IEA HIA: A Sustainable International Framework & Strategies for Collaborative RD&D in Hydrogen Energy

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Mr. Jan Jensen, Dr. Steven Pearce (ExCo. Vice Chairs)
Dr. Nicolas Lymberopoulos (UNIDO – ICHET)
Ms. Mary-Rose de Valladares (ExCo. Secretariat Manager)
Autonomous body within the Organization of Economic Cooperation and Development (OECD), founded in 1974 to carry out energy cooperation among member countries.
The International Energy Agency (IEA) is an intergovernmental organization of 30 member countries that aims to ensure sustainable energy policies. The IEA Organization is structured into several key groups:

- **Governing Board**
- **Standing Group on Long-Term Cooperation (SLT)**
- **Committee on Non-Member Countries (CNMC)**
- **Committee on Energy Research and Technology (CERT)**
- **Standing Group on Oil Market (SOM)**
- **Standing Group on Emergency Questions (SEQ)**

TheIEA has various working parties focused on different aspects of energy:

- **End-Use**
- **Fossil Fuels**
- **Renewable Energies**
- **Fusion**

Implementing Agreements is a collaborative R&D&D program under the IEA. The chart below illustrates the structure and key components of the IEA Organization.
Hydrogen Implementing Agreement (HIA)
A collaborative research and development (R,D&D) program
Created in 1977 on a task-shared, “bottom-up” basis

Strategic Framework

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 (RD&D) activities through
international cooperation and information exchange
<table>
<thead>
<tr>
<th>Collaborative R&amp;D</th>
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<tbody>
<tr>
<td><strong>Annex / Task:</strong></td>
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<tr>
<td>Basic unit of organization in HIA.</td>
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<td>Several members collaborate on each task.</td>
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<td><strong>Operating Agent:</strong></td>
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<td>Manages Annex – <strong>Experts</strong> do work</td>
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<td><strong>Tasks-Shared:</strong></td>
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<td>Member countries fund their expert researchers directly according to the level of person hours agreed upon in each task.</td>
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## IEA HIA Members - Executive Committee

### Europe

- **Denmark**
  - Mr. Jan Jensen
  - Co Vice-Chair
- **Germany**
  - Mr. J.-F. Hake
- **Italy**
  - Mr. Agostino Iacobazzi
- **Spain**
  - Mr. A. Garcia-Conde
  - Chair
- **The Netherlands**
  - Mr. Frank Denys
- **Finland**
  - Dr. Heikki Kotila
- **France**
  - Mr. Paul Lucchesi
- **Iceland**
  - Dr. Agusta Loftsdottir
- **Norway**
  - Dr. Stian Nygaard
- **Switzerland**
  - Dr. Stefan Oberholzer
- **United Kingdom**
  - Mr. Ray Eaton
- **United States**
  - Dr. Carole Read

### North America

- **Canada**
  - Mr. Nick Beck
- **United States**
  - Dr. Carole Read

### Asia - Pacific

- **Japan**
  - Dr. T. Itomi
- **Korea**
  - Mr. Kijune Kim

### Oceania

- **Australia**
  - Dr. J. Wright
- **New Zealand**
  - Dr. S. Pearce
  - Co Vice-Chair

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**23 Contracting Parties**

AN IMPLEMENTING AGREEMENT OF THE INTERNATIONAL ENERGY AGENCY
UNIDO in brief

- Established in 1966 in Vienna, Austria.
- **Mandate:** to promote industrial development for poverty reduction in developing countries and economies in transition.
- 173 States are members.
- First time that any UN agency joins the IEA.
- UNIDO’s participation delegated to ICHET.
### IEA HIA Tasks Since 1977

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<td>2. High-Temperature Reactors</td>
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<td>3. Potential Future Markets</td>
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<td>4. Electrolytic Production</td>
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<td>5. Solid Oxide Water Electrolysis</td>
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<td>6. Photocatalytic Water Electrolysis</td>
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<td>7. Storage, Conversion and Safety</td>
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<td>8. Techno-Economic Assessment</td>
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<td>9. Hydrogen Production</td>
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<td>10. Photoproduction of Hydrogen</td>
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<td>11. Integrated Systems</td>
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<td>12. Metal-Hydride for H₂ Storage</td>
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<td>14. Photoelectrolytic Production</td>
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<td>15. Photobiological Production</td>
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<td>16. H₂ from Carbon-containing mat.</td>
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<td>17. Solid &amp; Liquid Storage Materials</td>
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<td>18. Integrated Systems - II</td>
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<td>19. Hydrogen Safety - II</td>
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<td>22. Fundamental &amp; Applied H₂ Storage Materials Development</td>
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<td>25. High Temp. Processes for H₂ Production</td>
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<td>26. Advanced Materials for H₂ from Waterphotolysis</td>
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<td>27. Near-Market Routes to H₂ by co-utilization of biomass with fossil fuel</td>
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<td>28. Large Scale Hydrogen Delivery Infrastructure</td>
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Strategic Framework 2009 - 2014
2009 – 2014 Themes

