The role of Hydrogen in international energy scenarios and energy policies

Introductory talk to the round table

Paul Lucchese,
IEA Hydrogen TCP Chair

CEA, Université Paris Saclay;

22nd World Hydrogen Energy Conference
June 19th, 2018
IEA HYDROGEN Members - Executive Committee (June 2018)

Europe

- Denmark
  - Mr Jan Jensen
- Germany
  - Mr J.-F. Hake
- Italy
  - Dr Angelo Moreno
- Spain
  - Mr A. Garcia-Conde
- Finland
  - Dr Michael Gasik
- Greece
  - Dr Elli Varkaraki
- Lithuania
  - Dr R. Urbonas
- Sweden
  - Dr Bengt Ridell
- The Netherlands
  - Dr Simone te Buck
- France
  - Mr Paul Lucchese
- Belgium
  - Mr Adwin Martens
- Norway
  - Mr Trygve U. Riis
- Switzerland
  - Dr Stefan Oberholzer
- European Commission
  - Dr B Acosta-Iborra
- UNIDO (UN)
  - Dr F. Villatico-Campbell

Asia - Pacific

- Japan
  - Mr E Ohira
- Korea
  - Dr Y. Shul
- PRC
  - Dr. P. Chen & Dr. Lijun Jiang

Middle East

- Israel
  - Dr A Walter

Sponsors

- NOW
  - Dr Klaus Bonhoff
- Ia HySafe
  - Dr. T. Jordan
- Shell
  - Dr. C. Patil
- Southern Company
  - Dr Noah Meeks

Oceania

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

20 Countries + European Commission + UN + 4 Sponsors
Vision – a hydrogen future based on a clean, sustainable energy supply of global proportions that plays a key role in all sectors of the economy

Mission – accelerate H2 implementation and utilization to optimize environmental protection, improve energy security and economic development

Overarching Objectives
- Communicate role and value of hydrogen as flexible energy carrier in future integrated multi-sector energy system
- Analysis – IEA & other
- Infrastructure
- Industry engagement

Collaborative R,D&D Portfolios
- Production
- Storage
- Integrated Systems
- Integrated Infrastructure

Analysis Portfolios
- Technical
- Market
- Political Decision-making

Awareness, Understanding & Assessment (AUA) Portfolios
- Information Dissemination
- Safety
- Outreach
### IEA Hydrogen Task Portfolio Feb 2018 plus proposals and strategic activities

More than 200 Experts committed

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<td>Hydrogen in Marine Transport</td>
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<td>Data and modeling – a reference database (likely to become a “standing task”)</td>
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<td>Hydrogen in Industry, Intermediates and Buildings</td>
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<td>Successor tasks for renewable electrolysis, photoelectrochemical water-splitting (PEC), and solar thermochemical hydrogen production</td>
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### Strategic Activities

- Ongoing, cross-cutting cooperation with IEA Analysts
- Strategic Planning session May 2018
- Plans to release “Technology Briefs” with major reports

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**AN INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME**
Future strategic directions for IEA Hydrogen TCP
Strategic Plan 2020-2025
First Ideas/directions in progress inside IEA Hydrogen ExCo

Objective: become a reference IEA TCP for international initiatives
Increase dramatically collaboration with IEA and external bodies

- Increase dramatically Analysis work:
  - Work with IEA Mobility team on modelling approaches, comparison of different types of model
  - Establish a reliable, permanent, reference database for hydrogen and fuel cell in collaboration with AFC TCP
  - Work on integrated energy system scenarios

- Work on Infrastructure costs for BEV and FCEC with ETP, EV TCPs and EVI
  - Work on derisking strategies for investment
  - Work on heavy transport maritime, truck, buses etc..
  - Create an IEA FCEV Initiative (like EVI)
  - Hydrogen Uptake studies, investment and funding

