

Next Wave

Input to a Nordic Hydrogen Vision

June 2022



Nordic
Innovation





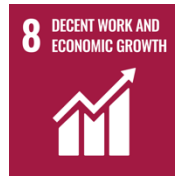
Disclaimer

This publication is part of the Nordic Smart Mobility and Connectivity initiative **Next Wave** (Next Nordic Green Transport Wave - Large Vehicles) co-financed by **Nordic Innovation**.

The project partners are responsible for its content.

About Next Wave

- Next Wave focuses on providing infrastructure for a large-scale deployment of hydrogen trucks, buses, and machinery. The goal is to further stimulate the global technological lead, which the Nordic countries have by stimulating the very first hydrogen infrastructure rollout for larger vehicles while at the same time map how the infrastructure build-up best can be done.
- Time span: 01.10.2019 – 31.12.2021
- Financed by: Nordic Innovation and project partners



Sponsor:



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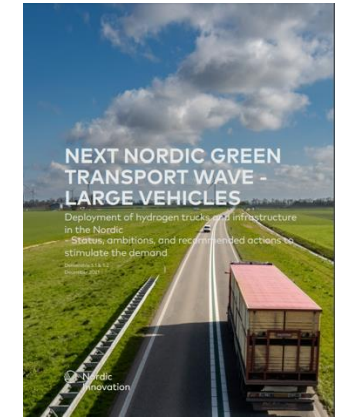
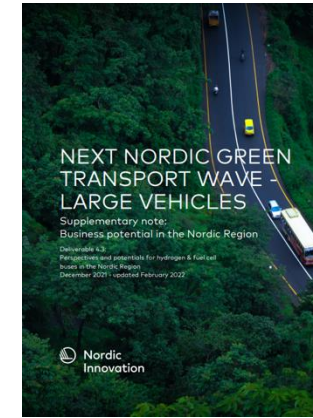
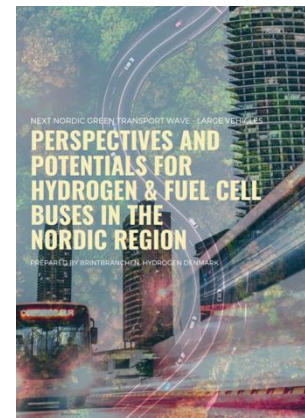
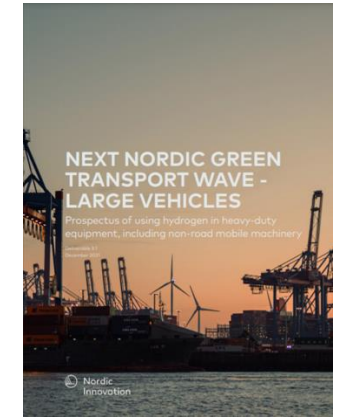
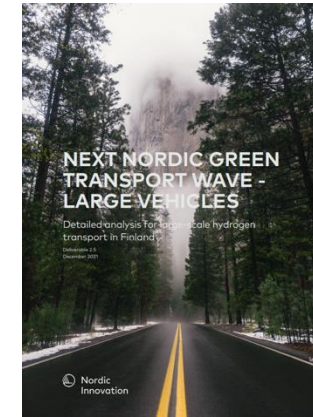
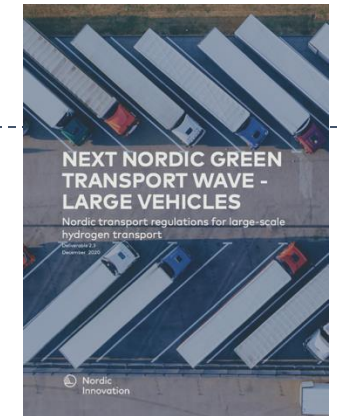
Next Wave Reports

The Next Wave reports represents the most updated and comprehensive work on hydrogen in the Nordics.

Here, you'll find facts and figures, modelling and analysis, as well as the partners joint ambitions, plans and recommendations – in other words everything that is needed in preparing for implementation.

