iea hydrogen

Global Perspectives on hydrogen and IEA hydrogen activities

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Workshop on Hydrogen Production with CCS
Chatou, 6th November 2019

Les positions exprimées dans cette présentation ni ne reflètent ni n'engagent celles de l IEA

Outline

- **Long term Perspectives for hydrogen in energy transition and Paris Agreement objectives**
- **Focus on H2 production**
- **IEA activities on hydrogen**
- **IEA Hydrogen TCP**
- **Conclusions : questions/issues to be adressed**

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Unprecedented momentum on Hydrogen since last 3 years...

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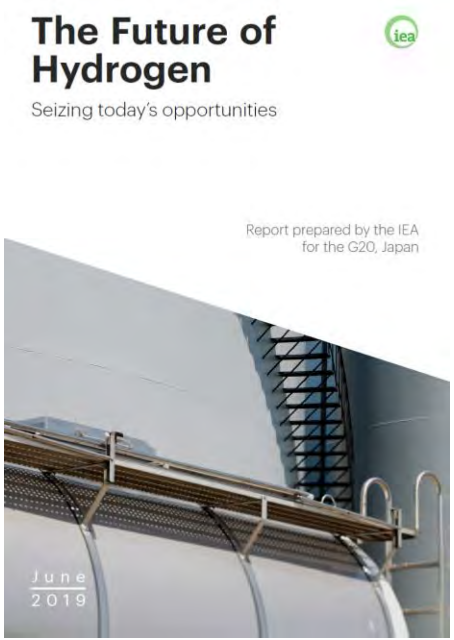
World Governments

- **2015** **COP21** Paris Agreement
- **2017** Davos 2017: Creation of Hydrogen Council
- **2017** Japanese Prime Minister announces **Japan's intent** to become **world's first hydrogen society**
- **2018** Hydrogen adopted as **8th MISSION INNOVATION Challenge** in May
- **2018** European Ministries – **Linz Declaration** on Hydrogen in September
- **2018** **IPCC Special Report** on Global Warming of 1.5° C in October; hydrogen workshop in October
- **2018** **Japan makes voluntary contribution to IEA** for preparation of G20 Report on Hydrogen to be delivered June 2019 at G20 Meeting
- **2018** First Hydrogen Ministerial Meeting in Japan in October produces **"Tokyo Statement"**
- **2019** **FCH2JU Study** Hydrogen Roadmap Europe – published in February
- **2019** Hydrogen Initiative at CEM, Vancouver will be managed by IEA
- **2019** Delivery of **IEA Hydrogen Report at G20 Meeting** in June with strategic workshop in June
- **2019** 2nd Hydrogen Ministerial Meeting in fall and IRENA report on Hydrogen

Why Now? Drivers

- **Emissions CO2 increasing despite unprecedented deployment of renewables >> H2**
- **Electric Renewable like PV, On shore or Off shore Wind at very low costs (cf Portugal Aunction 15€/Mwh) >> H2 compétitif**
- **H2 Technologies mature**
  - 12 000 vehicles, HRS, 24 000 Forklift,275 000 stationnary system with fuel cells
  - 200 Demo projects Prod and Power to Gas 1-20 MW
  - Fuel cells costs divided by 3 (2015), 10(2005) , lifetime 10 000h- 80 000h
  - Hydrogen gas turbine
- **The time is right to tap into hydrogen's potential to play a key role in a clean, secure and affordable energy future.**
- **Hydrogen can help tackle various critical energy challenges, including Hard to Abate sector.**
- **Hydrogen can enable renewables to provide an even greater contribution.**
- **There have been false starts for hydrogen in the past; this time could be different.**
- **Hydrogen can be used much more widely.**
- **Hydrogen allows flexibility**
- **Hydrogen is versatile, adressing different goals: Climate, Air Quality, Energy Security, Economic growth, Energy access**
- **Hydrogen: optimise existing energy infrastructure assets**



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The IEA's 7 Key Recommendations to scale up Hydrogen

- **Establish a role for hydrogen in long-term energy strategies**
- **Stimulate commercial demand for clean hydrogen**
- **Address investment risks for first-movers**
- **Support R&D to bring down costs**
- **Eliminate unnecessary regulatory barriers and harmonise standards**
- **Engage internationally and track progress**
- **Focus on four key opportunities to further increase momentum over the next decade**

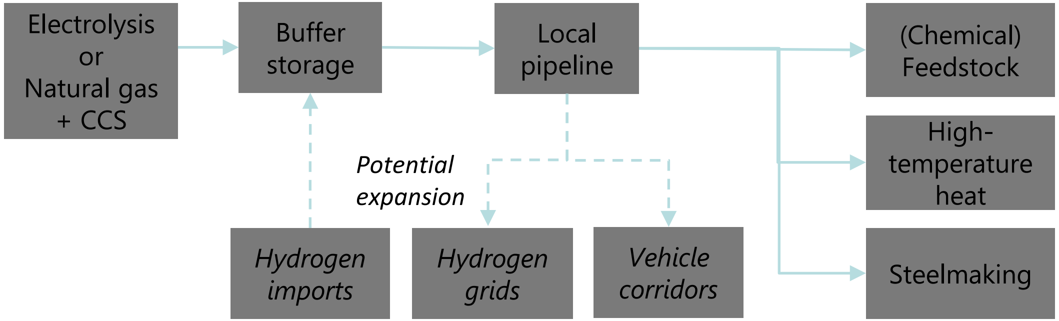
Source IEA, 2019
The future of Hydrogen,
Webinar

The IEA has identified four near-term opportunities to boost hydrogen on the path towards its clean, widespread use:

