Information on Fuel Cells and Hydrogen Developments in the Netherlands

Introduction

The Netherlands represented by the Ministry of Infrastructure and the Environment, hereby applies for membership in the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). The Netherlands have a strong track record in hydrogen and the ambition to continue supporting the role of hydrogen and fuel cells in the economy. Key drivers for this ambition are the potential of hydrogen to mitigate climate change and to reduce oil dependency. The Netherlands activities in the field of hydrogen and fuel cells involve multiple stakeholders: the national government, industry, as well as universities and research institutions. The next sections provide an overview of the Netherlands track record, current status, vision and ambitions regarding hydrogen and fuels cells, thereby showing:

- Our long-term resource commitment to hydrogen and fuel cell technology research and development activities.
- Our well-defined vision and national strategy to advance technology deployment and infrastructure development.
- Our commitment reflected in policies and strategies that effectively advance private sector development of a hydrogen economy.

1. Dutch vision and strategy: hydrogen as part of a sustainable fuel mix

National strategy

For over two decades The Netherlands support the greening of the economy with a focus on the decarbonisation of the energy intensive sectors. For this reason hydrogen, being a carbon free energy carrier, has been supported to enhance its application in industry, the power sector and the transport sector. Especially over the last few years the application of hydrogen in transport has been supported as one of the key future solutions to decarbonize the transport sector, to improve air quality and to reduce oil dependency. In 2013 the Dutch government and a multitude of stakeholders *together* set ambitious targets in the field of energy and climate. These targets are described in the SER (The Social and Economic Council of the Netherlands (SER)) Energy Agreement for Sustainable Growth: (www.ser.nl/en/publications/publications/2013/energy-agreement-sustainable-growth.aspx).
As a next step, facilitated by the Ministry of Infrastructure and the Environment, more than a hundred experts and stakeholders developed a vision for a sustainable fuel mix for transport. This vision aims at 100% zero emission passenger transport by 2050 with a big role for electric drive trains, powered by batteries as well as fuel cells.

This sustainable fuels vision[1] is not only supported by the government but also by industry, universities and R&D organizations. As such, the vision aims to connect, inspire, and to provide insight in various pathways allowing the transport sector to set course for a zero-emission transport future. It therefore serves as a reference framework, and basis for action plans to enable a transition to a sustainable fuel mix for transport, including hydrogen as one of the key solutions (www.energieakkoordser.nl/nieuws/brandstofvisie.aspx; English version available in the right

[1] Note that the Dutch vision and resulting action plans for sustainable transport fuels are in line with the EU directive on the deployment of alternative fuels infrastructure (2014/94/EU) that calls for the development of national policy frameworks and actions plan. In addition the vision and action plans support the requirements set by the EC directives on Renewable Energy (RED) and Fuel Quality (FQD).

pane). In order to reach the ambitious targets for the transport sector, a set of action plans has been and is being developed.

Key goals of the national strategy regarding sustainable transport are:

- 2020: 15 – 20 PJ extra energy saving compared to 2012 baseline studies
- 2030: maximum of 25 Mton CO_2 equivalents, relative to 1990 (-17%).
- 2035: all new passenger cars are capable of zero-emission driving.
- 2050: 60% CO_2 emission reduction (tank to wheel) relative to 1990.

Hydrogen roundtable: policy framework and vision

To streamline discussions and progress in the national fuel vision, the process was organized on the basis of six 'roundtables', including one table for hydrogen: *the roundtable on renewable hydrogen in road transport*[2].

As an outcome of the Hydrogen table a national hydrogen ambition was defined, that was agreed upon by the national government in close cooperation with key stakeholders from industry, universities and R&D organizations. All stakeholders underpinned the economic importance of hydrogen notably for industries relating to hydrogen-fuel-cell technology, system integration, the production and distribution of hydrogen, and the supply industry. In support of the national hydrogen ambition, a high-level view on the roll-out of hydrogen was developed, including specific targets and actions over time for both hydrogen refueling infrastructure and vehicles. These ambitions, high-level view and targets are explained in more detail in the next sections.

