

H2 – opportunities & challenges

WEBINAR ATIC

Atic

for HVAC professionals



Dia 1

MOU1 Kleur wijzigen of afbeeldingen invoegen?

1. Selecteer op het tabblad Ontwerpen de optie Achtergrond opmaken.
2. Selecteer Afbeelding uit bestand of Vullen met effen kleur.

of

1. Rechtermuisknop
2. Achtergrond opmaken
3. Opvullen met afbeeldingen of Vullen met effen kleur.

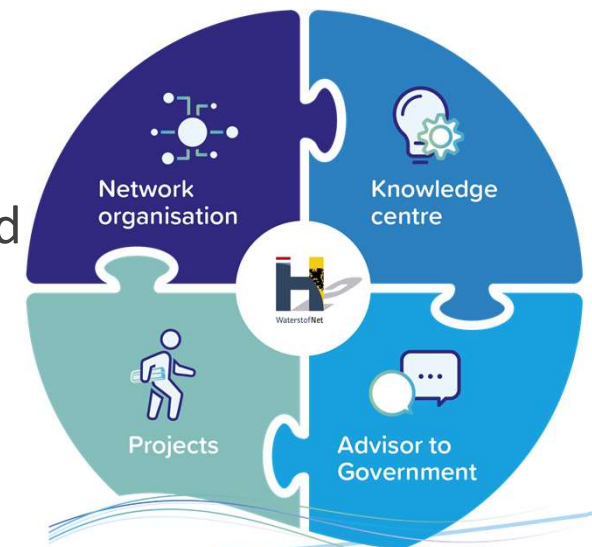
Microsoft Office User; 28/09/2020

Outline

- WaterstofNet, who are we?
- Production & applications of hydrogen
- Status 'clean H₂' in Flanders
 - Existing pilots
 - Large sea-port & infrastructure projects in development
 - H₂ Import
 - Built environment
- Policy context Europe-Belgium- Flanders
- Challenges

WaterstofNet

- Start 2009
- Project organisation located in Turnhout and Helmond (NL)
- Focus on projects and roadmaps:
 - 0-emission mobility
 - energy storage
- Collaboration with industry, knowledge institutes and governments
- Hands-on experience:
 - 5y exploitation & maintenance H2 fuelling station Helmond
 - Facilitate several demonstration projects (focus mobility)
 - Mobile H2 station



WaterstofNet coordinates the “Waterstof Industrie Cluster” In BE/NL

members x 2 during last 1,5 years



Hydrogen, what is it?

Hydrogen is a energy carrier

Main properties of hydrogen

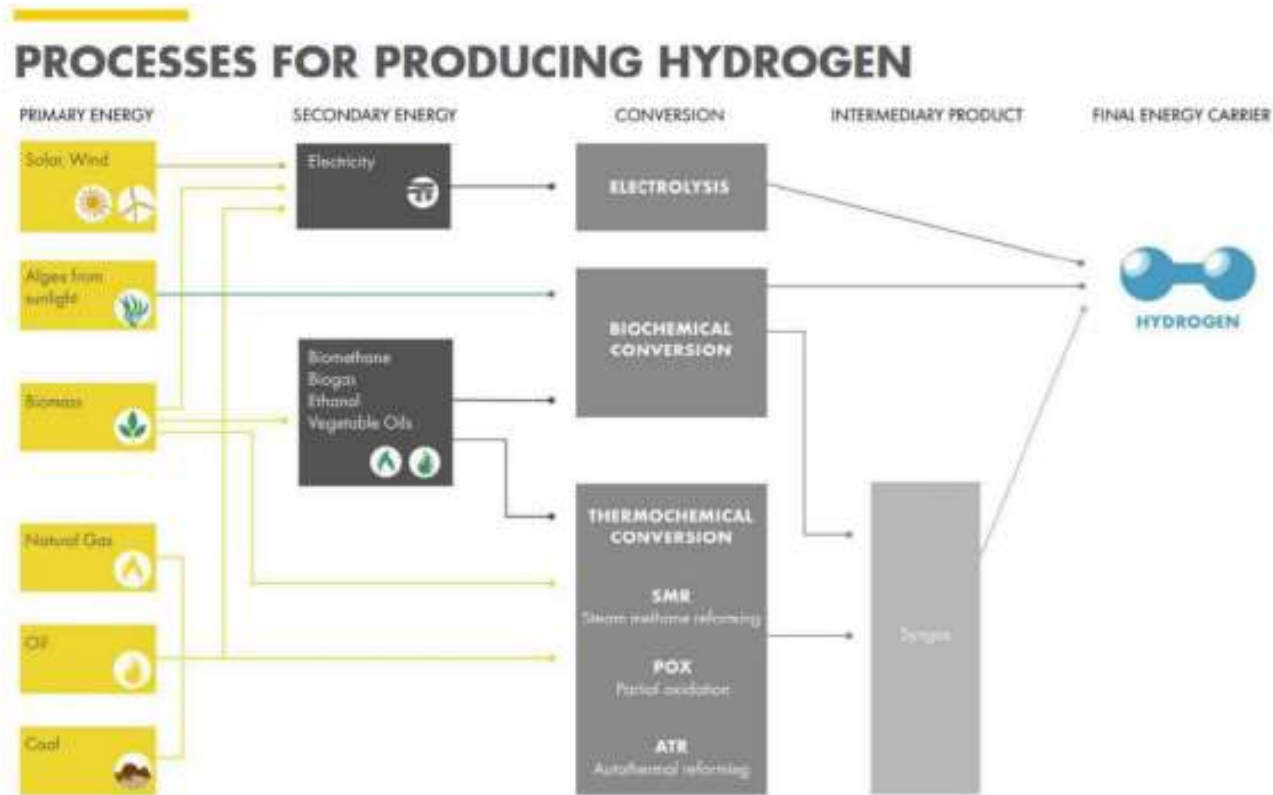


WaterstofNet

Hydrogen: basics

- Symbol H (1 proton/1electron) molecule H₂
- More than 90% of all atoms in the universe is hydrogen
- On earth, almost always connected to other materials:
 - oxygen (O₂) water
 - carbon (C) methane (CH₄), C₂H₆,.....
 -
- So, H₂ has to be produced, it is an energy carrier, not an energy source

Hydrogen production: many resources



Source: Shell Hydrogen Study, Wuppertal Institute

H2 properties: Energy density

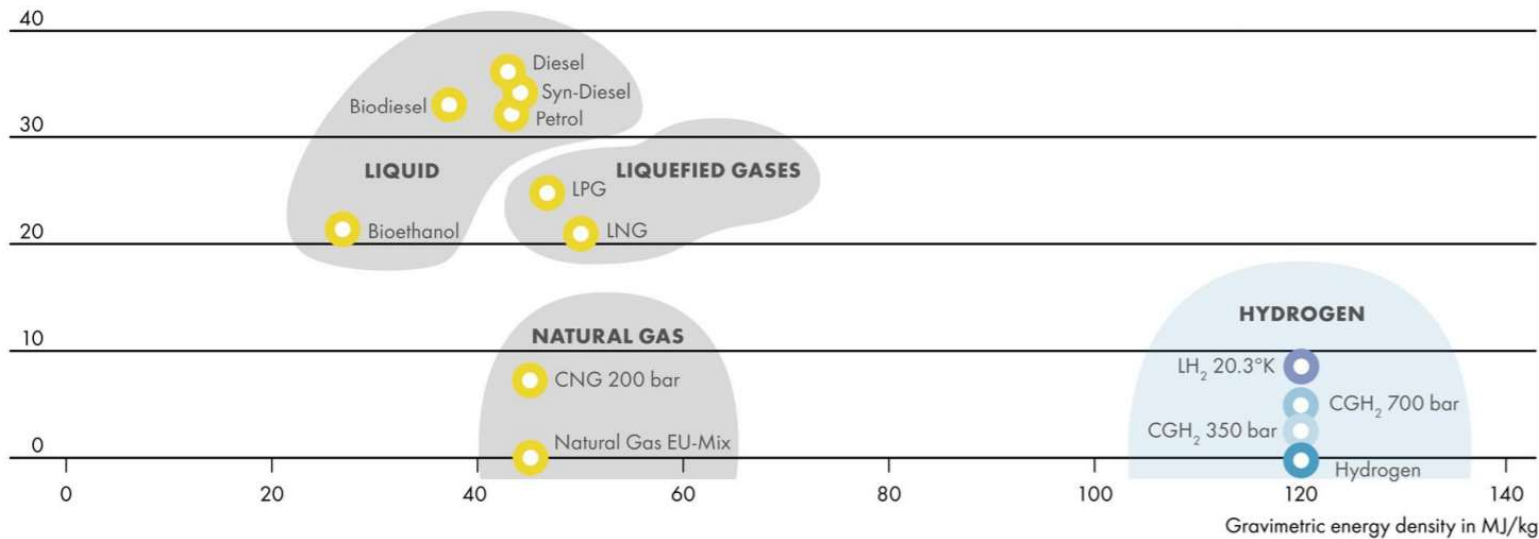


High per unit of mass => advantage (for mobile applications) compared to batteries
low per unit of volume => store under high pressure (80-350-700bar) or in liquid form (-253°C)



ENERGY DENSITY OF FUELS

50 Volumetric energy density MJ/l



Production & applications of hydrogen

Hydrogen 'colours'

Industry-transport & built environment

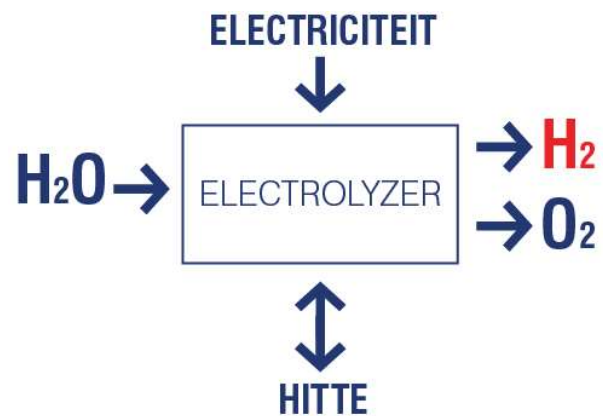
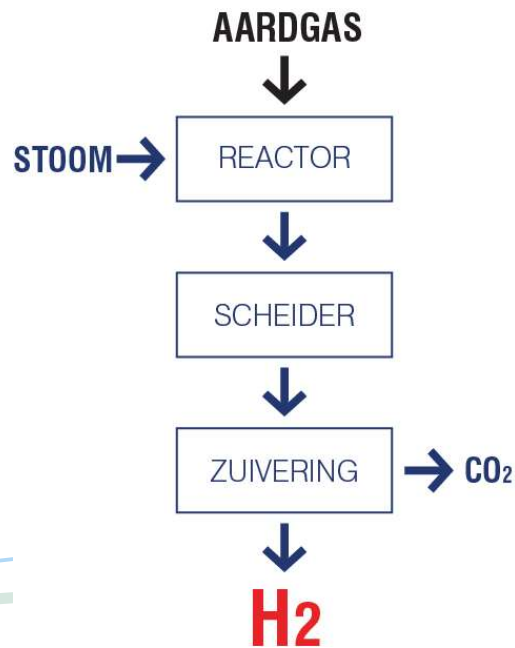
Technologies



