

The Second Generation HIA R&D: An Overview, Past to Present

IPHE Education Workshop

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Mary-Rose de Valladares, Nick Beck, Trygve Riis
and Andreas Luzzi

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Mary-Rose de Valladares - Slide#1



AN IMPLEMENTING AGREEMENT OF THE INTERNATIONAL ENERGY AGENCY



Fundamentals

International Energy Agency (IEA)

Autonomous body within the Organization of Economic Cooperation and Development (OECD), founded in **1974** to carry out **energy cooperation** among member countries

IEA Implementing Agreement (IA)

A **collaborative** research and development (**R&D**) program

Annex / Task

Basic unit of organization; Next level is sub-task; **Operating Agent** manages Annex; Experts do work

Hydrogen Implementing Agreement (HIA)

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



HIA Outcomes & Impacts

Though begun with uncertainty, HIA's journey has made significant progress in long-term hydrogen RD&D
Activities and achievements contribute to global consideration of hydrogen

The HIA has proven to be a sustainable vehicle for collaborative RD&D

- ❑ The democratic, "bottom-up" approach to strategic planning has been a very effective process
- ❑ HIA experience is a model for international cooperation in a world increasingly challenged by energy and environmental needs



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

Present

15. Photobiological Production
16. H₂ from Carbon-Containing Materials
17. Solid & Liquid State Storage Materials
18. Integrated Systems - II
19. Safety
20. Hydrogen from Waterphotolysis



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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Canada
Mr Nick Beck (Chairman)



Australia
Dr John Wright



European Commission
Dr Stathis Peteves



Japan
Dr Yoshiteru Sato



Italy
Dr Agostino Iacobazzi



Iceland
Mr Agust Vatfells



Lithuania
Dr Jurgis Vilemas



The Netherlands
Dr Henk Barten



France
Dr Paul Lucchese



New Zealand
Dr Ralph Sims

HIA Member Countries

Norway



Ms Line Amlund Hagen

Spain



Dr Antonio Garcia-Conde

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 5-Year Plan (2004 - 2009)



