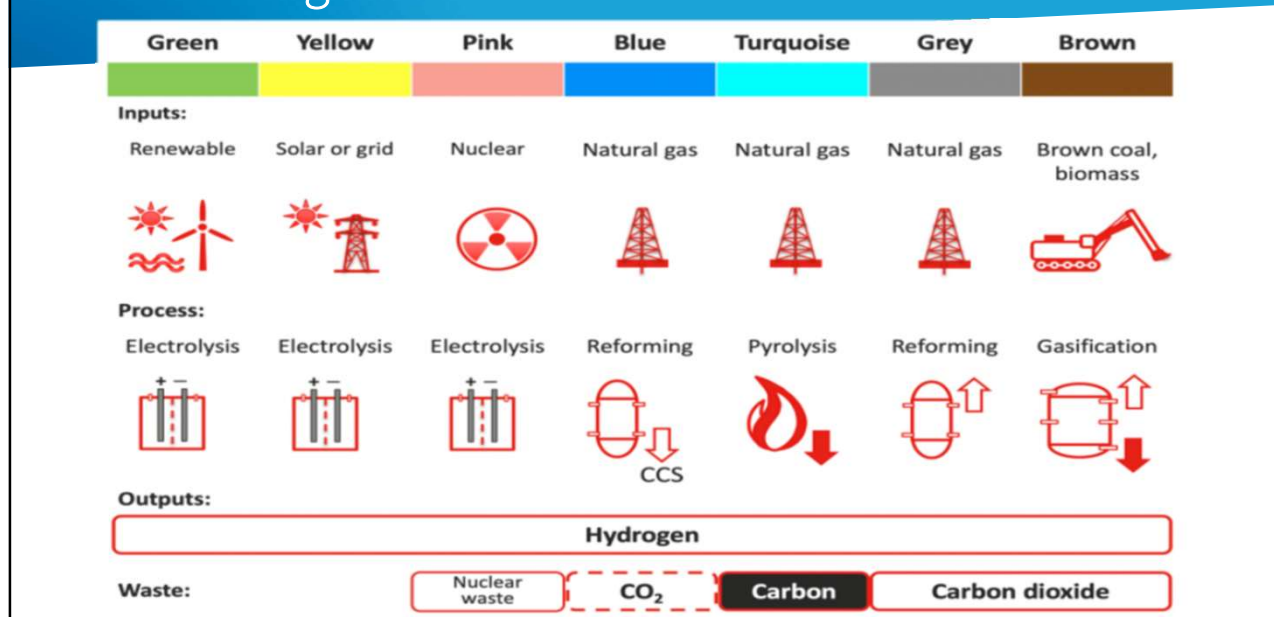
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- moodustab 75 % kogu Universumi ja 73,46 % Päikese massist
- inimkehas 3. enim levinud element (hapniku ja süsiniku järel)
- avastati 1766 a. inglase Henry Cavendish'i ja sõltumatuna prantslase Antoine Laurent de Lavoisier'i poolt, kes pani nimeks *hydrogène* - 'veetekitaja')
- puhas H_2 süttib temperatuuril 500 °C (bensiin 246 °C, diisel 210 °C)
- 1 kg H_2 tootmiseks elektrolüüsi teel vaja ca 8 kg vett ja 39-50 kWh elektrit

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Vesiniku liigitamine

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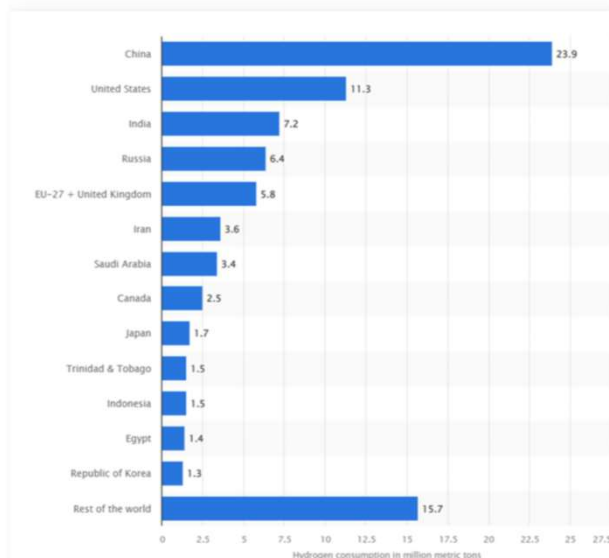