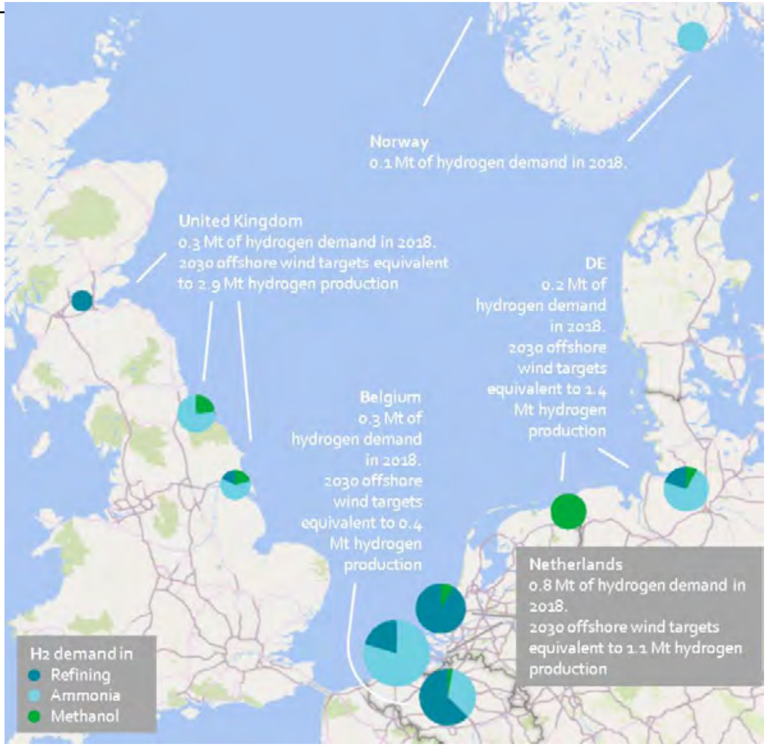
1. **Make industrial ports the nerve centres for scaling up the use of clean hydrogen.**
2. **Build on existing infrastructure, such as millions of kilometres of natural gas pipelines.**
3. **Expand hydrogen in transport through fleets, freight and corridors.**
4. **Launch the hydrogen trade's first international shipping routes.**

Focalisation sur 4 opportunités pour le passage à **l'échelle**

Coastal industrial clusters: Gateways to building hydrogen hubs



Source IEA, 2019
The future of Hydrogen, Webinar



Industrial clusters are places where existing uses of hydrogen can be leveraged as sources of demand for new hydrogen production facilities and CCUS without extensive new infrastructure.

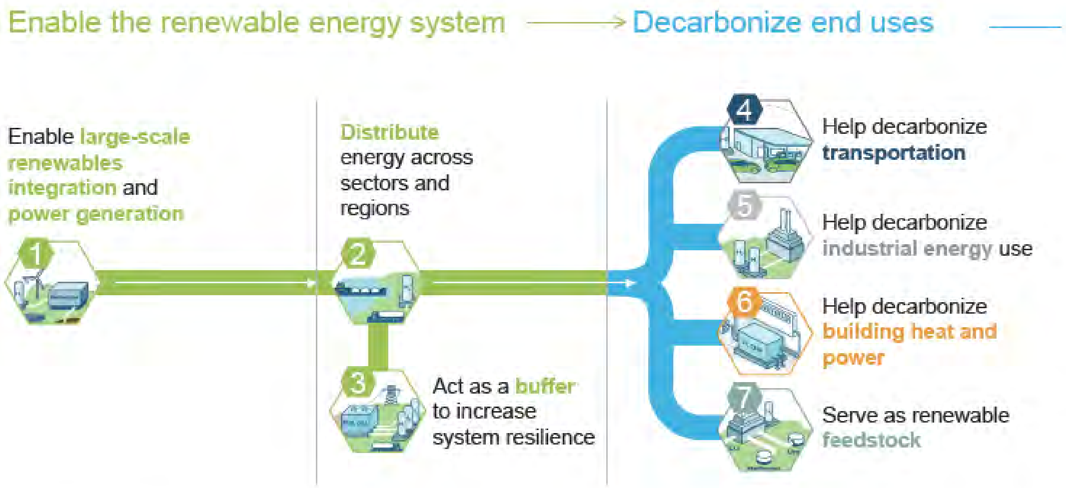
But « hydrogen momentum » is fragile
Challenges

- Hydrogen deployment is strongly dependent on climate policies and policy makers commitment
- Costs remain high
  - Centralized versus decentralized option, costs for transport and distribution
  - Incertainties on CCS CCUS
- Value chain complexity
  - Investors trust
  - Scale up for international Public private coordination for invstments
  - Uncertainties on public money avaibility
  - Innovations à faire dans les relations contractuelles
  - New energy complex system modelling
- Infrastructure deployment needs time and needs public/private coordination and geographical alignment
- Legal and reglementary barriers
  - Codes and standards safety
  - Taxes
  - LCA
  - Low carbon Hydrogen market

Les positions exprimées dans cette présentation ni ne reflètent ni n'engagent celles de l IEA

Hydrogen Council Vision

Air Liquide ALSTOM AngloAmerican BMW GROUP DAIMLER ENGIE HONDA HYUNDAI Kawasaki Shell THE LINDE GROUP TOTAL TOYOTA