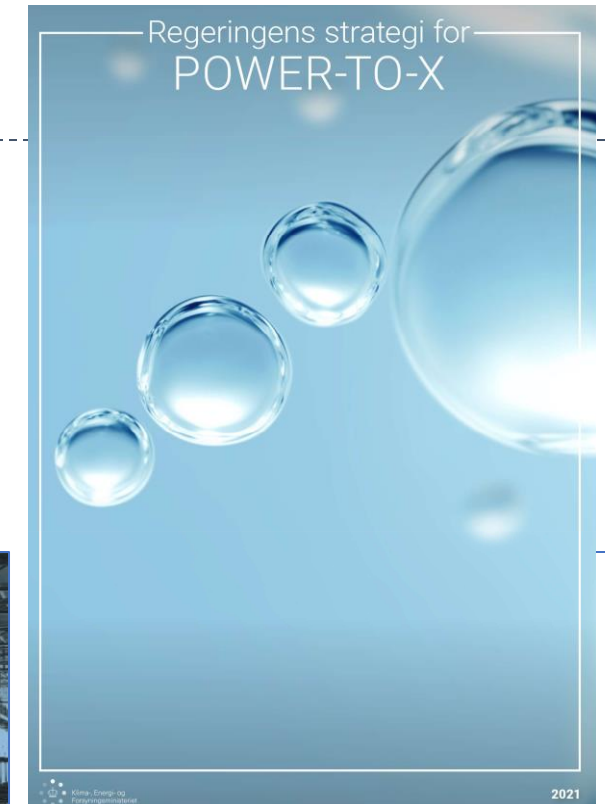
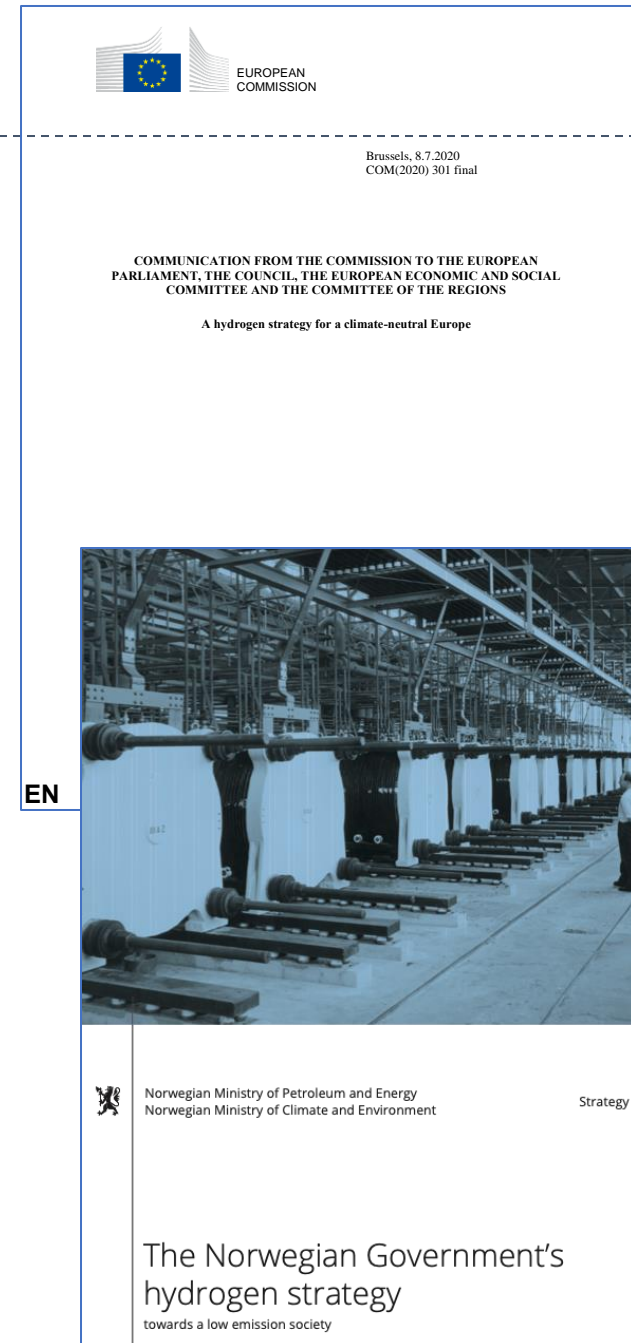
Thus, Let's-a go!

The reports are available for download from:
<http://www.nordichydrogenpartnership.com/nextwave/>



The Hydrogen Landscape

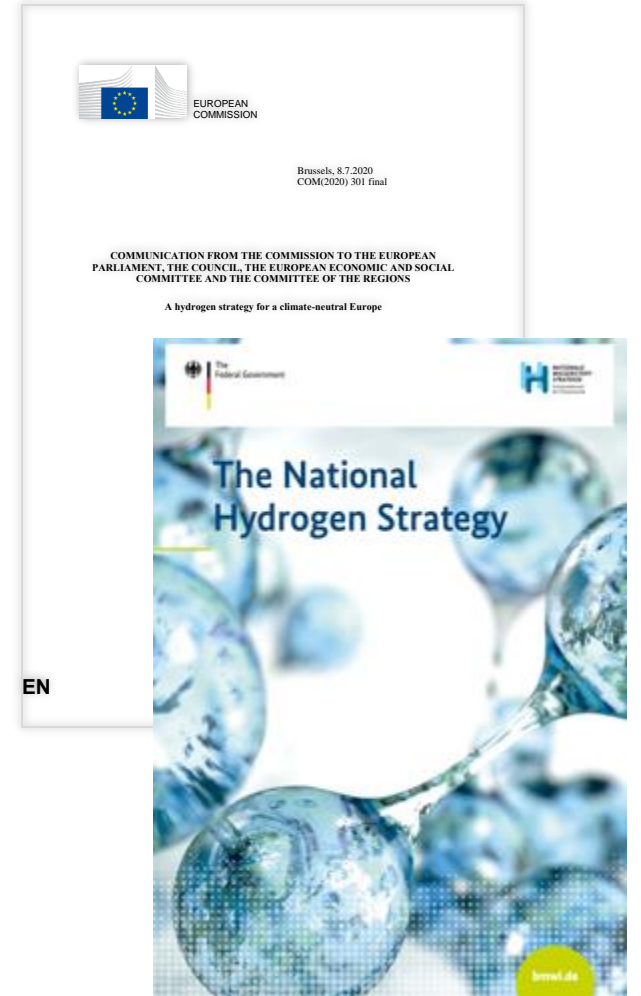
- National strategies are currently being developed all over the world
- European focus: Decarbonising industrial and transport sectors
- **Status in the Nordics:**
 - Norway: Strategy (2020) and Roadmap (2021)
 - Sweden: Proposed strategy publisher in 2021, to be adopted 2022
 - Denmark: Strategy adopted 2022
 - Finland: National strategy expected 2022
 - Iceland: Hydrogen & Electrofuel Roadmap expected to be published 2022