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Vesiniku tarbimine

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Hydrogen consumption worldwide in 2020, by country
(in million metric tons)



2020 a tarbiti maailmas
kokku 120 miljonit tonni H₂

<https://www.statista.com/statistics>

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Halli vesiniku kasutus Euroopas 2015 a

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		H ₂ kasutus		Primaarenergiast osakaal	
		TWh, kokku	MWh/elaniku kohta	TWh	H ₂ osakaal
EL28		325.0	0.633	14 100	2.3%
Saksamaa		55.0	0.656	2 475	2.2%
Holland		32.5	1.897	571	5.7%
Norra		7.5	1.383	217	3.4%
Soome		5.0	0.902	281	1.8%

Allikas: National Hydrogen Roadmap for Finland 2020

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Vesiniku tootmine

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Recent Increased Interest in Hydrogen: Global Drivers

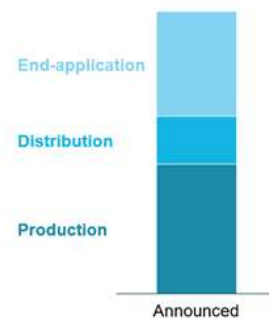
- ✓ **Low-cost renewables** are now available

- ✓ **Countries see clean H₂ can help meet climate goals**

- Hard to decarbonize sectors
- Energy storage
- Import/export opportunities

200-fold electrolyzer growth by 2030
Over 40 GW planned

\$80B Global Government Funding, 6X More with Private Sector through 2025



Source: McKinsey, H2 Council, Spring 2021

Studies show potential for 10 to 25% global GHG reduction using clean hydrogen. \$2.5T Revenue. 30M Jobs.

U.S. DEPARTMENT OF ENERGY

OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY

HYDROGEN AND FUEL CELL TECHNOLOGIES OFFICE

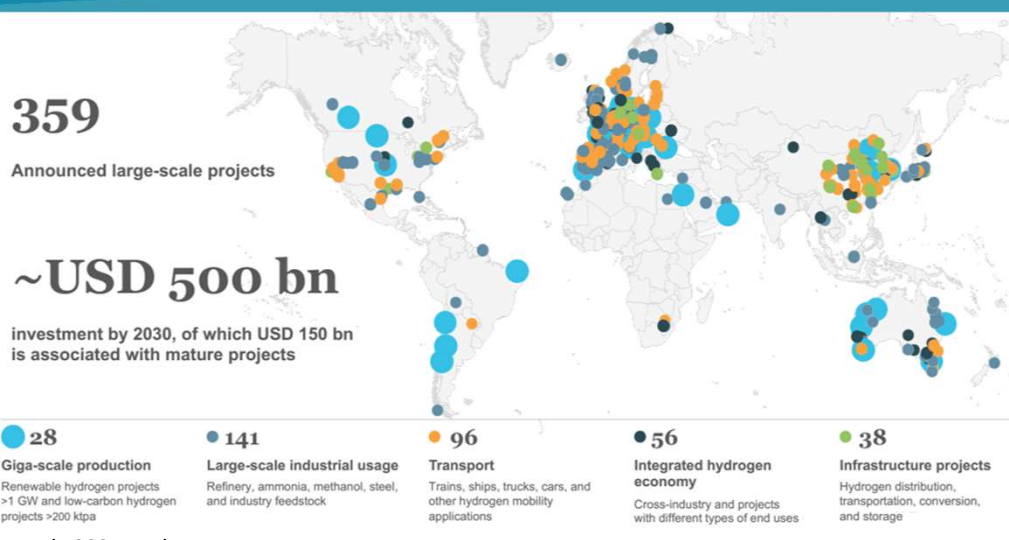
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Vesiniku plaanid 2021 a

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Exhibit 1: Global hydrogen projects and investment across the value chain