SOURCE: Hydrogen Council

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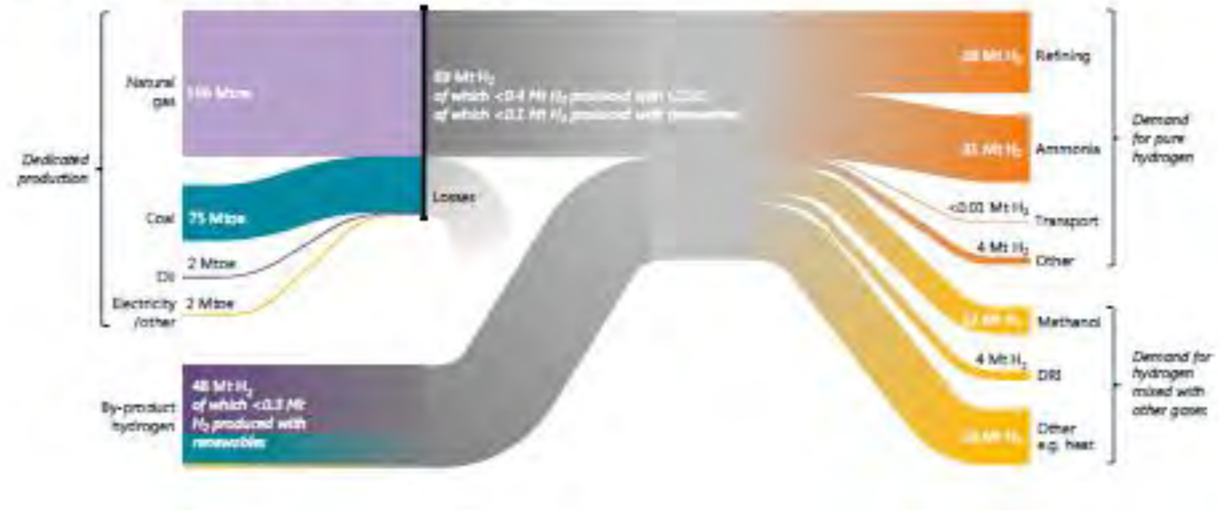
Hydrogen today

Figure 6. Today's hydrogen value chains



- Hydrogen Production 275 Mtoe, 2% Final energy
- Needs:
  - 205 Bm3 Natural gas (6% total consumption
  - 107 Mt Coal(2% total Consumption)
  - 617 M m3 water(1,3% total
- Replacement by electrolysis will need:
  - 3600 TWh Electricity (Europe production)
- 1 Ton Hydrogen produces
  - 10 t CO2 (ex nat gas).
  - 12t CO2 from oil residues
  - 19t CO2 from coal

Source IEA, 2019
The future of Hydrogen, Webinar

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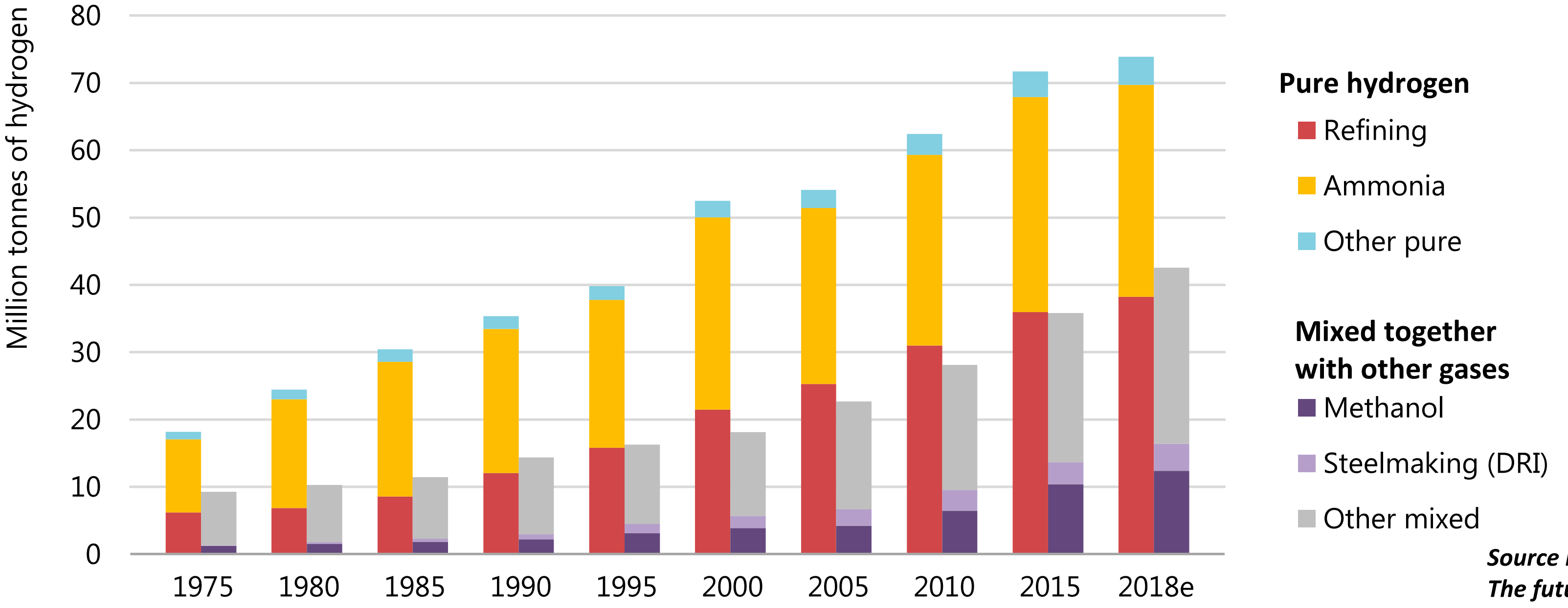
Hydrogen today



