

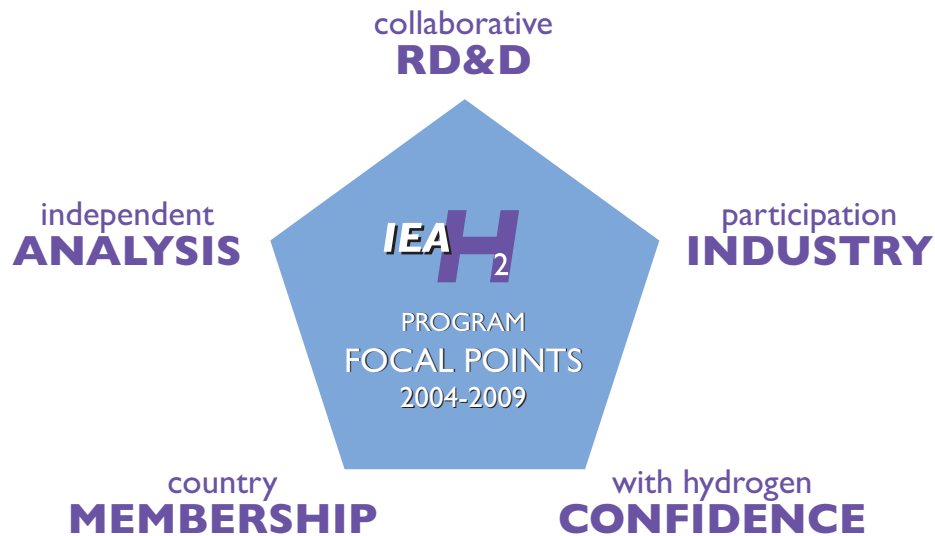


HYDROGEN IMPLEMENTING AGREEMENT

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

MARCH 2009





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

SUBMITTED TO IEA REWP

BY

IEA AGREEMENT
ON THE PRODUCTION AND
UTILIZATION OF HYDROGEN

MARCH 2009

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Preface

The IEA Agreement on the Production and Utilization of Hydrogen, commonly known as the Hydrogen Implementing Agreement (HIA) was created in 1977. Its most recent term of operation, which spans the period 2004-2009, ends 30 June 2009.

This End of Term (EOT) Report and Strategic Plan are submitted in fulfillment of IEA requirements and Committee on Energy Research and Technology (CERT) Guidelines for End of Term Reports issued 26-27 June 2001 by CERT and subsequently revised on 28 November 2001 and 7 June 2002. The structure and content reflect the CERT Guidelines for End-of-Term Reports [IEA/CERT (2001)35]. The content further reflects the Criteria and Review Process for the Extension of Implementing Agreements – Reviewed set forth in CERT(2002) 24 and updated in CERT (2006) 51.pdf.

This report was prepared by the Secretariat, Mary-Rose de Valladares of M.R.S. Enterprises, LLC after the fourth quarter 2008 HIA Executive Committee meeting pursuant to preparations by and under the guidance of the HIA Strategic Planning Committee and leadership (Chairman and Co-Chairs). The HIA Strategic Planning Committee was chaired by Dr. Carole Read of the U.S. Department of Energy. The other Committee members were Mr. Antonio G. García-Conde, HIA Chair, from Spain's Instituto Nacional de Técnica Aeroespacial; Mr. Jan Jensen, HIA Co Vice-Chair, from the Danish Gas Technology Center; Dr. Steven Pearce, HIA Co Vice-Chair, from Solid Energy New Zealand Ltd.; and Mr. Jürgen Hake from Germany's Institut of Energy Research, Forschungszentrum Jülich GmbH.

The planning process for the five year term 2009-2015 included a strategic planning session for the entire Executive Committee, which was held at the fourth quarter meeting. The in-person exchange was followed by submission of written comments from members and Operating Agents. The resulting Strategic Plan for the period 2009-2015 is consistent with CERT Strategic Plan 2007-2011. Following review and approval by the Executive Committee, the EOT Report and Strategic Plan will be sent to the Renewable Energy Working Party (REWP) for review and approval. On REWP approval, the EOT and Strategic Plan will be sent to the CERT for final review and approval.

Executive Summary

Part I End of Term Report

The 2004-2009 term of the International Energy Agency (IEA) Agreement on Production and Utilization of Hydrogen, commonly known as the IEA Hydrogen Implementing Agreement (HIA), ends 30 June 2009. As planned, the HIA experienced substantial growth in activity level, accomplishments, membership and Secretariat capacity during this five year period. The 2004-2009 term marked the beginning of the “Second Generation HIA,” following 25+ years of productive R,D&D cooperation. The HIA recognizes that a near, mid and long-term R,D&D is required to realize the significant technological potential of hydrogen technologies. While its core business is collaborative R,D&D, the HIA effort considers the entire technology system and the entire value chain. HIA activities also feature techno-economic analysis and outreach. Interest in hydrogen technologies has heightened in the recent past, driven by the sharpening global focus on energy and the challenge of climate change. With its track record for collaboration, Strategic Plan and increased Secretariat capacity, the HIA was well-positioned to convert this resurgence of interest into effective cooperation on H₂ R,D&D.

