HYDROGEN IMPLEMENTING AGREEMENT

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

- **H_2 production based on separation of H_2 from feedstocks:**
  - Carbon containing materials (fossil energy and biomass)
  - Diverse array of primary sources (renewables, nuclear and fossil) can also be used to extract H_2 from water (H_20)
- **Global diversity of production options enhances hydrogen's appeal.**

Feedstock and Process Alternatives for Hydrogen Production

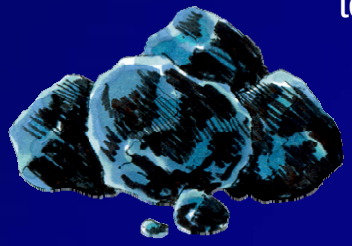
Gas: Natural gas or bio-gas are H_2 sources with steam reforming or partial oxidation

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

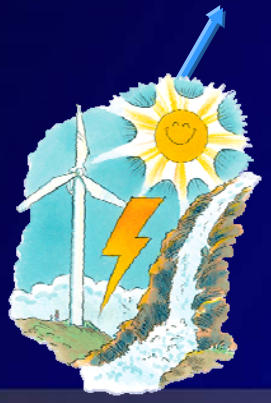
H_2

Coal: With gasification technology H_2 may be produced from coal



Wood: Pyrolysis technology for hydrogen from biomass

Power: Water electrolysis from renewable sources and nuclear



Alcohols like ethanol and methanol derived from gas or biomass – are rich in H_2 and may be reformed to H_2

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

IEA HIA Members

IEA HIA June 2008

Canada
Mr Nick Beck

European Commission
Dr Stathis Peteves

Japan
Dr Yoshiteru Sato

Italy
Mr Agostino Iacobazzi

Iceland
Dr Agusta Loftsdottir

Lithuania
Dr Jurgis Vilemas

The Netherlands
Mr Frank Denys

France
Mr Paul Lucchese

Australia
Dr John Wright

Germany
Mr J.-F. Hake

Greece
Dr Elli Varkaraki

Turkey
Dr Alper Sarioglan

Korea Mr Kijune Kim

New Zealand Dr Steven Pearce Co Vice-Chair

Norway
Ms E Fjermestad-Hagen

Spain
Mr Antonio Garcia-Conde
Chair

Sweden
Dr Lars Vallander

Switzerland
Dr Stefan Oberholzer

United Kingdom
Mr Ray Eaton

United States
Dr Carole Read

Denmark
Mr Jan Jensen
Co Vice-Chair

Finland
Dr Heikki Kotila

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 H_2 Storage
13. Design &Optimization Integ. Systems
14. Photoelectrolytic Production
15. Photobiological Production
16. H2 from Carbon-Containing Mat.
17. Solid & Liquid State Storage Materials
20. Hydrogen from Waterphotolysis

Current Portfolio

18. **Integrated Systems - II**
19. **Hydrogen Safety**
21. **BioHydrogen**
22. **Fundamental & Applied H_2 Storage Materials Development**
23. **Small-Scale Reformers for On-Site H2 Supply (SSR for H_2)**
24. **Wind Energy and H2 Integration**
25. **High Temperature Processes for H_2 Production**
26. **Advanced Materials for H_2 from Waterphotolysis**
27. **Co-Gasification with Biomass**

Current Tasks by Goal and Focus Area

Science and Technology

Production

21. BioHydrogen
23. Small-Scale Reformers for On-Site H_2 Supply (SSR for H2)
24. Wind Energy and H2 Integration
25. High Temperature Processes for H_2 Production
26. Advanced Materials for Waterphotolysis of Hydrogen