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



Current HIA Annexes

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

Present

15. Photobiological Production
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

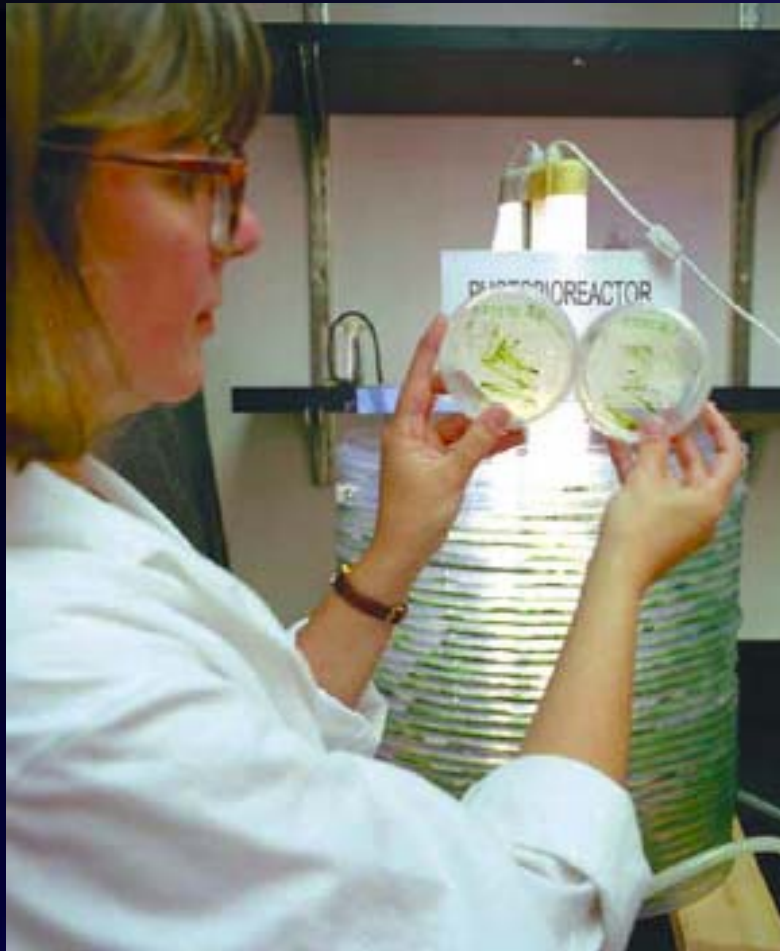
May 1999 – July 2005

- ❑ Completed – evolving 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**

OA: Dr Peter Lindblad (Uppsala University, Sweden)



Gene-Mutated Algae Cultures for Hydrogen Production



NREL



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 underway
- ❑ Review of **small-scale stationary reformers** for hydrogen production from fossil fuels with CUTE update

