

Pioneering Experiences in Permitting and Safety of Hydrogen Demonstration Systems

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HYDROGEN IMPLEMENTING AGREEMENT





Presentation Outline

- Introduction to International Energy Agency (IEA) Hydrogen Implementing Agreement (HIA)
- Task 18: Evaluation of Integrated Hydrogen Systems
- Hydrogen Demonstration Project Portfolio
- Lessons Learned
 - Permitting, Safety, Codes and Standards
 - Incidents
- Status and Plans



Task 18 - Integrated Systems Evaluation

- **Objectives:** To provide information on progress in the hydrogen economy; To assess integrated hydrogen demonstration projects in member countries; coordinates with Task 19 (Safety)
- **Task 18 Phase 1: two subtasks**
 - **Subtask A: Information Base Development;** led by Jean Dubé, Canada
 - **Subtask B: Demonstration Project Evaluation;** led by Ø. Ulleberg, Norway
- **Task 18 Schedule**
 - Began 1 January, 2004; Phase I concluded 31 December, 2006
 - Phase 2 began January 2007 and continues through December 2009
 - Experts meet two times per year, spring and fall, at demo sites



Canada
Natural Resources Canada



Norway
IFE



France
CEA



Denmark
Gas Technology Center



Japan
AIST Laboratory



Spain
INTA



European Commission
Joint Research Center



Italy
ENEA



Sweden
E.ON



The Netherlands
ECN



Iceland
Icelandic New Energy



United Kingdom
UK Consortium



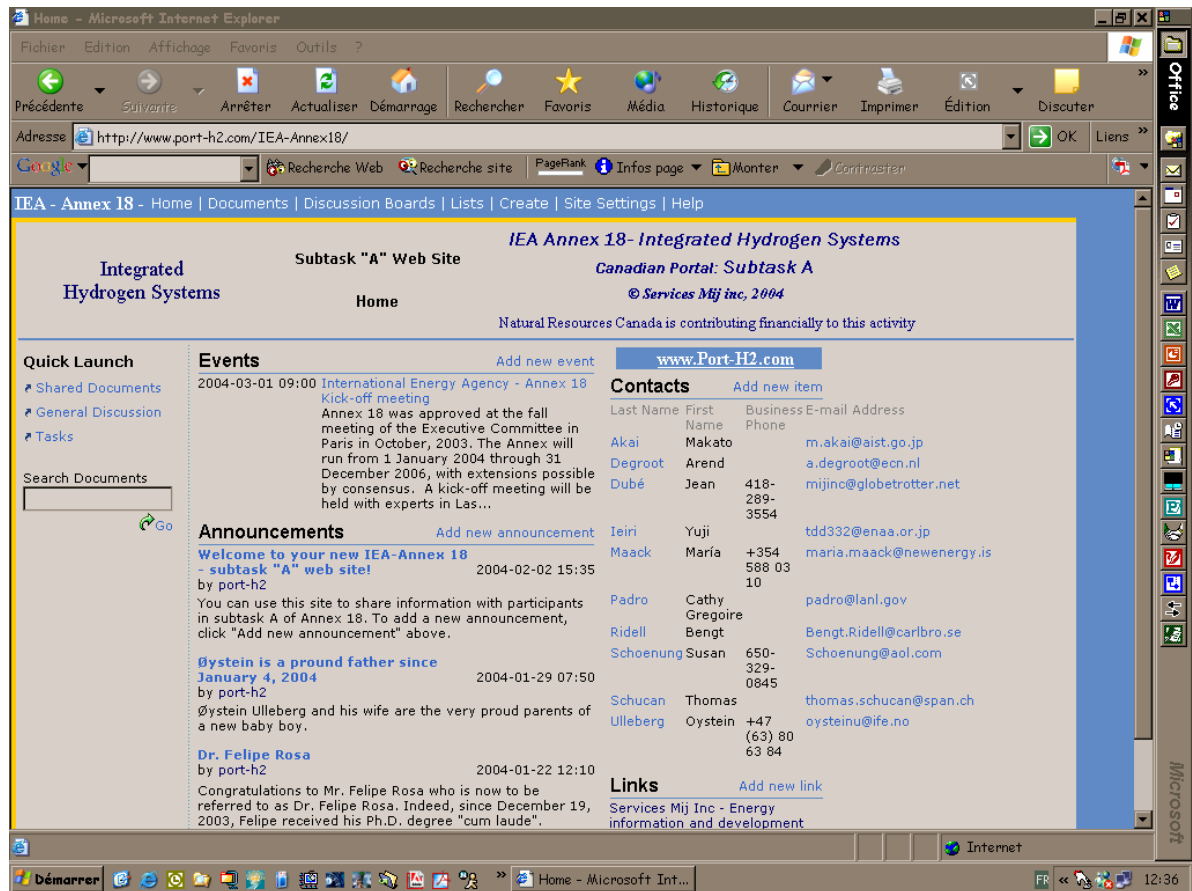
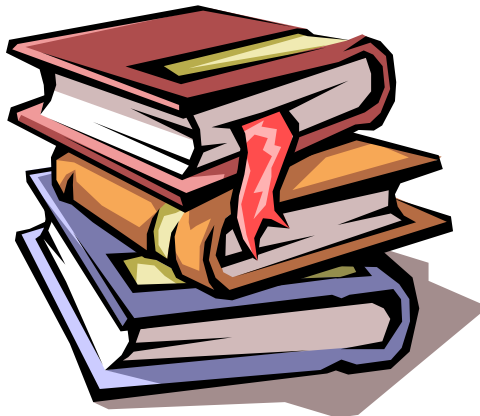
United States
Department of Energy