WaterstofNet

Production methods

- Production method defines the ‘colour’ of hydrogen: grey, blue, green, turquoise
- Worldwide & Belgium: mostly grey hydrogen via SMR (fossile source)
- Sustainable H2: **elektrolysis**, byproduct H2 or fossile source + CO₂ capture, **pyrolysis**



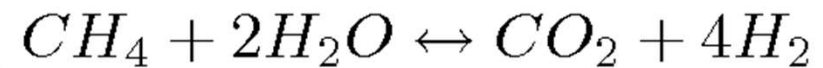
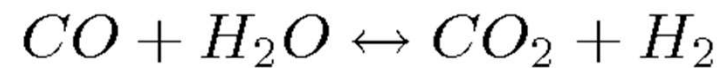
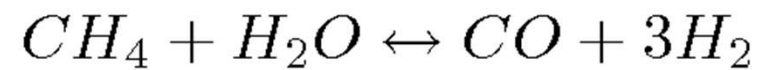
H₂ productie in de wereld

Steam Methane Reforming (incl. CCS)

Reforming hydrogen

= 90-95% of worldwide production

- Large scale (BASF in Antwerp or Air Products Rotterdam)
- Small scale (on-site) f.e. HyGear



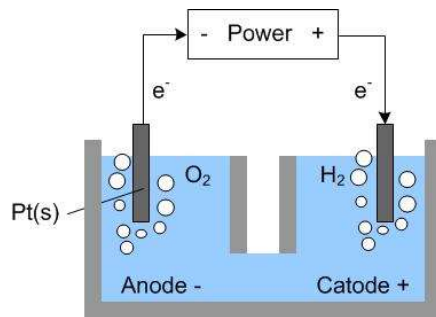
Water-electrolysis



- PEM (Polymere Electrolyte membrane)
- Alkaline (KOH, sodium or potassium hydroxide electrolyte)
- Solid Oxide



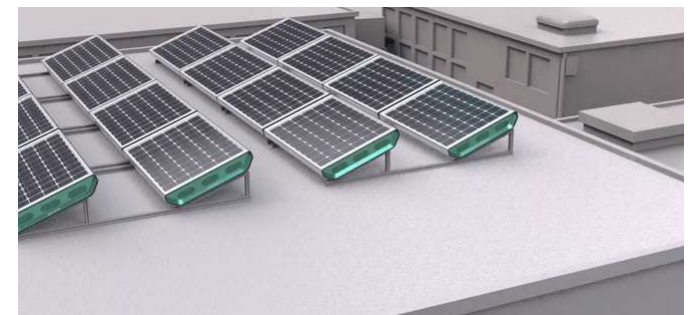
=> H2 atmospheric or under pressure (1<p>30 bar, devel. 350 bar)



Direct conversion sunlight → hydrogen (e.g. KU-Leuven)

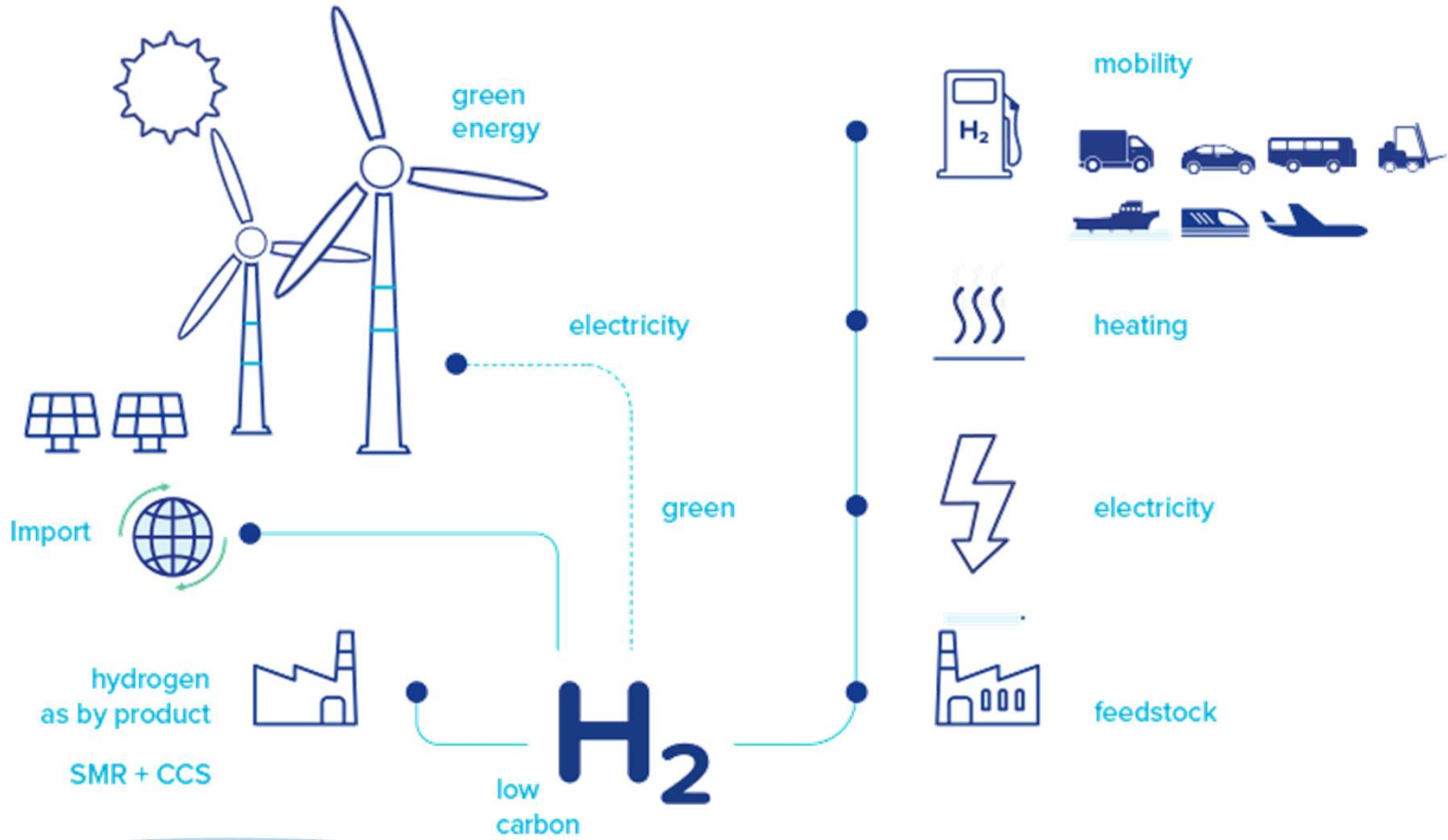


- Hydrogen produced in solar panel
- Use of water from the air
- Cheaper material than electrolysis
- <http://solhyd.org/nl/>



'Photo-electrolysis'

Applications of hydrogen



Hydrogen in industry today

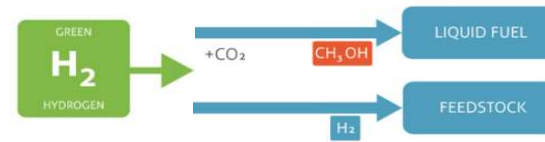
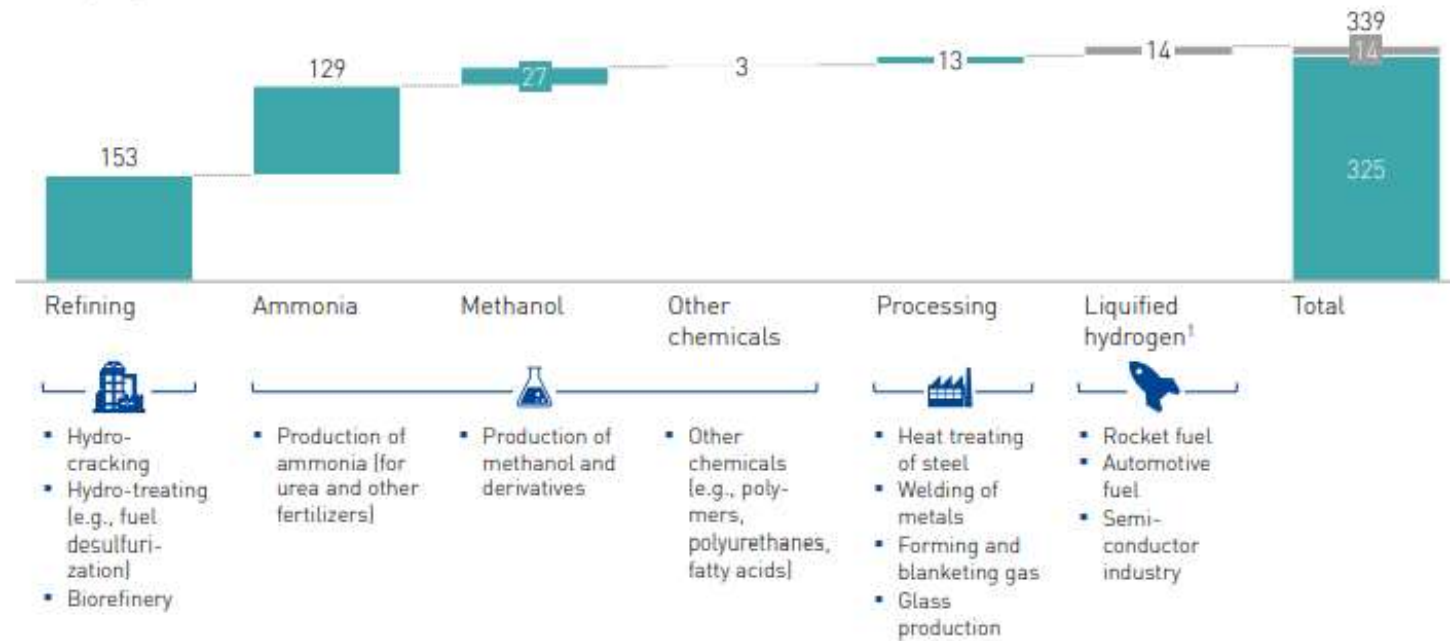