Hydrogen ambition

- The Netherlands aim for a position in a leading group of countries[3]
- Unique characteristics for early market development in the Netherlands:
  - High population/market density
  - High GDP per capita/purchasing power
  - Large hydrogen production capacity[4]
  - Centrally located in NW-Europe; well connected to countries that share a comparable vision on rolling out a hydrogen fueling infrastructure: D, DK, B, FR and UK;
  - Strong track record for early and wide adoption of innovative clean cars, e.g.:
    - largest share of hybrids in EU
    - frontrunner in plug-in cars market penetration

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2 The other 5 roundtables are: renewable liquid fuels in road transport; renewable gaseous fuels in road transport; renewable electricity in road transport; sustainable shipping; sustainable aviation.

3 The Netherlands have a strong position in the fields of system knowledge, materials, 'auxiliaries' and components, fuel services and logistics, charging infrastructure, special vehicles and transport, gas, agriculture and chemicals. That position, coupled with the country's mainports, increases the opportunities for alternative fuels in transport. For example, in the production and transfer of non-fossil fuels renewable gas, power-to-gas, and hydrogen.'

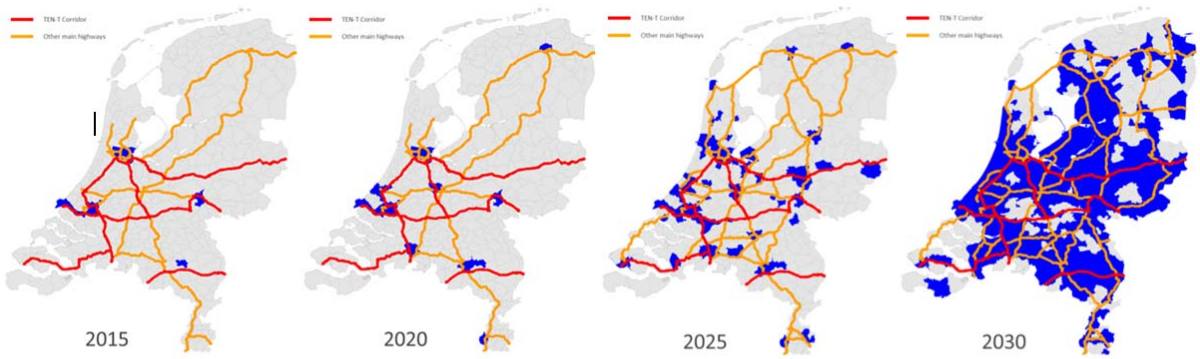
4 Large scale industrial hydrogen production (fertilizer industry, refineries) as well as by-product hydrogen (chlor-alkali plants).

Hydrogen targets 2015-2020[5]

- 20 public hydrogen refueling stations (currently 2)
- 1.500 up to 2.000 fuel cell cars on the road (currently 22 FCEVs)
- 100 public transport fuel cell buses and corresponding refueling stations (on the short term 12 scheduled)
- Up to 500 vans and 20 trucks for zero-emission logistics in urban areas (currently 2)

Hydrogen roundtable high-level view on rollout

Figure: *Projection of the roll-out of FCEVs and hydrogen refueling stations along highways, ranging from the early market penetration phase in 2015 to the mass market phase in 2030. Also shown: the development of TEN-T corridors with hydrogen stations (red) and other main highways (yellow), along with the share of the of the population that will have access to hydrogen mobility (blue).*



Car fleet	Few → 1,500	1,500 → 15,000	15,000 → 125,000	→ > 2.5 mln
HRS network	2 → 20	20 → 50	50 → 200	→ > 1,000
Population	3.3 mln (20%)	8.0 mln (50%)	15.0 mln (90%)	(100%)

2. National hydrogen support and initiatives

The national vision, ambition and commitment to hydrogen use, as described above, builds upon a 20 year trajectory of research and development, policy support and (inter)national cooperation. This track record in hydrogen and fuel cells is explained in the next sections, by presenting a selection of key activities, structured along the following categories:

- Research programs – hydrogen related (current, past).
- Projects – hydrogen specific (current, past).

