

HYDROGEN IMPLEMENTING AGREEMENT

**Longstanding IEA HIA Collaboration
in Hydrogen Science and Technology:
Global Investment
in our Energy, Economic and Environmental Future**

Mary-Rose de Valladares

July 31, 2009 Washington, D.C.

U.S. Senate Hydrogen and Fuel Cell Caucus Briefing JULY 31, 2009

AN IMPLEMENTING AGREEMENT OF THE INTERNATIONAL ENERGY AGENCY

IEA HIA Presentation

- IEA Context
- IEA HIA Fundamentals
- Overview of IEA HIA Portfolio Activities and Accomplishments:
 - Collaborative R,D&D
 - Analysis that Positions Hydrogen
 - H2 Awareness, Understanding and Acceptance
- Value Proposition and Investment Benefits

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INTERNATIONAL ENERGY AGENCY

International Energy Agency
Created in 1974; 28 Member Countries
Autonomous agency linked with the OECD

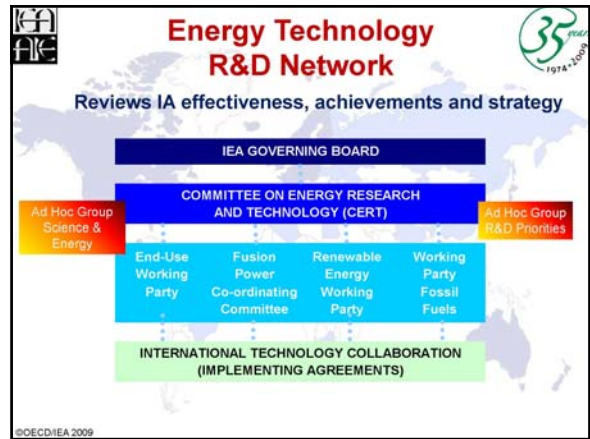
Goals:

- energy security
- environmental protection
- economic growth

Activities:

- co-ordinates efforts to ensure energy security
- compiles energy statistics
- conducts policy analysis
- reviews energy policies & programs
- provides a framework for technology collaboration

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42 Implementing Agreements

Supply

FOSSIL FUELS
Clean Coal Sciences
Enhanced Oil Recovery
Fluidized Bed Conversion
IEA Clean Coal Centre
IEA Greenhouse Gas RD
Multiphase Flow Sciences

RENEWABLE ENERGY TECHNOLOGIES
Bioenergy
Geothermal
Hydrogen
Hydropower
Ocean Energy Systems
Photovoltaic Power Systems
Renewable Technology Deployment
Solar Heating and Cooling
SolarPACES
Wind Energy Systems

FUSION POWER
ASDEX-Upgrade
Environmental, Safety, Economy
Fusion Materials
Large Tokamaks
Nuclear Technology Fusion Reactors
Plasma Wall Interaction in TEXTOR
Reversed Field Pinches
Spherical Tori
Stellarator Concept

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Demand

TRANSPORT
Advanced Fuel Cells
Advanced Materials for Transportation
Advanced Motor Fuels
Hybrid and Electric Vehicles

BUILDINGS
Buildings and Community Systems
District Heating and Cooling
Energy Efficient Electrical Equipment
Energy Storage
Heat Pumping Technologies

ELECTRICITY
Demand/Side Management
Electricity Networks
High-Temperature Superconductivity

INDUSTRY
Emissions Reduction in Combustion
Industrial Energy and Technologies

Horizontal

INFORMATION AND MODELLING
Climate Technology Initiative
Energy Technology Data Exchange
Energy Technology Systems Analysis

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IEA HIA Members July 2009

Canada Mr Nick Beck	Australia Dr John Wight	Norway Dr. Stian Nygaard
European Commission Dr Marc Steen	Germany Mr J.-F. Hake	Spain Mr Antonio Garcia-Conde Chair
Japan Dr Yoshiteru Sato	Greece Dr Eli Varkarakis	Sweden Dr Lars Vallander
Italy Mr Agostino Iacobazzi	Iceland Dr Agustia Loftsdottir	Switzerland Dr Stefan Oberholzer
Lithuania Dr Rolandas Urbonas	Turkey Dr Alper Saridoglan	United Kingdom Mr Ray Eaton
The Netherlands Mr Frank Denys	Korea Mr Kijune Kim	United States Dr Carole Read
France Mr Paul Lucchese	New Zealand Dr Steven Pearce Co Vice-Chair	Denmark Mr Jan Jensen Co Vice-Chair
		Finland Dr Heikki Kotilla

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Member Programs and Activity Highlights

Australia
H2 Roadmap Commissioned; National H2 Materials Alliance

Canada
Hydrogen Program targets: sustainable H2 production, storage, fuel cells & safety, codes & standards

Denmark
No tax on h2 fueled and electric vehicles; significant funding for H2 and fuel cell activities; Copenhagen to host COP 15 and Bright Green exhibit December 2009

European Commission
Joint Technology Initiative (JTI) launched late 2008 – 1 billion euros over 6 years (EU Framework 7)