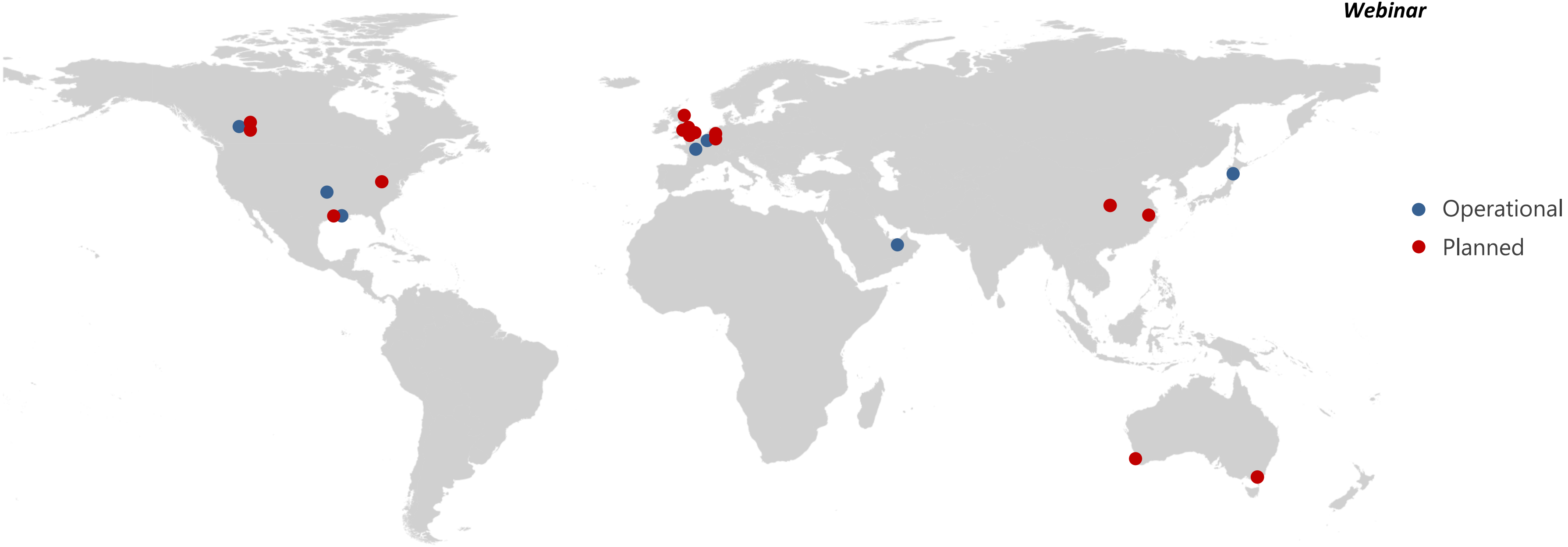
Source IEA, 2019
The future of Hydrogen,
Webinar

Global demand for hydrogen in pure forms has grown steadily over the past 50 years to around 70 Mt today. More than 40 Mt is also produced in a mixture of other gases.

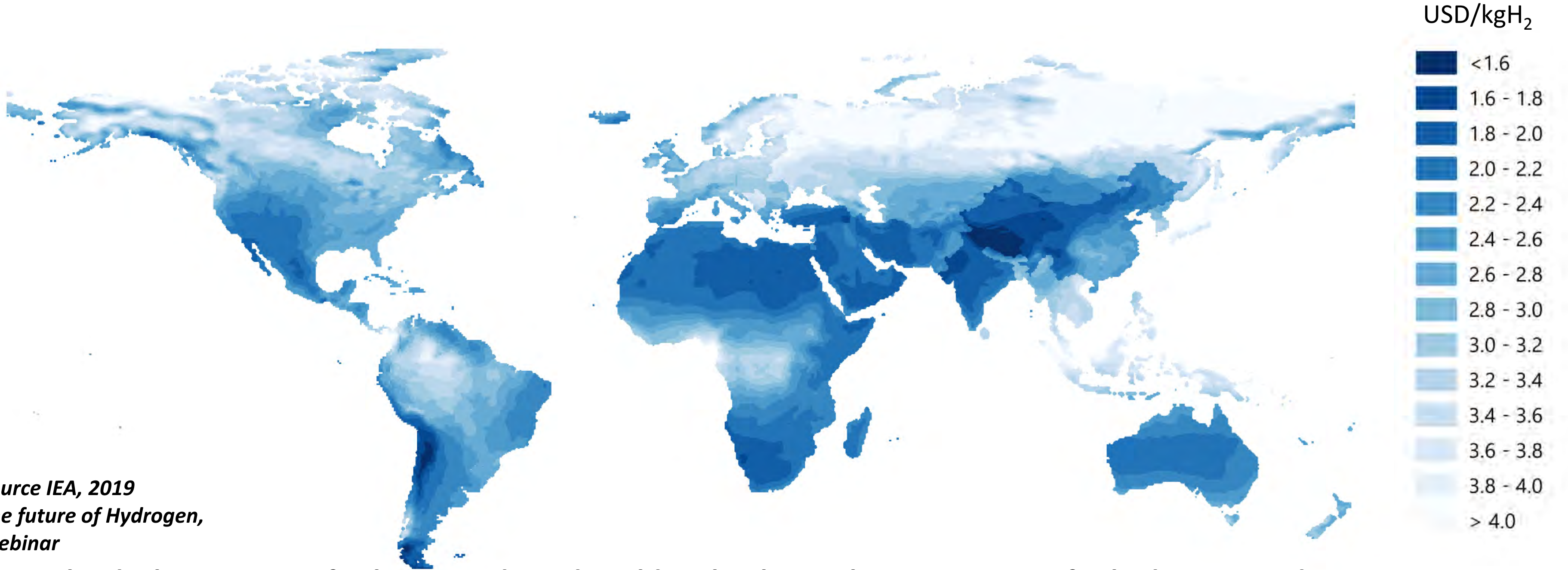
Hydrogen production with CCS

Facilities with hydrogen production and CCUS

Source IEA, 2019
The future of Hydrogen, Webinar



Massive and competitive hydrogen production
In low cost Renewable Areas



Source IEA, 2019
The future of Hydrogen,
Webinar

The declining costs of solar PV and wind could make them a low-cost source for hydrogen production in regions with favourable resource conditions.