- Enlarge the role of hydrogen as an enabler for a global smart energy system

- Enlarge to Hydrogen for Industry, Gas network, Electrofuels/synfuels:
  - Enlarge Hydrogen for mobility for liquid/gaseous fuel, electrofuels, synfuels biofuels in in collaboration with bioenergy, Oil&gas, AMF
  - Develop collaboration with renewables TCPs (Wind, PVPS) to work on massive production of hydrogen
  - Develop work on New international trade of Hydrogen, export/import, materials carriers
  - Collaboration with ISGAN « Towards a Smart energy system »
  - Specific work on Hydrogen for combustion turbine (collaboration to be initiated with Combustion TCP)
  - Common work with ECES (energy storage) and Power to gas tasks

Green Hydrogen Inside
Hydrogen in international policies and energy scenarios
Where are Energy Policy topics/issues discussed at international multi-lateral level?

**Energy Ministerial Meeting:**
- **G7 (1976) and G20(1999)** Energy Ministerial meetings>> input for G7/G20 meetings
- **Clean Energy Ministerial** (2010, CEM, 28 countries) and **Mission Innovation** (2015, 24 countries) meetings
- **IEA Ministerial meeting** (1976): European Countries, North America (*Mexico* new IEA member), Japan, Korea, Australia, New Zealand, Turkey,

**International organizations**
- IEA(1974) and OECD (1045)
- IRENA (2009)
- REN 21 (2005, UNEP secretariat)
- **United Nations UNIDO, World Economic Forum**
- Plus private organization: World Energy Council, WBCSD, Energy Breakthrough Coalition...
- Thematic Initiative (GBEP, IPHE, CSLF, REEP) and Initiative from COP21

**IEA has a leading role in the international energy landscape**
- Official secretariat for Clean Energy Ministerial,
- Strong cooperation with Mission Innovation
- Collaboration with IRENA, REN21
“G20 countries recognised the IEA’s deep expertise and analysis on the challenges of the energy transitions. They welcomed the Energy Transitions report presented by the IEA under the lead of the Presidency, during the ETWG, which assesses countries’ energy transitions, and the Tracking Clean Energy Progress report launched by the IEA in May. Power system flexibility, clean energy innovation, barriers to carbon capture, utilisation and storage, transparency and sharing of best practice were identified as key areas to accelerate the low-carbon transition.”

Second Point G20 conclusions
- MOU signed between IEA and Argentina
G20 highlights the importance of Latin America for global energy collaboration.
- Collaboration with Mexico(Full IEA member), with Chile(Accession country) and Brazil(Association country).

- A regional programme of statistics cooperation (support of the Inter-American Development Bank in cooperation the Latin American Energy Organization, OLADE)
increasing global clean energy investment and finance,
using long-term energy scenarios to inform policy-making,
increasing gender diversity in the energy sector,
enhancing deployment of carbon capture, utilisation and storage solutions.

enhancing the overall flexibility of modern power systems,
accelerating the cost-efficient deployment of distributed generation solutions,
exploring the role of civil nuclear power in integrated energy systems,
furthering regional integration of power systems to enhance efficiencies, decarbonisation and resilience.
MISSION INNOVATION
creation of IC#8 Hydrogen (New Innovation Challenge)@ MI-3 Malmöe, 24th May 2018

- “Hydrogen companies and Mission Innovation governments agreed to work together to develop the hydrogen supply chain”.
- “New initiatives at the national and international level which will help to deliver the Innovation Challenges were announced, include a new Innovation Challenge on Hydrogen co-led by Australia, the EU and Germany was announced”.
New strategic directions for IEA

- expanding the IEA’s mandate on energy security beyond oil to natural gas and electricity;
- opening the agency’s doors to emerging countries: Brazil, Chile, China, India, Indonesia, Morocco, Singapore, South Africa, Thailand
- and turning the IEA into a global clean energy hub, including for energy efficiency, **enhancing TCPs Role**.

the importance of a truly global energy dialogue between government and industry. IEA Energy Business Council*

**Clean Energy Transitions Programme**, a new multi-year, 30M€/year plan to support clean energy transitions around the world and to leverage the IEA’s unique energy expertise across all fuels and technologies to help accelerate global