EXHIBIT 17: USE OF HYDROGEN TODAY

Total hydrogen use in the EU, in TWh



¹ Counted in transportation segment

Source: Hydrogen Roadmap Europe, FCH-JU, 2019

Clean Hydrogen in industry - future

Replacement (drop-in) of (fossil) H₂ in existing applications/processes

- Refineries
- Ammonia -> fertilizers
- Other

Large-scale offtake possible \Rightarrow upscaling of hydrogen production

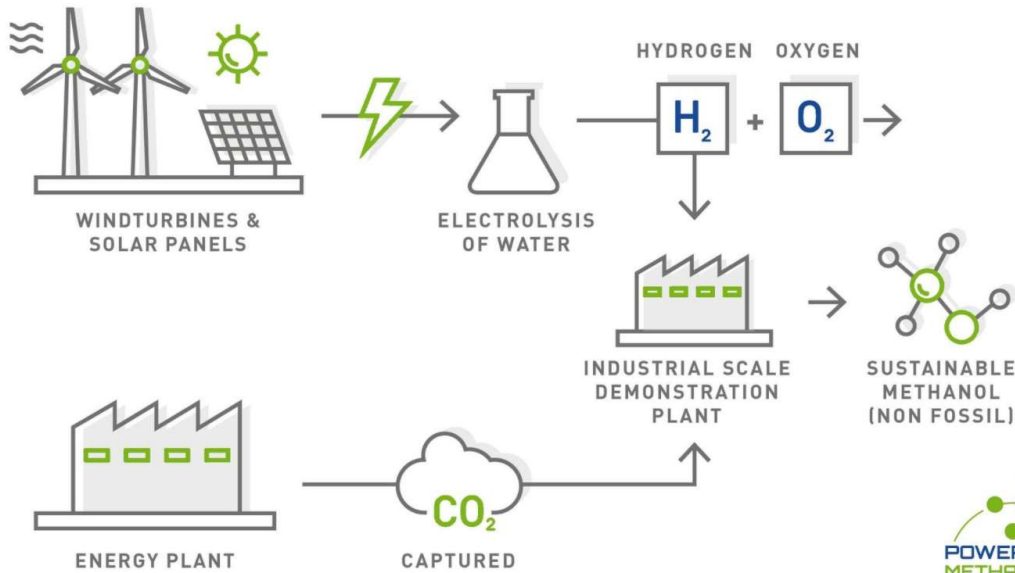
New applications of H₂

- Heat (mid/high grade), replacing natural gas
- Steel production, replacing cokes
- Feedstock for chemicals or synthetic fuels based on H₂ and recycled CO₂.

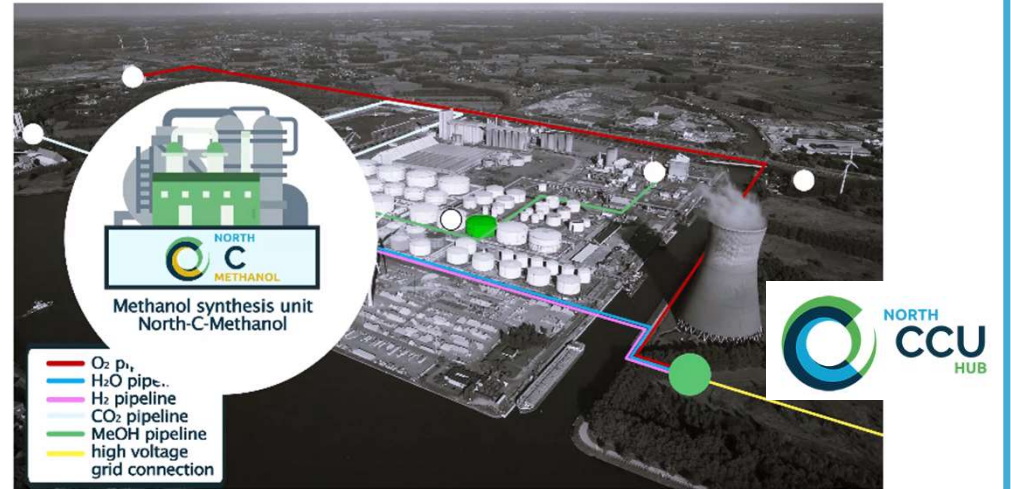
Pilot projects in refinery (RefHyne Shell/ITM Germany), steel (H₂future Sweden), methanol (CRI Iceland.)

Example projects in BE

<https://powertomethanolantwerp.com/>



<https://northccuhub.eu/north-c-methanol/>
North-C-Methanol partners



Partners involved in the construction and operation of North-C-Methanol have signed a Joint Development Agreement. These include the partners below. They will sign other agreements with other parties involved in the value chain.



Primeur in België: INEOS Phenol en ENGIE gebruiken waterstof in industriële installatie in Antwerpen

Press releases

18/02/2021

Waterstof zal een belangrijke schakel in de energietransitie zijn en biedt tal van mogelijkheden om te evolueren naar een klimaatneutrale samenleving. Een mogelijke evolutie in de komende decennia is de graduele vervanging van aardgas door waterstof, op termijn groene waterstof opgewekt door hernieuwbare energie via elektrolyse. Hierdoor kan de CO₂-uitstoot van huidige processen, op basis van aardgas, geleidelijk aan verminderd worden. Voor het eerst in België wil ENGIE het gebruik van waterstof testen in een warmtekrachtkoppeling op de site van INEOS Phenol in Antwerpen.

- Proefproject voor de geleidelijke vervanging van aardgas door waterstof
- Voor het eerst getest in WKK-centrale waarop industriële installatie in bedrijf is aangesloten
- Moet potentieel conversie bestaande installaties naar waterstof aantonen als springplank voor verdere industriële opschaling

<https://corporate.engie.be/nl/press/release/primeur-belgie-ineos-phenol-en-engie-gebruiken-waterstof-industriele-installatie>

Steel production

Blast furnaces: replace part of cokes by H₂

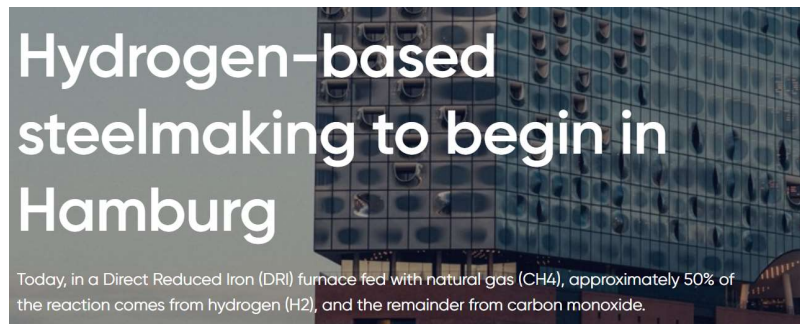
DRI process: replace natural gas by 100% H₂

Manufacturing News

ArcelorMittal to build DRI and electric furnaces in Gent

By **Stainless Steel World Publisher** - October 7, 2021

ArcelorMittal announced that it has signed a letter of intent with the Governments of Belgium and Flanders, supporting a €1.1bn project to build a 2.5 million-tonne direct reduced iron (DRI) plant at its site in Gent, as well as two new electric furnaces.

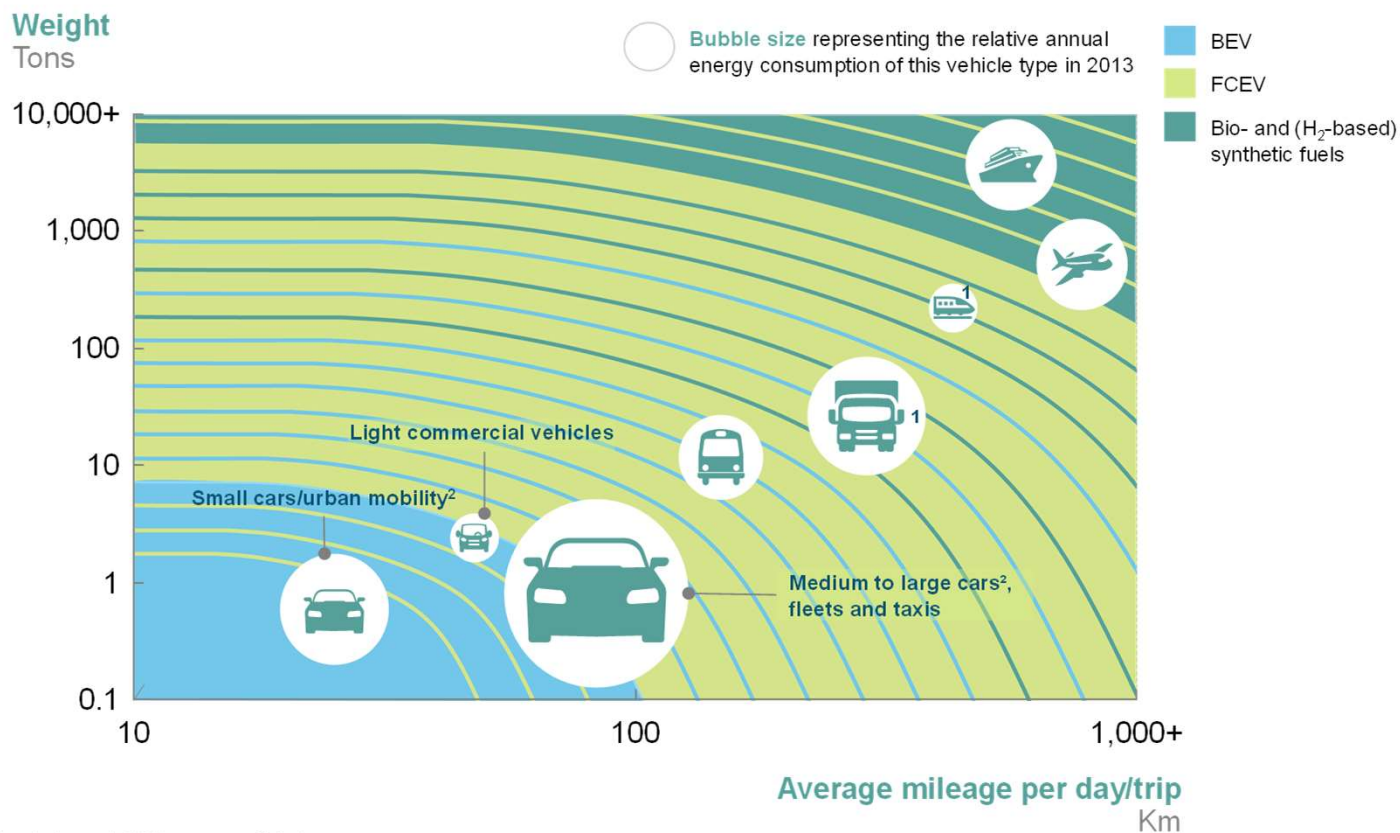


Hydrogen in transport applications



Reference: HYDROGEN-COUNCIL-Vision-document

Different technologies are complementary!