[5] These above mentioned short term target, are also part of the upcoming Green Deal H2-economy – see also the section on public-private cooperation

- Fiscal initiatives and support.
- Public-private cooperation.
- International participation.

Research programs (current):

- Top consortia for Knowledge & Innovation' (TKI's) – subtopic Energy
  - Goal: Clean and efficient energy generation which strengthens the Dutch economy. Focus on energy innovations, including hydrogen research, contributing to reduction in CO_2 emissions and costs. The Top sector energy is structured along seven 'Top consortia for Knowledge & Innovation' (TKI's) including one dedicated TKI on Gas. The TKI Gas wants to involve the entire gas sector in the necessary transition and innovation, specifically addressing hydrogen as one of the future key solutions.
  - Duration: 2012 - present
  - Budget: multi billion
  - Additional information:
    - http://topsectorenergie.nl/english/
    - (http://topsectorenergie.nl/wp-content/uploads/2013/10/TSE_Factsheet-TKI-Gas-ENG.pdf)
  - Selection of studies and pilots on alternative fuels
    - PurifHy: Selective extraction of hydrogen from gaseous streams with a high hydrogen concentration, allowing feed-in in the current natural gas distribution network (www.tki-gas.nl/projecten/teg0413002) (in Dutch, with some docs in English).
    - Analysis P2G, Power2Gas. Analysis of the future potential for power-to-gas; i.e. the conversion of (renewable) electricity into a gas (hydrogen, methane). A model-based evaluation of the drivers and bottlenecks for the P2G business case from an energy system perspective. (www.ecn.nl/docs/library/report/2014/e14026.pdf)
    - Innovative process concepts for the integrated valorization of by-products hydrogen and carbon dioxide (EOS framework short term).
    - Hydrogen Storage materials and Reactors: HyStoRe.
    - Plasmolysis basic research. Hydrogen production by plasma conversion of carbon dioxide and water plasmolysis, as an alternative to electrolysis (www.tki-gas.nl/projecten/teg0413006).
    - Membrane reactor for energy efficient hydrogen production and dehydrogenation.

Research programs (past)

- EOS: Energy Research Subsidy (Dutch: Energie Onderzoek Subsidie)
  - Goal: Facilitating R&D Fuel Cells on hydrogen production, storage and infrastructure.
  - Duration: 2005 – 2010
  - Budget: 255 million euros.
  - Internet information:
    - https://setis.ec.europa.eu/energy-research/content/energy-research-subsidy
- Clean & efficient (Dutch: Schoon & Zuinig)
  - Goal: Programme by the NL Ministry of the Environment to achieve in 2020 in NL: 30% GHG reduction (relative to 1990), 20% renewable energy, annual energy saving of 2%. Covering all energy sectors, including Transport.
  - Duration: 2007 – 2011

- Budget: As part of overall budget, for energy efficiency in transport: 15 million euros. In addition, substantial budgets for fiscal incentives for greening of the transport sector (see also section below on "Fiscal initiatives and support").
- Key programme for the transport sector: 'The future car hits the road' (Dutch "De auto van de toekomst gaat rijden"), aimed at accelerating the market penetration of innovative technologies for sustainable mobility. The Netherlands as a test lab for sustainable mobility including: efficiency labeling of cars, greening of car taxes and lease contracts, alternative fuels including hydrogen, smart ICT and ITS, and multimodality mobility chains.
  Selection of relevant demonstration projects:
  - Demo: Innovative public buses
  - Demo: Truck of the future
  - Demo: Green gas as transport fuel
  - Demo: electric driving
  - Demo: hydrogen as transport fuel[6]
- Additional internet information (only in Dutch):
  - www.europadecentraal.nl/wp-content/uploads/2013/01/Werkprogramma-Schoon-en-Zuinig.pdf
  - www.rvo.nl/sites/default/files/bijlagen/Brochure%20EOS-Onderzoeksprogramma.pdf
  - http://www.klimaatportaal.nl/pro1/general/start.asp?i=5&j=1&k=3&p=4&itemid=665