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



“Small-scale” Natural Gas Reformer



Mahler

Task 17: Liquid & Solid Hydrogen Storage

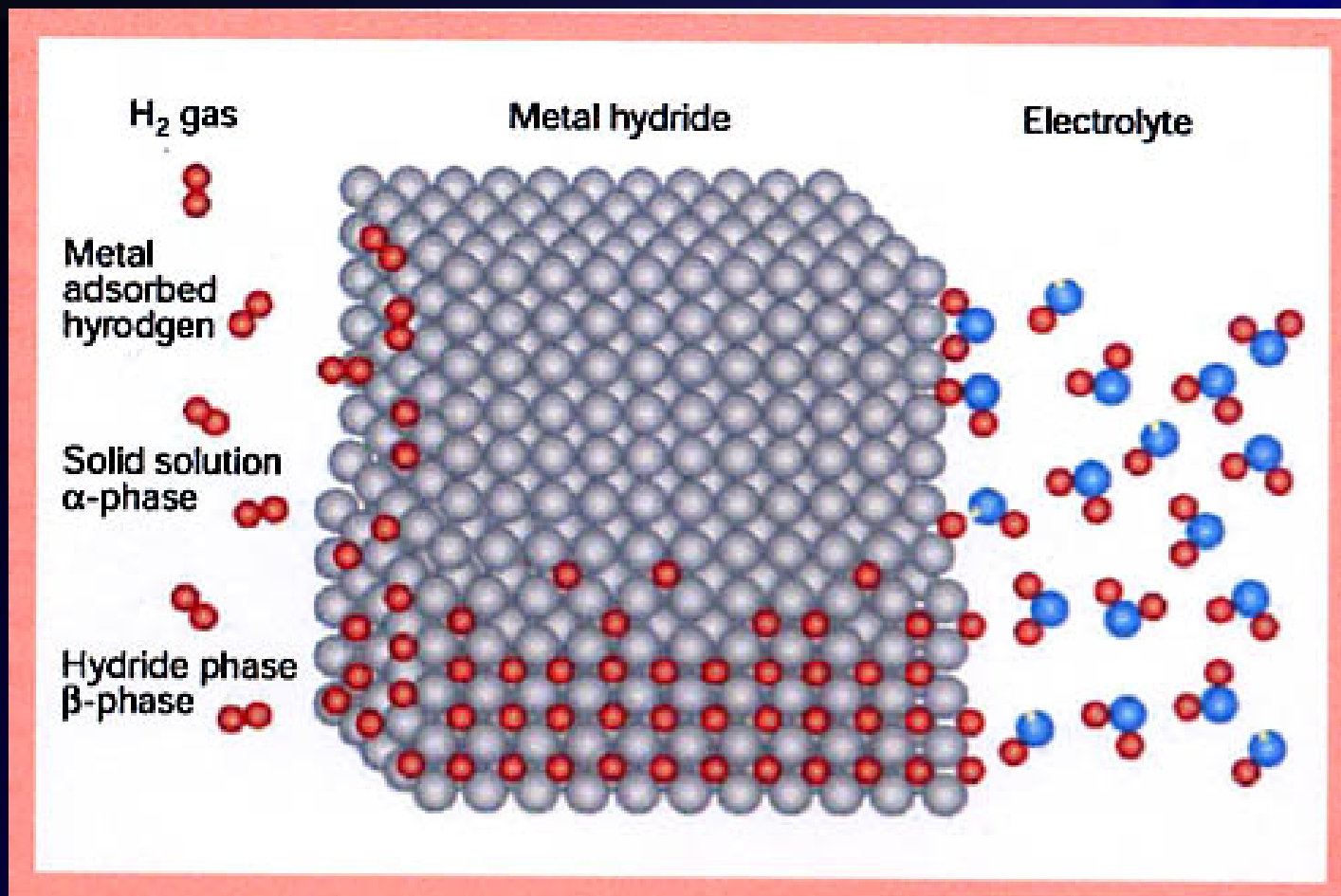
June 2001 – May 2006

- ❑ **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 19 **metal hydride**, 12 **combined hydride/carbon** and 4 **carbon projects**

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



Hydriding Mechanisms



L. Schlapbach

Task 18: Integrated Hydrogen Systems

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
- ❑ Hydrogen **Resources Study** now underway