Förslag till Sveriges nationella
strategi för vätgas,
elektrobränslen och
ammoniak

Europe

- **Hydrogen to play an important role in**
 - Decarbonisation of the energy system
 - Developing European industry
 - Fit for 55 – meeting ambitious climate targets
- **EU's Hydrogen Strategy – specifying targets for**
 - Green and blue hydrogen production by 2025 and 2030
 - Investments in electrolysers, connection to solar and wind power, transport, distribution, and storage
 - Total investments: 320-458 billion Euros until 2030
- **Germany's Hydrogen Strategy**
 - Budget: 9 billion Euros
 - 38 measures over the complete value chain
 - Dedicated work on regulations and directives to stimulate development and deployment of hydrogen stations and vehicles
 - Ramp-up of fuel cell applications over all segments and respective infrastructure as well as power-based fuel
 - To be updated and upgraded by new government



Standards and Directives Stimulating Transition to Zero-emission

1 CO₂ Emission Standards – LDVs



2 CO₂ Emission Standards – HDVs



3 Clean Vehicle Directive



4 Alternative Fuels Infrastructure Directive*



5 Renewable Energy Directive

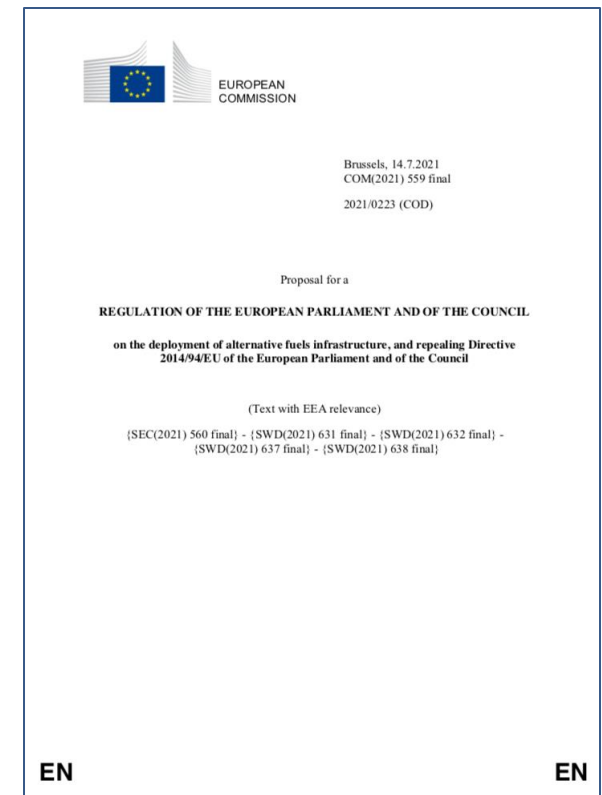


6 Energy Taxation Directive



Alternative Fuel Infrastructure Regulation (AFIR)

- Proposal to be adopted by the Commission spring 2022
- Member States should notify a national policy framework for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure by January 1st 2025
- **Proposed for hydrogen:**
 - Member States shall ensure that by 31 December 2030 publicly accessible hydrogen refuelling stations with a minimum capacity of 2 t/day and equipped with at least a 700 bars dispenser are deployed with a maximum distance of 150 km in-between them along the TEN-T core and the TEN-T comprehensive network. Liquid hydrogen shall be made available at publicly accessible refuelling stations with a maximum distance of 450 km in-between them.
 - Neighbouring Member States shall ensure that the maximum distance referred to in Paragraph 1, second subparagraph is not exceeded for cross-border sections of the TEN-T core and the TEN-T comprehensive network.
 - The operator of a publicly accessible refuelling station shall ensure that the station is designed to serve light-duty and heavy-duty vehicles. In freight terminals, operators or owners of these publicly accessible hydrogen refuelling stations shall ensure that these stations also serve liquid hydrogen.