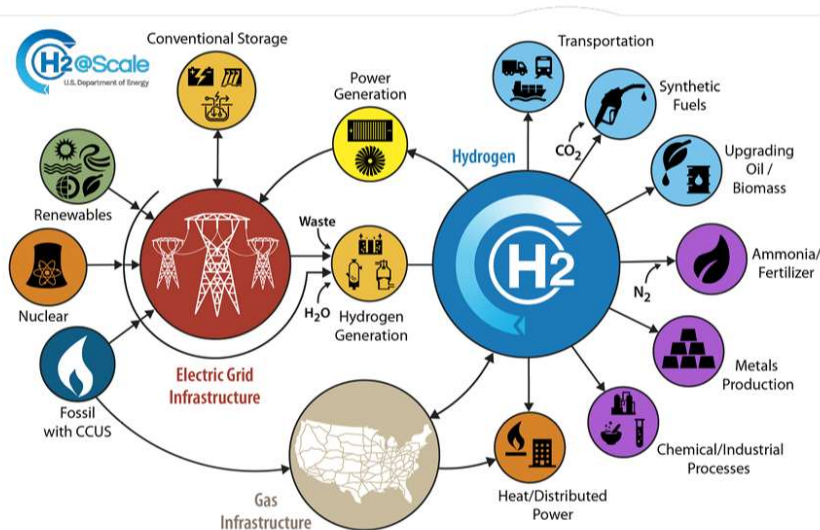


Hydrogen Insights July 2021 Update
Hydrogen Council, McKinsey & Company

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Vesiniku plaanid USA-s 2021 a

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Potential

- 10 MMT of H_2 /yr produced today with scenarios for ~5X growth
- 10 MMT H_2 would ~ double today's solar or wind deployment
- Industry study shows potential for \$140B in revenue, 700K jobs, 16% GHG reduction. Analysis underway, including on export potential.

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Valminud projekte maailmast

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Fukushima, Japan, 10 MW elektrolüüser, transpordi kütus, 2020 a



SUISEI FRONTIER, Jaapan, vedela H_2 transpordi tanker, 116 m pikk, DWT 9000 tonni, 1,250 m³ mahuti; 2022 esimene vedu Austraaliast-Jaapanisse



HyBalance, Taani, 1,2 MW elektrolüüs, kütuseelement ja el.võrgu tasakaalustamine, 2018 a

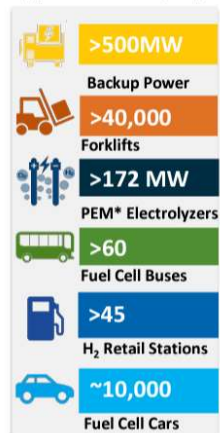


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Valminud projektid, H₂ tootmine USA-s

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Examples of Applications Deployed

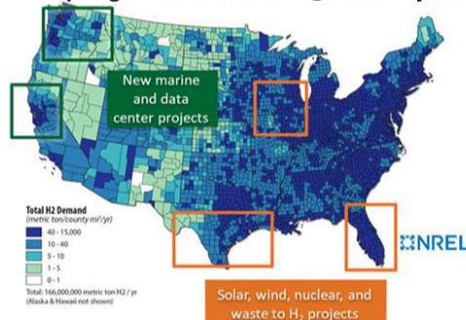


Major Hydrogen Production Sites



- 10 million metric tons produced annually
- More than 1,600 miles of H₂ pipeline
- World's largest H₂ storage cavern

Hydrogen Demand and H₂@Scale Projects



Hydrogen Stations Plans Across States

California	Northeast	HI, OH, SC, NY, CT, MA, CO, UT, TX, MI And Others
200 Stations Planned	12 – 20 Stations Planned	
California Fuel Cell Partnership Goal		

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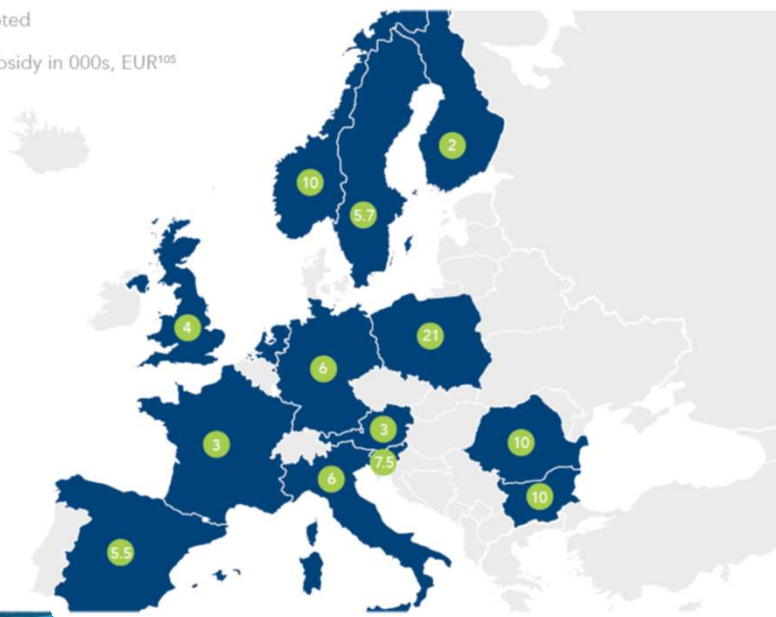
Euroopa Liidus toetused H₂ sõiduauto ostul