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

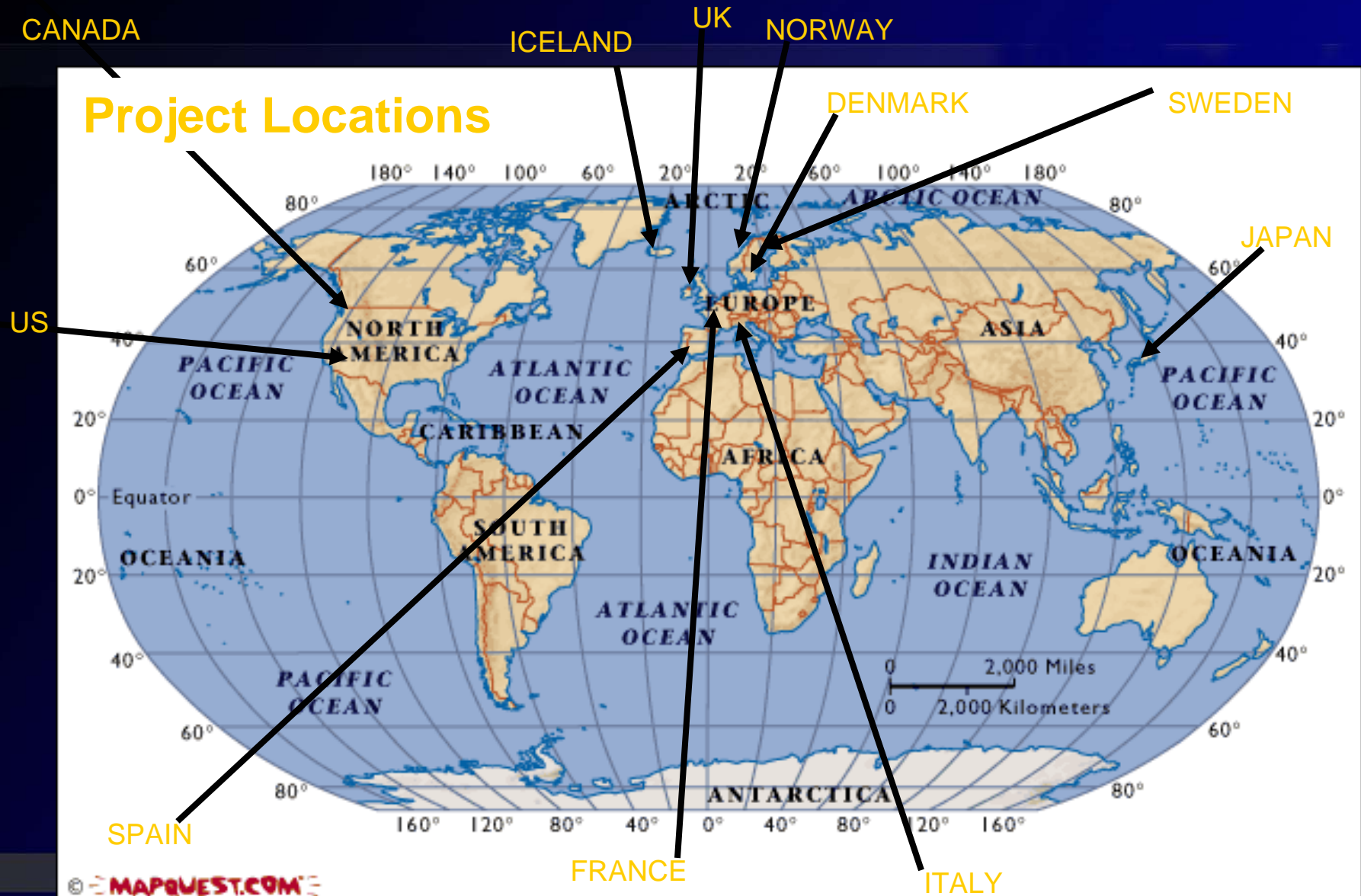


Task 18 - Demonstration Sites

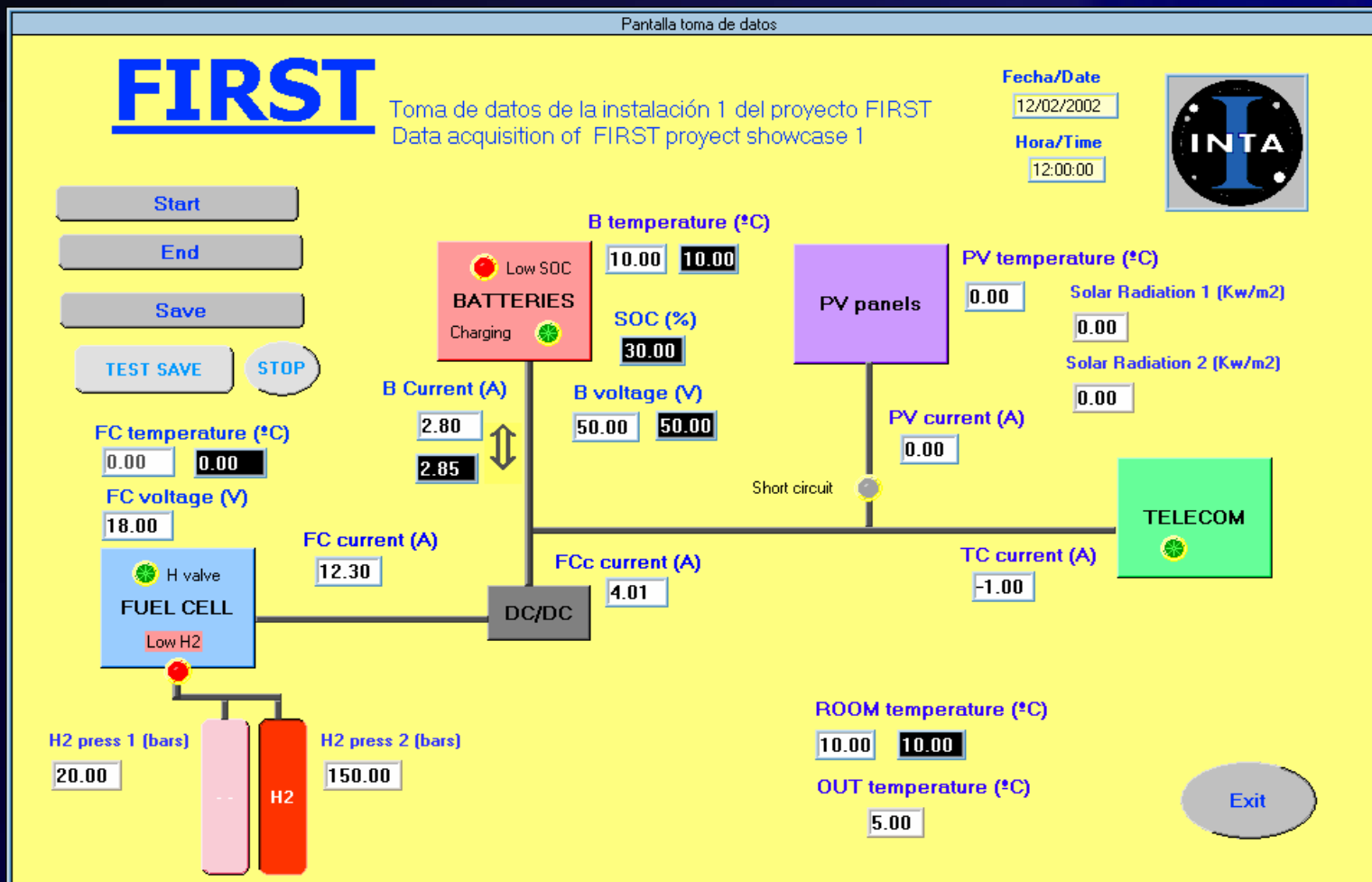
SPAIN	The Fuel Cell Innovative Remote Systems for Telecommunications (FIRST) project
SWEDEN	Malmö filling station and hythane-fueled buses
ICELAND	Hydrogen bus /refueling project (ECTOS)
JAPAN	AIST laboratory demo of regenerative fuel cell system. Evaluation is underway ; data promised for mid 2005.
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 in NG grids (infrastructure)
FRANCE	Pipeline systems evaluation