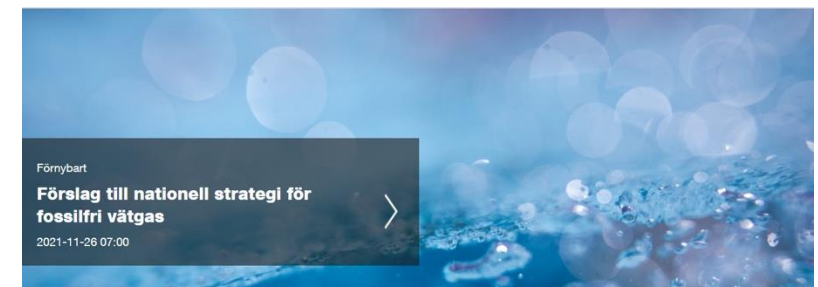
Norway

- **Hydrogen Strategy published June 2020**
 - Public procurement to stimulate zero emission transport
 - Prioritizing Industry and maritime transport
 - More a description than a strategy; missing ambitions and concrete targets
- **Hydrogen Roadmap published June 2021**
 - **By 2025:**
 - **5 hydrogen hubs in maritime** sector with opportunities for the development of land transport,
 - **1-2 industry projects,**
 - **5-10 pilot projects**
 - **By 2030:**
 - **Network** of hubs with supply to vessels and vehicles,
 - hydrogen vessels are **competitive and safe,**
 - realization of full-scale hydrogen projects in the **industry,**
 - use of hydrogen is a **competitive alternative** to fossil energy,
 - **export** of hydrogen and technologies
- **2021: New government has taken office. More efforts within hydrogen is expected**
 - Will build a coherent value chain where hydrogen production, distribution and use are developed in parallel
 - Will set a target for annual production of blue and green hydrogen by 2030



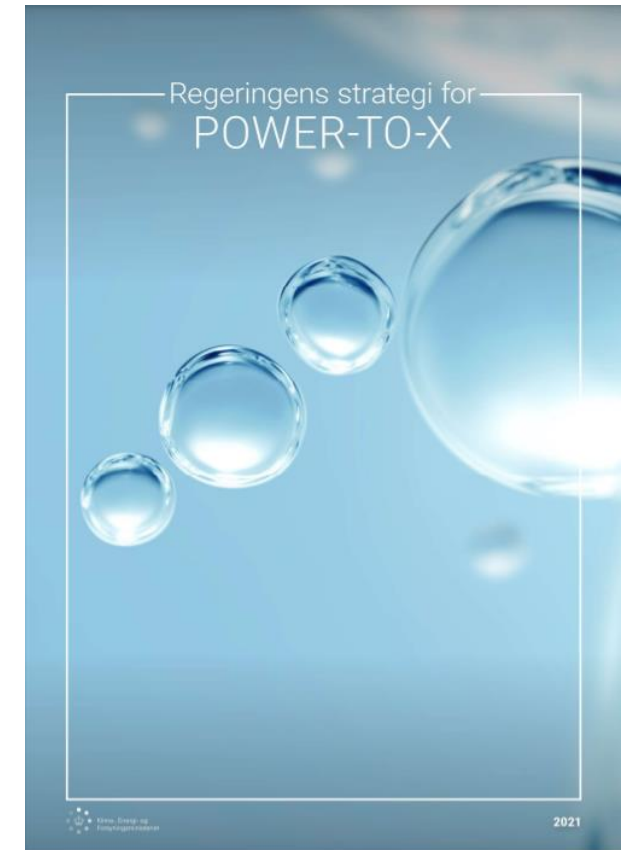
Sweden

- **Swedish Hydrogen Strategy proposal published by National Energy Agency in November 2021, with following guiding principles:**
 - The use of hydrogen will contribute to the transition to fossil-free society
 - The hydrogen gas must be used where it is economically efficient and make the most of system benefits
 - Security of supply must be strengthened
 - Sweden should be a pioneer internationally
 - Sweden will export climate-smart products and services to contribute to elimination of fossil energy abroad
- **Main intentions:**
 - Utilise Sweden's fossil-free electricity mix for building strong position on the international scene
 - Explore policy instruments that can help to close the cost gap between fossil- and fossil-free hydrogen
 - Systemic view is important to develop cross-sectoral benefits
 - Continue building collaboration platforms between industry, academia and public sector
 - Take active role in Nordic- and international cooperation
- **Specific objectives**
 - **By 2030: 5 GW electrolyser capacity installed**
 - **By 2045: 15 GW electrolyser capacity installed**