A new and emergent topic: international trade for hydrogen

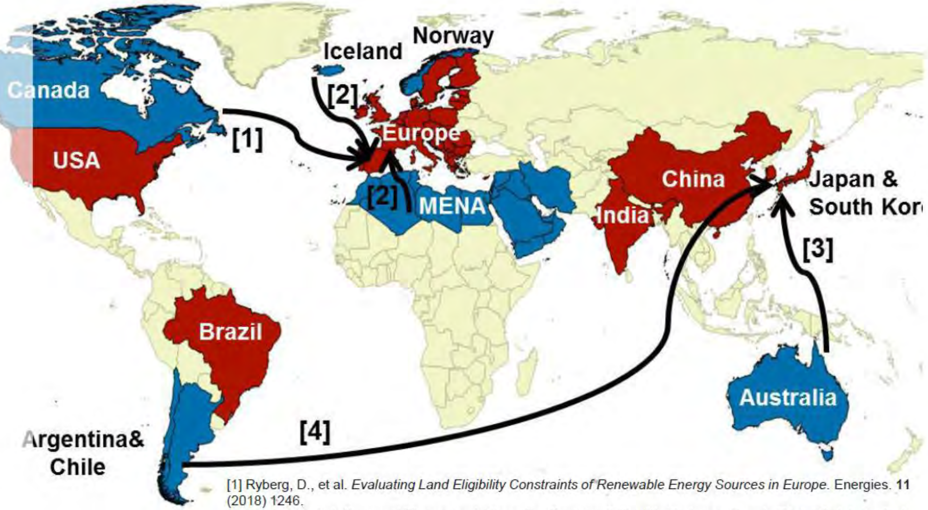
What will be the new roads of hydrogen

Renewable hydrogen production – Global perspective

- Due to location boundaries Germany will have the demand for energy import
- High potentials for RE offer the opportunity for green PtX with competitive prizes
- Enable regions to be self-sufficient in energy and potentially chemical feedstocks

→ Global transport infrastructure

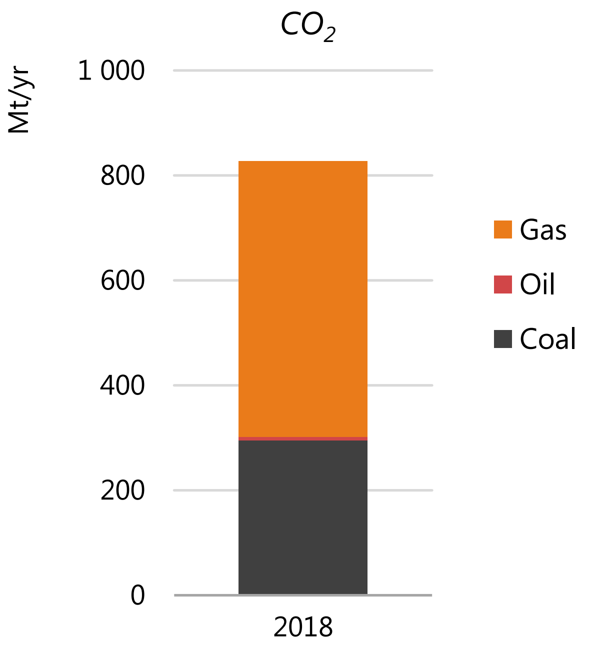
- PtX offers the opportunity of versatile, scalable, intelligent and flexible system integration with high shares of RE

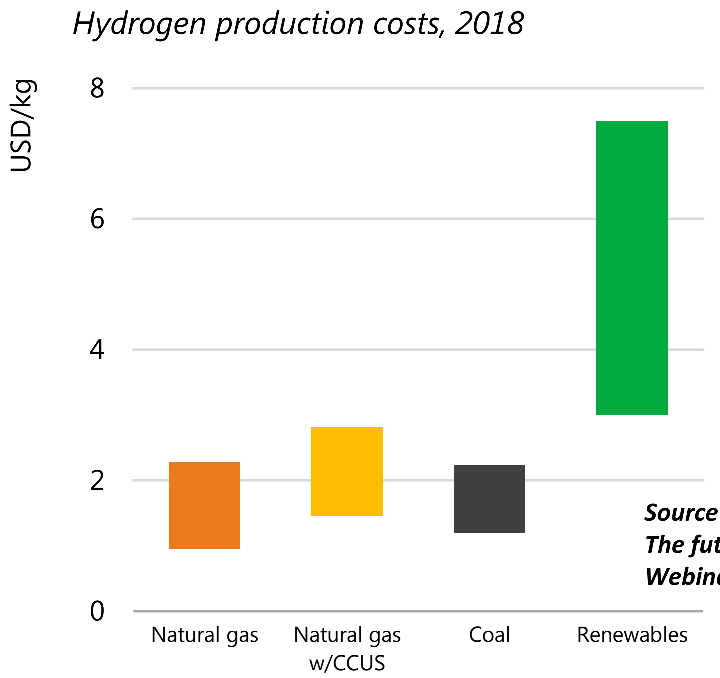


[1] Ryberg, D., et al. *Evaluating Land Eligibility Constraints of Renewable Energy Sources in Europe*. Energies. **11** (2018) 1246.
[2] Reuß, M., et al. *Seasonal Storage and Alternative Carriers: A Flexible Hydrogen Supply Chain Model*. Applied Energy. **200** (2017) 290-302.