Source: Hydrogen Roadmap Europe, FCH-JU, 2019

1 Battery-hydrogen hybrid to ensure sufficient power

2 Split in A- and B-segment LDVs (small cars) and C+-segment LDVs (medium to large cars) based on a 30% market share of A/B-segment cars and a 50% less energy demand

Source: Toyota, Hyundai, Daimler

Hydrogen in transport applications



ROAD

- Large passenger vehicles with long-ranges (e.g. taxi-fleets)
- Public transport regional buses
 - ✓ Centralised, dedicated infrastructure → high equipment utilization
 - ✓ Fast filling ↔ BEVs: limited # vehicles charged in given timeframe.
 - ✓ Operational flexibility
- Heavy-duty trucks
 - ✓ Short refuelling time
 - ✓ Available payload ↔ BEVs: weight and payload penalty
- Status: cars and buses “commercially available”; trucks in pilot phase



Example projects

Van Hool delivers first hydrogen bus for STIB-MIVB in Brussels.



17 September 2021

Hydrogen heavy-duty projects joining forces

Interreg North-West Europe projects H2-Share and HECTOR recently joined forces with the FCH-JU project REVIVE. Last week the mobile hydrogen refuelling station of H2-Share (the 'WyRefueler') refuelled two zero-emission garbage trucks simultaneously in Breda. It is a first that three different heavy-duty, hydrogen projects join forces and reinforce each other.

HyTrucks consortium aims to have 300 hydrogen-powered trucks on the road in Belgium by 2025

Air Liquide, DATS 24 and Port of Antwerp join forces in the HyTrucks consortium to deploy 30 hydrogen-powered trucks and the related renewable hydrogen production infrastructure and supply chain assets in Belgium as part of the HyTrucks initiative. This project aims at enabling



Hydrogen in transport applications



RAIL

- Zero-emission alternative for Diesel trains
- Avoid construction of catenary lines → often positive business case
- Dedicated infrastructure with high utilisation rates
- Freight transport

WATER

- Ferry's/ Inland barges for limited distance
- Seaships: high density fuel needed (loss of payload)
→ Liquid hydrogen or H₂ carrier (ammonia)
- Status: pilots



Example projects

<https://www.alstom.com/solutions/rolling-stock/coradia-ilinttm-worlds-1st-hydrogen-powered-train>

Hydroville Antwerp (CMB)



Hydrotug Port of Antwerp (2022)



Coradia iLint™ – the world's 1st hydrogen powered train



**Future
Proof
Shipping**

Hydrogen in transport applications



AIR

- EU flights → H₂ combustion in gas turbines / fuel cells / liquid hydrogen tanks
 - Status: R&D phase
- Intercontinental flights → high energy density required
 - **Synthetic kerosene** → admix in fossil kerosene during transition period

<https://www.airbus.com/innovation/zero-emission/hydrogen/zeroe.html>



- Synthetic kerosine: recent announcement Synkero in Amsterdam port, production as of 2027

Hydrogen in power & heating



Decarbonizing natural gas grid

- Inject H₂ in existing gas grid (admixing with N. gas or pure H₂)
- Synthetic methane (from green H₂)
- CCGT - power plants to operate on H₂?

BE gas plants:
conditions for sustainability

- End of 2026 : feasibility of reduction of CO₂
- End of 2027: reduction plan ready,
with targets for 2035 and 2045 -2050
- 2050: zero emission realised => H₂??

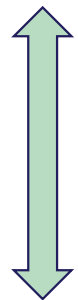
Storage of electricity (seasonal storage)

- Difficult on short term => not enough surplus RE in Belgium to have a case

Hydrogen in built environment

Central production

- Hydrogen imported via gas grid from central source; transport & distribution via gas grid



Local production

- Hydrogen production on district level, distribution via local gas/H2 grid



- Hydrogen is **produced in/close to** the building from onsite produced energy (solar)



H21 project in Leeds



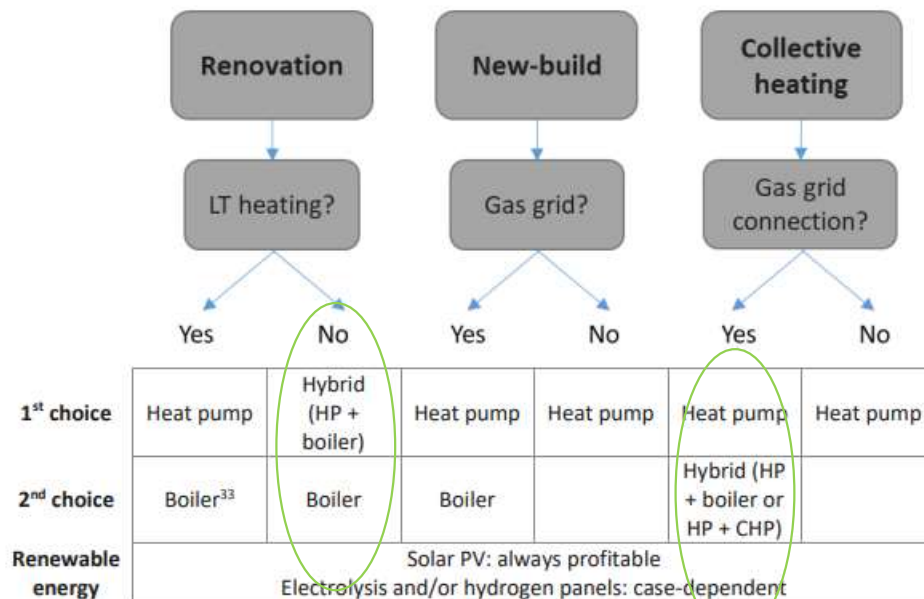
Hydrogen in built environment?



Role of hydrogen, next to alternatives all-electric?



- Study BatHyBuild ([link final report](#))



Interesting:

Combination heat pumps + H2 ketels/CHP for collective application.

Question mark:

Will the electricity grid system cope with the large scale application of HP/EV and peak supply of solar panels

Test projects in built environment NL

Waterstofwijk Hoogeveen

https://research.hanze.nl/ws/portalfiles/portal/34882351/HANZE_20_0635_Publieksvriendelijke_versie_Waterstofwijk_Gewijzigde_Herdruk.pdf

- **New district Nijstad Oost**, “Greenfield project”, 80-100 new houses,
Connected to **new local H2 grid**
- **Existing district Erflanden**, 1150 buildings, built in 2000-2005 (no low T-heating)
Using **existing gas grid**
- Technology: H2 boiler
- Planning: 2021-2022

- fase 1: **Externe aanvoer/opslag** H2, 2021 (tube trailer)
- fase 2: **Lokale productie** H2, 2023
- fase 3: Aanvoer H2, via **backbone**, 2027

Project Engie-Duinkerke (F), GHRYD project

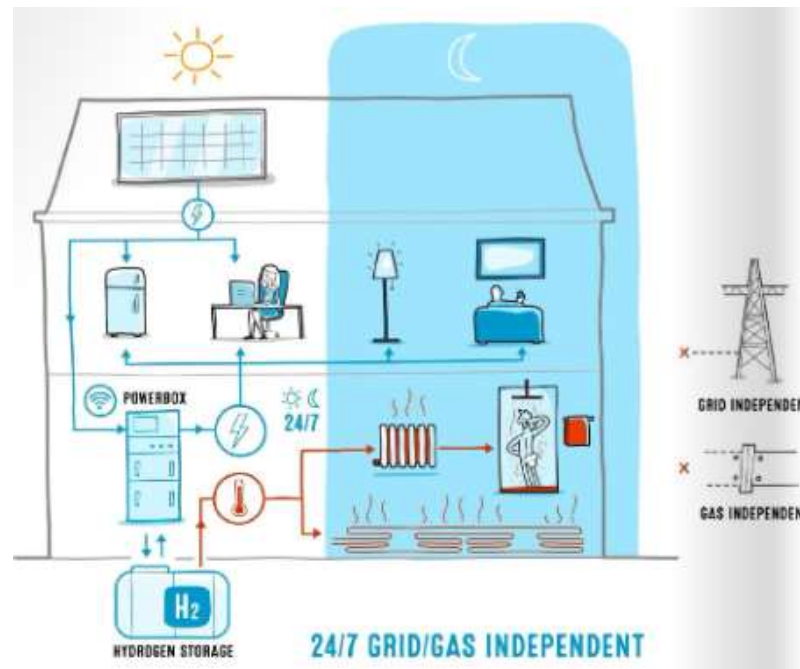
<https://www.engie.com/en/business-case/engie-x-ghryd>

Admixing of H2 in local gas grid to 20%



Opslag van lokaal geproduceerde elektriciteit

- Opslag van lokaal geproduceerde energie (PV) in waterstof; re-elektrificatie met WKK/brandstofcel

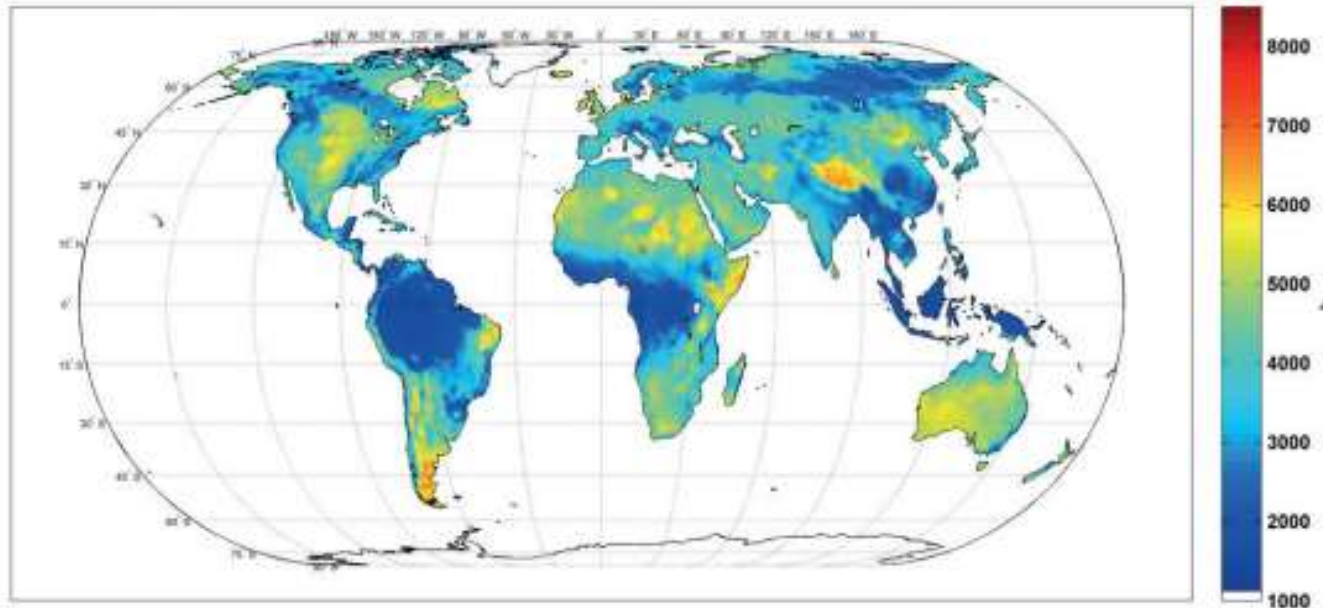


Source:
Solenco power

Transport of renewable electricity from regions with ideal conditions



Figure 8. Hybrid solar and wind full load hours adjusted by critical overlap in 2005