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- Purchase subsidy adopted
- 5 Maximum purchase subsidy in 000s, EUR¹⁰⁵



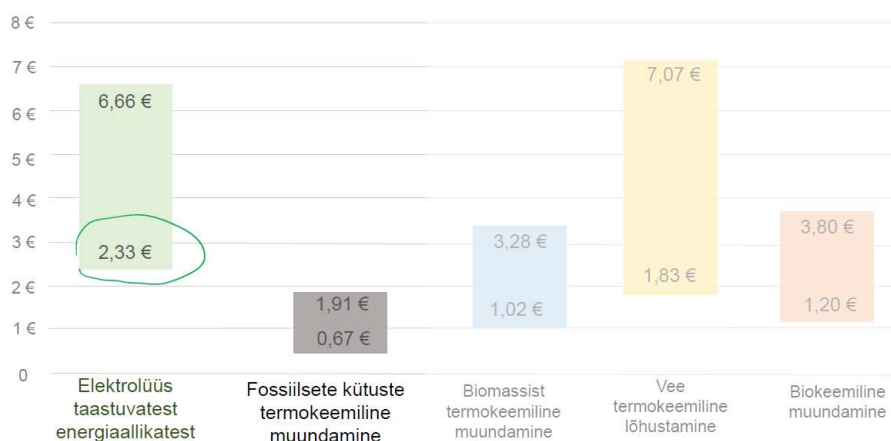
Hydrogen Europe vahendusel Fuel Cells and Hydrogen Observatory (fcobservatory.eu)



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Vesiniku tootmise kulud 2021 a

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TARTU ÜLIKOOL
keemia instituut

Eesti vesinikuressurside kasutuselevõtu analüüs. Lõpparuanne, mai 2021

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Laevade kütuste turuvalmidus 1/2

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What is the best fuel option?

	Availability	Infrastructure & Storage	Maturity of technology	Energy density	Price	Green credentials
VLSFO/MGO	Green	Green	Green	Green	Green	Red
LNG	Green	Yellow	Green	Yellow	Yellow	Yellow
LPG	Green	Yellow	Yellow	Yellow	Yellow	Yellow
Methanol	Yellow	Yellow	Green	Yellow	Yellow	Yellow
Bio-/e-fuels	Red	Green	Yellow	Green	Red	Green
Hydrogen	Red	Red	Red	Red	Red	Green
Ammonia	Red	Yellow	Red	Yellow	Yellow	Green

The picture as we see it in 2022

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DNV

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Laevade kütuste turuvalmidus 2/2

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What is the best fuel option?

	Availability	Infrastructure & Storage	Maturity of technology	Energy density	Price	Green credentials
VLSFO/MGO	Green	Green	Green	Green	Green	Red
LNG	Green	Yellow	Green	Yellow	Yellow	Yellow
LPG	Green	Yellow	Yellow	Yellow	Yellow	Yellow
Methanol	Yellow	Yellow	Green	Yellow	Yellow	Yellow
Bio-/e-fuels	Yellow	Green	Green	Green	Red	Light Green
Hydrogen	Yellow	Red	Yellow	Red	Red	Light Green
Ammonia	Yellow	Yellow	Yellow	Yellow	Yellow	Light Green

A possible picture in 2035

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Laevade mootorite turuvalmidus