Storage

22. Fundamental and Applied H_2 Storage Materials Development

Market Environment

Analysis, Safety and Economics

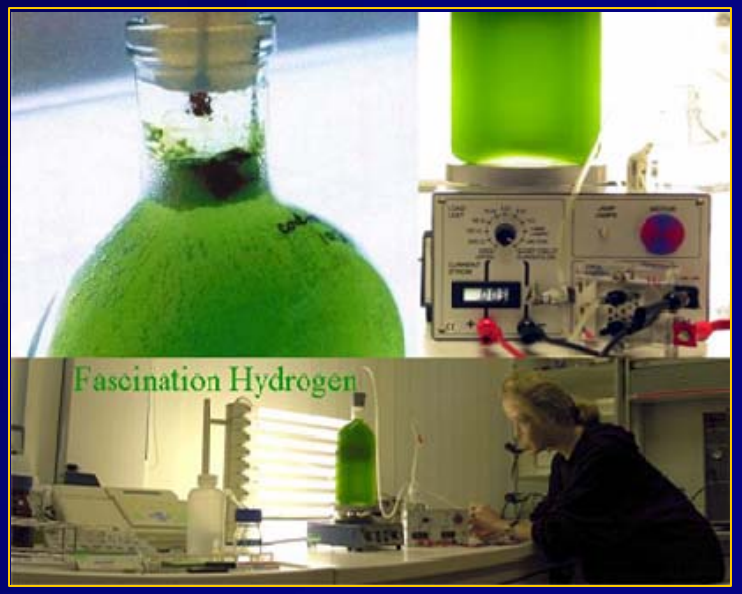
18. Integrated Systems Evaluation
19. Safety

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 H_2 Supply

December 2006-December 2009

- **Development of reformer technologies and distributed on-site reformer based H_2 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 H_2 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 H_2 Production

May 2007 – May 2010

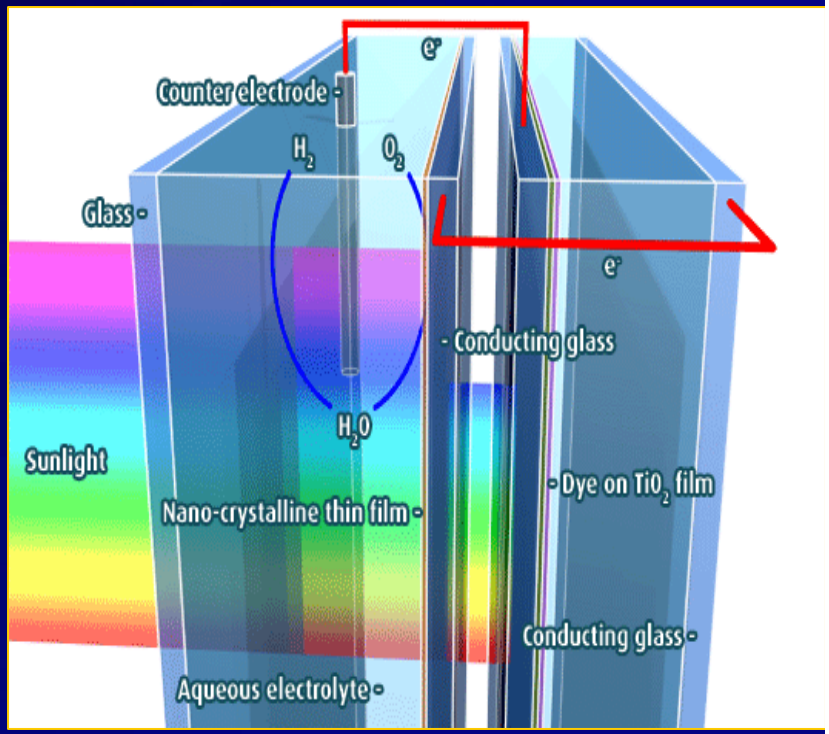
- Will Support production of massive quantities of zero-emission H_2 through use of high temperature processes (> 500 ° C) coupled with nuclear and solar heat sources
- **Three process families**: thermochemical cycles, steam electrolysis and innovative water splitting
- **Four Subtasks**
  - **Subtask 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 A - Comprehensive information datasets** and **summary compilation** of **integrated hydrogen demonstration systems and development plans** - www.port-h2.com/IEA-Annex-18/
- **Subtask B - Modeling and existing analysis tools** used to **evaluate hydrogen demonstration projects.**
- Case Studies (http://www.ieahia.org/case_studies.html)