Subtask A: Information Base Development

Task 18 website: Searchable portal

- National documents
- Demonstration progress
- Hydrogen resources
- Vendors / capabilities
- Infrastructure studies
- Codes and Standards
- Economic analysis
- HySociety database
- Links to others



Public website: www.port-h2.com/IEA-Annex-18/



Subtask B: Demonstration Project Evaluation

- Objective:

–“...to gather data on hydrogen projects and exercise modeling and analysis capabilities to evaluate demonstration projects, or guide the design of them.”

- Technical:

- Performance (efficiencies, operating hours)
- Economics (investments, O&M → COE)
- Environment (emissions, fuel savings, RE-penetration)

**Quantitative
Modeling**

- Non-Technical:

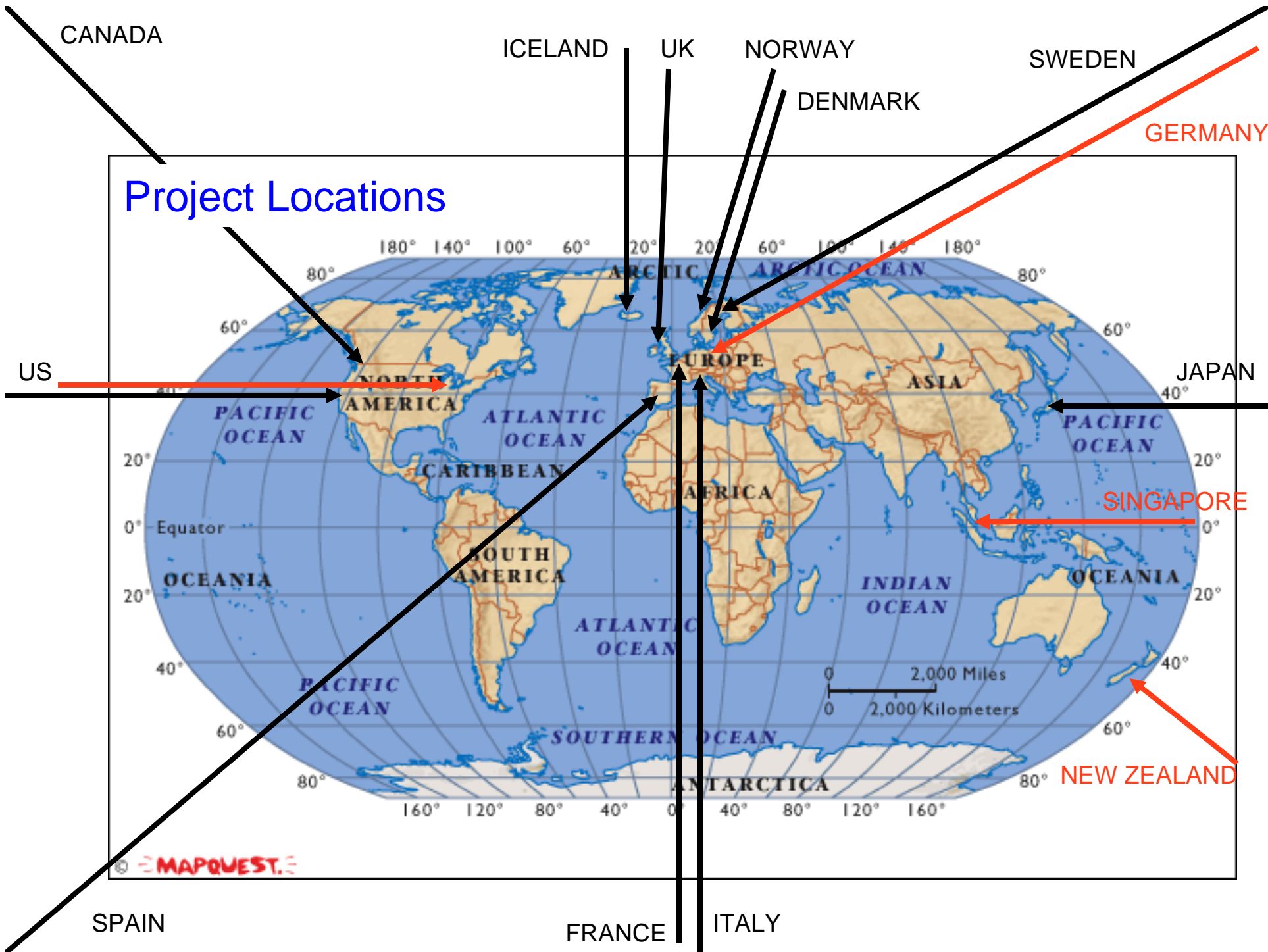
- System Design (components, technology & market readiness, **permitting & safety**)
- Project Design (planning & management)
- Overall Performance (user-friendliness, utilization)

**Qualitative
Analysis**



Task 18 Project Portfolio

Country	Projects	Location
Refueling Stations		
Sweden	Hydrogen filling station (re grid/electrolysis)	Malm
Iceland	Hydrogen filling station (grid/electrolysis)	Reykjavik
Canada	Hydrogen filling station (grid/electrolysis)	Vancouver
Grid-connected or stand-alone power systems		
Spain	PV/MH-telecom showcase (RE)	Madrid
Japan	Regenerative PEM FC-power system (grid)	Aichi
UK	RE/H2-project	Loughborough
Italy	Hydrogen from the Sun	Brescia
Combined fuel and electricity generation		
USA	Hydrogen energy/refuelling station (NG)	Las Vegas
USA	Hydrogen power park (RE)	DTE or HI
Infrastructure demonstrations		
Denmark	Natural gas / hydrogen pipeline, boiler	Copenhagen
Residential heat and power		
France	Building fuel cell evaluation	5 sites
Other Potential Phase 2 projects		
New Zealand	Renewable hydrogen at remote site	Totara Valley
Spain	Renewable hydrogen for desalination plant	Canary Islands
Germany	Refueling station	Munich or Berlin



H₂ Fueling Station, Reykjavik



Alkaline electrolyzer
(Norsk Hydro)



Citaro bus with Ballard fuel cell
(3 Buses total)