Projects – hydrogen specific

Project	Description
Mobility Demonstration	
CUTE and HyFleet: CUTE	European demonstration project with Hydrogen buses in 10 European cities. For the Netherlands involving two buses in Amsterdam operated by the Municipal Transport Company (GVB). http://www.global-hydrogen-bus-platform.com/www.global-hydrogen-bus-platform.com/index.html
Phileas fuel cell bus	Demonstration project with Dutch company VDL (largest bus building company in NL). Phileas fuel cell buses in a joint project in Amsterdam and Cologne
3Emotion	Upcoming demonstration project hydrogen buses (6 buses) in Rotterdam and the Province of "Zuid-Holland". Project supported by/spin-off of the above mentioned demo 'hydrogen as transport fuel', within the framework of the programme "Clean & Efficient".
(Hydrogen) car as Power Plant	Just like EVs, eventually FCEVs will likely be used to provide energy for homes and offices. While the vehicle is parked, the fuel cell continues to produce electricity which can also be used to provide power to many houses (www.tudelft.nl/en/current/latest-news/article/detail/brandstofcelauto-op-waterstof-wordt-energiecentrale)
5 public hydrogen buses, launched in 2016	Supported by a national subsidy of 4,25 million euros. Programme is a spin-off of the above mentioned demo 'hydrogen as transport fuel', within the framework of the programme "Clean & Efficient.
Upcoming: FCH JU project: 500 H2-buses in EU, with NL participation (100 H2-buses)	The Netherlands joined the initiative of the FCH-JU (www.fch.europa.eu/page/projects), on the Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe (http://www.fch.europa.eu/sites/default/files/150909_FINAL_Bus_Study_Report_OUT_0.PDF)

[6] This demo was scheduled too early relative to the market phase of the vehicles, Currently 5 projects with 10 public hydrogen buses. Follow-up: EU FCH JU commercialization study

Mobility System Analysis	
HyWays	Hydrogen roadmap, coordinated by the Energy research Centre of the Netherlands (ECN). http://www.hyways.de/. The project showed in 2008 that hydrogen energy could reduce oil consumption in road transport by 40% by 2050
THRIVE	Scenario study on rollout of fuel cell electric cars and an associated hydrogen refuelling infrastructure in the Netherlands
Hydrogen region Flanders – South Netherlands	Development of the region of Flanders-Southern Netherlands as a knowledge intensive region in the field of hydrogen applications, making use of sustainably produced hydrogen (http://www.waterstofnet.eu/english.html)
HIT-1; HIT 2- corridors; H2 Nodes	3 consecutive EU TEN-T project coordinated by the Dutch Ministry of Infrastructure and the Environment; Related to the National Implementation Plan for hydrogen mobility in the Netherlands as well as the 'Synchronised Implementation Plan' (SIP - http://www.hit-tent.eu/2012/11/about-hit/). In addition it relates to the installation of a hydrogen refuelling station near Rotterdam (In operation since September 2014)
Stationary Demonstration	
Ameland project	Power-to-Gas demonstration project on admixing of hydrogen into the gas grid with delivery to and use of the mixture in apartment building
Fuel Cell-plant	50 kW PEM power plant demo at AKZONobel in Delfzijl
Stedin POWERTOGAS Rozenburg	A practical test in Rozenburg, Rotterdam district, where residents of an apartment will make natural gas, by converting electricity in hydrogen (power-to-gas), followed by a methanisation step based on CO_2 addition.
Stationary System Analysis	
Naturalhy	European project coordinated by Dutch Gasunie Research on potential of admixing of hydrogen in the natural gas grid Preparing for the hydrogen economy by identifying and removing the potential barriers regarding the introduction of hydrogen into the society, using the existing natural gas system as a catalyst ftp://ftp.cordis.europa.eu/pub/sustdev/docs/energy/sustdev_eu-russia_h2-fc_florisson.pdf
HyUnder	Participation in European project on the possibility for large-scale underground hydrogen storage (http://cordis.europa.eu/result/rcn/143849_en.html)
P2G systems analysis	Integral energy systems analysis into the potential role of Power-to-Gas in the future Dutch energy system ((www.ecn.nl/docs/library/report/2014/e14026.pdf))