engagent celles de l IEA

Hydrogen costs today





Source IEA, 2019
The future of Hydrogen, Webinar

Virtually all hydrogen today is produced using fossil fuels, as a result of favourable economics

Electrofuels
or « Low Carbon Hydrogen Inside » Fuels

Electro fuels: a broad definition

	Without carbon	Containing carbon
Gaseous	Hydrogen gas (H_2)	Methane (CH_4)
Liquids	Ammonia (NH_3)	Alcohols (C_xH_yOH) Hydrocarbons (C_xH_y)

There is a great diversity of options for electro fuels, all based on hydrogen, which may correspond to different needs and uses

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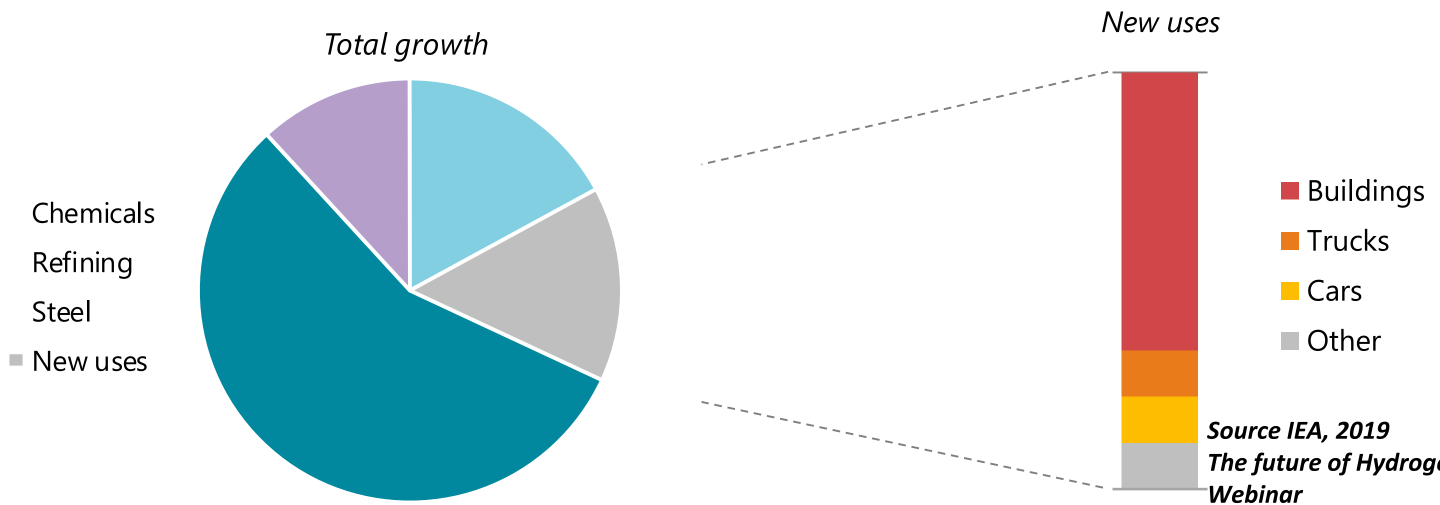
2030: Extent Hydrogen usages

Growth in hydrogen use based on announced policies, 2018-2030



Source IEA, 2019
The future of Hydrogen, Webinar

Dependable demand from current industrial applications can be used to boost clean hydrogen production; policies & industry targets suggest increasing use in other sectors, but ambition needs to increase.

IRENA Report (september 2019): CCS issues adressed

- **Blue hydrogen is deployed in limited niche applications today**; At large scale, it is critical to ensure that all projects producing hydrogen from fossil fuels include CCS from the start.

• **Deployment of blue hydrogen is not necessarily CO_2-free. CO_2-capture efficiencies are expected to reach 85-95% at best**, which means that 5-15% of all CO_2 is leaked. However, the current flagship CCS projects achieve far lower capture rates. The Petra Nova project in the US captures just over a third of the flue gas from **one of four coal-fired units**, while the Boundary Dam project in Canada has an overall CO2 capture rate of 31% (FT, 2019). As the ultimate goal is greenhouse gas reduction, other gases also deserve attention:

- • CO_2 can be stored underground, as proven by several megatonne (Mt)-scale projects. **However, there is increased focus on CO_2** use. The vast majority of CO_2 that is captured today is used for enhanced oil recovery (EOR). Underground CO_2 retention varies by EOR project and over time. A significant share of CO_2 can be release again in the EOR operation, with no monitoring currently in place. Because the majority of the around 20 CCS projects currently in operation are dedicated to EOR, it is crucial to ensure that CO_2 is retained after injection. While data for dedicated geological storage facilities show no leakage (Rock et al., 2017), this is not the case for EOR projects, with retention rates during EOR production ranging from as high as 96% to as low as 28%, largely depending on the formation type (Olea, 2015). Therefore, EOR project design must consider maximised storage at a cost, or the effectiveness can be low (Rock et al., 2017; Olea, 2015).
- • If captured CO_2 is used for sparkling drinks or for petrochemical products or synfuels, no CO_2 is emitted from the original source, but **the CO_2 is released after use**. So instead of two units of CO_2 that are emitted without CCUS, one unit is released in total. The net effect is therefore a halving of emissions. This represents a significant improvement, but it is not consistent with the need to decarbonise the global energy system by 2050.
- **• With any CCS system it is key to have monitoring, reporting and verification (MRV)** systems in place to ensure that the capture and storage rate is maximised, and that remaining emissions are correctly accounted for. It is also crucial to account for the storage efficiency, where only geological formations currently offer a viable prospect for carbon neutrality.