**Chair, Minister Ibrahim Baylan, Sweden, of the 2017 IEA Ministerial Meeting, 7-8 November 2017**

“In achieving these ambitions, the prominence of the IEA as the world’s leading source of authoritative energy analysis, data and statistics, and a platform for effective international collaboration on global energy challenges was underscored. A key highlight of discussions was the IEA’s unique positioning as the only organisation that covers the full energy mix, enabling a holistic perspective on developments and their 2 (4) implications at a time when the global energy system is transforming rapidly, with implications both in the medium and long term on energy security”

IEA
A three pillar organization

An influential expert international organizations

PARIS Secretariat Team
A referent expert in Energy analysis Scenarios

Network of 39 TCPs

The IEA’s Technology Collaboration Programmes (TCPs)

- A time-proven, flexible mechanism
- Created or discontinued according to energy policy challenges
- Currently 39 TCPs
  - Cross-cutting activities
  - Energy efficiency
  - Fossil fuels
  - Fusion power
  - Renewable energy and hydrogen

AN INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME
### 39 TCPs
### 6000 experts committed

<table>
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<th>Cross-cutting</th>
<th>Fusion power</th>
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<tr>
<td>Climate Technology Initiative (CTI TCP)</td>
<td>Environmental, Safety and Economy of Fusion Power (ESEFP TCP)</td>
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<tr>
<td>Energy Technology Systems Analysis (ETSAP TCP)</td>
<td>Fusion Materials (FM TCP)</td>
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<tr>
<td><strong>End use:</strong> Buildings</td>
<td>Nuclear Technology of Fusion Reactors (NTFR TCP)</td>
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<td>Buildings</td>
<td>Plasma Wall Interaction (PWI TCP)</td>
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<td>District Heating and Cooling (DHC TCP)</td>
<td>Reversed Field Pinches (RFP TCP)</td>
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<td>Energy Storage (ECES TCP)</td>
<td>Spherical Tori (ST TCP)</td>
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<td>Energy Efficient End-Use Equipment (4E TCP)</td>
<td>Stellarator-Heliotron Concept (SH TCP)</td>
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<td>Heat Pumping Technologies (HPT TCP)</td>
<td>Tokamak Programmes (CTP TCP)</td>
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<td><strong>End use:</strong> Electricity</td>
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<td>Demand-Side Management (DSM TCP)</td>
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<td>High-Temperature Superconductivity (HTS TCP)</td>
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<td>Smart Grids (ISGAN TCP)</td>
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<td><strong>End use:</strong> Industry</td>
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<td>Industrial Technologies and Systems (IETS TCP)</td>
<td>Bioenergy TCP</td>
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<td><strong>End use:</strong> Transport</td>
<td>Concentrated Solar Power (SolarPACES TCP)</td>
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<td>Advanced Fuel Cells (AFC TCP)</td>
<td>Geothermal Energy (Geothermal TCP)</td>
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<td>Advanced Materials For Transportation (AMT TCP)</td>
<td>Hydrogen TCP</td>
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<td>Advanced Motor Fuels (AMF TCP)</td>
<td>Hydropower TCP</td>
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<td>Emissions Reduction In Combustion (Combustion TCP)</td>
<td>Ocean Energy Systems (OES TCP)</td>
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<td>Hybrid and Electric Vehicles (HEV TCP)</td>
<td>Photovoltaic Power Systems (PVPS TCP)</td>
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<td><strong>Fossil fuels</strong></td>
<td>Renewable Energy Technology Deployment (RETD TCP)</td>
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<td>Solar Heating and Cooling (SHC TCP)</td>
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<td>Enhanced Oil Recovery (EOR TCP)</td>
<td>Wind Energy (Wind TCP)</td>
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<td>Fluidized Bed Conversion (FBC TCP)</td>
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<td>Gas and Oil Technologies (GOTCP)</td>
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<td>Greenhouse Gas R&amp;D (GHG TCP)</td>
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Climate change mitigation according to COP21 Paris agreement
The IEA 2 Degres Scenario

Key technologies for reducing global CO₂ emissions

Technologies

Renewables 30%
CCS 13%
Power generation efficiency and fuel switching 1%
End-use fuel switching 10%
End-use fuel and electricity efficiency 38%
Nuclear 8%
Transport Sector
ETP 2016: 0.3% H2, ETP 2017?

