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 addressed
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Unprecedented momentum on Hydrogen since last 3 years...

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, addressing 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

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.

Source IEA, 2019
The future of Hydrogen, Webinar

Potential expansion

Electrolysis or Natural gas + CCS
Buffer storage
Local pipeline
(Chemical) Feedstock

Hydrogen imports
Hydrogen grids
Vehicle corridors

Steelmaking

High-temperature heat

Potential expansion

Source IEA, 2019
The future of Hydrogen, Webinar
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 investments
  - Uncertainties on public money availability
  - 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

Enable the renewable energy system → Decarbonize end uses

Enable large-scale renewables integration and power generation

Distribute energy across sectors and regions

Act as a buffer to increase system resilience

Help decarbonize transportation

Help decarbonize industrial energy use

Help decarbonize building heat and power

Serve as renewable feedstock

18% of final energy demand
6 Gt annual CO₂ abatement
$2.5 trillion annual sales (hydrogen and equipment)
30 million jobs created

SOURCE: Hydrogen Council

Technology Collaboration Programme
by 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
Hydrogen today

- 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

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

Operational
Planned
Massive and competitive hydrogen production
In low cost Renewable Areas

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

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

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<th>Without carbon</th>
<th>Containing carbon</th>
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<td><strong>Gaseous</strong></td>
<td>Hydrogen gas (H₂)</td>
<td>Methane (CH₄)</td>
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<td><strong>Liquids</strong></td>
<td>Ammonia (NH₃)</td>
<td>Alcohols (CₓHᵧOH)</td>
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<td>Hydrocarbons (CₓHᵧ)</td>
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There is a great diversity of options for electro fuels, all based on hydrogen, which may correspond to different needs and uses.
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 addressed

- **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 CO₂-free. CO₂-capture efficiencies are expected to reach 85-95% at best,** which means that 5-15% of all CO₂ 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:

  - CO₂ can be stored underground, as proven by several megatonne (Mt)-scale projects. **However, there is increased focus on CO₂ use.** The vast majority of CO₂ that is captured today is used for enhanced oil recovery (EOR). Underground CO₂ retention varies by EOR project and over time. A significant share of CO₂ can be released 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 CO₂ 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 CO₂ is used for sparkling drinks or for petrochemical products or synfuels, no CO₂ is emitted from the original source, but the CO₂ is released **after use.** So instead of two units of CO₂ 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.
- 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 of September 2019. The IEA set targets for CCUS capture levels to reach 350 Mt CO₂/year in power and 400 Mt CO₂/year in industry by 2030. As of September 2019, CCUS reached 2.4 Mt CO₂/year in the power sector and a “potential of” 32 Mt CO₂/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) from the national government and from the government of Alberta (Finanzen.net, 2019).
Outline

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**Multi-lateral Discussions on Energy**

**Energy Ministerial Meeting:**
- 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, Morocco, Singapore...)

**International organizations**
- OECD (1945) and IEA(1974), ITF (2006), AEN (1958)
- IRENA (2009)
- REN 21 (2005, UNEP secretariat)
- 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”
“All of IEA” effort on hydrogen in 2019

Reports / new hydrogen web portal

Technology Network

Convening Power / Business Network

Events

Secretariat

Source IEA, 2019, EBC April 2019

IEA Workshop on HYDROGEN
11 February 2019, Paris

Electrofuels

Date: Monday 10 September 2018
IEA(Paris) Beyond G20 Report...

- IEA Hydrogen platform
  - 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...

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. Eli Varkaraki
- Lithuania: Dr. R. Urbonas
- Sweden: Dr. M. Lindqvist
- The Netherlands: Dr. Simone te Buck

Europe
- European Commission: Dr Beatriz Acosta-Ibora
- UNIDO (UN): Dr Federico Villatico-Campbell

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

Asia-Pacific
- Japan: Mr. Eiji Ohira
- Korea: Dr. Y. Shul, Mr. Seok-Jai Choi
- PRC: Dr. P. Chen & Dr. Lijun Jiang

Middle East
- Israel: Dr. Zvi Tamari

Oceania
- Australia: Dr. Craig Buckley
- New Zealand: Dr. J. Leaver

Hydrogen Council

Austrian Plus 3 sponsors from India Argentina and Hydrogen Council

Singapore, Portugal, Canada and Thailand in advanced discussion...
# 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

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<td>vi</td>
<td>Industrial Use of Hydrogen in Middle Income Developing countries</td>
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<td>Proposed new</td>
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</table>
# Overarching objectives 2020-2024

<table>
<thead>
<tr>
<th>#</th>
<th>Topics</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Special Focus</td>
<td>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</td>
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<tr>
<td>2.</td>
<td>Climate</td>
<td>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</td>
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<td>3.</td>
<td>Core</td>
<td>Sustain the focus on the core IEA Hydrogen business of R,D&amp;D cooperation on production, storage, infrastructure, distribution and safety, enlarging the spectrum of hydrogen applications</td>
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<td>4.</td>
<td>Global analysis</td>
<td>Consolidate Reference Data base and global sector analysis, maintaining a &quot;living document&quot; on technology development and learning experiences including roadmaps and modeling results</td>
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<td>5.</td>
<td>Outreach</td>
<td>Communicate IEA Hydrogen knowledge and results, as well as hydrogen information from governments, industries and academe to policy makers, decisionmakers and the greater public</td>
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<td>6.</td>
<td>Demand &amp; trade</td>
<td>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</td>
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<td>7.</td>
<td>IEA H2 Role</td>
<td>Position IEA Hydrogen as the key network and hub for international collaboration on H2 R,D&amp;D within the IEA Technology Network as well as the greater energy community, while cooperating closely with the new IEA hydrogen initiative</td>
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<tr>
<td>8.</td>
<td>IEA H2 Capacity</td>
<td>Enlarge IEA Hydrogen expert network and grow IEA Hydrogen membership, thus enhancing resources and capabilities</td>
</tr>
</tbody>
</table>

*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 addressed
Expectations for this workshop and beyond,

- Assessment 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