Collaborative R, D & D
that advances hydrogen Science and Technology
- Hydrogen Production
- Hydrogen Storage
- Integrated Hydrogen Systems
- Hydrogen integration in existing infrastructure

Analysis that Positions Hydrogen for
- Technical progress and optimization
- Market preparation and deployment
- Support in political decision-making

Hydrogen Understanding, Awareness and Acceptance
that foster technology diffusion and commercialization
- Information Dissemination
- Safety
- Outreach

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Current Tasks by Theme and Portfolio

Collaborative R,D&D

**Production**
23. Small-Scale Reformers for On-Site H₂ Supply (SSR for H₂)
24. Wind Energy and H₂ Integration
25. High Temperature Processes for H₂ Production
26. Advanced Materials for Waterphotolysis of Hydrogen
27. Near Term Market Routes to Hydrogen by Co Utilization of Biomass as a Renewable Source with Fossil Fuels

**Storage**
22. Fundamental and Applied H₂ Storage Materials Development

**Integrated H₂ Systems**
18. Integrated Systems Evaluation
23. Small-Scale Reformers for On-Site H₂ Supply (SSR for H₂)
2X. Distributed and Community Hydrogen (in definition)

**H₂ Integration in the Existing Infrastructure**
23. Small-Scale Reformers for On-Site H₂ Supply (SSR for H₂)
28. Large Scale Hydrogen Infrastructure and Mass Storage
Current Tasks by Theme and Portfolio

Analysis that Positions Hydrogen

**Technical, Market and Support for Political Decision-making:**

3X. New Analysis Task (in definition).

Hydrogen Awareness, Understanding and Acceptance

**Safety:**

19. Safety

**Information Dissemination**

**Outreach**
Theme: Collaborative R,D&D

Portfolio: HYDROGEN PRODUCTION
Task 21: BioHydrogen

October 2005-May 2009 (Successor task proposed)

- Evolved from Task 15
  May 1999-July 2005 (completed)
  R&D Progress toward development of H₂ production by microalgae

- Includes four areas of investigation:
  - Hydrogen dark fermentations
  - Photobiological hydrogen production systems
  - Bio-inspired systems
  - Overall analysis

Achieved better genomic understanding of H₂ producing strict anaerobes

OA: Dr. Jun Miyake
Task 23: Small-Scale Reformers for On-Site $H_2$ Supply

December 2006 - December 2011 (recently extended)

- Development of reformer technologies and distributed on-site reformer based $H_2$ supply systems
- Contributing to norms & fast-tracking deployment
- Three Subtasks:
  1) Harmonized Industrialization
  2) Sustainability and Renewable Sources
  3) Market Studies

OA: Dr. Ingrid Schjølberg of Sintef
Task 24: Wind Energy and H₂ Integration

December 2006-December 2010

- Mid-term R&D for entire wind to hydrogen production chain
- Four Subtasks:
  1) Subtask A – State of the Art
  2) Subtask B – Improvements and System Integration
  3) Subtask C – Business Concept Dev.
  4) Subtask D – Applications with Emphasis on wind energy management
- Setting the stage for large-scale use of renewable wind energy for H₂ production
- Aims for full wind and H₂ integration via storage and electrical conversion

OAs: Dr. Luis Correas - Ismael Aso (Hidrógeno Aragón)
Task 25: High Temperature Processes for H\textsubscript{2} Production

May 2007 - May 2011

- Will support production of massive quantities of zero-emission H\textsubscript{2} through use of high temperature processes (> 500 °C) coupled with nuclear and solar heat sources.
- Three process families: thermochemical cycles, steam electrolysis, and innovative water splitting.
- Four subtasks:
  A. State of the Art
  B. Methodology approach of HTPs
  C. HTP R&D and future industrial development
  D. Information Dissemination
- Producing Summary Sheets on high temp processes in general and detailed versions.