Vehicle sales and technology shares under different scenarios
Light-duty Vehicles (millions)

- Gasoline ICE
- Diesel ICE
- CNG/LPG
- Hybrids
- Electric & FCV

Heavy-Duty Vehicles (millions)

World electricity demand to double in 2050 time frame
Spectacular market share for electricity in Transport sector
Specific attention/priority to mobility from IEA Team: opportunity (and weakness) for IEA Hydrogen

Biofuels and EVs are complementary solutions for transport decarbonisation

Transport sector final energy demand by fuel in the IEA’s 2DS (2014-60)

Questions for discussion

- How can we put transport decarbonisation at the center of the renewable policy agenda?
- What are the most effective policies to stimulate innovation e.g. cost and GHG emissions reduction, for future transport fuels and technologies?
- Should technology neutral policies to deliver set reductions in fuel GHG intensity e.g. California’s low carbon fuel standard, be more widely adopted?
- What more can be done to accelerate decarbonisation of long haul transport e.g. road freight, shipping and aviation?
- What is needed to develop synergies between EV deployment and increasing shares of variable renewable electricity generation.

Collaboration

- Joint IEA, IRENA and REN21 report on renewable energy policies, including transport.
- IEA electrofuels workshop in 2018
- Bioenergy focus in Renewables 2018
- TCP activity on transport:
How to decarbonize Industry sector?

Note: Direct net CO₂ emissions include energy-related and process emissions.
New 2017 Study from IEA Renewable Division
Renewable Hydrogen (for industrial application) is now an option!

The emergence of low-cost renewable power is a game-changer

Hybrid solar and wind full load hours adjusted for overlap

Capacity factors of combined wind and solar power exceed 50% in vast areas, often remote from large consumption centers, potentially delivering huge amounts of power at less than $30/MWh

Source: Fushi & Breyer, 2017

Competition driving costs down

Announced wind and solar PV average auction prices by commissioning date

Price discovery through competitive auctions effectively reduces costs along the entire value chain. Forthcoming expansion of auctions to more countries will accelerate cost reduction trends.
Producing hydrogen from cheap solar and wind power

At USD 30/MWh or less, and with high capacity factors, solar and wind power in best resources areas can now generate hydrogen at competitive costs.

Producing ammonia from cheap solar and wind

At USD 30/MWh or less, and with high capacity factors, solar and wind power in best resources areas can now run all-electric ammonia plants at competitive costs.
May 2018: Renewable Energy for Industry: Offshore Wind in Northern Europe

Next Step: WEO?

Question Mark:
- Competition with imported H2 from Low cost Renewables región
- Competition with H2 from fossil Plus CCS/CCUS
- Policy framework for International trade of Renewable Hydrogen

Table 1: Offshore wind potential in Northern Europe

<table>
<thead>
<tr>
<th>Volumes in TWh/y</th>
<th>Equivalence to EU demand (%)</th>
<th>Capacity (GW)</th>
<th>Average marginal cost, €/MWh</th>
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<tr>
<td>810</td>
<td>25%</td>
<td>197</td>
<td>54</td>
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<tr>
<td>1620</td>
<td>50%</td>
<td>394</td>
<td>60</td>
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<td>3240</td>
<td>100%</td>
<td>788</td>
<td>64</td>
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<tr>
<td>6480</td>
<td>200%</td>
<td>1576</td>
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Figure 4: Cost of hydrogen from water electrolysis for various electricity prices and electrolysers load factors.