Transport of energy:
Pipelines/shipping

Energy carriers:
(Liquid) hydrogen,
Ammonia, Methanol, e-CH₄

Disclaimer: The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: Adapted and based on
Fuels Production and Global Tra

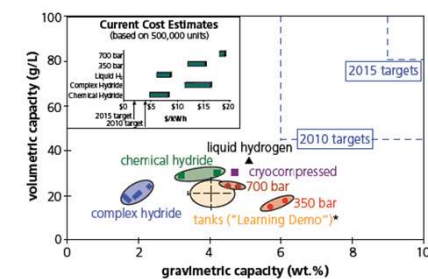
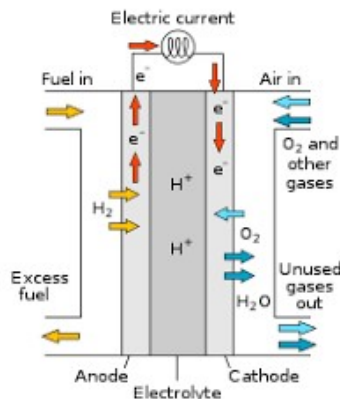
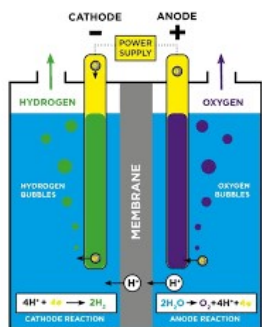
Source: [Renewable Energy for](#)



Hydrogen Import Coalition

<https://www.waterstofnet.eu/en/knowledge-centre/roadmaps-and-studies/h2-importcoalition>

Technologies



Electrolysers



Fuel Cells



Engines



Storage

Status 'clean H₂' in Belgium

Existing pilots

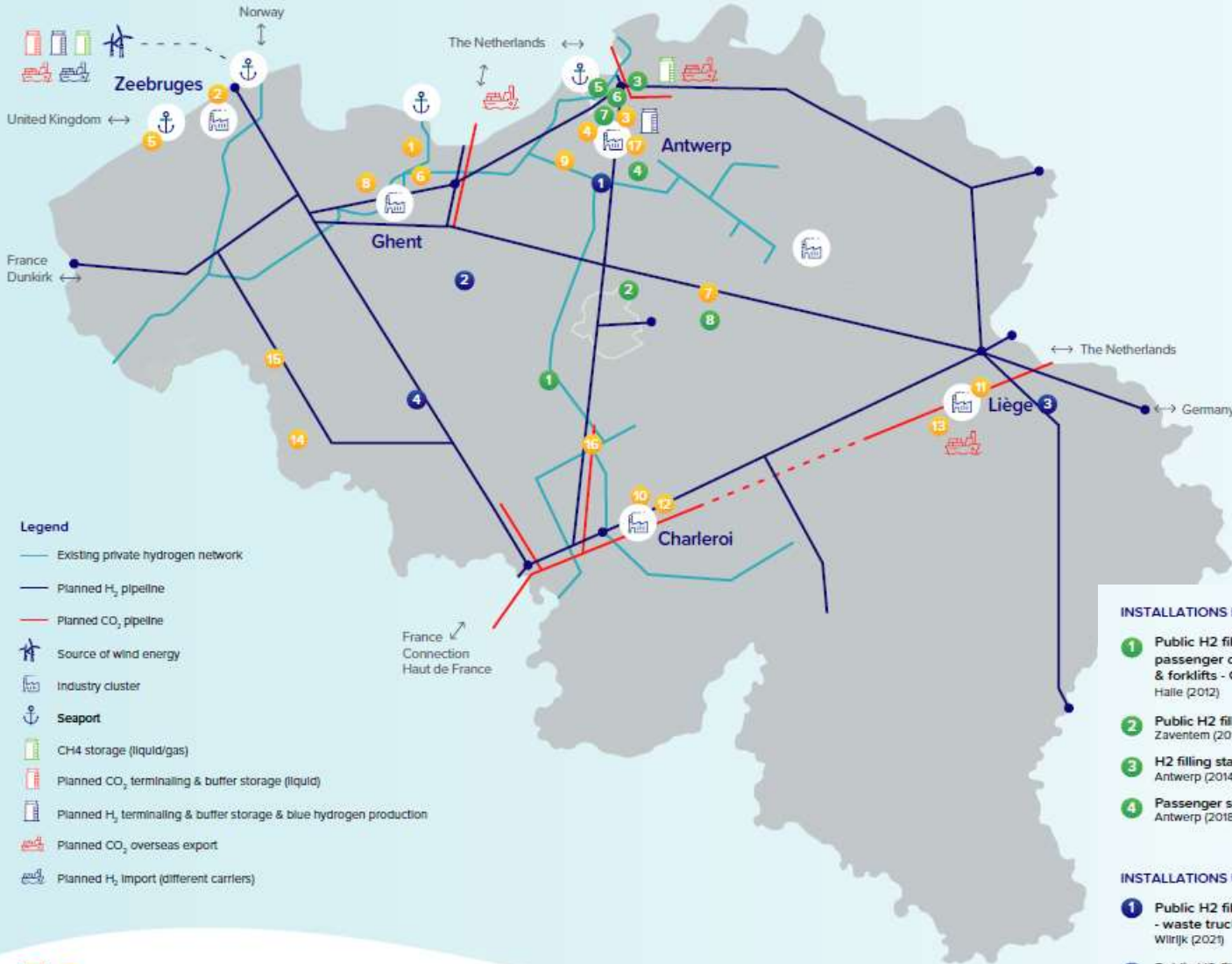
Large sea-port & infrastructure projects in development

H₂ Import











WaterstofNet

Status 'clean H2' in Belgium: existing pilot projects



Legend

- Existing private hydrogen network
- Planned H₂ pipeline
- Planned CO₂ pipeline
-  Source of wind energy
-  Industry cluster
-  Seaport
-  CH₄ storage (liquid/gas)
-  Planned CO₂ terminalling & buffer storage (liquid)
-  Planned H₂ terminalling & buffer storage & blue hydrogen production
-  Planned CO₂ overseas export
-  Planned H₂ import (different carriers)

INSTALLATIONS IN OPERATION

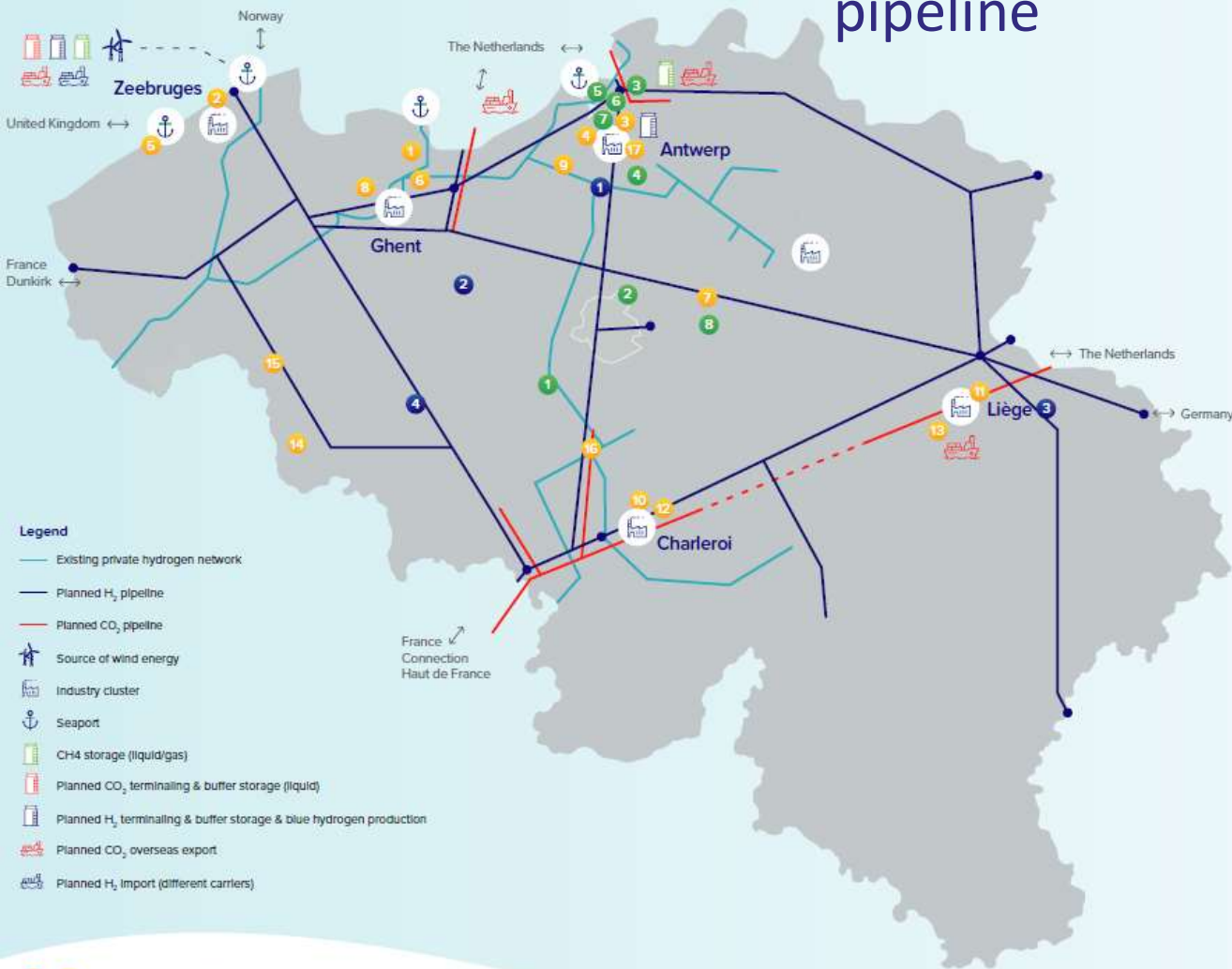
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- 3** H₂ filling station for buses - 5 buses Antwerp (2014)
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- 8** Public H₂ filling station for passenger cars Haasrode (2021)