IRENA Report (september 2019)

- • **Finally, fossil CCS investments may divert limited capital away from renewable energy** deployment back to fossil fuels. Given the significant increase in renewable energy deployment pace required to meet the 2030 emissions reduction targets, this might not be the most effective use of limited financial resources.
- Rapid scale-up of CCS demonstration and deployment was identified early on as a necessary condition for its uptake (IEA, 2004). However, as of today, CCS remains off track in both power generation (IEA, 2019b) and **industry** (IEA, 2019c), with only 2 and 17 projects, respectively, in operation as ofSeptember 2019. The IEA set targets for CCUS capture levels to reach 350 Mt CO_2/year in power and 400 Mt CO_2/year in industry by 2030. As of September 2019, CCUS reached 2.4 Mt CO_2/year in the power sector and a “potential of” 32 Mt CO_2/year in industry.
- **Many projects have been abandoned or suffered significant delays**. For instance, the Gorgon CCS facility was due to start operations in 2009 (IEA, 2004), while in reality it started a decade later (Global CCS Institute, 2019). Some of the recommendations from the 2004 IEA report remain unaddressed today, and pipeline projects identified suffer significant delays. Thus, as of today, CCS has not scaled up in line with the earlier objectives.
- Currently, two of the operating CCS projects are dedicated to hydrogen production. Both projects are related to refineries, where hydrogen is produced from steam methane reforming and used in refinery processes. One of them, Air Products’ SMR in Port Arthur, Texas, injects CO2 into oil fields for EOR. The second facility, Quest in Alberta, Canada, injects around 1 Mt CO2 /year for long-term geological storage, with successful MRV in place and performed by a third party, DNV GL. The capture rate of 80% was reached most days during the first year of operations, although some days this dropped significantly for various reasons (Rock et al., 2017). The costs of the initial projects are high: the project in Canada has received public funding on the order of CAD 865 million (USD 657 million)3 from the national government and from the government of Alberta (Finanzen.net, 2019).

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Multi-lateral Discussions on Energy

G20 2019 JAPAN

CLEAN ENERGY MINISTERIAL
Accelerating the Transition to Clean Energy Technologies

Energy Ministerial Meeting:

- **G7 (1976) and G20(1999)** Energy Ministerial meetings>> input for G7/G20 meetings
- **Clean Energy Ministerial** (2010,CEM, 28 countries 9 initiatives) and **Mission Innovation** (2015, 24 countries, 8 challenges) meetings
- **IEA Ministerial meeting** (1976): European Countries, North America (*Mexico*), Chile, Japan, Korea, Australia, New Zealand, Turkey, Associate and partners countries (Chine, Inde, Argentina, Russie, Brazil, Indonesia, South Africa, Thailand, Moroccco, Singapore…)

International organizations

- OECD (1945) and IEA(1974), ITF (2006), AEN (1958)
- IRENA (2009)
- REN 21(2005, UNEP secretariat)
- ***United Nations(1945), UNIDO(1967), PNUE (1972), World Economic Forum(Davos) (1971)***
- Plus private organization: World Energy Council(1923), WBCSD(1991), Energy Breakthrough Coalition(2015)…
- Thematic Initiative (GBEP, CSLF, IPHE, REEP, H2 ministerial meeting) and Initiative from CEM, COP21(MI, ISA…)

IEA has a leading role in the international energy landscape

- EBC Energy Business Council, EVI, E4, SDG
- CETP programme
- Official secretariat for Clean Energy Ministerial,
- Strong cooperation with Mission Innovation
- Collaboration with IRENA, REN21

"the IEA's unique positioning as the only organisation that covers the full energy mix, enabling a holistic perspective on developments and their implications at a time when the global energy system is transforming rapidly, with implications both in the medium and long term on energy security"

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“All of IEA” effort on hydrogen in 2019

G20 2019 JAPAN

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Reports / new hydrogen web portal

Source IEA, 2019, EBC April 2019

Technology Network

iea Energy Technology Network
Technology Collaboration Programmes

iea hydrogen

Events

IEA Workshop on HYDROGEN
11 February 2019, Paris

International Energy Agency — Secure Sustainable Together
European Commission

Joint workshop by the International Energy Agency and the European Commission

Electrofuels

Date: Monday 10 September 2018

Convening Power / Business Network

Energy Business Council

Secretariat

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

IEA(Paris) **Beyond G20 Report…**

- **IEA Hydrogen plat form**
  - TCEP H2 Tracking Clean Energy Progress
- **Management of CEM Initiative on Hydrogen**
- **One dedicated person (Junior analyst, modelisation TIMES+ coordination)**
- **Hydrogen Intégration in ETP WEO**
- **Work in progress : Renewable Hydrogen for e-fuel, chemicals, biofuels…**
- **Leading role to coordinate the different international initiatives**
  - CEM Hydrogen, IPHE, Mission Innovation Challenge #8 Hydrogen, Japan Ministerial meeting, Irena
- **Strong integration of Hydrogen TCP as the leading hydrogen TCP in this framework, and other TCPs**
- **Commitment of IEA committee, CERT**

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In 2018 4 new members!

