

VII.6 IEA Hydrogen Task 18: Evaluation of Integrated Demonstration Systems

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Project Start Date: January 1, 2004
Project End Date: December 31, 2009

Objectives

- Operate international working group to address hydrogen technology integration in member countries.
- Establish database of international hydrogen development activities, capabilities and demonstrations.
- Evaluate integrated hydrogen systems for performance, cost, safety and codes and standards permitting policies.
- Synthesize lessons learned from projects and prepare trend analysis for dissemination.

Technical Barriers

This project addresses the following technical barriers of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

Technology Validation (3.5.4)

- (B) Hydrogen Storage
- (C) Lack of Hydrogen Refueling Infrastructure Performance and Availability Data
- (E) Codes and Standards
- (H) Hydrogen from Renewable Resources
- (I) Hydrogen and Electricity Co-Production

Systems Analysis (4.5)

- (C) Inconsistent Data, Assumptions and Guidelines
- (D) Suite of Models and Tools

Hydrogen Safety (3.7.4)

- (A) Limited Historical Database
- (E) Variation in Standard Practice of Safety Assessments for Components and Energy Systems
- (H) Lack of Hydrogen Knowledge by Authorities Having Jurisdiction

Hydrogen Codes and Standards (3.6.4)

- (D) Large Number of Local Government Jurisdictions (approximately 44,000)
- (I) Conflicts between Domestic and International Standards
- (J) Lack of National Consensus on Codes and Standards
- (N) Insufficient Technical Data to Revise Standards
- (P) Large Footprint Requirements for Hydrogen Fueling Stations

Hydrogen Production (3.1.4.2.2)

- (H) System Efficiency
- (J) Renewable Electricity Generation Integration

Hydrogen Delivery (3.2.4)

- (B) Reliability and Costs of Hydrogen Compression

Hydrogen Storage (3.3.4)

- (J) Thermal Management

Contribution to Achievement of DOE Safety or Codes and Standards Milestones

This project will contribute to achievement of the following DOE Hydrogen Safety or Hydrogen Codes and Standards milestones from the Hydrogen Safety or Hydrogen Codes and Standards section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Safety milestone 11:** “Develop design protocol that employs passive system or holistic design techniques. (3Q, 2007)”
- **Safety milestone 19:** “Publish a Best Practices Handbook. (1Q, 2008)”
- **Codes and Standards milestone 21:** “Completion of necessary codes and standards needed for the early commercialization and market entry of hydrogen energy technologies. (4Q, 2012)”

- **Codes and Standards milestone 25:** “Draft regulation for comprehensive hydrogen fuel cell vehicle requirements as a GTR approved (UN Global Technical Regulation). (4Q, 2010)”

Accomplishments for the Period June 2006 – June 2007

- Continued information base development: database contains over 200 documents.
 - Includes hydrogen resources database
 - Subtask A Phase 1 final report published
- Completed analysis of seven demonstration projects in seven countries, including reviews of relevant permitting and development of enhanced component models for electrolyzer, compressor and thermal management of metal hydride storage:
 - Spain - Fuel Cell Research Project for Telecommunications
 - United Kingdom (U.K.) - Hydrogen and Renewables Integrations (HARI) project
 - Sweden - Malmö bus refueling station
 - Japan - Reversible fuel cell system
 - Iceland - Bus refueling station
 - U.S. - Combined fuel and electricity system
 - Canada - Vehicle refueling station
- All assessments include documentation of safety, codes and standards, and permitting requirements.
- Case studies: three completed within the last year:
 - U.K. - HARI
 - Denmark - H2 Truck
 - France – PEM Fuel Cells in Real Conditions (EPACOp)
- Incorporated modeling participation of Sandia personnel (Andy Lutz, Emma Stewart).
- Led two international experts meetings, one in Glasgow, Scotland and one in Brunate, Italy to address the modeling and evaluation of demonstration projects, and to continue building of a database on hydrogen experiences worldwide.
- Participated in two Hydrogen Implementing Agreement Executive Committee meetings in November 2006 and May 2007, including presentation of annual report and incorporation of new activities.
- Maintained task web sites and public web site for dissemination of information from Task 18.



Introduction

The overall goal of Task 18 is to provide information about hydrogen integration into society around the world. Specific objectives are:

- to provide information, data and analysis to the task members and the hydrogen community in general,
- to use modeling and analysis tools to evaluate hydrogen demonstration projects, and
- to disseminate lessons learned, comparative assessments and trend analysis.

The operating agent for Annex 18 is Dr. Susan Schoenung of Longitude 122 West, Inc. Her work is sponsored by the U.S. Department of Energy, which has sponsored two previous tasks on integrated hydrogen systems.

