

H Y D R O G E N I M P L E M E N T I N G A G R E E M E N T

Current IEA Hydrogen Implementing Agreement (HIA) R,D&D Contributions to Hydrogen Sustainability

Nick Beck, Yoshiteru Sato, Antonio García-Conde,
Agostino Iacobazzi, Mary-Rose de Valladares

WHTC 2007

7 November 2007 Montecatini, Italy

World Hydrogen Technologies Convention (WHTC)

Italy 2007



AN IMPLEMENTING AGREEMENT OF THE INTERNATIONAL ENERGY AGENCY



IEA HIA Presentation

- IEA HIA Fundamentals
- Overview of IEA HIA Portfolio
- IEA HIA Value Proposition



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

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IEA HIA Members



Canada
Mr Nick Beck (Chairman)



European Commission
Dr Stathis Peteves



Japan
Dr Yoshiteru Sato



Italy
Dr Agostino Iacobazzi



Iceland
Dr Agusta Loftsdottir



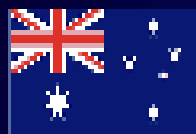
Lithuania
Dr Jurgis Vilemas



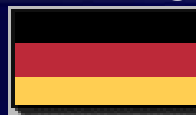
The Netherlands
Mr Frank Denys



France
Dr Paul Lucchese



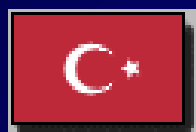
Australia
Dr John Wright



Germany
Mr J.-F. Hake



Greece
Dr Eli Varkaraki



Turkey
Dr Alper Sarioglan



Korea Mr Kijune Kim



New Zealand Dr Steven Pearce

IEA HIA July 2007

Norway
Ms Line Amlund Hagen



Spain
Dr Antonio Garcia-Condé



Sweden
Dr Lars Vallander



Switzerland
Dr Andreas Gut



United Kingdom
Dr Ray Eaton



United States
Dr Carole Read



Denmark
Mr Jan Jensen



Finland
Dr Heikki Kotila



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



HIA Annexes 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
 13. Design and Optimization of Integrated Systems
 14. Photoelectrolytic Production
 15. Photobiological Production
 16. H₂ from Carbon-Containing Materials
 17. Solid & Liquid State Storage Materials
- Current Portfolio**
18. Integrated Systems - II
 19. Hydrogen Safety
 20. Hydrogen from Waterphotolysis
 21. BioHydrogen
 22. Fundamental and 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