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Engine and fuel system	Blue ammonia Blue hydrogen							Status – Technical maturity
	e-MGO	e-LNG	e-LPG	e-methanol	e-ammonia	e-hydrogen	Electricity from grid	
	bio-MGO	bio-LNG	bio-methanol					
	HFO	VLSFO/MGO	LNG	LPG	Methanol			
MF ICE		●						
MF ICE (+ scrubber)	●	●						
DF LNG ICE		●	●					
DF LPG ICE		●		●				
DF methanol ICE		●		●				
DF ammonia ICE		●			●			
DF hydrogen ICE		●				●		
LNG FC			●					
Hydrogen FC						●		
Ammonia FC					●			
Battery EM							●	

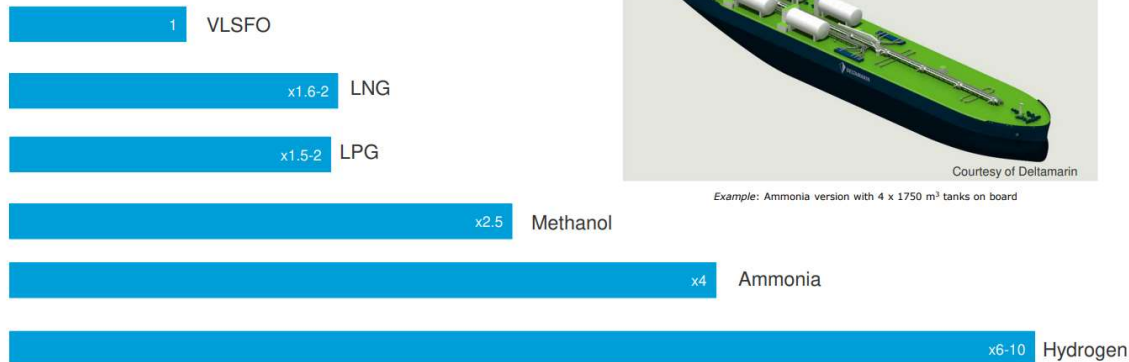
MF: mono-fuel. DF: Dual fuel. ICE: Internal combustion engines. FC: Fuel cells

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Alternative fuels introduce new storage challenges – or, bunkering intervals

Fuel tank volume



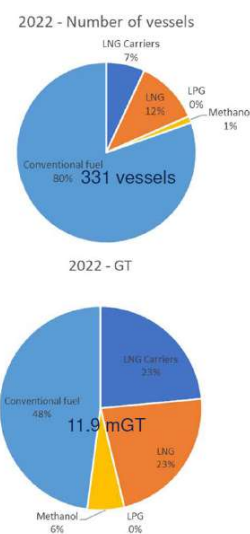
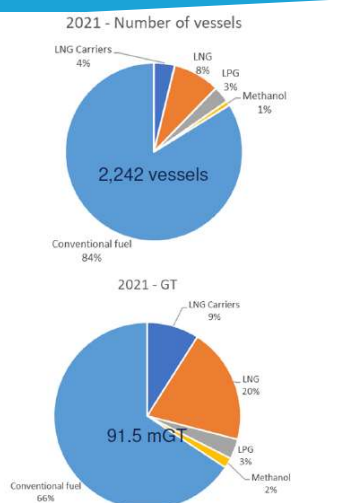
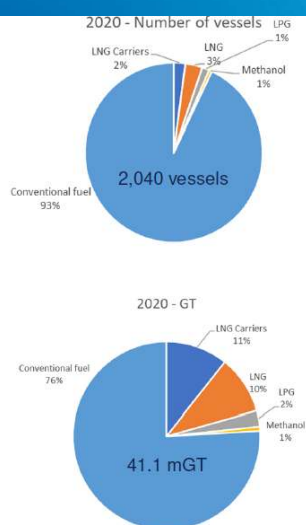
Example: Ammonia version with 4 x 1750 m³ tanks on board

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Uute laevade tellimused kütuste kaupa



