



HYDROGEN IMPLEMENTING AGREEMENT

IEA Hydrogen Implementing Agreement (HIA) Three Decades of Global Collaboration in Hydrogen R&D

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IEA Energy Technology Day – NEET Launch
May 3, 2006

AN IMPLEMENTING AGREEMENT OF THE INTERNATIONAL ENERGY AGENCY



IEA HIA Presentation

- ❑ IEA HIA Fundamentals
- ❑ Overview of IEA HIA Portfolio
- ❑ Gaps and Priorities in Hydrogen R&D
- ❑ Collaboration Experience and Activities
- ❑ Technology Cooperation Perspective for the Future: IEA HIA and the NEET initiative

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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





Canada
Mr Nick Beck (Chairman)



European Commission
Dr Stathis Peteves



Japan
Dr Yoshiteru Sato



Italy
Dr Agostino Iacobazzi



Iceland
Ms Agusta Loftsdottir



Lithuania
Dr Jurgis Vilemas



The Netherlands
Mr Frank Denys



France
Dr Paul Lucchese



Australia
Dr John Wright

HIA Members



Korea
Mr. Young-Sam Kim

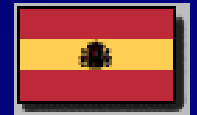


New Zealand
Dr Steven Pearce

Norway
Ms Line Amlund Hagen



Spain
Dr Antonio Garcia-Condé



Sweden
Dr Lars Vallander



Switzerland
Dr Gerhard Schriber



United Kingdom
Dr Ray Eaton



United States
Mr Patrick Davis



Denmark
Mr Jan Jensen



Finland
Dr Heikki Kotila



HIA 25th Anniversary Report "In Pursuit of the Future"

Luzzi / Bonadio / McCann



released at the National Press Club, Washington DC, 7-Sep-04

- 1) provides a serious introduction to the complex, interconnected issues associated with the development of a hydrogen infrastructure and the adoption of hydrogen as the “future fuel”
- 2) conveys the attractive fundamentals of the hydrogen energy proposition
- 3) highlights important HIA **contributions** to the advancement of hydrogen science and technology

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

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HIA 5-Year Plan (2004 - 2009)



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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
- Present**
16. H₂ from Carbon-Containing Materials
 17. Solid & Liquid State Storage Materials
 18. Integrated Systems - II
 19. Safety
 20. Hydrogen from Waterphotolysis
 21. BioHydrogen



Task 15: Photobiological Hydrogen Production

May 1999 – July 2005

- ❑ **Completed.**
(evolved into Task-21)
- ❑ **Various process-development-scale photo-bioreactor systems being tested.**
- ❑ **Comprehensive global database established on hydrogen-producing microorganisms.**
- ❑ **Hydrogen production from a green algae demonstrated.**



NREL

OA: Dr Peter Lindblad (Uppsala University, Sweden)

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Task 16: H₂ from Carbon-Containing Materials

April 2002 – December 2005

- ❑ Completed concept study of large-scale integrated hydrogen production project for power production with decarbonization
- ❑ Comprehensive status and R&D challenges report on hydrogen production from biomass complete; Resource, technology and market analysis for biomass feedstock also complete
- ❑ Review of small-scale stationary reformers for hydrogen production from fossil fuels with CUTE update
- ❑ Final reports for all three sub-tasks available soon



OA: Elisabet Fjermestad-Hagen (Norsk Hydro, Norway)

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Task 17: Liquid & Solid Hydrogen Storage

June 2001 – May 2006



- ❑ Global database created:
<http://hydpark/ca.sandia.gov>
- ❑ R&D on catalyzed sodium aluminum hydrides led to identification of hydride capable of 4 wt% reversible hydrogen @ 120°C
- ❑ Metal hydride storage material with 5 wt% @ 150°C confirmed.
- ❑ Joint R&D on 20 metal hydride, 12 combined hydride/carbon and 4 carbon projects.

OA: Dr Gary Sandrock (Suna Tech inc, USA)

Task 18: Integrated Systems Evaluation

January 2004 – January 2008



- ❑ Development of comprehensive information datasets and summary compilation of integrated hydrogen demonstration systems and development plans
- ❑ Modeling and use of previously developed analysis tools to evaluate hydrogen demonstration projects
- ❑ **Case Studies** (http://www.ieahia.org/case_studies.html)
- ❑ **Hydrogen Resources Study** now underway

OA: Dr Susan Schoenung (Longitude 122 West, Inc, USA)