Sustainability by Category: Current Annexes

Production

20. Hydrogen from Waterphotolysis
21. BioHydrogen
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

Storage

17. Solid & Liquid State Storage Materials
22. Fundamental and Applied H₂ Storage Materials Development

Analysis, Safety and Economics

18. Integrated Systems
19. Safety



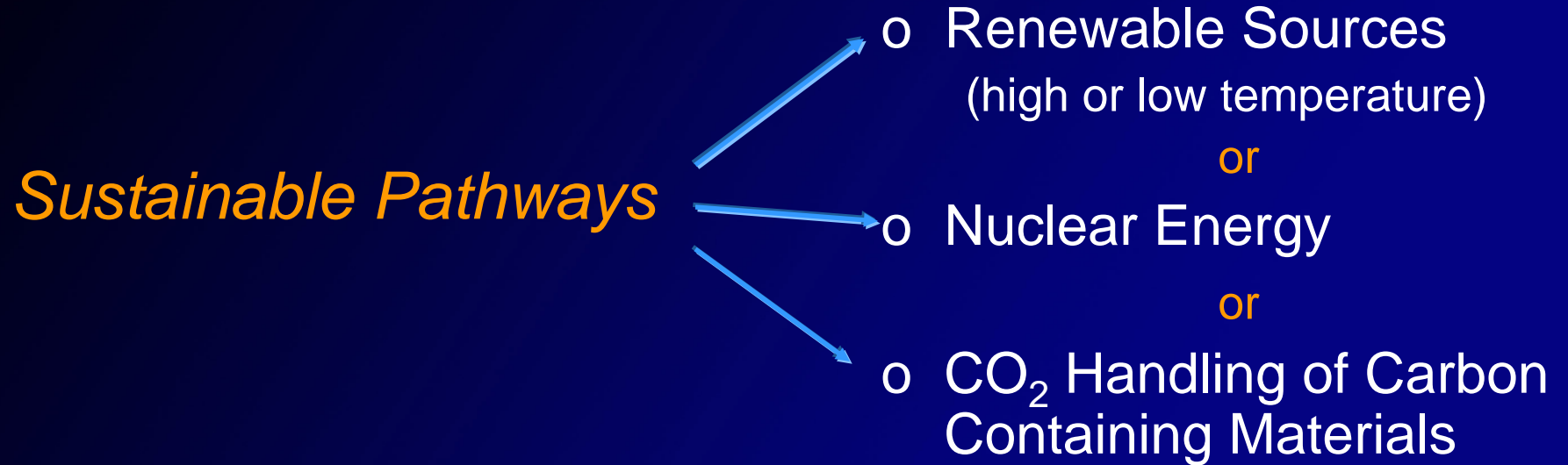
HYDROGEN PRODUCTION

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Hydrogen Production Pathways



Task 16: H₂ from Carbon-Containing Materials

April 2002 – December 2005 – **recently completed**

- ❑ Three Subtasks:
 - ❑ *Subtask A* – Large Scale Integrated H₂ Production
 - ❑ *Subtask B* – Hydrogen from Biomass
 - ❑ *Subtask C* – Small Stationary Reformers for Distributed H₂ Production
- ❑ Final Reports or all subtasks may be accessed at <http://www.ieahia.org/page.php?s=static&p=task16>
- ❑ Significant industry participation
- ❑ Two successor annexes: Task 23 (reformer technology) and Biomass

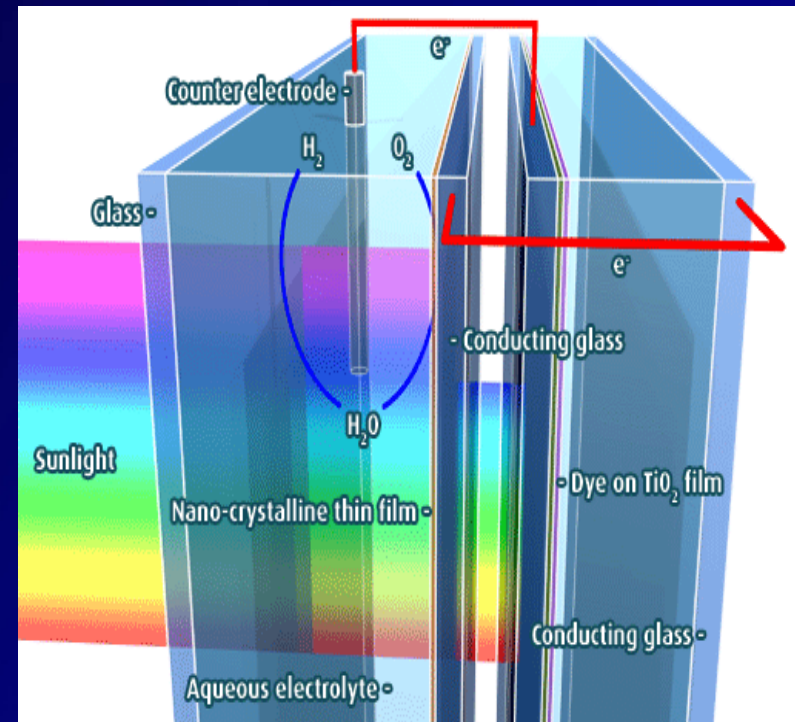


OA: Elisabet Fjermestad-Hagen (Hydro, Norway)

Task 20: Hydrogen from Waterphotolysis

October 2004 – June 2008

- ❑ Continuation and expansion of Task-14 (up to 14 countries and 37 research groups)
- ❑ Aim: Net solar-to-hydrogen conversion efficiency of 10%
- ❑ Objectives: Intensification of international collaboration, advancement of PEC materials science, development of engineering solutions, demonstration of leading concepts, promotion of photolysis of water