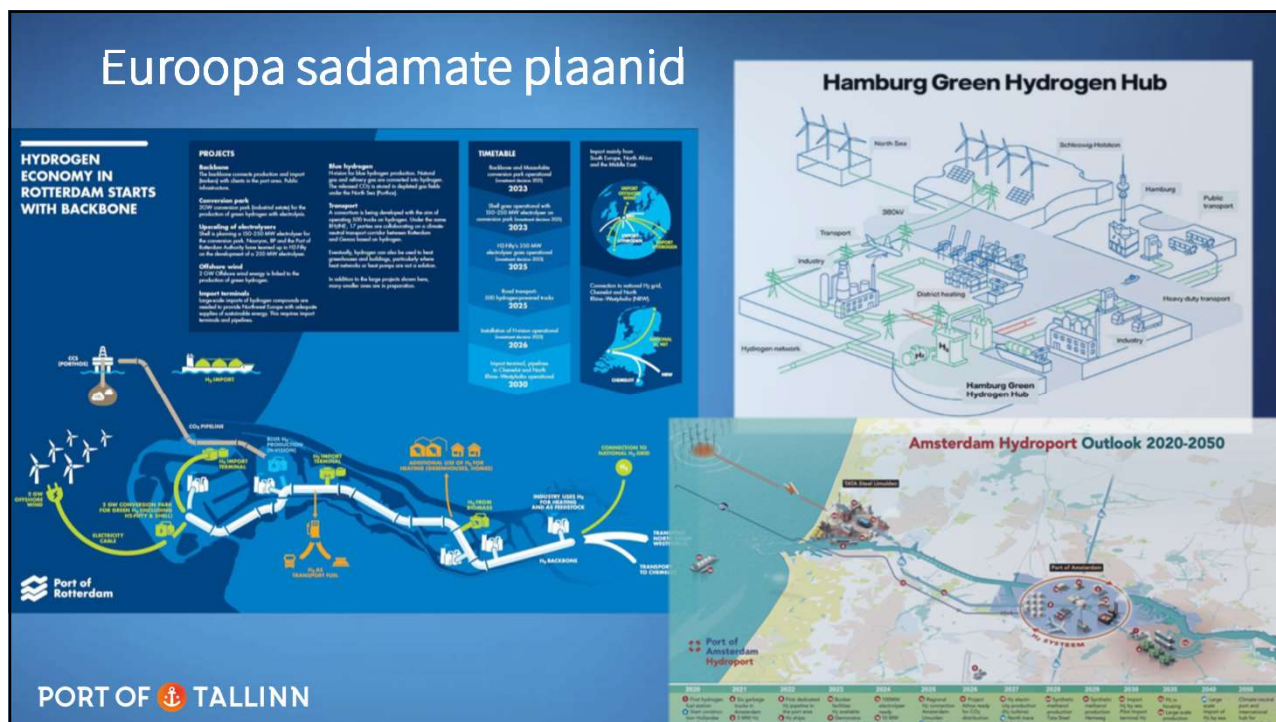
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Updated: April 2022



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Euroopa sadamate plaanid



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H₂ võimalikud kasutusalaad Eestis

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Transpordis

Puhas H₂ kui otsene kütus või aine segu ühe osana



Ehitiste kütmiseks

Kui rohe H₂ hakkab piisavalt saadaval olema / hind võrdne-soodsam kui maagaasil



Tööstus

Maagaasi asendaja; tooraine



Eksport

Kui Eesti kasutab maksimaalselt ära oma H₂ ja ka taastuvenergia potentsiaali, siis võimalik ülejääk müüa



Energia salvestamine

H₂ abil saab balanseerida kõikumisi elektrivõrgus tulevikus

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Tallinn's Old City Harbour OPS

EstH2OPS

OPS – Onshore Power Supply

- Fit for 55
- OPS at least for 4 cruise ships with max 16 MW each
- Challenges:
 - seasonal
 - high peak demand
 - lack of existing grid
 - lack of space for infrastructure/facilities
 - next to city center

PORT OF TALLINN ALEXELA HDF ENERGY stargate hydrogen

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TS Laevad & H₂

EHYTRANSP

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- Whole H₂ value chain
 - Retrofit the presently operating LMG 150-DE ferries to battery/hydrogen hybrid operation
 - H₂ production
 - filling stations
 - H₂ trailers, busses and trains

TS LAEVAD Eesti Energia ALEXELA

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H₂ terminal in Paldiski

EstH2Hub

Big regional hub :

- H₂ production and storage
- port infrastructure
- filling stations

AS Balti Gaas

ALEXELA



Paldiski South Harbour

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H₂ terminal in Muuga

HYEELIWTS

Local hub :

- H₂ production and storage
- port infrastructure
- grid connection

LIWATHON E.O.S.

Eesti Energia



Muuga Harbour

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Partnerid

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