INSTALLATIONS UNDER CONSTRUCTION

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- 4** Public H₂ filling station - HGV Ollignies (2021)

Sustainable hydrogen projects in Belgium

+ Projects in the pipeline



- Legend**
- Existing private hydrogen network
 - Planned H₂ pipeline
 - Planned CO₂ pipeline
 - Source of wind energy
 - Industry cluster
 - Seaport
 - CH₄ storage (liquid/gas)
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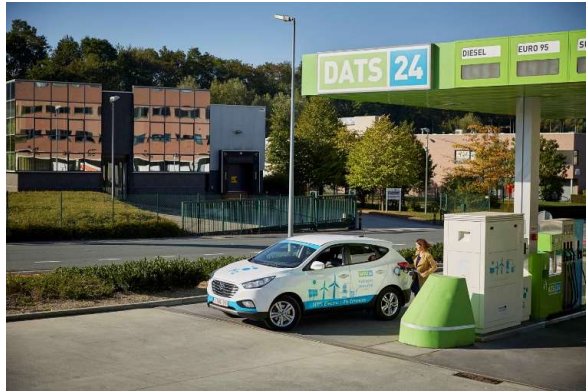
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PROJECTS IN THE PIPELINE (ANNOUNCED)

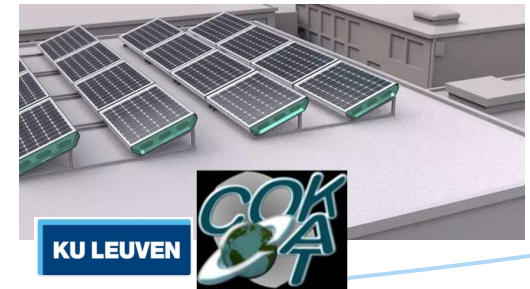
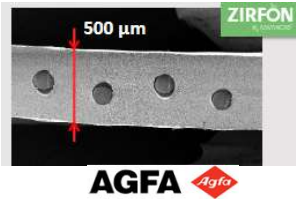
- 1** Terranova Hydrogen: Onsite H₂ production from solar & wind - H₂ for industry and transport Zelzate (2022)
- 2** Hyoffwind: Onsite H₂ production from offshore wind Grid balancing services Injection in natural gas grid Filling point for inland distribution Zeebrugse (2023)
- 3** Power-to-Methanol Antwerp: Onsite H₂ production from onshore wind Methanol production Antwerp (2023)
- 4** Hydrotug & Methatug: Tug boats on hydrogen and methanol Antwerp (2022)
- 5** Hyport: Onsite H₂ production from offshore wind Shore power, industry and transport Ostend (2025)
- 6** North-C Methanol: Onsite H₂ production from offshore wind Methanol production Ghent (2025)
- 7** Hydrogen panels for homes Oud-Heverlee (2021)
- 8** Hydrogen in CHP for heating of industrial building and charging battery electric vessel Ghent (2022)

- 9** Antwerp@C: Capture, transport and storage and/or recycling of CO₂ Antwerp
- 10** Columbus Project: onsite H₂ production + transforming CO₂ into e-methane Charleroi (2025)
- 11** HaYrport Project: onsite H₂ production H₂ for clean mobility on the airport site Liège
- 12** Waste-to-Wheels Project: onsite H₂ production at waste plants for refuse trucks and public buses Charleroi
- 13** Pilot Project of methane pyrolysis on CCGT power station Seraing
- 14** Public H₂ filling station with onsite H₂ production - passenger cars-HGV Tournal (2026)
- 15** Biogaz from potato waste & H₂ production for industrial and mobility users Mouscron (2024)
- 16** H2CoopStorage Project: hybrid storage solution (reverse fuel cell) within a citizen energy community Nivelles
- 17** HyTrucks Antwerpen: trucks and refuelling infrastructure - 6 HRS and 300 trucks Antwerp

Status H2 in Belgium: existing (pilot) projects



Status H2 in Belgium: technology development



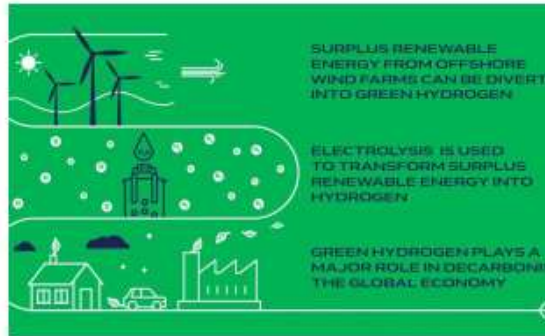
Sea-ports are developing large projects

Power-to-hydrogen: Hyoffwind



Project with Eoly and Parkwind to build an industrial-scale power-to-hydrogen facility in the port of Zeebrugge.

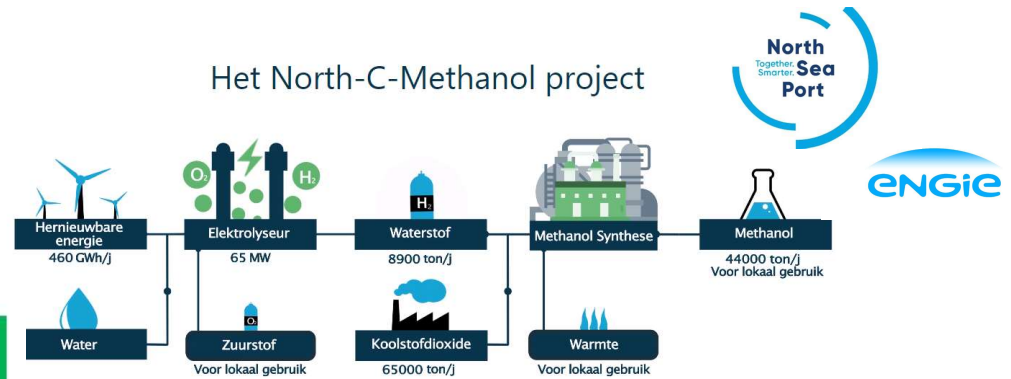
Source Fluxys website



27 JANUARY 2020

HYPOR[®]: green hydrogen plant in Ostend

Het North-C-Methanol project



Port of Antwerp

POWER TO METHANOL

ANTWERP B.V.

"THE FUTURE IS RENEWABLE AND CIRCULAR"

The Power to Methanol project has the ambition to advance the energy transition and to strengthen its presence in the Port of Antwerp not only for the business of today but also for that of tomorrow.

OUR CONCEPT

- Greener deal for a greener future -
- Energy transition: Hydrogen as the green energy carrier -
- Renewable power through e-methanol -
- Power to chemicals through Antwerp Petrochemicals Hub

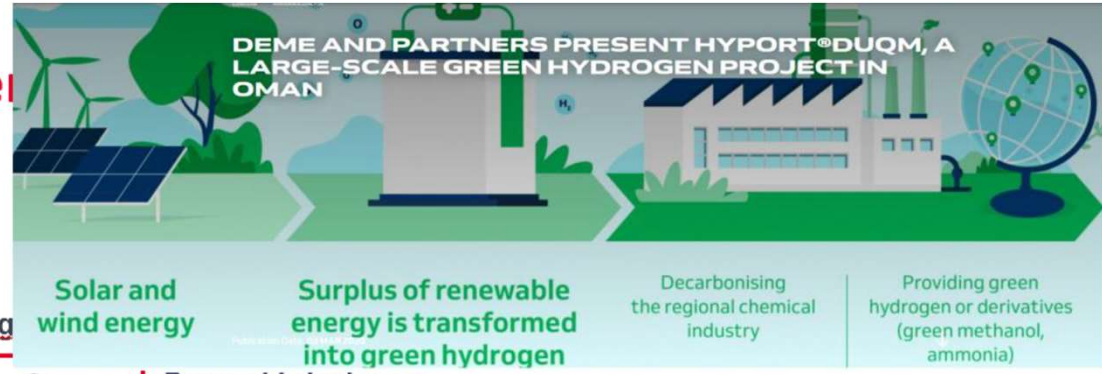
H2 import coalition

Groene waterstof: havens Antwerpen en Zeebrugge bundelen krachten met Chili



hydrogen market

Synthesis hydrogen



België sluit op COP26 overeenkomst met Namibië voor import groene waterstof



Renewable hydrogen
Renewable methane
In Chile, ENGIE Announces the Deployment of a 2 GW Renewable Energy Portfolio, With Hydrogen and Total Exit From Coal

By FuelCellsWorks | April 28, 2021 | 2 min read (354 words)