Project Locations



Fuel Cell Innovative Remote System For Telecommunication



INTA

Task 19: Safety

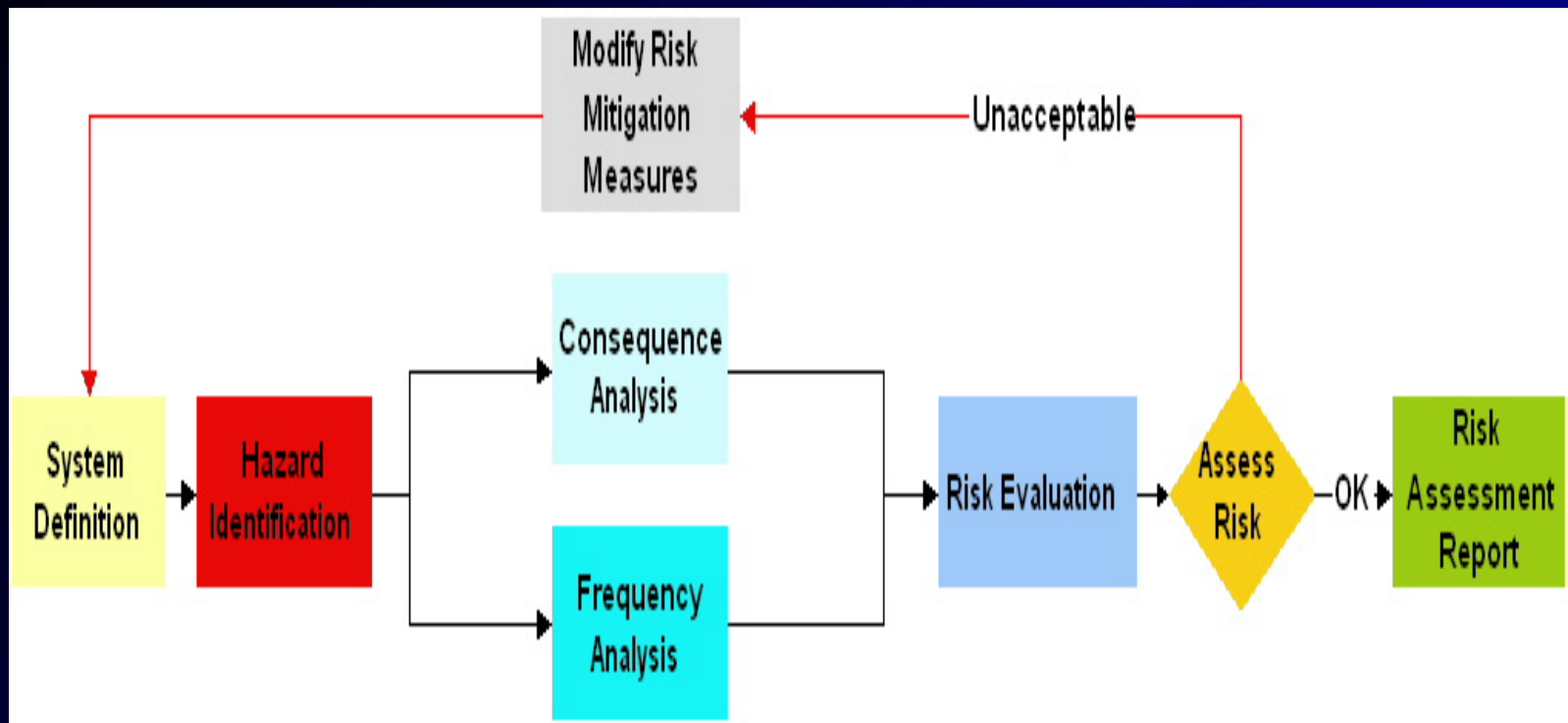
October 2004 – January 2008

- ❑ 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)



Task 19: Safety



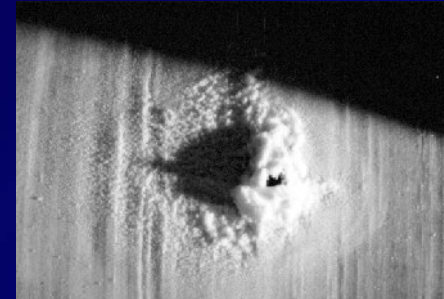
E.g.: High-Pressure Hydrogen Gas Tank Testing