The Annex has three major subtasks:

- Subtask A: Information Base Development
- Subtask B: Demonstration Project Evaluation
- Subtask C: Synthesis and Learning

The leader for Subtask A is Mr. Jean Dubé of Services Mij Inc. of Canada. The leader for Subtask B is Mr. Ismael Aso Aguarta of Spain. The leader for Subtask C is Ms. Shannon Miles of Natural Resources Canada.

Approach

The work of Task 18 is undertaken collaboratively by the 16 member countries. It consists of participation in all three subtasks. In Subtask A, members have helped build a significant web interactive information database, focusing on national documents, national capabilities, and demonstration projects. In Subtask B, members model, analyze, and assist in design of integrated hydrogen systems. In Subtask C, members synthesize the lessons learned from case studies and projects, and perform trend analysis based on exploration of hydrogen work from earlier dates to the present. As noted in Table 1, the demonstration projects span the globe and also the spectrum of possible hydrogen uses. To date, most of the systems analyzed have been based on renewable sources of hydrogen. Fossil fuel-based systems are being included in Phase 2.

Participants work in their home institutions and meet twice per year to report results and plan for future activities. Between meetings, participants also work collaboratively, either from a distance or by occasional separate meetings.

The project portfolio for Task 18 is shown in Table 1. It includes those projects completed in Phase 1 and those planned for Phase 2. In Table 1, RE refers to renewable projects; PV - solar photovoltaics; MH

TABLE 1. Project Portfolio for International Energy Agency (IEA) Hydrogen Task 18

Country	Projects	Location	Modeling Focus	Evaluation Status
Refueling Stations				
Sweden	Hydrogen filling station (renewable grid/electrolysis)	Malmö	System sizing	Complete
Iceland	Hydrogen filling station (renewable grid/electrolysis)	Reykjavik	Electrolyzer performance	Complete
Canada	Hydrogen filling station (waste hydrogen)	Vancouver	Compressor performance	In progress
Grid-Connected or Stand-Alone Power Systems				
Spain	PV/MH-telecom showcase	Madrid	Storage sizing	Complete
Japan	Regenerative PEM FC-power system (grid)	Aichi	Storage thermal control	Complete
U.K.	RE/H ₂ -project	Loughborough	Economic performance	Completing
Italy	Hydrogen from the Sun	Brunate	System efficiency	Phase 2
Combined Fuel and Electricity Generation				
U.S.	Hydrogen energy/refuelling station (NG)	Las Vegas	System performance	Complete
U.S.	Hydrogen power park (RE)	DTE Energy or Hawaii	Performance, economics	Phase 2
Infrastructure Demonstrations				
Denmark	Natural gas / hydrogen pipeline, boiler	Copenhagen	Economics	In negotiation
Residential Heat and Power				
France	Building fuel cell evaluation	5 sites	Fuel cell / system performance	Case Study
Other Potential Phase 2 Projects				
New Zealand	Renewable hydrogen at remote site	Totara Valley	Renewables integration	Phase 2
Spain	Renewable hydrogen for desalination plant	Canary Islands	System sizing and optimization	Phase 2
Germany	Refueling station	Munich or Berlin	Station sizing and economics	Phase 2

- metal hydride storage; NG - natural gas; FC - fuel cell; and PEM - proton exchange membrane.

The national documents sub-web site went public at the end of 2006. The structure is shown in Figure 1.

Results

This effort, carried out in collaboration with the 13 members of the IEA Hydrogen Implementing Agreement Task 18, has resulted in several significant sets of accomplishments this year.

- The Information Base work now consists of searchable documents in the following sets:
 - National documents.
 - National capabilities and vendor listings.
 - Demonstration projects.
 - Case studies and summaries of case studies.
 - A database of costs and performance of the Hydrogen Resource Study: “Where will the hydrogen come from?”
 - Links to the HySociety database.
 - Links to other information sources.

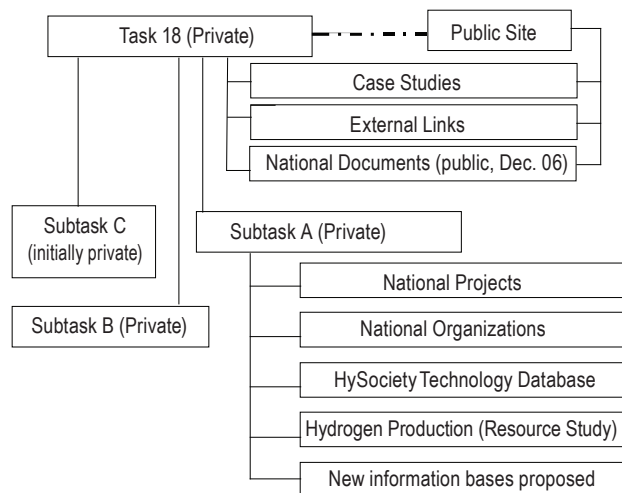


FIGURE 1. Structure of Information Bases

2. Significant work has been done to verify the models for the demonstration projects in Iceland, Sweden, Canada, Japan, the U.K. and Spain. This model is based on “Hydrogems” which was developed in Norway. It has proven compatible with models operated at Sandia National Laboratories. In fact, the modelers at Sandia and the Institute for Energy Research in Norway are exchanging approaches to improve both their platforms. These skills are being passed along to other members of the task.
3. The work plan for the new Subtask C has been drafted and will include additional case studies, comparative studies, a demonstration project guidebook, and synthesis of lessons learned. The relationship between the three subtasks is shown in Figure 2.
4. Task 18 is working collaboratively with other tasks and activities. This collaboration is indicated in Figure 3.