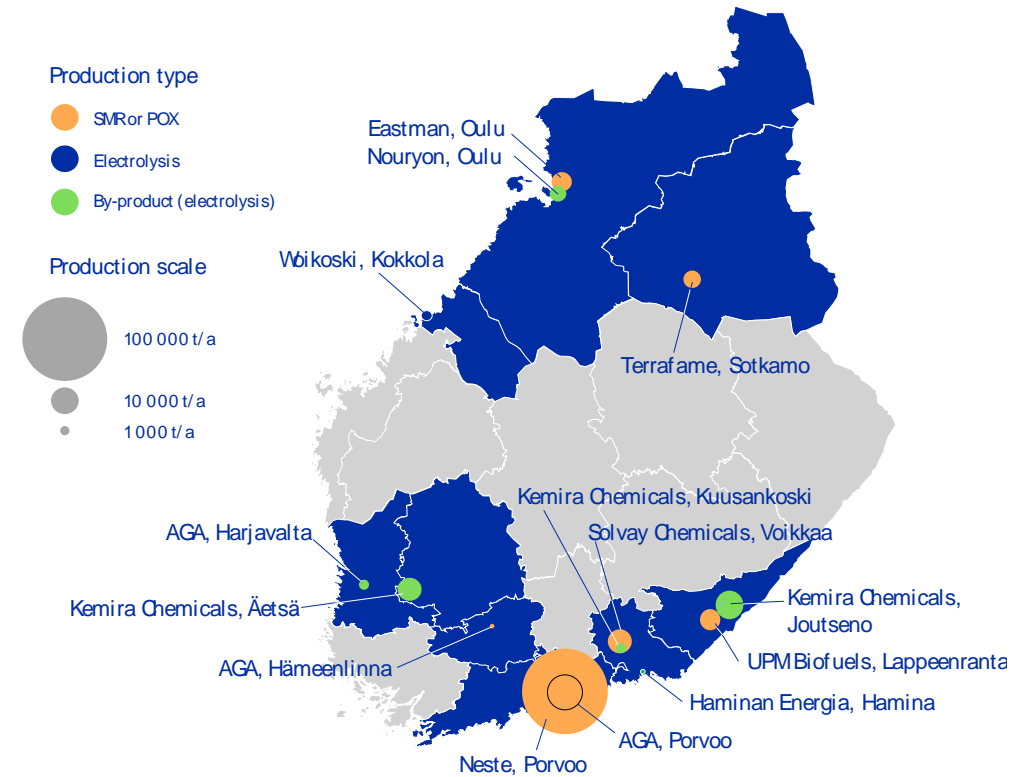
Denmark

- **National Hydrogen Strategy published by the Government on the 15th of December 2021**
 - <https://kefm.dk/aktuelt/nyheder/2021/dec/regeringen-vil-kickstarte-udvikling-af-groenne-braendstoffer-med-milliardstoette->
 - Will provide better access to the electricity grid and enable direct connections between RE and H₂-production
 - Main focus heavy transport and production of liquid fuels for aviation and shipping and to some extent road transport
 - Construction of H₂ infrastructure at both DSO and TSO level – connection to Germany and potentially Sweden
- Government aims for at least 4-6 GW electrolyser capacity in 2030
- Overall project portfolio for planned Hydrogen projects at 6+ GW in December 2021
<https://brintbranchen.dk/brintbranchen-praesenterer-brint-i-tal/>
- Strategy now to be negotiated in Q1 2022 in Parliament
- Further build up of RE capacity agreed in order to ensure sufficient supply for H₂-production
- Separate strategy for ZE heavy duty transport to be developed in 2022



Finland

- **Finland does not have a separate hydrogen strategy**
 - Hydrogen is an important part of the national climate and energy strategy of Finland, which will be published Q1 2022
 - Business Finland prepared a National Hydrogen Roadmap in November 2020
 - Industry drive National Hydrogen Cluster published White paper in September 2020
- Hydrogen in Finland has an important role for flexible energy use and decarbonisation of industry
- Finland has a goal to have predictable and competitive investment environment for hydrogen economy



Iceland

- **Vision for H₂ published in 2020**
 - Icelandic New Energy responsible for the documentation
 - Gives insight into the potential role of H₂ until 2030 and even beyond
- **Hydrogen & Electrofuel Roadmap in the making (initiated by the Government)**
 - Plans to publish in Q1 2022
 - Roland Berger (author) hosted a stakeholder forum in October 2021 to get feedback
 - Includes vision for use of H₂ and electrofuels to replace all use of fossil fuel with a vision, 2030; again 2040, and finally 2050
 - Includes target goals for the maritime sector, aviation, and land transport
 - Iceland was a pioneer and already restarted:
 - **Two refuelling stations** are in operation
 - Small fleet of **FCEVs** is being tested
 - Investment policy and incentives – hopefully based on the Roadmap – will determine speed of deployment
- **2021: New government has taken office. Very high emphasis on energy shift in all sectors, goal to be fossil fuel free by 2040**
 - Hydrogen will play an important role

Nordic Hydrogen Industry in Lead Position

- **Developing world-leading hydrogen technology**
 - Electrolysers
 - Storage and transport systems
 - Hydrogen stations
- **Use of hydrogen in industry**
 - Zero emission steel manufacturing
 - Ammonia and fertilizers
 - e-fuels
- **Hydrogen production**
 - Green hydrogen
 - Blue hydrogen



Status: Vehicles

- **Passenger vehicles**

- Available: Toyota Mirai and Hyundai Nexo. Range: ~650 km.
- Expected: Limited series from some OEMs. Small volumes the next years.