0 Comments



Policy context Europe-Belgium- Flanders

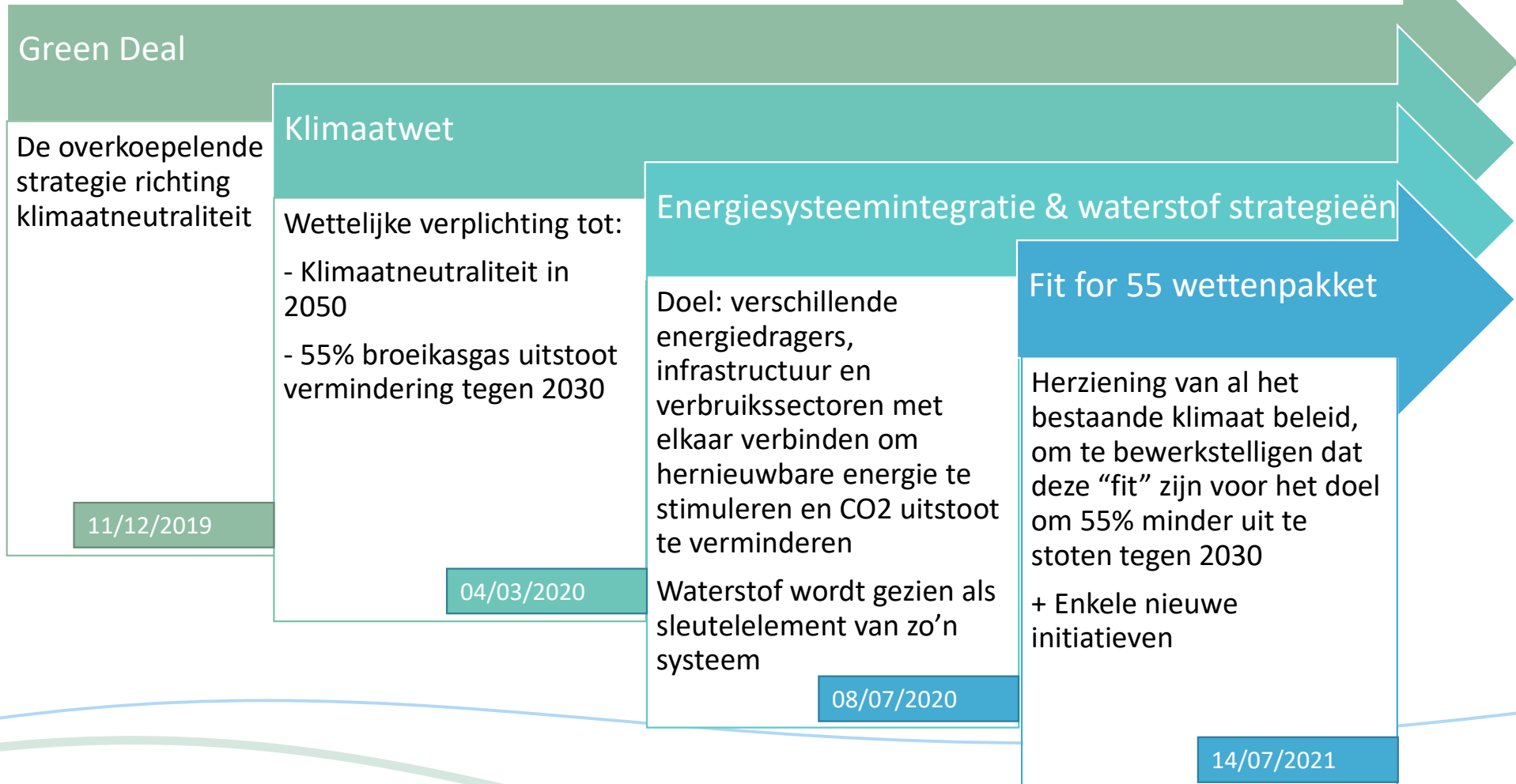
Hydrogen strategy documents

European directives



WaterstofNet

Eu framework



Fit for 55 pakket: overview of relevant policies for H2

Revision of existing policy

- **Renewable Energy Directive (RED)**
- Energy Efficiency Directive (EED)
- Alternative Fuels Infrastructure Regulation (AFIR - formerly AFID)
- CO2 Standards Regulation
- **EU Emissions Trading Scheme (ETS)**
- Effort Sharing Regulation (ESR)
- Energy Taxation Directive (ETD)

New initiatives

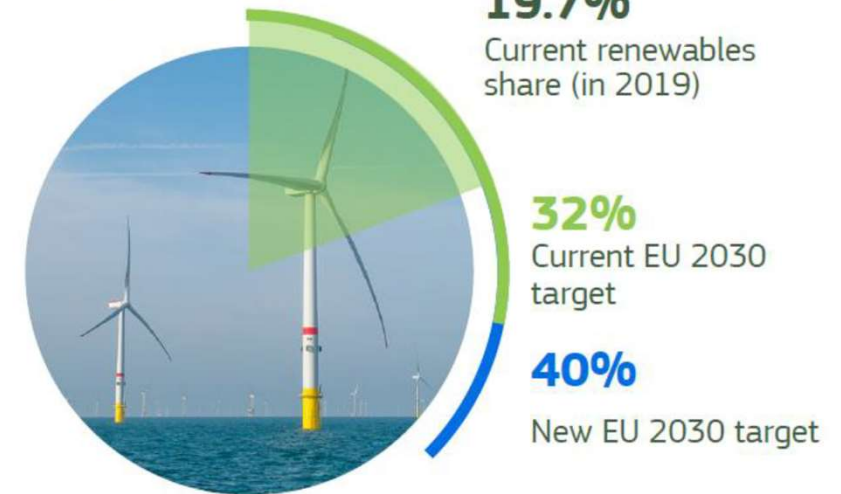
- Carbon Border Adjustment Mechanism (CBAM)
- FuelEU Maritime
- RefuelEU Aviation

Fit for 55: Renewable Energy Directive (RED III)

- Revision of target for 2030:
 - From 32% to 40% renewables in the energy mix
- More stringent rules for bio-energy

- Specific sub-targets for use of renewable van hydrogen/RFNBO's in "hard-to-decarbonise" sectors:
 - **50% in 2030** in industry
 - **2,6% in 2030** in transport
- 13% green house gas reduction in transport in 2030

Renewables in the EU energy mix





Flemish hydrogen vision-H2 Task force - IPCEI

Vlaamse waterstofvisie 'Europese koploper via duurzame innovatie'



Groene waterstof: deze 5 Vlaamse projecten zijn in de maak



BUSINESS



Door Emmanuel Vanbrussel

Gepubliceerd op Dinsdag 19 oktober 2021 om 10:38 • oktober 2021

3 min lezen

Foto Tractebel Engie

De Vlaamse regering maakt 106 miljoen euro vrij om vijf grote projecten rond duurzame waterstof te helpen financieren. Het gaat om een eerste golf van in totaal tien projecten die in de pijplijn zitten. De uitgebreide staatssteun is mogelijk mits de Europese Commissie de projecten goedkeurt als strategisch belangrijk voor Europa, binnen het zogeheten IPCEI-programma. Dat staat voor Important Projects of Common European Interest.

Nieuwe taskforce Vlaamse waterstof economie

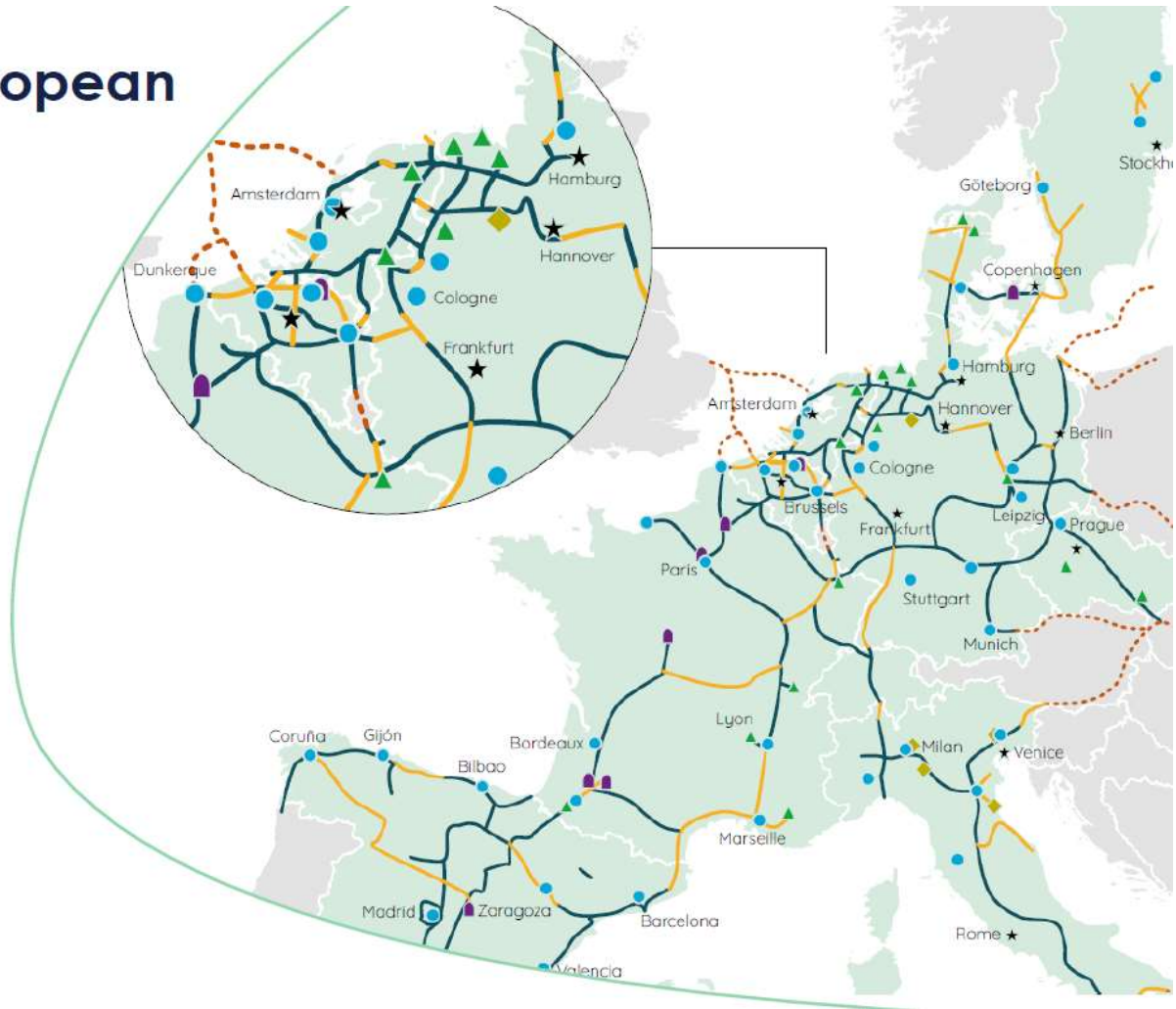
Belgian federal H2 vision

Belgian Federal Hydrogen Vision and Strategy: 4 pillars

- Belgium as import hub for renewable hydrogen in Europe
 - Limited domestic production
 - Belgian estimated H2 demand :
 - » 2030: between 3 - 6 TWh
 - » 2050 : 100 -165 TWh
- The creation of a Hydrogen backbone and a robust hydrogen market
 - Create hydrogen pipelines by 2026
 - Connect with neighboring countries by 2030
 - Legislative Framework expected in 2022 (TPA to infrastructure)

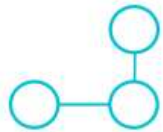


Integrated into the European hydrogen backbone



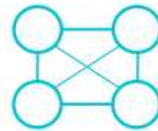
Fluxys proposal: develop progressively H₂ & CO₂ infrastructure

