IEA Hydrogen: Technology diplomacy in practice

Mary-Rose de Valladares
Stefan Oberholzer, Paul Lucchese

WHTC 14 July 2017
### IEA HIA Members - Executive Committee (July 2017)

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<tr>
<th>Europe</th>
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<tr>
<td>Denmark</td>
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<td>Germany</td>
<td>Mr J.-F. Hake</td>
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<td>Italy</td>
<td>Dr Angelo Moreno</td>
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<td>Spain</td>
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<td>Dr Michael Gasik</td>
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<td>France</td>
<td>Mr Paul Lucchesse</td>
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<td>Mr Adwin Martens</td>
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<td>Mr Y. Lethbridge</td>
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<td>Ms Hayasaka</td>
<td>Dr Y. Shul</td>
<td>Dr. P. Chen &amp; Dr. Lijun Jiang</td>
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21 Countries + European Commission + UN + 4 Sponsors
IEA HIA Strategic Framework

AN INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME
The culture of science

- The essence of science is **discovery**
- Scientists “lean In” to conditions that enhance the discovery process in the service of their research
- Scientists seek to **understand**

*Science is built up of facts, as a house is built of stones; but an accumulation of facts is no more a science than a heap of stones is a house.* (Henri Poincare, “a polymath)

- This feature of “scientific culture” – the drive to understand -- generally tends to **reduce barriers to cooperation and community development.**
- **Cooperation** – with other scientists and research efforts – facilitates the discovery process
culture

is a system of values and norms that are shared among a group of people and that when taken together constitute a design for living.

Source: Slideshare
Determinants of Culture

Source: Slideshare
Norms are the social rules and guidelines that prescribe appropriate behavior in particular situations.

Source: Slideshare
Values

Values are abstract ideas about what a group believes to be good, right, and desirable.

Source: Slideshare
Culture

**society**

refers to a **group of people who share a common set of values and norms**

Source: Slideshare
Determinants of Culture Continued

Source: Slideshare
Competitive Advantage of Nations (and Regions)

Michael E. Porter’s Diamond Model

- Government
- Firm Strategy, Structure, and Rivalry
- Factor Conditions
- Demand Conditions
- Related and Supporting Industries
- Chance
Industry Outreach in Hydrogen

New Hydrogen Council launched at WEF in Davos, January 2017
13 leading energy, transport and industry companies have launched a global initiative to voice a united vision and long-term ambition to help achieve the ambitious goal of reaching the 2 degrees Celsius target.

«How hydrogen empowers the energy transition»
www.hydrogencouncil.com, January 2017
Analysis and Budget
AN INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME

POLICY MAKING AND BUDGET DEVELOPMENT
1-2 YEAR CYCLE

POLICY MAKING AND BUDGET DEVELOPMENT
5 YEAR CYCLE

POLICY MAKING AND BUDGET DEVELOPMENT
10 YEAR CYCLE

ANALYSIS

POLICY

2010

2030
There are bankable business cases for PtoH in Europe already today

- By 2025, the European market for PtoH is estimated at a cumulative 2.8 GW, representing a market value of 4.2B€ and 400 ktons H2 per year.
- Bankability can be achieved by complementing hydrogen sales with electricity grid flexibility services
- Combining PtoH for mobility/industry applications and gas grid injection is more cost-effective than stand-alone injection
- PtoH is a practical and system-beneficial way to value excess of RES but requires a long-term view on grid fees, taxes and levies to enable bankability
Leading Western and Asian Countries H2 Infrastructure Plans

How hydrogen empowers the energy transition
www.hydrogencouncil.com
January 2017

1 Publicly available HRS from countries with a significant HRS network development
2 Countries or states with no major HRS outlook as of today
3 Depending on the number of FCEVs on the road
Source: Hy Mobility, US DOE, Hydrogen Europe, Air Liquide
AN INTERNATIONAL ENERGY AGENCY TECHNOLOGY COLLABORATION PROGRAMME

- Perspectives
- Members
- Strategic Framework
- Themes
- Task Portfolios

- Success Stories – IEA HIA wide
- Success Stories - Tasks
- Information Dissemination & Outreach
- Key Numbers & Outcomes

- Overarching Objectives
- Priorities for all themes
- Priorities for Analysis portfolios
- Current task highlights

- The IEA Technology Roadmap for Hydrogen and Fuel Cells
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:
To accelerate hydrogen implementation and widespread utilization to optimize environmental protection, improve energy security and promote economic development internationally while establishing the HIA as a premier global resource for expertise in hydrogen