- **Vans**

- Available: Peugeot e-Expert, Opel Vivaro, Hyvia (France), Gaz (Russia), Renault Kangoo and Master. Range ~450 km.
- Expected: Quantron, Hyzon, and H2X.

- **Trucks**

- Available: Hyundai XCient, Hyzon. Range: ~400 km.
- Expected: Quantron (2022), Scania (2023, limited series), Iveco / Nikola (2024), Volvo (2025), Mercedes (2025).

- **Buses**

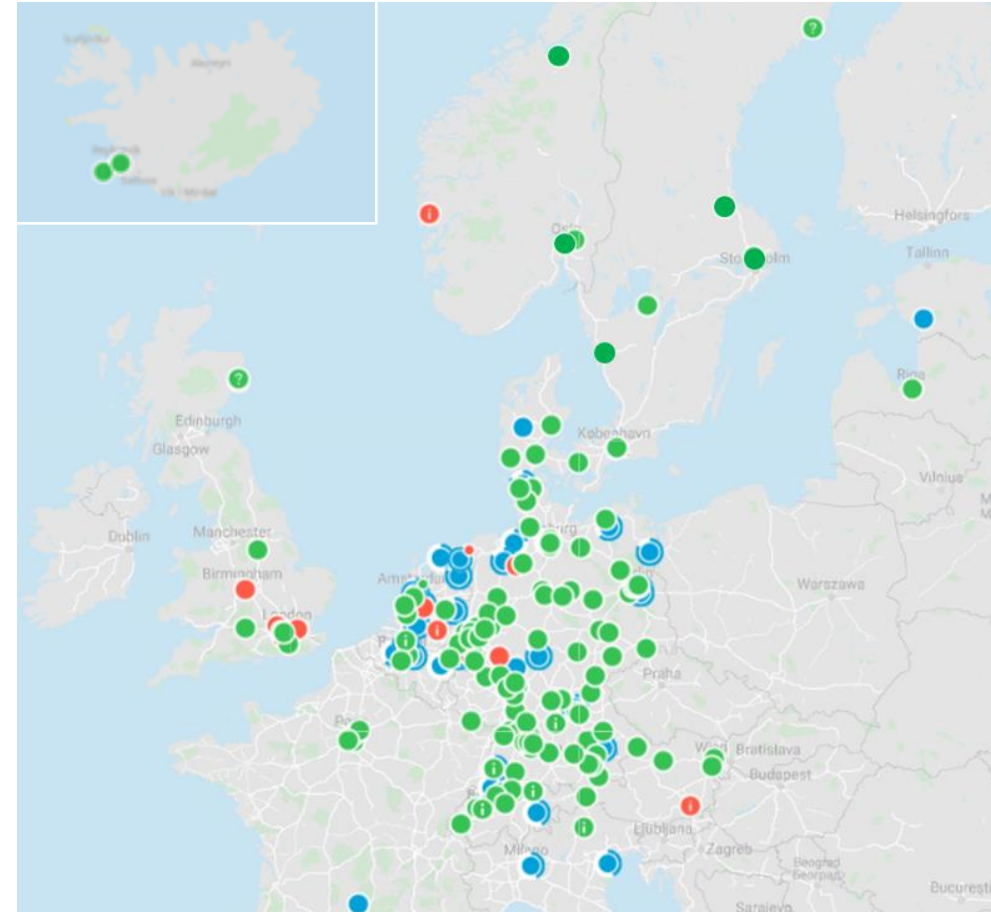
- Available: Solaris, Van Hool, Alexander Dennis, Caetanobus, Citaro, Wright. Range: ~350 km.
- Expected: Quantron (2022) and H2X.



Photo: Toyota, Peugeot, Solaris, Hyundai

Status: Infrastructure (Dec 21st, 2021)

- **Nordic operators:**
 - Everfuel, Hynion, VänerEnergi, Linde, Oazer, Orkan, ASKO
- **Nordic stations for passenger vehicles:**
 - N (3): Bærum, Lillestrøm, Trondheim (ASKO)
 - SE: (4) Gothenburg, Arlanda, Mariestad, Sandviken
 - DK: (6) Århus, Kolding, Esbjerg, Korsør, København (2)
 - IS: (2) Reykjavik, Keflavik
- **Nordic stations for trucks:**
 - ASKO (N)
 - Gothenburg (SE)