Fiscal initiatives and support

- EIA Energy Investment Tax Deduction (Dutch: EIA = Energie Investerings Aftrek).
  The Netherlands has put in place an Energy Investment Deduction, a tax rebate scheme for private companies, which can be applied to the purchase or production of energy efficient equipment and sustainable energy. This regulation includes a category "Fuel Cell systems".
- MIA/VAMIL fiscal incentives.
  The MIA (Environmental Investment Rebate) and Vamil (Arbitrary depreciation of environmental investments) are two different schemes, using the same Environmental List (list with environmentally friendly products). The MIA/Vamil scheme, provides fiscal advantage to invest in environmentally friendly products or company resources and bring innovative environmentally-friendly products onto the market more quickly. The MIA/VAMIL incentives also cover hydrogen related projects, including FCE's, light duty and heavy duty fuel cell vehicles and buses, as well as small scale hydrogen production distribution facilities.

(http://english.rvo.nl/subsidies-programmes/mia-environmental-investment-rebate-and-vamil-arbitrary-depreciation-environmental-investments).

- Sustainable Energy Tax Deduction
  The DEI scheme (Dutch: Duurzame Energie Innovatie) is one of the financial instruments in support of reaching the goals of the SER Energy agreement (see page 1). It offers financial support for new demonstration projects on innovative energy saving technologies, including demonstration projects in the field of hydrogen.
  2015 Budget € 20 million, subsidy % ranging from 30-65% (depending on project type).
  http://www.rvo.nl/subsidies-regelingen/demonstratie-energie-innovatie-tse
- Fiscal support for hydrogen (as a transport fuel).
  To support the initial market phase of hydrogen mobility, hydrogen is currently exempted from excise duties and/or VAT (in contrast to fossil transport fuels which are subject to high excise duties and in addition VAT).
- Fiscal support for purchasing hydrogen vehicles.
  The Netherlands have been supporting the purchase of zero emission vehicles, including FCEVs[7], by a multitude of measures, notably:
  - Exempting ZEVs from vehicle registration tax.
  - Exempting ZEVs from circulation tax.
  - Exempting ZEVs from surcharge on income taxes for private use of company (lease) cars[8].
  - Soft measures - mostly at the local/city level - such as access to bus lanes or otherwise restricted areas, reduced parking fees etc.
  - Post 2016 fiscal policies: The Dutch government has recently published the so called "Automobile letter 2" (In Dutch: "Autobrief 2"[9]). This letter includes a number of changes to the car taxes. However the fiscal stimulation of ZEVs (including FCEVs), relative to conventional vehicles, will continue. During the period 2017-2020 the new rules will be introduced gradually. For (conventional) lease cars there will be a 22% additional rate of surcharge of the catalogue car value on the taxable income. For zero emission vehicles, including FCEVs, a much more favorable percentage of 4% is maintained.

Public-private cooperation

The deployment of hydrogen technology and infrastructure development is further supported by strategic cooperation between industry, research institutions and policy makers. Key examples of this cooperation include:

- National Hydrogen Platform (H2NL)
  This national platform for public-private cooperation fosters the role of hydrogen in the future economy by: combining and strengthening of individual initiatives; identification barriers, and prioritizing actions; coordination of actions and new initiatives. The Platform is organized in four task forces: (1) Sustainable hydrogen economy, (2) Infrastructure for mobility, (3) Buses, (4) Vans, trucks and specials. (http://www.nationaalwaterstofplatform.nl). In addition to the participation of the Ministry of Infrastructure and the Environment, the platform involves active participation of key industrial partners (automotive industry, gas producing companies, chemical industry, refineries, seaports etc.).
- "Green Deals" : public -private agreements

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7 Although FCEVs have only recently become commercially available in the Netherlands, the Dutch ZEV supporting measures are (and have been) applicable for all ZEVs, thus including FCEVs.