Strategy:
To facilitate, coordinate and maintain innovative research, development and demonstration activities through international cooperation and information exchange
Themes and Portfolios

Collaborative RD&D that advances hydrogen science and technology
- Hydrogen production
- Hydrogen storage
- Integrated hydrogen systems
- Integration of hydrogen in existing infrastructure

Analysis that positions hydrogen
- Technical progress and optimization
- Market preparation and deployment
- Support in political decision-making

Understanding, Awareness and Acceptance that fosters technology diffusion and commercialization
- Information dissemination
- Safety
- Outreach
Overarching Objectives for the period 2015-2020

- **Broaden the perspective on the transformative role of H2** by articulating and communicating its functions and value as a highly flexible energy vector and energy carrier capable of serving as a **weapon against climate change** in an integrated future multi-sector energy system.

- **Focus on the development and implementation of the H2 infrastructure**

- Formulate messages derived from IEA HIA technical and analytic activities guide in order to guide and inform **policy making** activities.

- **Foster productivity and progress**

- **Cultivate and deepen industry participation**

- **Strengthen analysis activities**

- **Raise the profile of the IEA HIA**
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<td>Fundamental &amp; Applied H2Storage Materials Development</td>
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<td>Small-Scale Reformers for on-Site H2Supply</td>
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<td>Wind Energy and Hydrogen Production (Electrolysis)</td>
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<td>High Temperature Production of Hydrogen</td>
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<td>Advanced Materials for Waterphotolysis with H2</td>
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<td>Near-Term Market Routes to H2via Co-Gasification with Biomass</td>
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<td>Large-Scale Hydrogen Delivery Infrastructure</td>
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<td>Distributed and Community Hydrogen (DISCO H2)</td>
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<td>32</td>
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<td>Local H2Supply for Energy Applications</td>
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<td>BioH2 for Energy &amp; Environment (Successor to Task 21)</td>
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<td>35</td>
<td>Renewable Hydrogen (Super Task)</td>
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<td>36</td>
<td>Life Cycle Sustainability Assessment (LCSA) (Successor Task 30)</td>
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<td>37</td>
<td>Safety (Successor to Task 31)</td>
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<td>38</td>
<td>Power-to-Hydrogen and Hydrogen to X</td>
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<td>39</td>
<td>Hydrogen in Marine Transport</td>
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R,D&D: Production

Task 33: Local H2 Supply for Energy Applications
(2013-2016) – Applied (successor to Task 23)

- Evaluation and harmonization of various technologies for local H2 supply for reduced costs and increased employment
- Expands research to include electrolysers as well as reformers
- Significant industry participation = INDUSTRY NETWORK
- 16 Participants from 15 organizations in 10 Member countries plus EC

Key Findings:

- Small-scale electrolysers and reformer systems with hydrogen capacities in the range of 50-500Nm3/hr are commercially available. The specific cost (CAPEX) [USD /per NM3/hr] of small scale water electrolyzers and reformers are comparable

- Both alkaline and PEM water electrolyzers are available in MW scale. While PEM is less proven and more costly (CAPEX) than alkaline, it is more compact and suitable for dynamic load following.
**R,D&D: Production**

- Subtask 1 - BioHydrogen production (Dark Fermentation and Bioelectrolysis; light-drive BioHydrogen production; Enzymatic and Bio-inspired Molecular Systems)
- Subtask 2 – Applied Research and Biohydrogen Production
- 11 Participants: Member Countries; Asian concentration; solid European participation; participation expected to grow (Europe, Asia, Latin America)

**Key Findings:**
- Key drivers for biohydrogen technology are not only the demand for renewable energy
- But also the need for waste treatment, water recovery and other valuable resources such as phosphate
R&D&D: Production

Task 35 Renewable Hydrogen Production (2014-2017) - Basic

- **SUPER TASK**
- Subtask 1 – Renewable Electrolysis
- Subtask 2 – Photoelectrochemical Solar Water-Splitting
- Subtask 3 – Solar High Temperature Thermochemical Cycles
- 30 Participants from 10 Member countries plus EC; US concentration

**Renewable Hydrogen Options**
R,D&D: Production

Recent Highlights

- **Subtask 1 – Renewable Electrolysis**
  - Several Megawatt scale wind to hydrogen projects underway in the US

