The IEA HIA: Global Collaboration in Hydrogen R,D&D

Mr. Antonio García-Conde, Mr. Jan Jensen, Dr. Steven Pearce and Ms. Mary-Rose de Valladares

Roads2HyCom with IEA HIA Workshop
4 November, 2008 - Athens, Greece
IEA HIA Presentation

- The Hydrogen Opportunity as we know it
- IEA HIA Fundamentals
- Overview of IEA HIA Portfolio:
  - Science and Technology
  - Market Environment
  - Outreach Program
- Collaboration: Participation & Membership
- IEA HIA Value Proposition
The HYDROGEN Opportunity

Offers promise as an energy carrier and a fuel
clean, abundant, sustainable

- H₂ production based on separation of H₂ from feedstocks:
  - Carbon containing materials (fossil energy and biomass)
  - Diverse array of primary sources (renewables, nuclear and fossil) can also be used to extract H₂ from water (H₂O)

- Global diversity of production options enhances hydrogen’s appeal.

Roads2HyCom with IEA HIA Workshop
**Feedstock and Process Alternatives for Hydrogen Production**

- **Gas**: Natural gas or bio-gas are $H_2$ sources with steam reforming or partial oxidation.
- **Oil**: $H_2$ is produced with steam reforming or partial oxidation from fossil or renewable oils.
- **Algae**: Methods for utilizing the photo-synthesis for $H_2$ production.
- **Wood**: Pyrolysis technology for hydrogen from biomass.
- **Alcohols**: Like ethanol and methanol derived from gas or biomass – are rich in $H_2$ and may be reformed to $H_2$.
- **Coal**: With gasification technology $H_2$ may be produced from coal.
- **Power**: Water electrolysis from renewable sources and nuclear.

Source: Hydro
Hydrogen Implementing Agreement (HIA)

A collaborative research and development (R&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

Strategy
To facilitate, coordinate and maintain innovative research, development and demonstration (RD&D) activities through international cooperation and information exchange

Annex / Task
Basic unit of organization; Next level is sub-task; Operating Agent manages Annex; Experts do work

Roads2HyCom with IEA HIA Workshop
<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td></td>
<td>Mr Nick Beck</td>
</tr>
<tr>
<td>European Commission</td>
<td></td>
<td>Dr Stathis Peteves</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td>Dr Yoshiteru Sato</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>Mr Agostino Iacobazzi</td>
</tr>
<tr>
<td>Iceland</td>
<td></td>
<td>Dr Agusta Loftsdottir</td>
</tr>
<tr>
<td>Lithuania</td>
<td></td>
<td>Dr Jurgis Vilemas</td>
</tr>
<tr>
<td>The Netherlands</td>
<td></td>
<td>Mr Frank Denys</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>Mr Paul Lucchesb</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td>Dr John Wright</td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td>Mr J.-F. Hake</td>
</tr>
<tr>
<td>Greece</td>
<td></td>
<td>Dr Elli Varkaraki</td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
<td>Dr Alper Sarioglan</td>
</tr>
<tr>
<td>Korea</td>
<td></td>
<td>Mr KiJune Kim</td>
</tr>
<tr>
<td>New Zealand</td>
<td></td>
<td>Dr Steven Pearce</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td>Ms E Fjermestad-Hagen</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td>Mr Antonio Garcia-Conde</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>Dr Lars Vallander</td>
</tr>
<tr>
<td>Switzerland</td>
<td></td>
<td>Dr Stefan Oberholzer</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td>Mr Ray Eaton</td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td>Dr Carole Read</td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
<td>Mr Jan Jensen</td>
</tr>
<tr>
<td>Finland</td>
<td></td>
<td>Dr Heikki Kotila</td>
</tr>
<tr>
<td>Korea</td>
<td></td>
<td>Mr Kijune Kim</td>
</tr>
</tbody>
</table>
IEA HIA Goals

Science & Technology Goal
Advancement of Science via Pre-Commercial Collaborative RD&D
- Hydrogen Production
- Hydrogen Storage
- Hydrogen Systems

Market Environment Goal
Assessment of Market Environment, including Non-Energy Sector
- Non-Energy and Industrial Processes
- Foundation for Codes & Standard
- Infrastructure

Outreach Program Goal
Increasing Knowledge and Comfort with Hydrogen
- Membership and Participation
- Information Dissemination
- Synchronization worldwide
IEA HIA Tasks Since 1977