Scenarios IRENA Scenarios: transport sector

- **Transport sector**: Some countries see a potential for hydrogen as a transport fuel. IRENA’s REmap analysis estimates that hydrogen may cover close to 10% of the passenger car and freight segment’s energy demand by 2050, representing close to 7 EJ.

Under REmap, fossil fuels would represent a quarter of sector’s total energy use. Biofuels would represent a quarter of the total demand. Electricity about 44%. The remainder 8% would originate from hydrogen.

Hydrogen fuel cells represent 20% of the total energy demand of the freight sector in REmap 2050.
IRENA scenarios: industrial sector

**Industry sector:** Under REMap, renewables-based hydrogen accounts for around 1% of all industrial energy demand by 2050, or 0.9 EJ. Mainly to replace gas in the process of direct reduction of iron ore, and for the production of ammonia and methanol.

**INDUSTRY**

- Petrochemicals - 25% bioplastics and biofibres - from <4% today
- Cement - 35% new cement types (2.1 Gt)
- Iron and steel - H₂-based processes, more DRI, relocation - 200 iron plants affected

Annually, 1.4 Gt industrial CO₂ emissions are captured.
Hydrogen in World Energy Council scenarios

**Figure 14: Modern Jazz Share of Fuels in Transport (% Share)**
- 2014: 2,619 MTOE
- 2030: 3,079 MTOE
- 2060: 3,423 MTOE

**Figure 38: Hard Rock Share of Fuels in Transport (% Share)**
- 2014: 2,619 MTOE
- 2030: 3,256 MTOE
- 2060: 3,904 MTOE

**Figure 26: Unfinished Symphony Share of Fuels in Transport (% Share)**
- 2014: 2,619 MTOE
- 2030: 3,050 MTOE
- 2060: 3,123 MTOE

**Figure 47: Diversification of Light-Duty Vehicle Fleet in 2010 and 2060**
- Modern Jazz 2060: 29% EV/Plug-in Hybrid, 26% Hydrogen
- Unfinished Symphony 2060: 24% EV/Plug-in Hybrid, 32% Hydrogen
- Hard Rock 2060: 31% EV/Plug-in Hybrid, 10% Hydrogen

Source: The World Energy Council, Paul Scherrer Institute, Accenture Strategy

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Conclusions

• International Organization, especially IEA play a fundamental role in international discussion at government level
• Hydrogen is not yet seen as essential to energy transition and is far behind topics like EV, Bioenergy, smart Grid, renewables
• There is a first recognition of Hydrogen and a « consensus »: Renewable Hydrogen for Industry (IEA, IRENA)
• This must be translated soon in energy scenarios
• Power to Gas is considered as interesting but no business model soon
• Hydrogen for mobility
  • First application for fleet, heavy and public transportation could be « considered »
  • **Tough Point: Hydrogen doesn’t exist for massive application like passenger cars (a lot of skepticism)**
• Hydrogen community must work inside international organization to understand and convince
• IEA Hydrogen will act strongly to that goal. with others organizations
Questions for Round Table

1- Could you please explain briefly how you design energy scenarios? What are your models and tools?

2- Does hydrogen play a role? If not, could you tell us why?

3- As you know, hydrogen could play a role in a number of sectors (industry, transport, residential). Hydrogen can also facilitate the development of renewables by providing flexibility to the electricity grid (through balancing services), and by interconnecting energy networks such as gas, heat and power. How taking this into account in the models?

4- Good models are based on reliable and consistent data. What would be your recommendations to develop a reliable hydrogen dataset to be used by modellers?

5- Do you see other key issues for hydrogen to be introduced in energy scenarios?

6- To conclude, do you have any additional comment?

Video from IEA Paris
Video from Tractebel
Panel for the round table

- Sheila Samtsatli University of Bath, UK
- Reinhold Wurster, LBST, Germany
- Martin Robinius, FZJ, Germany
- David Hart, E4Tech, UK and Switzerland
- Guillaume de Smedt, Hydrogen Council
- Paul Lucchese, IEA Hydrogen