Local clusters



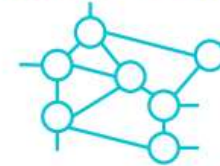
Phase 1
2020 - 2024

Connecting clusters

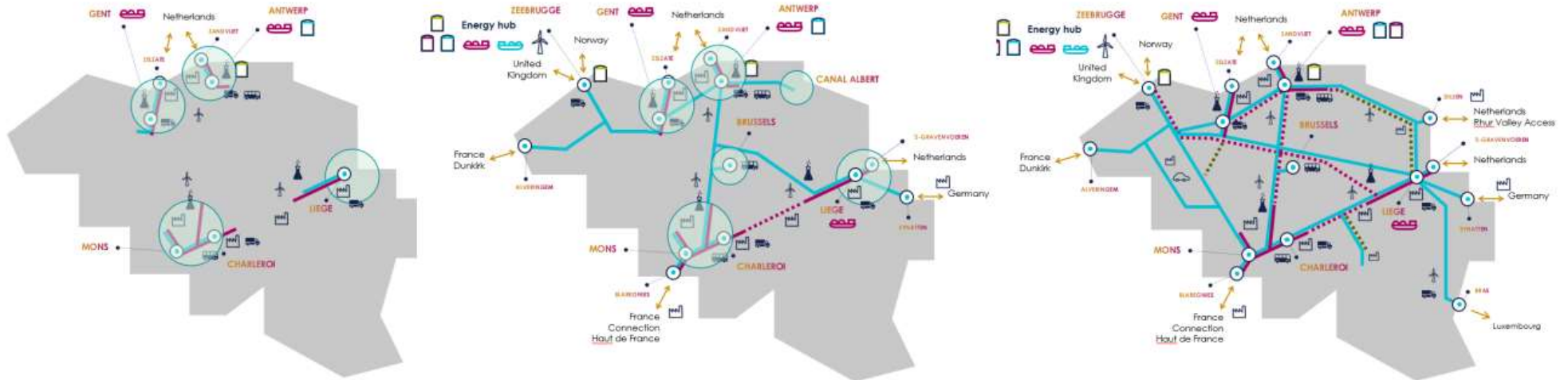


Phase 2
2025 - 2030

Mature backbone



Phase 3
2030 onwards



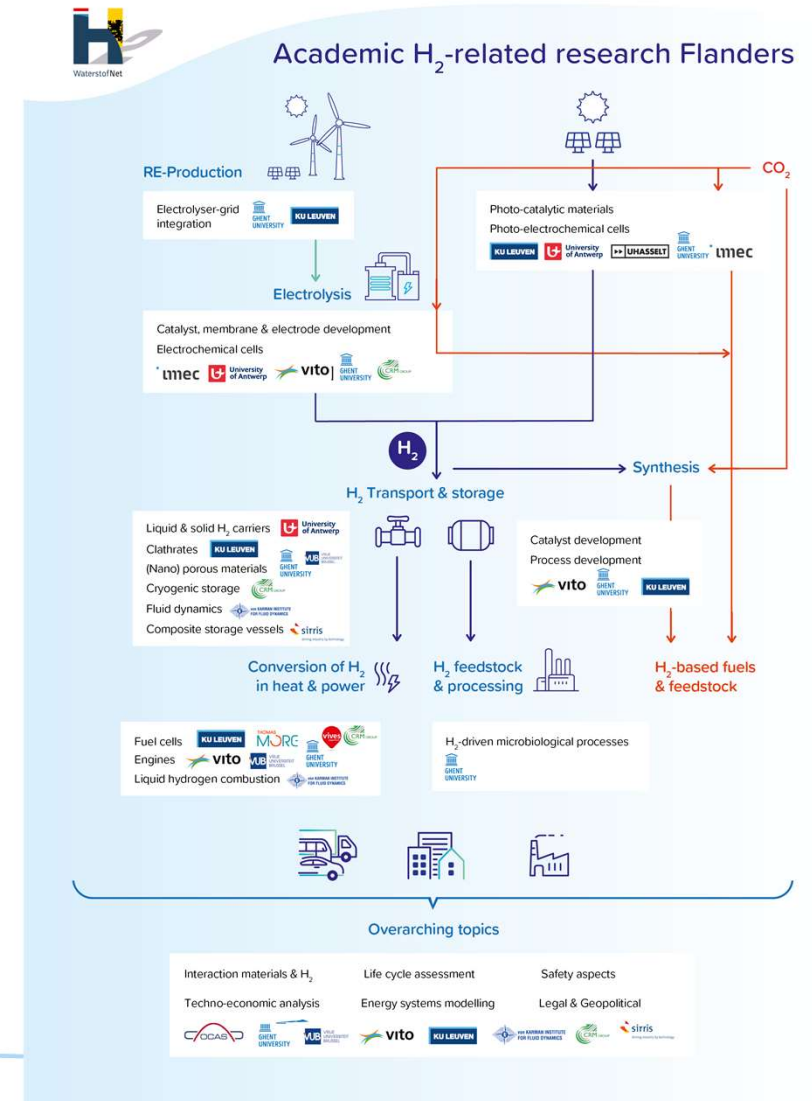
In line with EU strategy



Link (academic) research to industry

Flemish “research agenda”

- Inventory of all H₂ related research in Flanders
- Universities and research institutes
- Next step: exchange info/match with industry
- “Flemish” hydrogen program



Challenges

Renewable energy capacity Belgium-Europe

Cost price technology

Cost price electricity



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Renewable energy capacity in Belgium/Europe

FIGURE 10: COMPARISON BETWEEN THE TOTAL ELECTRICITY DEMAND AND THE ELECTRICITY SUPPLY FOR BOTH TRANSFORMATION PATHWAYS AND ALL THREE SUPPLY SCENARIOS FOR BELGIUM IN 2050

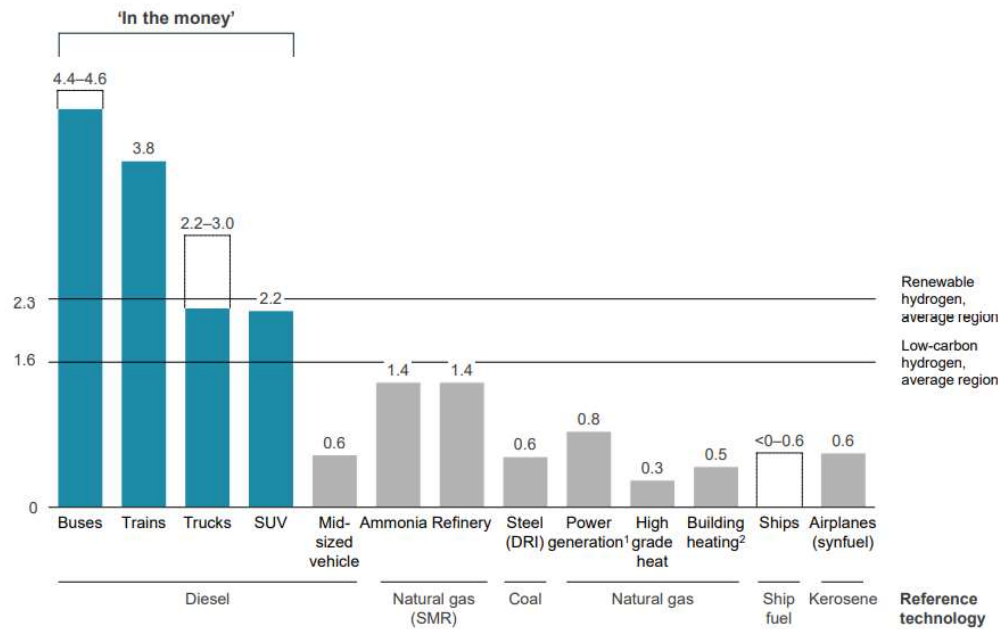


Source: Roadmap to net zero Elia Group's vision on building a climate-neutral European energy system by 2050 (nov 2021)

Cost price gap

Exhibit 18: Required hydrogen production cost for breakeven with conventional solutions, without carbon costs

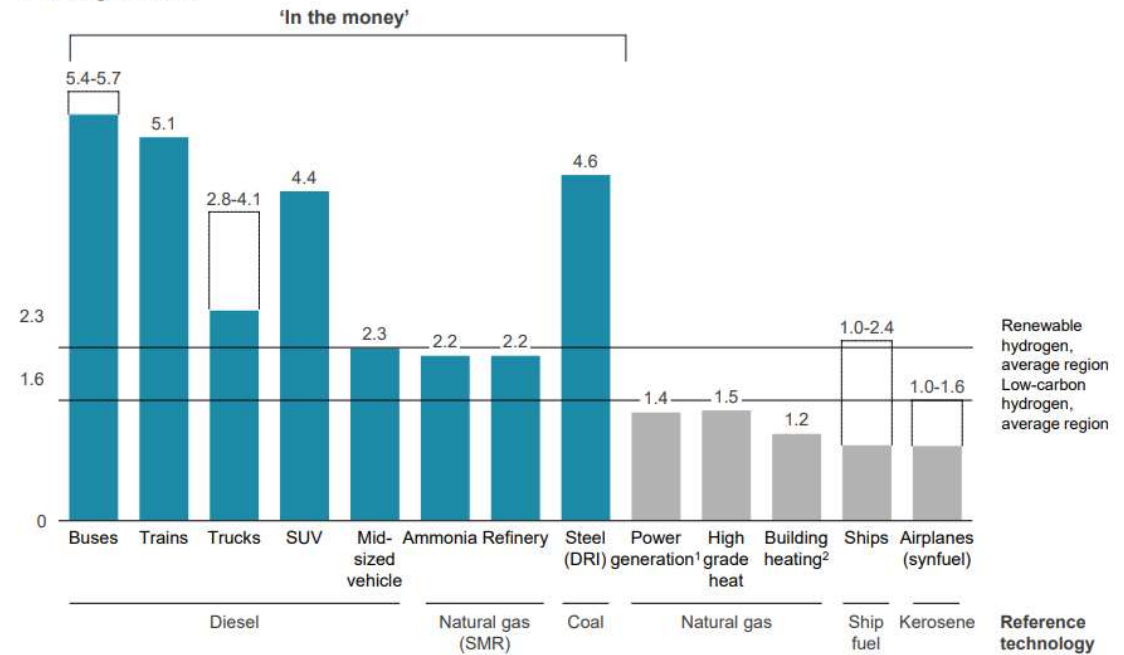
USD/kg in 2030



1. Average of combined cycle and single cycle turbine applications
2. Boiler with existing network

Exhibit 19: Required hydrogen production cost for breakeven with conventional solutions, with 100 USD/t CO₂e

USD/kg in 2030



1. Average of combined cycle and single cycle turbine applications
2. Boiler with existing network

Conclusions

- Pilot projects realised in Belgium, focus on mobility
- Strategy and task force in place in FL, BE, Wallonia working on their strategy
- The sea-ports are setting the scene with large project initiatives
- Domestic production but focus on import
- Strong growing interest in industry => WIC growing fast
- EU is showing the way and is supporting

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Bedankt voor uw aandacht!
Thank you for your attention!



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