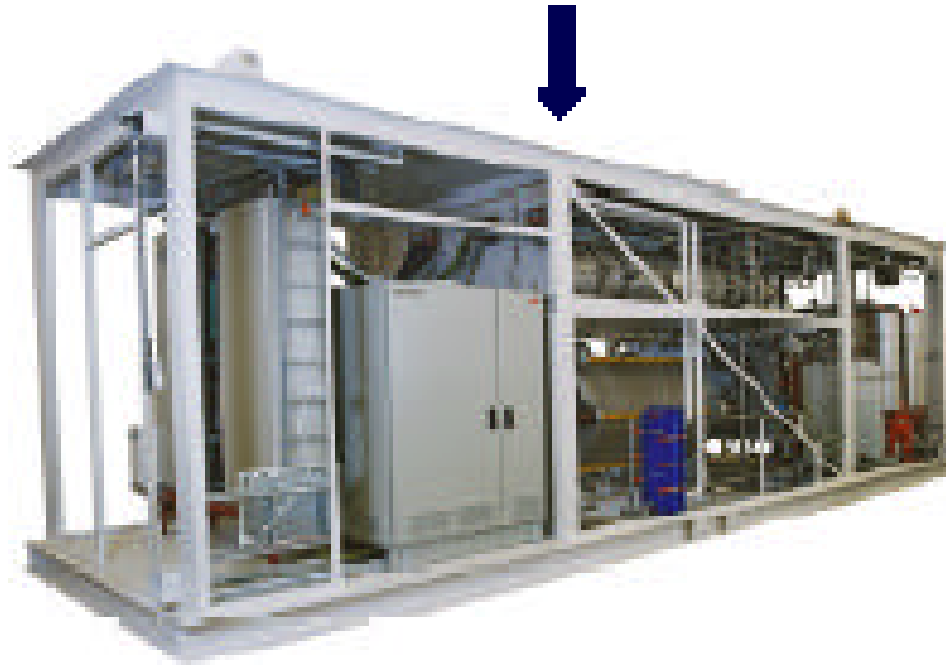
Objective: Test Fuel cell bus and operate prototype infrastructure and maintenance bay

Permitting at ECTOS Site in Reykjavik

- Existing codes from other countries, primarily Germany, were applied.
- Det Norske Veritas was contracted for the safety plan.
- The electrolyzer building is divided into hazardous and safe zones, per IEC 60079-10.
- NFPA 50A was used to determine keep-out distances for stored hydrogen.
- Station walls fortified (at extra cost), as station is located on a public street.

ECTOS Electrolyzer System

Non Hazardous Area Hazardous Area



Containerized electrolyser without wall panels showing the electrolyser unit separated by a wall into hazardous and non-hazardous areas. Based on IEC 60079-10.

Reykjavik Bus Incident



Cooling loop failed

Cooling liquid sprayed over the hot engine

Steam, smelling of glycoles, came from the vehicle, also inside

Police and firebrigade clueless, what to do??

They shut down roads around

Maintenance team arrived reconnected and drove away

Very important learning for the authorities, regarding incident reaction

H₂ Refueling Station, Malmö, Sweden



CNG bus with CNG/H₂ fuel mixture (2 buses total)

Objectives: Increase engine efficiency 5 to 7%; Decrease NOX emission >10%; Decrease GHG emissions 10 to 20%

Permitting at Malmö bus filling station

- Hydrogen-enriched natural gas is treated as natural gas; therefore no extra requirements are enforced for the station or the buses.
- Expanded use planned; contractor will be responsible for safety of hydrogen equipment.