Finland
Phase one H2 & fuel cell program in 2008 – 300 participants, 60 companies – R&D in 11 corporate and 15 research projects valued at 27M Euros

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Member Programs and Activity Highlights

France
H2# program – 7 yr R&D investment of 200M Euros has 20 partners

Germany
10 yr National Innovation Program – 700M Euros federal funding

Greece
Several national projects in 2008, including renewable H2 system

Iceland
SMART H-2, SMART H2 Boat (Sustainable Marine & Road Transport)

Italy
Five year National Research Plan features H2 & fuel cells; coal gasification with carbon capture at ENEA by 2010

Japan
NEDO 2008 project budgets: 2,953.48 B Yen

Korea
National R,D&D organization for H2 & Fuel Cells ; MEST launced H2 Energy R&D Center; major industry funding – US \$250M in 2007

Lithuania
Lithuanian H2 and Fuel Cell created 2007; H2 a priority in national energy strategy

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Member Programs and Activity Highlights

The Netherlands
New energy research strategy (EOS) features H2 as doe ACTS, pre-competitive chemical R&D

New Zealand
Rep- by NZ Council for Sustainable Business Development; H2 Roadmap

Norway
2008 public funding H2 R,D&D >100 MNOK. HyNor route under constructi

Spain
Spanish Technology Platform for H2 and Fc – 2005. Multiple R,D&D projects

Sweden
Focus on photoelectrolytic and biohydrogen

Switzerland
Focus on photoelectrolytic H2 production

Turkey
Vision 2030 includes hydrogen. Focus on biomass; multiple demo projects

United Kingdom
New Dept of Energy and Climate Change funding demos under Environmental Transomation Fund

United States
FY 2008 Funding \$211,062M

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HYDROGEN IMPLEMENTING AGREEMENT

END-OF-TERM REPORT | 2004-2009
STRATEGIC PLAN | 2009-2014

STRATEGIC PLAN (2009 - 2014)

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- ### 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
 13. Design & Optimization Integ. Systems
 14. Photoelectrolytic Production
 15. Photobiological Production
 16. H₂ from Carbon-containing mat.
 17. Solid & Liquid Storage Materials
 20. Hydrogen from Waterphotolysis
- Current Portfolio**
18. Integrated Systems - II
 19. Hydrogen Safety -II
 21. BioHydrogen - II
 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. Near-Market Routes to H₂ by co-utilization of biomass with fossil fuel
- U.S. Senate Hydrogen and Fuel Cell Caucus Briefing JULY 31, 2009

Task Participation by Members

Members	15	16	17	18	19	20	21	22	23	24	25	26	27	Total Tasks/Member
Australia														5
Canada	1	1	1	1	1	1	1	1						8
Denmark									1	1	1	1	1	7
European Comm.		1	1	1	1								1	7
Finland								1				1	1	3
France		1	1	1	1	1	1	1	1	1	1	1	1	9
Germany		1	1				1	1	1	1	1			7
Greece											1	1		4
Iceland														2
Italy		1	1	1	1	1	1	1	1	1	1	1	1	8
Japan	1	1	1	1	1	1	1	1	1	1	1	1	1	10
Korea														4
Lithuania														2
The Netherlands	1	1	1	1	1	1	1	1	1				1	10
New Zealand													1	2
Norway	1	1	1	1	1	1	1	1	1				1	8
Spain		1	1	1						1	1	1	1	8
Sweden	1	1	1					1	1	1	1	1	1	6
Switzerland			1	1	1						1	1	1	8
Turkey													1	2
UK	1	1	1	1	1	1	1	1	1	1	1	1	1	9
US	1	1	1	1	1	1	1	1	1	1	1	1	1	13
Total Members/Task	7	13	9	17	9	8	12	19	9	10	11	10	8	

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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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Theme:
Collaborative R,D&D

Portfolio:
HYDROGEN PRODUCTION

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Task 16: Hydrogen from Carbon Containing Materials

April 2002 – December 2005 (completed)

- State of the Art Reports for all three subtasks:
 - Subtask A** – Large Scale Integrated H₂ Production for Power Generation /Precombustion Decarbonization
 - Subtask B** – Prospects for H₂ from Biomass
 - Subtask C** – Small-Scale Reformers for Stationary H₂ with Minimum CO₂ Emissions
- Substantial industry participation – HIA Benchmark
- Two Successors tasks – Task 23 and Task 27

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

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Task 21: BioHydrogen

October 2005-October 2010

- 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



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Task 23: Small-Scale Reformers for On-Site H₂ Supply

December 2006-December 2010

- 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 Schjolberg of Sintef



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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 - 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 Correias and Mr. Fernando Carpintero

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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 Rodriguez of CEA

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Task 26: Advanced Materials for Waterphotolysis of H₂

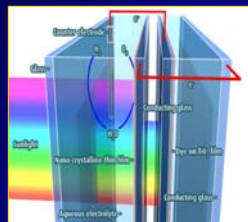
May 2008 - May 2011

- Continuation and expansion of Task 20, Hydrogen from Waterphotolysis - Final Report available May 2009.