1. Thermochemical Production
2. High-Temperature Reactors
3. Potential Future Markets
4. Electrolytic Production
5. Solid Oxide Water Electrolysis
6. Photocatalytic Water Electrolysis
7. Storage, Conversion and Safety
8. Techno-Economic Assessment
9. Hydrogen Production
10. Photoproduction of Hydrogen
11. Integrated Systems
12. Metal-Hydride for H₂ Storage
14. Photoelectrolytic Production
15. Photobiological Production
16. H₂ from Carbon-Containing Mat.
17. Solid & Liquid State Storage Materials
18. Integrated Systems - II
19. Hydrogen Safety
20. Hydrogen from Waterphotolysis
22. Fundamental & Applied H₂ Storage Materials Development
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 H₂ from Waterphotolysis
27. Co-Gasification with Biomass
Current Tasks by Goal and Focus Area

Science and Technology

**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

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

Market Environment

**Analysis, Safety and Economics**
18. Integrated Systems Evaluation
19. Safety
Science and Technology

HYDROGEN PRODUCTION
Task 21: BioHydrogen

October 2005-October 2008
(extension requested)

- Evolved from Task 15
- Includes four areas of investigation:
  - Hydrogen dark fermentations
  - Photobiological hydrogen production systems
  - Bio-inspired systems
  - Overall analysis

OA: Dr. Jun Miyake
Task 23: Small-Scale Reformers for On-Site H₂ Supply

December 2006-December 2009

- Development of reformer technologies and distributed on-site reformer based H₂ supply systems
- 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 2009

- **Mid-term R&D for entire wind to hydrogen production chain**
- **Four Subtasks:**
  1. **Subtask A** - State of the Art
  2. **Subtask B** - Needed Improvements and System Integration
  3. **Subtask C** - Business Concept Development
  4. **Subtask D** - Applications with Emphasis on wind energy management

**OAs:** Dr. Luis Correas and Mr. Fernando Carpintero
Task 25: High Temperature Processes for H₂ Production

May 2007 – May 2010

- Will Support production of massive quantities of zero-emission H₂ 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
  - Subtask A – State of the Art
  - Subtask B – Methodology approach of HTPs
  - Subtask C – HTP R&D and future industrial development
  - Subtask D – Information Dissemination

OA: Mr. Gilles Rodriquez of CEA
Task 26: Advanced Materials for Waterphotolysis of H$_2$

May 2008 – May 2011

- Continuation and expansion of Task 20, Hydrogen from Waterphotolysis - Final Report coming soon!
- 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 (Hawaii Natural Energy Institute, University of Hawaii, Manoa)
Science and Technology

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

December 2006-December 2009

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

- **17 HIA countries, 50 projects**
  - **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

**OA:** Dr. Bjørn C. Hauback of IET
Market Environment

ANALYSIS, SAFETY and ECONOMICS
Task 18: Integrated Systems Evaluation

January 2004 – January 2009


- **Subtask B** - Modeling and existing analysis tools used to evaluate hydrogen demonstration projects.


**Phase 1 had two Subtasks, A and B. Phase 2 will include:**

- **Subtask C** - 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 19: Safety

October 2004 – January 2008 recently extended

- Survey of Quantitative Risk Assessment (QRA) methodologies and testing methodologies
- 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
- Targeted information packages for stakeholder groups such as: permitting officials, insurance providers, system developers, manufacturers, early adopters

OA: William Hoagland (W. Hoagland & Associates, USA)
Analysis Related to Market Environment and Outreach Goals

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
Science and Technology Goal Related: **PRODUCTION**

- Near Term Market Routes to Hydrogen by Co Utilization of Biomass as a Renewable Source with Fossil Fuels

Both Science & Technology and Market Analysis Goals Related: **STORAGE AND ANALYSIS**

- Large Scale Hydrogen Infrastructure and Mass Storage
Outreach and Collaboration

Objectives

1) Increasing Membership and Participation
2) Information Dissemination
3) Synchronization Worldwide

Collaboration: Means and End
Information Dissemination
Download free at www.ieahia.org

25th Anniversary Report: In Pursuit of the Future
Luzzi / Bonadio / McCann Released at the National Press Club, Washington DC, 7-Sep-04

2007 Annual Report

Task 14 Final Report
Photoelectrolytic Production of Hydrogen

Roads2HyCom with IEA HIA Workshop
IEA HIA Value: a Sustainable Proposition

Provides a neutral international profile
- Knowledgeable, reliable, unbiased
- Access to technical experts
- Global reach (government, academia, industry)

Leverages resources
- Focus includes science & technology, market analyses and outreach
- Portfolio includes shorter term and long-term, pre-competitive activities
- Careful intellectual property (IP) treatment
- Established network of researchers

Offers assurance based on track record
- Collaborative research tasks completed over 30 years
- Growing Membership
International Energy Agency Hydrogen Implementing Agreement . . .

www.ieahia.org

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