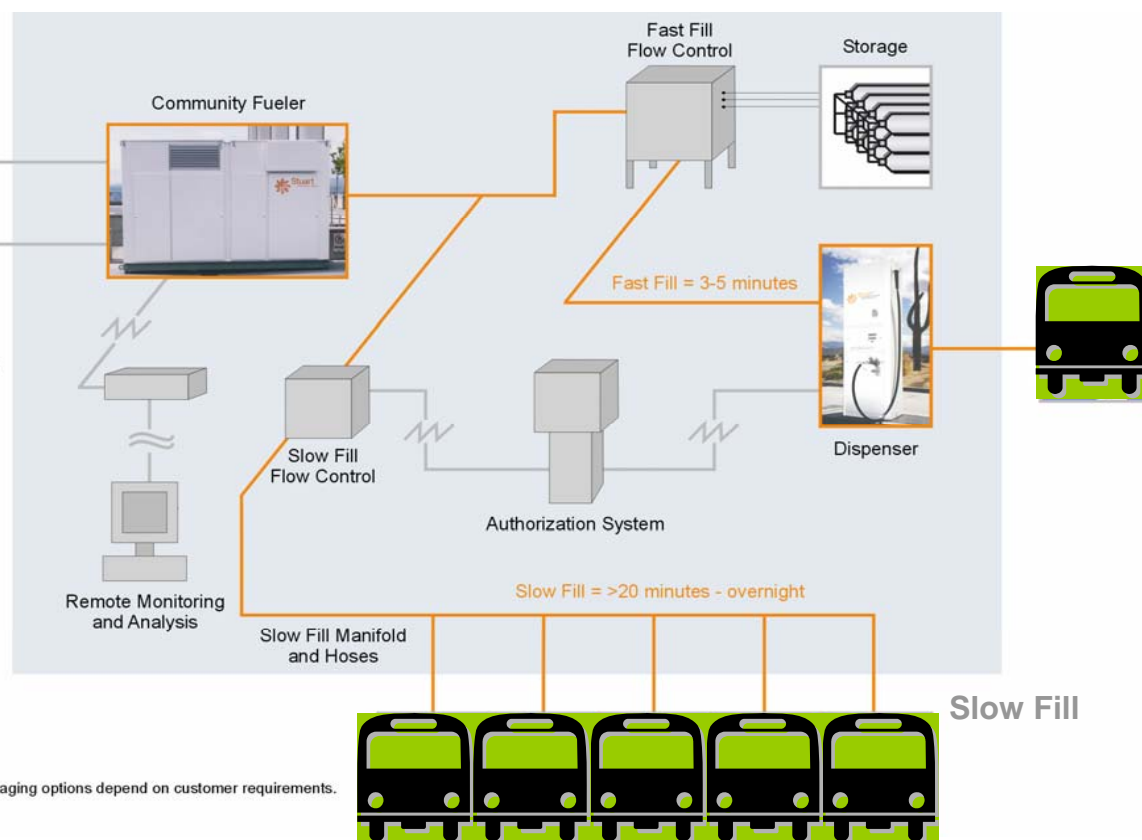
H₂ Refueling Station, Malmö, Sweden



Electrical Supply



Potable Water Supply



Evaluation status: Data analysis complete, analysis for expanded operations in progress

Pacific Spirit Station

- Located at the National Research Council's Institute for Fuel Cell Innovation on the campus of the University of British Columbia
- Integral part of Canadian Hydrogen Highway
- Participants include;
 - General Hydrogen (storage and dispenser)
 - BOC (integrator and compressor)
 - Fuel Cells Canada
 - Natural Resources Canada
 - National Research Council
- Operational since Spring 2005
- Five Ford Focus fuel cell cars