Austria Plus 3 sponsors from India Argentina and Hydrogen Council

Singapore, Portugal, Canada and Thailand in advanced discussion…

European Commission
Dr Beatriz Acosta-Iborra

UNIDO (UN)
Dr Federico Villatico-Campbell

Europe

Austria
Dr Theodor Zillner

Denmark
Mr Jan Jensen

Germany
Mr J.-F. Hake

Italy
Dr Alberto Giaconia

Spain
Dr M Pilar Argumosa

Finland
Dr Michael Gasik

Greece
Dr Elli Varkaraki

Lithuania
Dr R. Urbonas

Sweden
Dr Mikael Lindqvist

The Netherlands
Dr Simone te Buck

France
Mr Paul Lucchese

Belgium
Mr Adwin Martens
Dr Joris Proost

Norway
Mr Trygve U. Riis

Switzerland
Dr Stefan Oberholzer

United Kingdom
Mr Y. Lethbridge

Hychico
Mr Sergio M. Raballo

Shell
Dr C. Patil

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Dr Klaus Bonhoff

Southern Company
Dr N. Meeks

Hydrogen Council
Mr Guillaume de Smedt

Reliance Industries Ltd
Dr Anurag Pandey

Middle East

Israel
Dr Zvi Tamari

Asia - Pacific

Japan
Mr. Eiji Ohira

Korea
Dr Y. Shul
Mr. Seok-Jai Choi

PRC
Dr P. Chen &
Dr Lijun Jiang

Oceania

Australia
Dr Craig Buckley

New Zealand
Dr J. Leaver

ExCo: 21 Countries + European Commission + UN + 6 Sponsors + 1 CP in accession

IEA Hydrogen TCP Tasks – 2015-2020

Created 6 October 1977 Participating Experts – 200-350											
41 tasks approved in whole or part to date – production is most frequent task topic											
NR	NAME	15	16	17	18	19	20	21	22	23	STATUS
28	Large Scale Hydrogen Delivery Infrastructure										completed
29	Distributed and Community Hydrogen (DISCO-H2)										completed
32	H2Based Energy Storage										completed
33	LOCAL H2 Supply For Energy Applications										completed
34	BioH2 for Energy & Environment (Successor to Task 21)										completing
35	Renewable Hydrogen (Super Task)										completing
36	Life Cycle Sustainability Assessment (LCSA) (Successor Task 30)										completed
37	Safety (Successor to Task 31; extended 3 years through 2021)										current
38	Power-to-Hydrogen and Hydrogen to X										current
39	Hydrogen in Marine Transport										current
40	Energy Storage and Conversion based on Hydrogen										approved
41	Analysis and modeling – a reference database (likely to become a "standing task")										ST C approved others in definition
i	Market Deployment and Pathways to Scale										In definition
ii	Biological production & conversion of H2 for energy and chemicals (Successor Task 34)										In definition
iii	Hydrogen Export Supply Chains										In definition
iv	Hydrogen Applications In Primary Sectors (agriculture, mining and resource)										In definition
v	Successor tasks for renewable electrolysis, photoelectrochemical water-splitting (PEC), and solar thermochemical hydrogen production										In definition
vi	Industrial Use of Hydrogen in Middle Income Developing countries										Proposed new

ni n'engagent celles de l IEA

Overarching objectives 2020-2024

#	Topics	Description
1.	Special Focus	**Place special focus on the role of Hydrogen as a facilitator for a smart, sustainable energy system based on renewables:** Hydrogen as an energy carrier; Hydrogen as an energy storage medium; H2 as an Intermediate for e-fuels and chemicals; H2 for Smart Cities
2.	Climate	**Elaborate the role of H2 in deep decarbonization and sustainability of the energy system** for transport, power, heat and industrial uses, highlighting hydrogen's importance in sector coupling and energy storage as well as infrastructure
3.	Core	**Sustain the focus on the core IEA Hydrogen business of R,D&D cooperation** on production, storage, infrastructure, distribution and safety, enlarging the spectrum of hydrogen applications
4.	Global analysis	Consolidate Reference Data base and global sector analysis, maintaining a "living document" on technology development and learning experiences including roadmaps and modeling results
5.	Outreach	**Communicate IEA Hydrogen knowledge and results, as well as hydrogen information from governments, industries and academe** to policy makers, decisionmakers and the greater public
6.	Demand & trade	**Grow global demand for hydrogen and power to gas turbines** while paying special attention to high growth economies and **supporting development of a long distance supply chain and hydrogen trade**
7.	IEA H2 Role	**Position IEA Hydrogen as the key network and hub for international collaboration on H2 R,D&D within the IEA Technology Network** as well as the greater energy community, while cooperating closely with the new IEA hydrogen initiative
8.	IEA H2 Capacity	**Enlarge IEA Hydrogen expert network and grow IEA Hydrogen membership**, thus enhancing resources and capabilities

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Expectations for this workshop and beyond,,,

- **Assesement of CCS/CCUS potential**
- **Evaluation of CCS cost for hydrogen production**
- **Conditions of massive deployment**
- **Impact on financial investors**
- **Integration of CCS H2 in a comprehensive logistic chain**
- **Competition with Low cost low Carbon hydrogen**
- **Social acceptability of CCS CCUS**
- **« Guarantee of Origin » question (« blue Hydrogen »?)**
- **What are the R&D needs for CCS/CCUS to address its main challenges**
- **How to work together and with IEA Secretariat**

Thank you for your attention
Merci de votre attention