OA: Ms. Sabine Poitou of CEA
Task 26: Advanced Materials for Waterphotolysis of $H_2$

May 2008 – May 2011

- **Aim:** Photoelectrochemical (PEC) materials that enable net solar-to-hydrogen conversion efficiency of 10% in PEC water-splitting
- **4 Subtasks:**
  1. Materials “Theory” R&D
  2. Materials “Synthesis” R&D
  3. Materials “Characterization” R&D
  4. “Information Coordination/Database” Development

**OA:** Dr Eric Miller of Hawaii Natural Energy Institute, University of Hawaii, Manoa
Task 27: Near-Market Routes to \( \text{H}_2 \) by Co-Utilization of Biomass as a Renewable Energy Source with Fossil Fuel

2008 – 2011

**Objective:** To advance the development of \( \text{H}_2 \) production based on renewable sources (biomass) – focusing market

- **4 Subtasks:**
  - **A.** Co-gasification of biomass with fossil fuels
  - **B.** Hydrogen market facilitation based on distributed processing of biomass to new **tradable intermediates**
  - **C.** Near term stand-alone biomass gasification
  - **D.** Roadmap – development and verification

**OAs:** Dr Jan-Erik Hanssen and Ms. Elif Caglayan

Source: Shell
Theme: Collaborative R,D&D

Portfolio: HYDROGEN STORAGE
Task 22: Fundamental and Applied Hydrogen Storage Materials Development

December 2006-November 2012 (recently extended)

- **3 Targets:**
  - Reversible or regenerative storage media
  - Fundamental & engineering understanding
  - Storage materials for stationary apps.

- **20 HIA countries, 53 projects:** World’s largest collaboration on H$_2$ storage
  - **Project types:** experimental, engineering, theoretical, safety
  - **Classes of Materials:** Reversible metal hydrides, Regenerative hydrogen storage materials, Chemical hydrides, Nanoporous materials, Rechargeable organic liquids and solids
  - Gordon Conference style meetings: ultimate forum for expert cooperation;
  - 450+ publications/articles; 450+ presentations up to December 2008
  - 17 patents from predecessor Task 17 (June 2001-May 2006)

**OA:** Dr. Bjørn C. Hauback of IFE
Theme: Collaborative R,D&D

Portfolio: INTEGRATED H₂ SYSTEMS
Task 18: Integrated Systems Evaluation

January 2004 – December 2009 (recently completed)

- **Phase 1 - Subtasks A and B.**
  - Phase 2 includes Subtask C.

- **Subtask A Phase 1 - World’s best address for information and analysis on H₂ and integrated systems:** [http://iea-hia-annex18.sharedpointsite.net/Public/default.aspx](http://iea-hia-annex18.sharedpointsite.net/Public/default.aspx)

- **Subtask B Phase 1 - Modeling & existing analysis tools to evaluate H₂ projects.** H₂ Demonstration Projects Development covers state of the art

- **Case Studies** [http://www.ieahia.org/page.php?_s=d&p=casestudies](http://www.ieahia.org/page.php?_s=d&p=casestudies)

- **Subtask C Phase 2 - Synthesis and Learning** to bridge Subtask A and B experience and provide lessons learned, benchmark assessments and trend analysis

**OA:** Dr Susan Schoenung (Longitude 122 West, Inc., USA)
Task 23: Small-Scale Reformers for On-Site H₂ Supply

Development of reformer technologies and distributed on-site reformer based H₂ supply systems

Contributing to norms & fast-tracking deployment

Three Subtasks:

1) Harmonized Industrialization
2) Sustainability and Renewable Sources
3) Market Studies

OA: Dr. Ingrid Schjølberg of Sintef
Task in Definition

Distributed and Community Hydrogen

Coming soon!