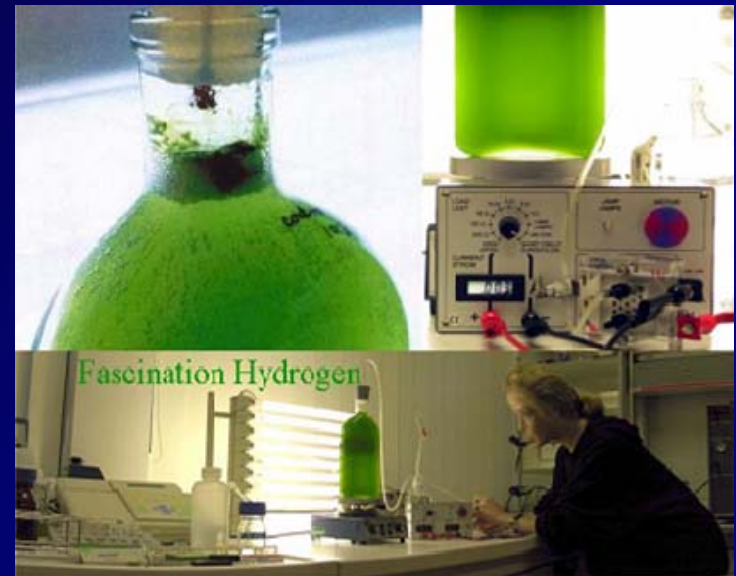


OA: Dr Andreas Luzzi (University of Applied Sciences Rapperswil, Switzerland)

Task 21: BioHydrogen

October 2005-October 2008

- ❑ 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 **NEW!**

- ❑ 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 Schjøberg of Sintef

Task 24: Wind Energy and H2 Integration

December 2006-December 2009 **NEW!**

- ❑ Mid-term R&D for entire wind to hydrogen production chain
- ❑ **Subtask A** – State of the Art
- ❑ **Subtask B** – Needed Improvements and System Integration
- ❑ **Subtask C** - Business Concept Development
- ❑ **Subtask D** - Applications with Emphasis on wind energy management



OAs: Dr. Luis Correias and Mr. Fernando Carpintero

Task 25: High Temperature Processes for H2 Production

May 2007

NEW!

- ❑ 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 Rodriguez of CEA

HYDROGEN STORAGE

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Task 17: Liquid & Solid Hydrogen Storage

June 2001 – May 2006

recently
completed



- ❑ World's largest collaboration in H₂ Storage is succeeded by Task 22
- ❑ Joint R&D on 20 metal hydride, 12 combined hydride/carbon and 4 carbon projects.
- ❑ Final Report with all project summaries accessible at <http://www.ieahia.org/page.php?s=static&p=task17>
800 publications, presentations and patents. Global database created: <http://hydpark/ca.sandia.gov>
- ❑ Metal hydride storage material with 5 wt% @ 150°C confirmed

OA: Dr Gary Sandrock (USA)



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

☐ 15 HIA countries, 43 experts, 39 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

ANALYSIS, SAFETY AND ECONOMICS

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Task 18: Integrated Systems Evaluation

January 2004 – January 2009 **recently extended**



- ❑ Comprehensive information datasets and summary compilation of integrated hydrogen demonstration systems and development plans - www.port-h2.com/IEA-Annex-18/
- ❑ 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 18 Demonstration Sites – Phase 1 and 2

CANADA	Pacific Spirit Station (H2 filling station)
DENMARK	Island Power
FRANCE	Review lessons learned from fuel cell evaluation (EPACOP)
GERMANY	Hydrogen Filling Station
GREECE	RES2H2
ICELAND	Hydrogen bus/refueling project (ECTOS)
ITALY	BEAM project: System efficiency; Control strategy
JAPAN	Regenerative PEM FC-power system (grid)
NEW ZEALAND	Renewable hydrogen at remote site
SPAIN	The Fuel Cell Innovative Remote Systems for Telecommunications (FIRST) project
SWEDEN	Malmö filling station and hythane-fueled buses
UK	Hydrogen and Renewables Integration (HARI) Project
USA	Las Vegas Energy Station
USA	Hydrogen Power Park