Bonfire test



Drop test



Gunfire test



Grenade test



Hydraulic burst test

Task 20: Hydrogen from Waterphotolysis

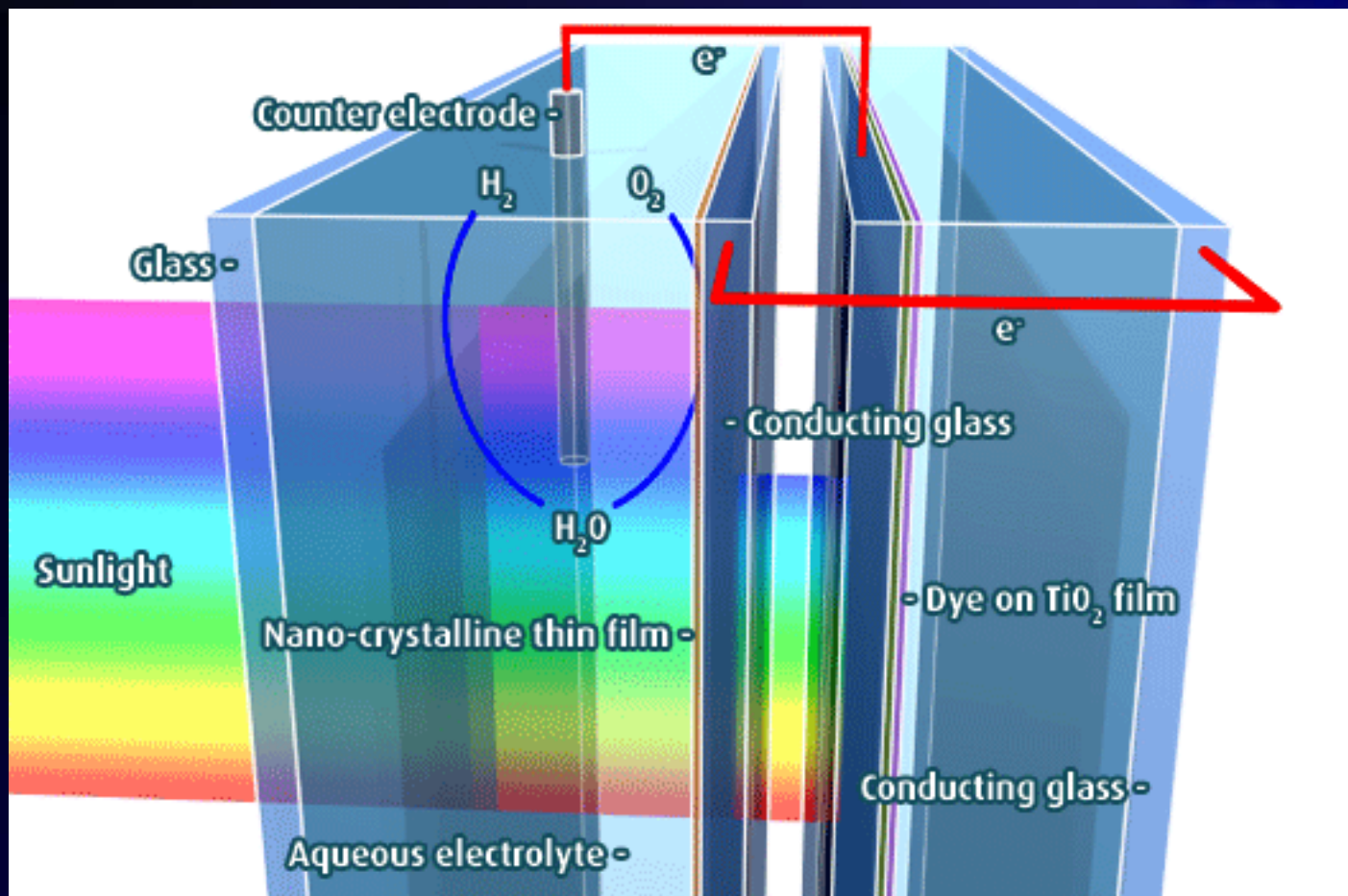
October 2004 – June 2008

- ❑ 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)



Photoelectrochemical (PEC) Tandem Cell



Hydrogen
Solar LLC (UK)

Task 21: BioHydrogen

- ❑ Evolved from Task 15
- ❑ Will include several components:
 - ❑ Hydrogen dark fermentations
 - ❑ Photobiological hydrogen production
 - ❑ In-vitro and biomimetic systems
 - ❑ Techno-economic analysis process integration

OA: Dr. Jun Miyake



Tasks Now in Definition

- ❑ 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



Annexes & Activities under Development

- ❑ Internal IEA **cooperation** – e.g., with Advanced Fuel Cells IA
- ❑ Hydrogen **storage** (focus on liquid & advanced solid state storage concepts)
- ❑ **Hydrogen education**
- ❑ Hydrogen **economics**
- ❑ **Compressed gas** assessment
- ❑ **Industrial uses** of hydrogen with **non-energy focus**
- ❑ **Infrastructure** for **stationary** applications



HIA and H₂Education

- ❑ Current focus on outreach
- ❑ High level of interest in education
- ❑ Awareness of education value proposition
- ❑ Future education inventory to capture array of activities in formal and informal education and workforce training at all levels
- ❑ Individual members at different stages in developing an education offering
- ❑ Commitment to international collaboration



HIA Members with current & near term anticipated H₂Education efforts

- ✓ Canada
- ☐ Denmark
 - Pending national hydrogen strategy
- ☐ France
 - Great interest
- ✓ Iceland
- ✓ Japan
- ✓ Lithuania
- ✓ Switzerland
- ✓ United States



Industry Participation : HIA Investment Value

Provides a neutral international profile

- ❑ Knowledgeable, reliable, unbiased
- ❑ Global reach (government, academia, industry)
- ❑ Non-compete operation

Leverages resources

- ❑ Focus includes science & technology, market analyses and outreach
- ❑ Portfolio includes shorter term and long-term, pre-competitive activities



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