*Hydrogen stations in Europe
by December 21st 2021
Source: h2.live.*

- In operation
- Temporarily out of order
- In preparation

Status: Instruments and Incentives

Incentives: hydrogen for transport	NO	SE	DK	FI	IS
Purchase of trucks	Enova: No specific program, but possible to get 40% of additional cost	Energimyndigheten: 20% funding of investment	No specific subsidies. Strategy for ZE trucks underway in 2022	No specific subsidy for trucks. Can be a part of larger demo.	100% depreciation in year 1. No VAT. Reduced annual fee. No excise tax for ZE trucks. No current funding.
Purchase of buses	Same as for trucks	Energimyndigheten: 20% funding of investment from 2022	Same as trucks – but public tenders almost all ZE	Same as for trucks	Same as for trucks
Hydrogen stations	Enova: No specific program but possible to get 40% of cost. Must be related to purchase of trucks	Naturvårdsverket – Klimatklivet: up to 70% funding of investment	No specific subsidy but tender for ZE infrastructure 72 mill DKK and 225 mill DKK underway	No specific subsidy for HRS. Can be a part of larger demo.	No incentives.
Annual CO₂ tax	Annual tax is 0,- for ZEVs and only 378 NOK for HD diesel trucks. CO ₂ -tax is 159,- NOK/ton (2021)	Currently 107 SEK/g CO ₂ for range 90-130 g/km and 132 SEK/g for emissions above 130 g/km according to official test cycle	Part of fuel tax – no general Co ₂ -tax but underway as part of “green tax reform” to be negotiated in 2022	No annual car tax since 1.10.2021	Gasoil + diesel 11,75 ISK/L Gasoline 10,25 ISK/L Fuel oil 14,45 ISK/kg Fossil gas 12,85 ISK/kg
Toll roads	Exemption	No exemption based on emissions	CO ₂ -based MAUT for trucks planned in principle from 2025	no toll roads in Finland	Full payment
National ferries	Exemption	No exemption based on emissions	Program underway – tender completed but not yet public	not relevant	Full payment
Zero emission zones	Being considered in some large cities	No zones yet	Legal framework on its way through parliament	No such zones in Finland	N.A.

Necessary Incentives for Hydrogen in Heavy-Duty Transport

- Clear national ambitions for decarbonisation of transport
- Harmonized incentives across the Nordics
- Public funding needed in the early stage
 - Purchase trucks, establish stations, production of hydrogen
- Long-term benefits for use of hydrogen trucks, i.e.,
 - Exemption on toll roads and public ferries
 - Exemption of annual fee for trucks
 - Introduction of zero-emission zones in cities
 - Access to zero-emission lanes, reserved parking, and reserved and timely favoured delivery of goods
- Increased CO₂ tax – polluter should pay principle
- Cross-border trade of liquid and gaseous hydrogen



Possible Barriers for Hydrogen Heavy-Duty Transport

- **Availability of trucks**
 - Small series/numbers available until 2025
 - Global competition for the trucks – incentives are important
- **Availability of infrastructure**
 - The stations must be in place before the trucks arrive
 - Difficult to find areas for energy stations
 - Long permitting-times
- **Lack of TCO and LCA**
- **Incentives not in place**
- **Legislation (“5 kW/ton”-rule)**
 - Commission regulation (EU) No 1230/2012 “The engine shall provide a power output of at least 5 kW per ton of the technically permissible maximum laden mass...”

Next Wave Vision

- for Nordic rollout of hydrogen trucks

- **Background - assumptions**

- Trucks will be available from 2023 in limited numbers, but enough to start deployment
- Distribution trucks will be available first
- Trucks for long-haul, including Volvo, Daimler and Iveco and other brands, will be available in large numbers from 2025
- TCO for hydrogen trucks will be equivalent with diesel by 2027 (Source: Roland Berger)