Task 18 - Demonstration Sites

SPAIN	The Fuel Cell Innovative Remote Systems for Telecommunications (FIRST) project
SWEDEN	Malmö filling station and hythane-fueled buses
ICELAND	Hydrogen bus/refueling project (ECTOS)
JAPAN	AIST laboratory demo of regenerative fuel cell system. Evaluation is underway; data have been promised for mid-year 2005.
CANADA	Pacific Spirit Station
UK	Hydrogen and Renewables Integration (HARI) Project
ITALY	Milan Bioccoca project or BEAM (<i>Brescia-Energy-Environment</i>) project.
U.S.	Las Vegas Energy Station
DENMARK	Hydrogen pipeline evaluation or NG replacement
FRANCE	Review lessons learned from fuel cell evaluation (EPACOP)



Task 19: Safety

October 2004 – January 2008



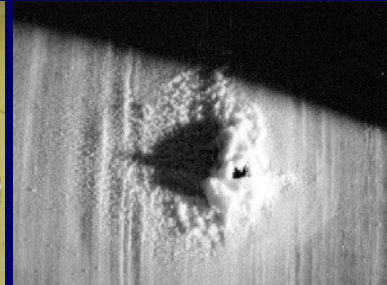
Bonfire test



Grenade test



Hydraulic burst
test



Gunfire test



Drop test

- ❑ Survey of Quantitative Risk Assessment (QRA) methodologies and testing methodologies
- ❑ Establishment of testing equipment to evaluate the effects of equipment, product and/or system failures under a range of real-life scenarios, environments or mitigation measures
- ❑ Development of targeted information packages for stakeholder groups

OA: William Hoagland (W. Hoagland & Associates, USA)

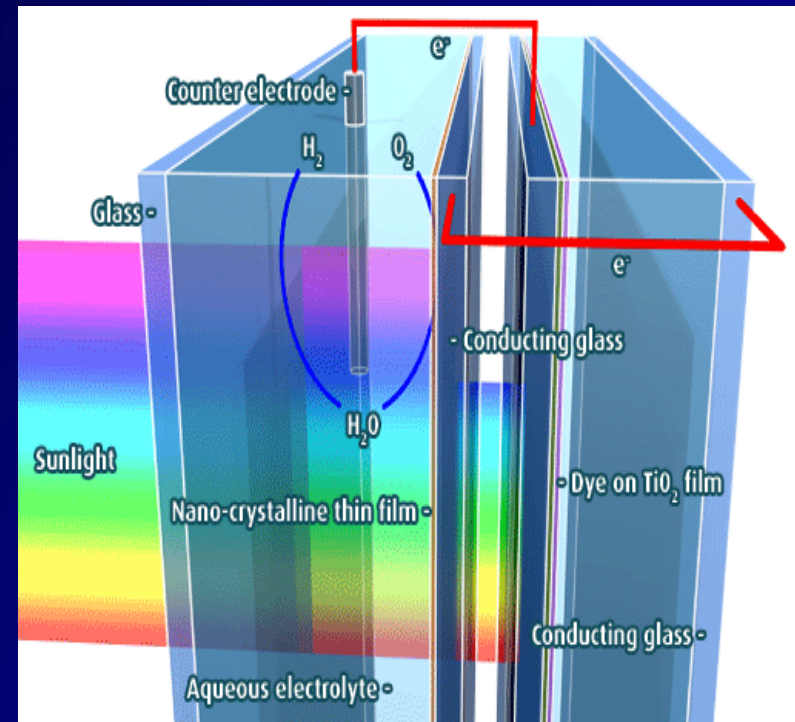
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Task 20: Hydrogen from Waterphotolysis

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
- ❑ Will include several components:
 - ❑ Hydrogen dark fermentations
 - ❑ Photobiological hydrogen production systems
 - ❑ In-vitro and bio-inspired systems
 - ❑ Techno-economic analysis process integration

OA: Dr. Jun Miyake



Tasks and Study Now in Definition

NEW TASKS

- ❑ Hydrogen production from low temperature processes with a focus on wind energy
- ❑ Hydrogen production from high temperature processes (HTP), with an emphasis on materials development, membrane and separation processes, benchmarking and integration of HTP in industrial processes and hydrogen chain
- ❑ Hydrogen for Non-Energy Applications



Future Challenges: the future has begun!