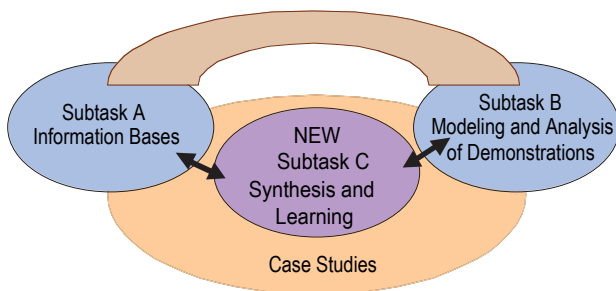


FIGURE 2. Diagram indication efforts and relationships of Subtasks A, B, and C

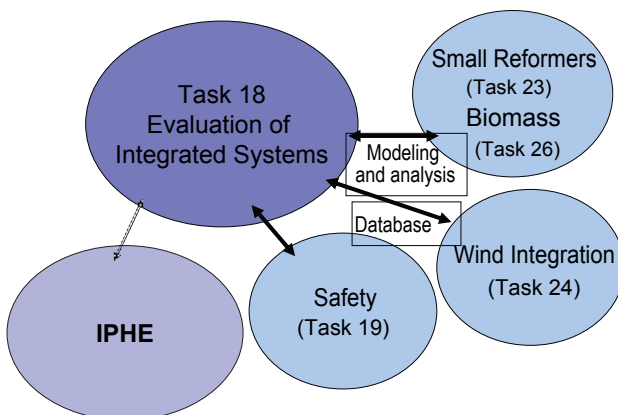


FIGURE 3. Diagram Indicating Collaborations with other Hydrogen Implementing Agreement Tasks and Activities

Conclusions and Future Directions

IEA Hydrogen Task 18 has been successful in implementing two subtasks to address international development of hydrogen demonstration projects, hydrogen directions, and specific issues including permitting and safety codes and standards.

For the coming year, the members of Task 18 foresee the following activities:

- With approval from the Executive Committee for Phase 2, Task 18 is now scheduled to continue through December 2009. A kick-off meeting for Phase 2 was held in April 2007 to make plans for the coming year, including the following.
- Meetings will be held semi-annually, in the fall and spring. The fall 2007 meeting will be held in Gran Canaria, Spain, in conjunction with a visit to the European hydrogen from renewables RES2H2 wind/hydrogen/desalination plant project. The meeting will be joint with the wind/hydrogen Task 24.
- The spring 2008 meeting will be held in either Hawaii, at the site of the Hawaii hydrogen power park, or in Athens at the Center for Renewable Energy Sources (CRES) wind/hydrogen plant.
- Final reports on Phase 1 B will be published.
- Summary of comparative experience in permitting and safety will be published in the National Hydrogen Association safety newsletter.
- Complete modeling of the Italian hydrogen house.
- Complete two additional case studies, one on the Greek CRES project and one on a fuel cell boat project in the Netherlands.
- Participate in IEA Executive Committee activities, including annual and semi-annual reporting. A fall 2007 meeting is planned for Italy in conjunction with the World Hydrogen Technology Conference in Montecatini. The spring 2008 meeting will take place in Brisbane, Australia, in conjunction with the World Hydrogen Energy Conference.

FY 2007 Publications/Presentations

2007 National Hydrogen Association Conference (San Antonio, TX)

1. “Pioneering Experiences in Permitting and Safety of Integrated Hydrogen Systems,” by Schoenung, et al.
2. “Analysis of the Italian Hydrogen House,” by Stewart, et al.

2007 Hydrogen and Fuel Cells Conference (Vancouver, Canada)

1. “Overview of International Energy Agency Annex 18 on Evaluation of Integrated Hydrogen Energy Systems,” by Schoenung, et al.

Hypothesis 2007

1. “Modeling and Simulation of a Thermally Coupled Electrolyzer/Metal Hydride/Fuel Cell System,” Thomas Førde, Harald Miland, Øystein Ulleberg.

Case studies (Available on IEA Hydrogen Implementing Agreement: web site: http://www.ieahia.org/case_studies.html)

1. “Hydrogen and Renewables Integration Program”.
2. “H2 Truck”.
3. “Fuel Cells in Real Environments (EPACOp)”.