- **Next Wave ambition**

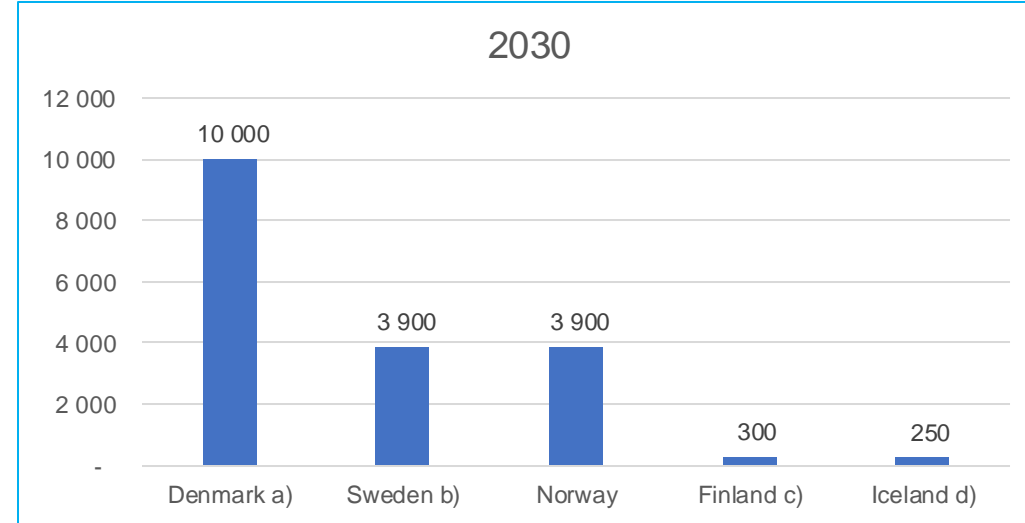
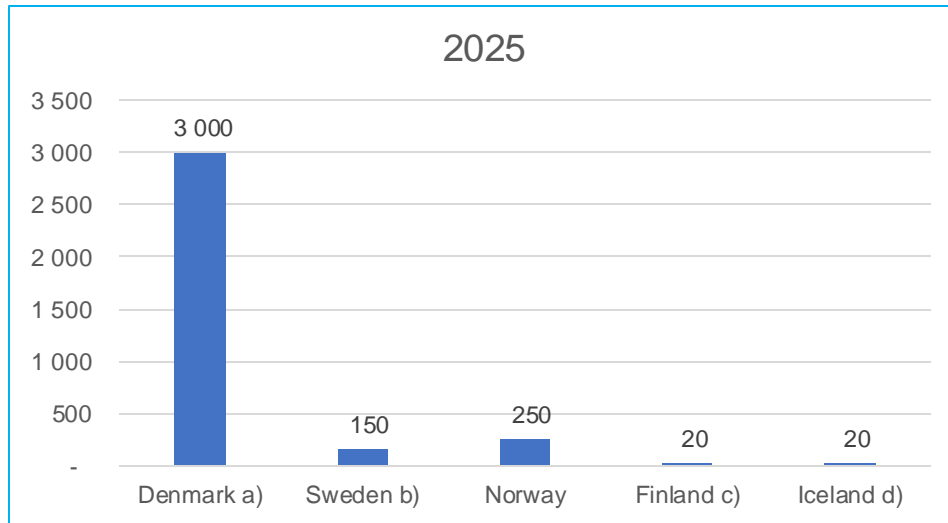
- **By 2025**

- **3,440 trucks** deployed in the Nordics (approx. 1,2% of total Nordic stock (~285,000) and 91% of all hydrogen trucks in Europe)
- Hydrogen trucks will be operating regional, national, and cross-border transport
- Heavy-duty paving the way for vans and passenger vehicles

- **By 2030**

- **18,350 trucks** deployed in the Nordics (approx. 6,4% of total Nordic stock and 18% of all hydrogen trucks in Europe)

Next Wave Ambition - for Nordic rollout of hydrogen trucks



Remarks:

- a) The numbers for Denmark is very ambitious and is based on input from the transport industry.
- b) The number for 2025 is relatively low because Swedish transport companies in general are waiting for the hydrogen trucks from Scania and Volvo, which are expected to be available in largest numbers by 2025 onwards.
- c) Finland has a high share of 60+ tonnes trucks, which are only operated in Finland (and to some degree in Sweden). These heavy-duty trucks are not expected to be available with hydrogen in larger numbers before 2030.
- d) For Iceland, the numbers are based on the current regime of investment incentives. The numbers are expected to be much higher if better incentives are made available.

Next Wave Vision

- for Nordic infrastructure for hydrogen heavy-duty vehicles

- **Background**

- Transport between domestic regions will be the basis for deployment of trucks – national networks of hydrogen stations is needed
- Ports as energy hubs will have a significant role in decarbonisation of transport – many hydrogen stations located at ports
- Cross-border stations are important to secure cross-border transport
- Hydrogen stations should serve both heavy-duty and light-duty segments
- Revised AFIR (Alternative Fuel Infrastructure Regulative) as a basis for the deployment:
 - Maximum 150 km between hydrogen stations along TEN-T core and comprehensive network
 - Neighbour countries responsible for cross-border infrastructure



- **Next Wave ambition:**

- **By 2025**

- First stations in national networks are in operation
- Hydrogen stations along the main cross-border corridors, according to AFIR
- Hydrogen stations at main ports for international ferries

- **By 2030**

- National networks of hydrogen stations are further developed
- Hydrogen stations securing cross-border transport are in operation
- Hydrogen stations in all ports facilitating land and maritime transport on hydrogen





Proposed Cross-border Infrastructure

This map shows the proposed hydrogen stations for cross-border transport only.

Border crossing is supposed to require hydrogen stations within 100 km from the border. Stations may be located on both sides of the border.

Important ports for international goods and passenger transport are included, as they will play an important role for deployment of hydrogen in the Nordics.

Legend:

-  Cross-border stations for road transport
-  Ports for border-crossing (deployment time not specified)



Next Wave Recommendation *- for development of a Nordic Hydrogen Vision*

Next Wave partners propose

- **Nordic Conferences** presenting national policies and discussing how to cooperate to stimulate decarbonisation of heavy-duty transport in the Nordics
 - **Part of the Nordic Hydrogen Conference and national conferences**
- **Assessment** – What is needed to stimulate decarbonisation of heavy-duty transport in the Nordics
 - **Developed by the Next Wave partners, Autumn 2022**
- **Note to the Nordic Council of Ministers** for decision on common targets and actions to decarbonise heavy-duty transport in the Nordics
 - **Spring 2023**

Thanks...



Photo: Lex Valshvili, Unsplash

for your attention!