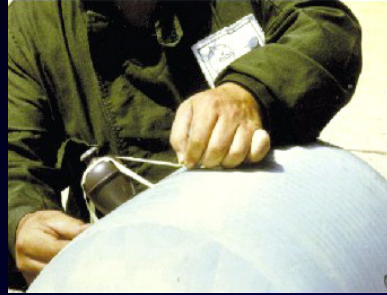


Task 19: Safety

October 2004 – January 2008



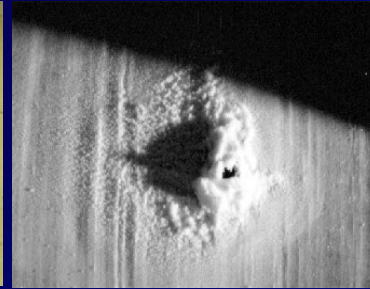
Bonfire test



Grenade test



Hydraulic burst test



Gunfire test

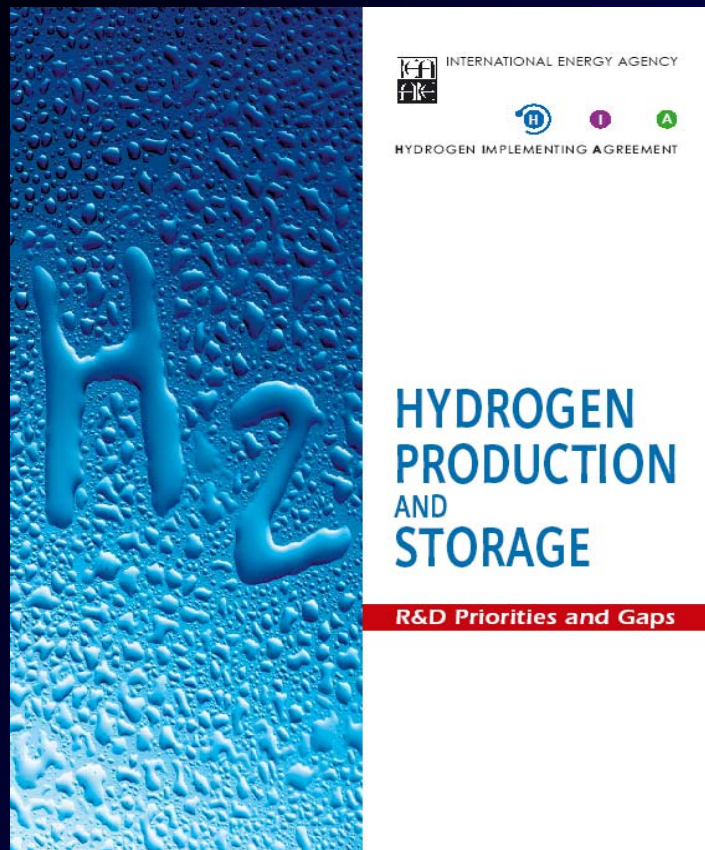


Drop test

- ❑ Survey of Quantitative Risk Assessment (QRA) methodologies and testing methodologies (**public report October 2007**)
- ❑ **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)

R&D Priorities and Gaps in H2 Production and Storage



Near Term

Medium Term

Long Term

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

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Other Tasks: Now in Definition or Proposed

PRODUCTION

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

STORAGE AND ANALYSIS

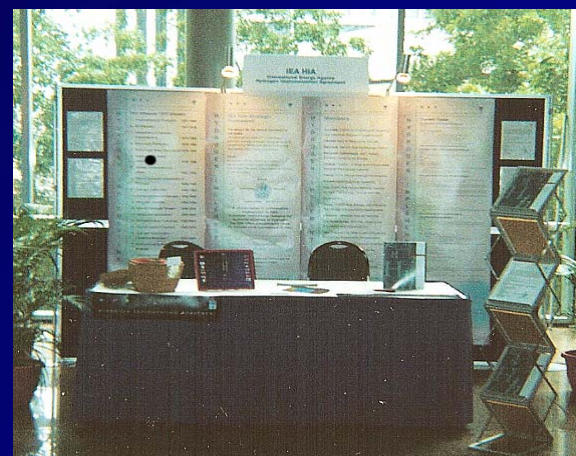
Hydrogen Distribution Infrastructure and Mass Storage



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



2006 Annual Report



Task 14 Final Report Photoelectrolytic Production of Hydrogen

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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

*. . . An R,D&D Collaboration pursuing
hydrogen sustainability*

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