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)

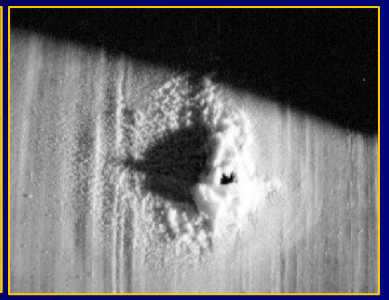
Task 19: Safety

October 2004 – January 2008 recently extended

Bonfire test

Grenade test

Hydraulic burst test



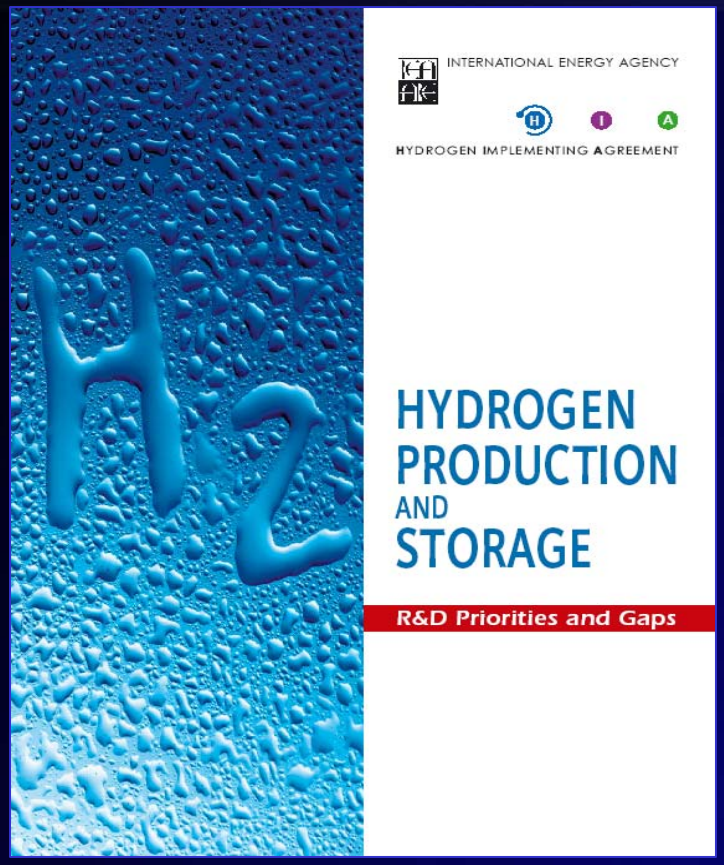
Gunfire test

Drop test

- 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 adoptors

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 H_2 Production and Storage

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

Tasks in Definition

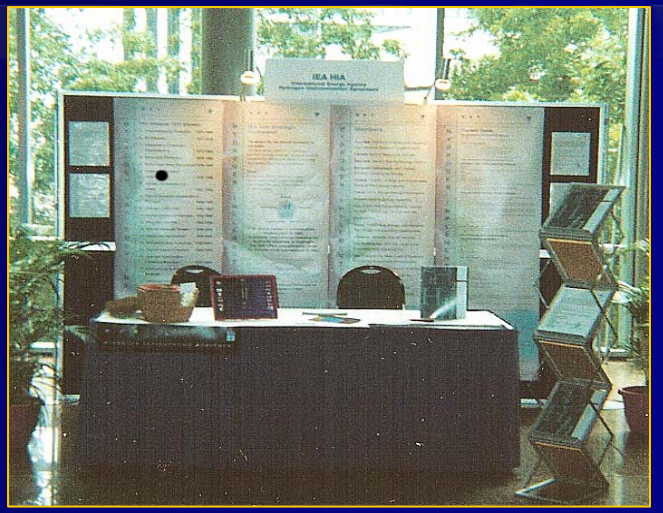
Science and Technology Goal Related : **PRODUCTION**

- 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 Hydrgoen

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