Membership and Participation

Nearing the end of the 2004-2009 term, membership in the HIA had increased ~60%, from 14 to 22 members. All members are Contracting Parties. There were no withdrawals during the five year period 2004-2009. Members are: Australia, Canada, Denmark, European Commission, Finland, France, Germany, Greece, Iceland, Italy, Japan, Korea, Lithuania, New Zealand, Norway, Spain, Sweden, Switzerland, the Netherlands, Turkey, UK and USA. All HIA members have discrete hydrogen programs or significant hydrogen activities. There are several potential members in the pipeline. Near-term candidates for accession include two Gleneagles “+ Five” countries and the United Nations Industrial Development Organization (UNIDO), which would be the first international organization to join the HIA. The role of industry in the HIA has grown during the 2004-2009 term. Although the HIA as yet has no industry sponsors, several tasks, notably Task 16 and Task 23, consist predominantly of industry participants.

As a task-shared Agreement, the aggregate level of effort over the five year 2004-2009 term came to 712 person years, conservatively valued at \$71 million USD in monetary terms.

Tasks, Activities and Strategic Framework

The current status of tasks active during this term appears in the Table A below.

| TASK | TASK NAME | STATUS |
|------|---|------------|
| 15 | Photo-biological production of H ₂ | Completed |
| 16 | H ₂ from Carbon-Containing Materials | Completed |
| 17 | Solid & Liquid State H ₂ Storage Materials | Completed |
| 18 | Integrated Systems Evaluation | Continuing |
| 19 | Hydrogen Safety | Continuing |
| 20 | H ₂ from Waterphotolysis | Completed |
| 21 | BioHydrogen | Continuing |
| 22 | Fundamental and Applied H ₂ Storage Materials Development | Continuing |
| 23 | Small-Scale Reformers for On-Site H ₂ Supply (SSR for Hydrogen) | Continuing |
| 24 | Wind Energy and Hydrogen Integration | Continuing |
| 25 | High Temperature Production of Hydrogen | Continuing |
| 26 | Advanced materials for Waterphotolysis | Continuing |
| 27 | Near-Term Market Routes to H ₂ by Co-Utilisation of Biomass as a Renewable Energy Source with Fossil Fuels | Continuing |

For the 5 year period 2004-2009, the HIA’s Strategic Framework featured three goals, each of which has three scopes. Tasks and activities are shown in Table A by goals and scopes.

Table A: HIA Portfolio by Strategic Goal and Scope of Work

| GOALS | Science & Technology Advancement of Science via Pre-Commercial Collaborative RD&D | | | Market Environment Assessment of Market Environment, including non-Energy Sector; and Analysis, Safety and Economics | | | Outreach Program Increasing Knowledge and Comfort with Hydrogen | | |
|---------------|---|---------|---------|--|----------------------------------|---------------------------------------|---|----------------------------|---------------------------|
| SCOPES | Production | Storage | Systems | Non-Energy & Ind. Processes | Foundation for Codes & Standards | Infrastructure | Membership and Participation | Information Dissemination | Synchronization Worldwide |
| TASKS | 15, 16, 20, 21, 23, 24, 25, 26, 27 | 17, 22 | 18 | | 19 | Infra. & Mass Storage (In def) 18, 23 | ExCo All Tasks Secretariat | ExCo All Tasks Secretariat | ExCo Secretariat |

Over its lifetime, the HIA has created a broad portfolio of twenty-seven (27) tasks. Nine of these tasks, 33% of the entire HIA portfolio, were approved during this five year term: eight in science and technology (seven [7] in production and one [1] in storage); and two (2) in market environment. At the end of the term, nine tasks were active and another market environment task related to infrastructure was in definition. Selected success stories appear below in Table B.

Table B - Success Stories

| Task | Success Stories 2004-2009 Term |
|--|--|
| Task 15 Photo-biological Prod. | R&D Progress toward development of H ₂ production by microalgae |
| Task 16 H ₂ from Carbon-Containing Materials | -State of the Art reports for all three subtasks: Subtask A- <i>Large Scale Integrated H₂ Production Decarbonisation</i> ; Subtask B – <i>Prospects for H₂ from Biomass</i> ; Subtask C – <i>Small-scale Reformers for Stationary H₂ Production with Minimum CO₂ emissions</i> . -Substantial industry participation is a benchmark for future industry participation |
| Task 17 Solid & Liquid Storage | Huge contribution to literature -900+ publications and presentations plus 17 patents |
| Task 18 Integrated Systems Evaluation | -World's best address for worldwide information and analysis on H ₂ and integrated systems; used technical simulations that may be applied to other projects to replicate results -General conclusions in critical areas plus lessons learned and trend analysis |
| Task 19 Safety | Laying foundation for codes and standards regulatory framework |
| Task 20 H ₂ from Waterphotolysis | -Development, acceptance and operation of two multi-year R&D PEC programs, one at U.S. DOE and the other, "NanoPEC" under EU 7 th Framework Program -Photoelectrochemical (PEC) work on tungsten trioxide led to development of novel, reliable and low-cost pollution control sensors for auto industry |
| Task 21 BioH ₂ | -Better genomic understanding of H ₂ strict anaerobes |
| Task 22 Fundamental & App. H ₂ Storage Materials | -World's largest collaboration to-date on hydrogen storage materials R&D -As of December 2008 it produced 450+ publications/articles, 450+ presentations and 16 patents. |
| Task 23 SSR for H ₂ | Contributing to development of norms for small-scale reformers to harmonize industrialization and carbon capture for H ₂ infrastructure and future distributed generation capability as well as fast-tracking technology deployment |
| Task 24 Wind Energy and H ₂ Integration | -Setting the stage for large-scale use of renewable wind energy for hydrogen production in the near future by addressing the entire wind to hydrogen production chain from technical, economical, social, environmental, market and legal perspectives. |
| Task 25 High Temp H ₂ Prod. | - Producing summary sheets on high temperature processes in both general and detailed versions |