□ Technical

- Production
- Storage

□ Regulatory

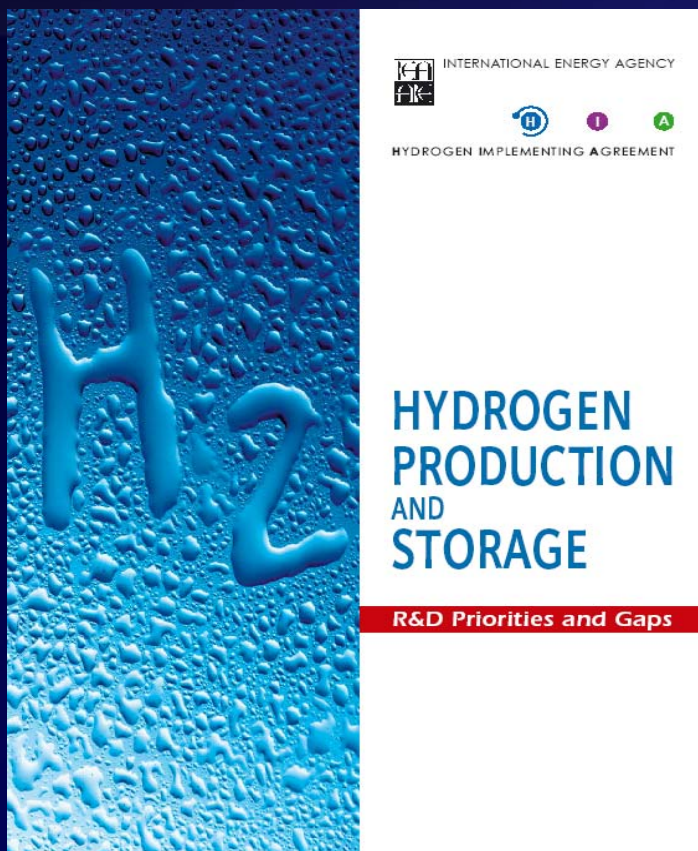
- Codes & Standards

□ Infrastructure

- Installation
- Distribution
- Delivery



R&D Priorities and Gaps in H2 Production and Storage



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

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Summary

Production Processes – Research Needs

For all hydrogen production processes – Significant improvement needs for:

- Increased plant **efficiency**
- Reduction of capital **costs**
- Reliability** and operating **flexibility**



Summary

Production Processes – Research Needs

Current/near term production options:

- ❑ **Electrolysis** – proven technology to be used in the early phases of building a hydrogen infrastructure for the transport sector
- ❑ **Small scale natural gas reformers** limited proven/commercial availability – several demonstration cases



Hydro
Berlin



NG reformer station
Madrid

Summary

Production Processes – Research Needs

Medium to long term production options:

- ❑ **Central fossil based production w/CO₂ capture and storage:** capture of CO₂ for storage purposes are not fully technically and commercially proven and requires R&D on absorption or separation processes and process line-up
- ❑ **Biomass to hydrogen processes:** More focus on feed preparation. Logistics is a challenge, production only economical at large scale.
- ❑ **Photo-electrolysis:** Early stage of development – material cost and practical issues to be solved.
- ❑ **Biological processes:** Very early stage of development - low conversion efficiencies.
- ❑ **High temperature processes:** Materials development, HT membranes, heat exchangers, etc.



Summary

Onboard H₂ Storage – Research Needs

Compressed Gas



- ❑ commercially available, costly (mainly due to transportation cost)
- ❑ best option: C-fibre composite vessels (6-10% H₂ at 350 –700 bar)
- ❑ R&D issues: fracture mechanics, safety, compression energy, volume

Liquid Hydrogen



- ❑ commercially available, costly (mainly due to liquefaction cost)
- ❑ best option – cryogenic insulated dewars (20wt%H₂ at 1 bar and –253°C)
- ❑ R&D issues: more efficient liquefaction, lower cost/better insulated containers, automated boil off capture (e.g., via hydrides) and re-liquefaction

Onboard H₂ storage – Research Needs

Solid State Storage

- ❑ very developmental
- ❑ **potential advantages:** lower volume, lower pressure (greater energy efficiency) higher purity H₂ output
- ❑ **R&D issues:** (many) weight, lower desorption temperatures, higher desorption kinetics, recharge time & pressure, heat management, cost, pyrophoricity, cyclic life, container compatibility and optimization
- ❑ **most developed option:** probably **metal hydrides** – potential for >8wt% gravimetric and >90kg/m³ volumetric system capacities at 10-60 bars.



Cross-Cutting Challenges for Hydrogen Economy

- ❑ Cost
- ❑ Complexity
- ❑ Competition
- ❑ Collaboration



Collaboration Experience and Activities

- ❑ As Task-shared IA, core R&D Activities and studies require HIA member collaboration
- ❑ Other collaborator categories:
 - Internal
 - Other IEA implementing agreements
 - IEA Paris Secretariat
 - External
 - Industry
 - IPHE
- ❑ Limited past activities with non-member countries



Technology Cooperation Perspective

Past Approach:

R&D Collaboration via HIA Membership

- Little direct participation by non-HIA members - observer only basis

Current Approach:

R&D Collaboration via Membership and Outreach

- Active member recruiting – developing and developed countries
- Awareness & education – publications, conference presentations and exhibitions, website, newsletter



Technology Cooperation Perspective for the Future: HIA and NEET

Proposed HIA support for IEA G8 Plan of Work

- 1) Technical expertise and experience in R&D and analysis
- 2) Outreach and promotional skills and capabilities



IEA Value 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 25 years
- ❑ Membership growing



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