Theme:
Collaborative R,D&D

Portfolio:
H₂ INTEGRATION IN EXISTING INFRASTRUCTURE
**Task 23: Small-Scale Reformers for On-Site H₂ Supply**

December 2006 - December 2011
( recently extended )

- **Development of reformer technologies and distributed on-site reformer based H₂ supply systems**
- **Contributing to norms & fast-tracking deployment**
- **Three Subtasks:**
  1) Harmonized Industrialization
  2) Sustainability and Renewable Sources
  3) Market Studies

**OA: Dr. Ingrid Schjølberg of Sintef**
Task 28: Large Scale H₂ Delivery Infrastructure

May 2010 – April 2013 (pending final approval in May)

- **Four objectives:**
  1. International expert group
  2. Development assessment criteria for application to various large scale infrastructure concepts
  3. Improve understanding of H₂ infrastructure
  4. Support IEA ETP

- **Seven Subtasks:**
  1. Coordination
  2. Definition
  3. Tools for design and analysis
  4. Boundary Cond. & Key Attributes
  5. H₂ Delivery Routes
  6. Knowledge Management
  7. Dissemination

**OA:** Dr. Marcel Weeda
Theme:
Analysis that Positions Hydrogen

Portfolio:
TECHNICAL, MARKET AND SUPPORT FOR POLITICAL DECISION-MAKING
Past Technical Analysis

Near Term

Medium Term

Long Term

R&D Priorities and Gaps in H₂ Production and Storage

Available for downloading at http://www.ieahia.org/iea_publications.html
Task in Definition

Analysis that Positions Hydrogen

Coming soon!
Theme:
Hydrogen Awareness, Understanding and Acceptance

Portfolio:
SAFETY
Three subtasks laying foundation for codes & standards:

A. Survey of Quantitative Risk Assessment (QRA) methodologies and testing methodologies

B. Testing and Experimental Program: will evaluate the effects of equipment, product and/or system failures under a range of real-life scenarios, environments or mitigation measures

C. Targeted information packages for stakeholder groups such as: permitting officials, insurance providers, system developers, manufacturers, early adopters.

OA: William Hoagland (W. Hoagland & Associates, USA)
Developed vs Developing World

A view of Hydrogen in Developing World

Dr. Nicolas Lymberopoulos (UNIDO - OCHET)
A Hydrogen-inclusive Future

**Developed World: well established players**
- US, Canada, Japan, EU, IEA-HIA, IPHE

**What about the developing world?**

- Over 70% of increase in world primary energy demand between 2004-2030 comes from developing countries.
- By 2030, China and India account for 57% of world coal demand, up from 43% in 2004.
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**CHINA**

**7.4 million USD** for basic research (937 Program) on:
1) Fundamentals of Large-scale Production, Storage and Transportation of Hydrogen and the Related Fuel Cells
2) Hydrogen Production using solar energy

**106 million USD** for demonstration, commercialization, support of Chinese car industry (863 Program):
1) Hydrogen technologies
2) High Temp fuel cells
3) Clean coal incl. H₂ production

In 2006, 10 prototype fuel cell cars were developed and tested
In 2003, a National Hydrogen Energy Board has been set up under Ministry of New and Renewable Energy.

In 2007 a Hydrogen Roadmap was published:

2. Green Initiative for Power Generation (GIP): 1000 MW of H₂ powered ICES, GTs, high temp FCs.
3. Recent order for 40,000 FC-based UPS for telecom.
BRAZIL

- The only Latin American country member of IPHE
- 50% share of global ethanol trade
- Brazilian Government is elaborating policy and strategies for the Hydrogen Economy – road map

1) Hydrogen will be part of the Brazilian energy resources in 2020
2) Ethanol is the main source of Hydrogen
3) Hydrogen production from electrolysis using excess power from hydroelectric power plants
4) Main applications: distributed generation, isolated systems, urban buses
SOUTH AFRICA

- South Africa’s dominating position in platinum reserves (more than 75% of the world known reserves),
- South Africa’s leading position in the coal gasification to liquid fuels technology.
- Abundant solar energy

1) Supply 25% of catalysts demand for the global fuel cell industry by 2020
2) Develop local cost competitive hydrogen generation solutions (PGM based & others)
3) Create sustainable jobs linked to the country’s minerals wealth
The International Centre for Hydrogen Energy Technologies is a UNIDO project with the mission of demonstrating viable implementations of hydrogen energy technologies and facilitating their widespread use in developing countries.
UNIDO-ICHET Background

- UNIDO-ICHET is located in Istanbul, Turkey
- Formed in 2003 - trust fund agreement between UNIDO and Turkish Government (Ministry of Energy and Natural Resources)
- Started operation in 2004
- Budget $40M over 5 years
- Currently, staff of about 25
ICHET Activities