Information Dissemination

The HIA's outreach program is communicating the potential of hydrogen energy as well as the substance and value of the Agreement's work to members, the IEA, external stakeholders and decision makers around the world. Currently, our outreach activities primarily serve IEA/OECD governments. Efforts are underway to expand HIA outreach efforts to non-IEA member countries. The HIA produced over 20 major

publications (including Annual Reports and its 25th Anniversary Report: *In Pursuit of the Future*) as well as some 1,153 publications/articles (see <http://www.ieahia.org/page.php?s=glance&p=plan>). Task experts delivered 1,015 presentations. In addition, the HIA redesigned its website, developed a biannual newsletter, an exhibition display and brochures. The HIA also developed a conference/meeting/event strategy at the Executive Committee level organized by internal (to IEA) and external (to IEA) conferences. External conferences were then segmented by target audience. During this term, the HIA made 12 presentations internally; externally, at the Executive Committee level, the HIA made 37 conference presentations and exhibited at 8 conferences. In 2008 the HIA co-sponsored a seminar in Athens Greece to launch Roads2HyCom.

To announce the release of our 25th anniversary report, *In Pursuit of the Future*, the HIA held a press conference at the National Press Club in Washington, D.C. in early September 2004. Some dozen press releases were prepared during this term.

The IEA HIA Individual Prize was created to celebrate hydrogen research and development distinguished by technical excellence and harmony in international cooperation that contributes to the understanding and advancement of basic and applied science. In June 2008 the Agreement awarded its inaugural IEA HIA Individual Prize to Dr. Gary Sandrock. The late Dr. Tapan Kumar Bose, who passed away in 2008, was also honored as the recipient of the IEA HIA Memorial Prize for lifetime achievements in hydrogen R&D.

Analysis

Analysis has played a large role in HIA activities at the task level (e.g., Tasks 18, 19, 23 and 24) during this term. At the Executive Committee level, an Analysis Group was created to focus on development of HIA analytic products, beginning with a study of “Where the H₂ will come from” that remains a work-in-progress.

Coordination and Collaboration

The HIA cooperates with the IEA on an ongoing basis. In 2004, at the request of the IEA Secretariat in satisfaction of Mr. Claude Mandil’s directive to the Hydrogen Coordinating Group (HCG), the HIA undertook a thorough and in-depth examination of near, mid and long-term gaps and priorities in hydrogen production and storage, the two key challenges to widespread, large scale use of hydrogen. The IEA then published the HIA findings and conclusions in *Hydrogen Production and Storage: R&D Priorities and Gap*. The HIA has contributed to the IEA’s *Energy Technologies at the Cutting Edge* and the Open Bulletin. The HIA has been fortunate to participate in all the Networks of Expertise in Energy Technology (NEET) workshops and hopes to soon count the Gleneagles “+5” nations as HIA members. The Agreement worked with the Ad-hoc Group on Science and Energy Technology (AGHSET) and will be part of the Steering Committee for its successor, the IEA Expert Group on Science for Energy (EGSE). The HIA has been a resource for the FEWP and the EUWP as well as the REWP. The Agreement has cooperated with several sister Agreements: Advanced Fuel Cells (AFC); Bioenergy; Electricity Networks Analysis, Research and Development (ENARD); Greenhouse Gas Programme; Wind (WIA); and Energy Technology Data Exchange (ETDE). Outside the IEA, the HIA has entered into a Memorandum of Understanding (MOU) with the International Partnership for a Hydrogen Economy (IPHE).

Common Fund

The HIA has a Common Fund for administration and promotion. In 2007, a financial review process was put in place. Dues are now set at \$10,000 per annum for most countries. The 2008 and 2009 budgets are \$215,000. The total Common Fund dues/member over the five year term were \$42,000: a modest investment has leveraged a substantial return.

Much technical progress has been achieved as a result of HIA coordinated research. Much growth is evident in the Agreement’s organizational capacity. With successful completion of the 2004-2009 term the HIA is poised to begin a new five year term of cooperation.