- **Subtask 2 – Photoelectrochemical Solar Water-Splitting (24 March 2017):**
  - World's largest artificial sun at DLR, Germany with 149 7-kW xenon short-arc lamps delivering
  - 11 MW/m² (max. 320 kW), used for research on hydrogen production with concentrated solar power
R,D&D: Hydrogen Storage

- Further research on new and improved compounds and demonstration of solid storage systems for stationary, mobile and portable applications, as well as electrochemical storage
- World’s largest R&D collaboration in H2 Storage
- Project based participation: 52 experts from 17 Member countries organized in 6 working groups:
  - Porous materials
  - Magnesium-based H2 and energy storage materials
  - Complex and liquid hydrides
  - Electrochemical storage of energy
  - Heat storage – concentrated solar thermal using meta hydrides
  - H2 storage systems for mobile applications
- A special issue of the international journal ‘Applied Physics A’ by Springer has recently been published

Key Findings:
- Concentrating Solar-thermal power plant, heat storage tank system - Andasol 28,500 t molten salt for storage of 1,000 MWh could be replaced by 1,100 t MgH2
- Modified Sodium hydride (NaH) shown to be reversible for the first time after four cycles
Market Readiness Assessment for “Japanese residential CHP”
Task 29, Subtask 4 – Concept Replicability

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<th>ASSESSMENT DIMENSION</th>
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<td>2</td>
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<td>1 Reformer subsystem maturity</td>
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<tr>
<td>2 Fuel cell subsystem maturity</td>
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<tr>
<td>3 Boiler subsystem maturity</td>
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<td>4 BOP system maturity</td>
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<td>5 System software maturity</td>
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<td>6 Integration between hydrogen components in the system</td>
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<tr>
<td>7 Integration with existing energy technologies</td>
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<td>8 Manufacturing capacity for replication</td>
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<td>9 Product documentation maturity – technical, marketing</td>
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<td>12 Economic validation – case studies, documentation</td>
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<td>14 Multiplicity of suppliers and market standardisation</td>
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<td>21 Application performance standards</td>
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R,D&D: Infrastructure Portfolios - Integrated H2 Systems/ Integration in Existing Infrastructure


Overall goal is to provide knowhow on the use of hydrogen and fuel cells in the maritime:

- Subtask 1 – Technology Overview
  - Investigate possibilities for use of hydrogen in the maritime
- Subtask 2 – New Concepts
  - Contribute to new concepts, technologies and components
- Subtask 3 – Demonstration
  - Provide input, evaluate and link international demonstration projects
- Subtask D – large-scale storage and greening of gas
- Growing Participation - To date11 Member countries and EC confirming (all European but clear US interest)

Rationale:

- Shipping is the primary means of transportation worldwide
- 90% of all trade between countries is on ships
- Ports in the UE handles 400 million passengers in 2013
- Nexus of land and sea provides infrastructure opportunities
Analysis

- Environmental challenges
- Economic Analysis
- Social Indicators and Integrative approaches for LCSA
- 2 papers published: one in Springer and one in Elsevier

Fig 1 shows the decision diagram designed for the harmonisation process. In the first block of the diagram, choices about general modelling approach, LCIA method and system boundaries are tackled.
Analysis

Task 38: Power to Hydrogen and Hydrogen-to-X: System Analysis of the techno-economic, legal and regulatory conditions

– Subtask 1: Management and Communication
– Subtask 2: Mapping and analysis of existing demo projects
– Subtask 3: Deliverables
– Subtask 4: Specific Case Studies
Hydrogen Awareness, Understanding and Acceptance (AUA): Safety

- Subtask A – Integrated Tool Kit for Hazards and Risk Assessment
- Subtask B – Accident Scenarios/Sequences Development
- Subtask C – Physical Effects
- Subtask D – Human Reliability Analysis (HRA)
- Subtask E – Materials Compatibility

Key Findings:
- Clear need to create harmonious safety codes and standards.
- (C&S) to accelerate worldwide adoption of hydrogen-based technologies.
- Insufficient technical data to revise C&S remains a challenge.
- Usage and access restrictions (for road tunnels, parking structures) are a challenge.
- Tasks 19/31 held an End of Task North American Workshop in 2013; a companion workshop is expected to be held in 14 September in Hamburg
ICHSH Conference 2017

INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY

September, 11-13 2017 - Hamburg (Germany)
Follow us on Twitter  @IEA_Hydrogen
Thank you from the IEA HIA
A premier global resource for technical expertise in H2 RD&D

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