- Design and implementation of demonstration projects
  - H₂ 3-wheelers, New Delhi, India
  - Bozca Hydrogen island, Turkey
  - FC-based UPS, Turkey
  - Fuel cell fork-lift, Turkey
  - Hydrogen FC boat, Turkey

- R&D projects / Test laboratories
  - PEM FCs
  - Bio-electrolysis
  - Photo-electrolysis

- Conferences and workshops

- Training and education

- Networking

- Support to UNIDO Director General

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ICHET Support Instruments

- **Pre-feasibility Studies**
  - Support up to 10 studies/year at US$ 10,000 per study, 100% funding
  - Application form available to download at web site
  - Allows expert/consortia to apply
  - Evaluations every 3 months

- **Pilot Projects**
  - Support 1-2 selected projects per year in developing countries with an ICHET support of up to 500,000 of US$, 50% funding

- **R&D Projects**
  - Support 1-2 selected projects per year in Turkey with an ICHET support of up to 500,000 of US$, 50% funding
**DEHY-3W**

**H₂ 3-wheelers in India**

- 15 vehicles will be converted to run on H₂ in the city of N. Delhi, taking visitors from the Metro station to the Pradap Meidan Exhibition Ground.

- 5 partners involved, IIT Delhi, Mahindra & Mahindra, UNIDO-India, Air Products, ICHET.

- Total budget >1 M US$, ICHET support of 0.5 M US$ in the form of funds to experts and equipment.
Demonstration Projects

Bozcaada, Turkey
H₂ island project

- 25 kW wind turbine
- Local grid 220V
- Control Strategy
- 25 kW Electrolyzer
- H₂ storage cylinders @220 bar
- H₂O
- Compressor
- Hospital
- Governor’s House
- 10 kW Fuel Cell UPS
- 5 kW Fuel Cell Boat
- 5 kW Fuel Cell Golf-cart
- 5 kW Fuel Cell UPS
- Total Budget 1.5M US$ 100% funded by ICHET

Hospital
Governor’s House
5 kW Fuel Cell Boat
5 kW Fuel Cell Golf-cart

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UNIDO
ICHET

UNIDO
ICHET
Demonstration Projects

Aitutaki, Cook Islands

H₂ island project

- Total Budget approx. 6.45 M US$
- GEF financing of 3 M US$
- Proposal has been approved by GEF Council
Project objectives:
- to design the prototype forklift using a 8 kW fuel cell and suitable hydrogen storage systems to fit within the existing battery compartment.

Project benefits:
- to provide consistent power while releasing no harmful emissions
- to conduct trial runs and demonstrations
- to submit healthy ambiance to the forklift operator

Project deliverables
- design and production of the forklift and procurement of the fuel cell
- mounting the fuel cell to the forklift
- operational trials and demonstration

Project partners:
ICHET, ÇUMİTAŞ

Tech Development Projects
Hydrogen-Fuel Cell Powered Forklift

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Theme: Hydrogen Awareness, Understanding and Acceptance

Portfolio: INFORMATION DISSEMINATION
Theme: Hydrogen Awareness, Understanding and Acceptance

Portfolio: OUTREACH
Conference/Meeting/Event Strategy

- 12 internal IEA presentations
- 40 external ExCo presentations
- 8 Conference Exhibits
- >1,015 task presentations
- >1,153 task publications
- 33 patents

Public Relations

- Creation and inaugural award of HIA Individual Prize for technical excellence in H2 R&D and harmony in international cooperation; Project Prize in 2010

Media Engagement

- Released 25th Anniversary Report at National Press Club in Washington, D.C.

Former IEA HIA Chair Trygve Riis

Dr. Gary Sandrock
Fundamental Safety Testing and Analysis of H₂ Storage Materials and Systems (H-25), a project of Task 22, Fundamental and Applied H₂ Storage Materials Development

- 4 country (Canada, Germany, Japan, USA) collaboration
- Project Leader: Dr. Don Anton

IETHER (Infraestructura Tecnológica del Hidrógeno y Energías Renovables) “Green Hydrogen from Wind and Solar Mobile Applications”, a project of Task 24, Wind Energy and Hydrogen Integration

- Developed by Fundación para el Desarrollo de Nuevas Tecnologías del Hidrógeno en Aragón

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International Energy Agency
Hydrogen Implementing Agreement . . .

. . . A premier global resource for technical expertise in H₂ RD&D

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Thank you very much !