- 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

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Task 27: Near-Market Routes to H₂ by Co-Utilization of Biomass as a Renewable Energy Source with Fossil Fuel

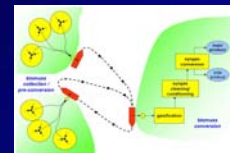
2008 - 2011

- Co-gasification of biomass with fossil fuels

- Hydrogen market facilitation based on distributed processing of biomass to new tradable intermediates

- Near term stand-alone biomass gasification

- Roadmap - development and verification



Source: Shell

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

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Theme:
Collaborative R,D&D

Portfolio:
HYDROGEN STORAGE

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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**
 - **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 IET



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HYDROGEN IMPLEMENTING AGREEMENT

Theme:
Collaborative R,D&D

Portfolio:
INTEGRATED SYSTEMS

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Task 18: Integrated Systems Evaluation

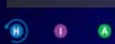

January 2004 - December 2009

- 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://lea-hia-annex18.sharedpoint.site.net/Public/default.aspx>
- Subtask B Phase 1 - Modeling & existing analysis tools evaluate H₂ projects. *H₂ Demonstration Projects Development covers state of the art*
- Case Studies <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)



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Task 23: Small-Scale Reformers for On-Site H₂ Supply

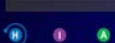

December 2006-December 2010

- 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



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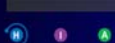




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Theme:
Collaborative R,D&D

Portfolio:
H₂ INTEGRATION IN EXISTING FRASTRUCTURE

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Task 23: Small-Scale Reformers for On-Site H₂ Supply

December 2006-December 2010

- Development of reformer technologies and distributed on-site reformer based H₂ supply systems
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 - 1) Harmonized Industrialization
 - 2) Sustainability and Renewable Sources
 - 3) Market Studies



OA: Dr. Ingrid Schjølberg of Sintef

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Task in Definition

Large Scale Hydrogen Infrastructure and Mass Storage

Task in definition

Approval expected at ExCo meeting Oct. 2009

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Theme:

Analysis that Positions Hydrogen

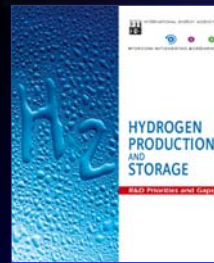
Portfolio:

TECHNICAL, MARKET AND SUPPORT FOR POLITICAL DECISION-MAKING

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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

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HYDROGEN IMPLEMENTING AGREEMENT

Theme:

Hydrogen Awareness, Understanding and Acceptance

Portfolio:

INFORMATION DISEMINATION

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Information Dissemination

Download free at www.ieahia.org



25th Anniversary Report:
In Pursuit of the Future

Issue 1 (February) / Article: Released at the National Press Club, Washington DC, 7-Sept-04

End-Of-Term Report 2004-2009
& Strategic Plan 2009-2014

2007 Annual Report

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Theme:
Hydrogen Awareness, Understanding and Acceptance

Portfolio:
SAFETY

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Task 19: Safety

October 2004 – December 2009 extended

Bonfire test **Grenade test** **Hydraulic burst test** **Gunfire test** **Drop test**

- Survey of Quantitative Risk Assessment (ORA) 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)

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HYDROGEN IMPLEMENTING AGREEMENT

Theme:
Hydrogen Awareness, Understanding and Acceptance

Portfolio:
OUTREACH

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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 2009

Dr. Gary Sandrock

Media Engagement

- Released 25th Anniversary Report at **National Press Club** in Washington, D.C.
- 12 Press Releases
- Letters to the Editor

IEA HIA Chair Trygve Riis

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IEA HIA 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 30 years
- Membership growing

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Additional Tracking of DOE Program Effectiveness

DOE is tracking commercial successes of technologies funded by the Hydrogen, Fuel Cells and Infrastructure Technologies Program.

Accelerating Commercialization:
 An increasing number of HFCIT-funded technologies have been entering the market.

PATENTS resulting from HFCIT-funded R&D:
 118 patents reviewed:
 - 60 fuel cell patents
 - 37 hydrogen production/delivery patents
 - 21 storage patents

Results will be documented in a report by PNNL:
Pathways to Commercial Success: Technologies and Products Supported by the Hydrogen, Fuel Cells and Infrastructure Technologies Program

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Investment Benefits

Technology Development and Deployment Benefits

- Accelerated development and deployment
- Greater Project Scale
- Linking research, industry and policy
- Harmonized technical standards

Member Benefits

- Strengthened National R,D&D capabilities
- Reduction in R,D&D cost and duplication of effort (->700 persons level of effort in 2004-2009)
- Opportunity to participate in all IEA HIA tasks at modest cost
- Information sharing and networking at the ideal time for cooperation in the technology development cycle.

**Positioning hydrogen technology and IEA HIA members
for success and sustainability in the global economy**

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*International Energy Agency Hydrogen
Implementing Agreement . . .*

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expertise in Hydrogen RD&D*

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