8 In The Netherlands, income tax has to be paid on the private use of company cars. This is done by imposing a surcharge of the catalogue car value on the taxable income, currently (2015) ranging from 4% for ZEVs up to 25% for most conventional vehicles.

9 Only available in Dutch at: www.rijksoverheid.nl/documenten/kamerstukken/2015/06/19/autobrief-ii)

A large number of public-private “Green deals” in the field of sustainable mobility have been agreed on. Several “Green Deals” also involve hydrogen vehicles and/or refueling infrastructure, including roll-out targets over time (www.greendeals.nl/wp-content/uploads/2015/03/Green-Deals-folder-ENG.pdf).

- Green Deal Zero-Emission Public Bus Transport: Goal: in 2025 all the public buses in the Netherlands (about 5.000) have to be zero emission. A substantial part will be hydrogen-buses
- Green Deal Zero-Emission City Logistics (www.e-traction.com/en/news/120-e-traction-signs-green-deal).
- Green Deal on hydrogen is under development. Draft deal published July 2015; to be finalized and signed at the 26th of April 2016.

- Formula E-team

  The Formula E-Team (FET) has been promoting Electric Mobility in the Netherlands. The FET has reinforced the position of the Netherlands as an attractive country for electric mobility. It features prominently in the public eye through the combination of the participating automotive related organisations: ANWB, BOVAG, Energie Nederland, ICToffice, Netbeheer NL, RAI association, VNA [the association for Dutch car lease companies], VNB [Association of Dutch Banks]. Action plan Electric Mobility gets up to speed (2011-2015): (www.rvo.nl/sites/default/files/bijlagen/Action%20Plan%20English.pdf)
- Public-private cooperation on hydrogen safety

  Safety aspects are an important issue in licensing procedures for new hydrogen refueling infrastructure. In order to facilitate the licensing procedures, do’s and don’ts regarding installations for delivery of hydrogen have been developed and published, following a joint project by the government and industry. This safety publication fits in the national “Series on Dangerous Substances”. April 2015: Hydrogen: Installations for delivery of hydrogen to road vehicles http://www.publicatiereeksgevaarlijkestoffen.nl/publicaties/PGS35.html (also available in English).

Participation International Technology Platforms

The Netherlands participate in several international platforms and bodies fostering the future of hydrogen through international cooperation.

- IEA Hydrogen Implementing Agreement (http://ieahia.org/)
  IEA Hydrogen Implementing Agreement is a partnership between 40 countries. The Netherlands are an active member for over 15 years and play an important role in the following tasks:
  - Task 28: Large Scale Hydrogen Delivery Infrastructure (NL coordination/operating agent)
  - Task 30: Power to Gas
  - Task 32: Hydrogen based storage
  - Task 33: Local Hydrogen Supply for Energy Application
  - Task 34: Biological Hydrogen for Energy and Environment
  - Task 35: Renewable Hydrogen Production

- IEA Hybrid Electric Vehicle Implementing Agreement (http://www.ieahev.org/)
  The IEA Hybrid Electric Vehicle Implementing Agreement is a partnership between 18 countries with the aim to facilitate international cooperation and R&D regarding all aspects of electromobility. The Netherlands, represented by the Netherlands Enterprise Agency (www.rvo.nl) are an active member http://www.ieahev.org/by-country/the-netherlands

- IEA Electric Vehicle Initiative (www.iea.org/topics/transport/subtopics/electricvehiclesinitiative/)
  The Electric Vehicles Initiative is a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide. Launched in 2010 under the Clean Energy Ministerial the partnership currently includes 16 member governments, including the Netherlands. The important contributions by the Netherlands are for example shown in the recent update of the "City Casebook": www.iea.org/topics/transport/subtopics/electricvehiclesinitiative/EVI_2014_Casebook.pdf

- Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) (www.fch.europa.eu/)
  The FCH-JU is a public private partnership supporting R&D and demonstration activities in fuel cell and hydrogen energy technologies in Europe. The Netherlands are actively connected to the FCH-JU by the NL members in the Industry Grouping: AkzoNobel, HyGear, HyET, HyMove, Nedstack, Shell, VDL (www.new-ig.eu/members)