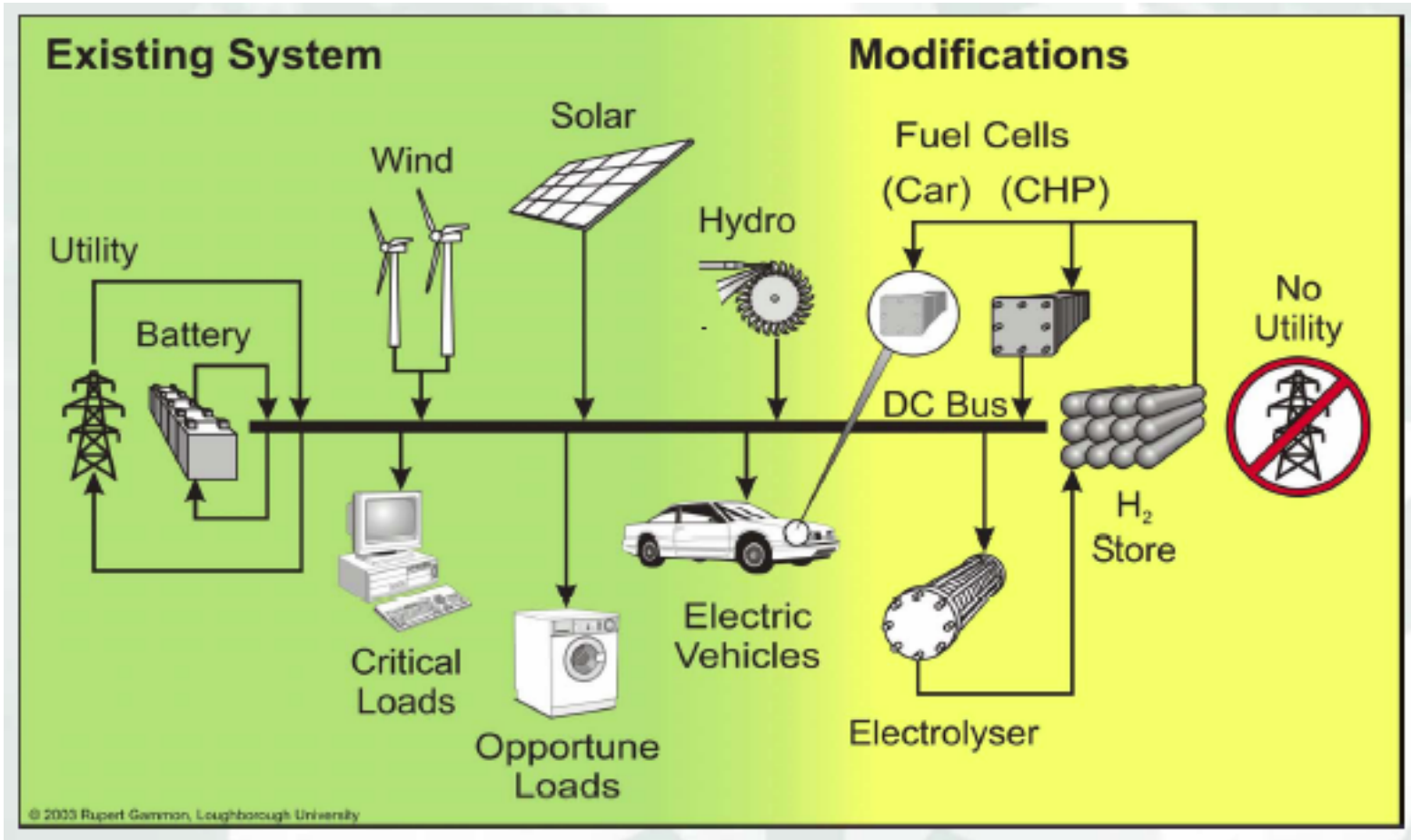
Objective: To serve fuel cell vehicles and to increase awareness with public and investors.

Evaluation status: Data gathering and evaluation in progress; emphasis on compressor performance

Permitting in British Columbia

- The Pacific Spirit Station is located on a federal site. Permitting was from the BC Safety Authority.
- In Victoria, the new station is located at a public transit facility. Permitting from BC Safety Authority, the Municipality and local fire department, which requires an emergency response plan.
- At Powertech, the hydrogen components are located on private property - an industrial site. HAZOPS and FMEA processes.
- The *Canadian Hydrogen Installation Code* is in review at this time for future stations on the Canadian Hydrogen Highway.

Hydrogen and Renewables Integration (HARI) Project - UK

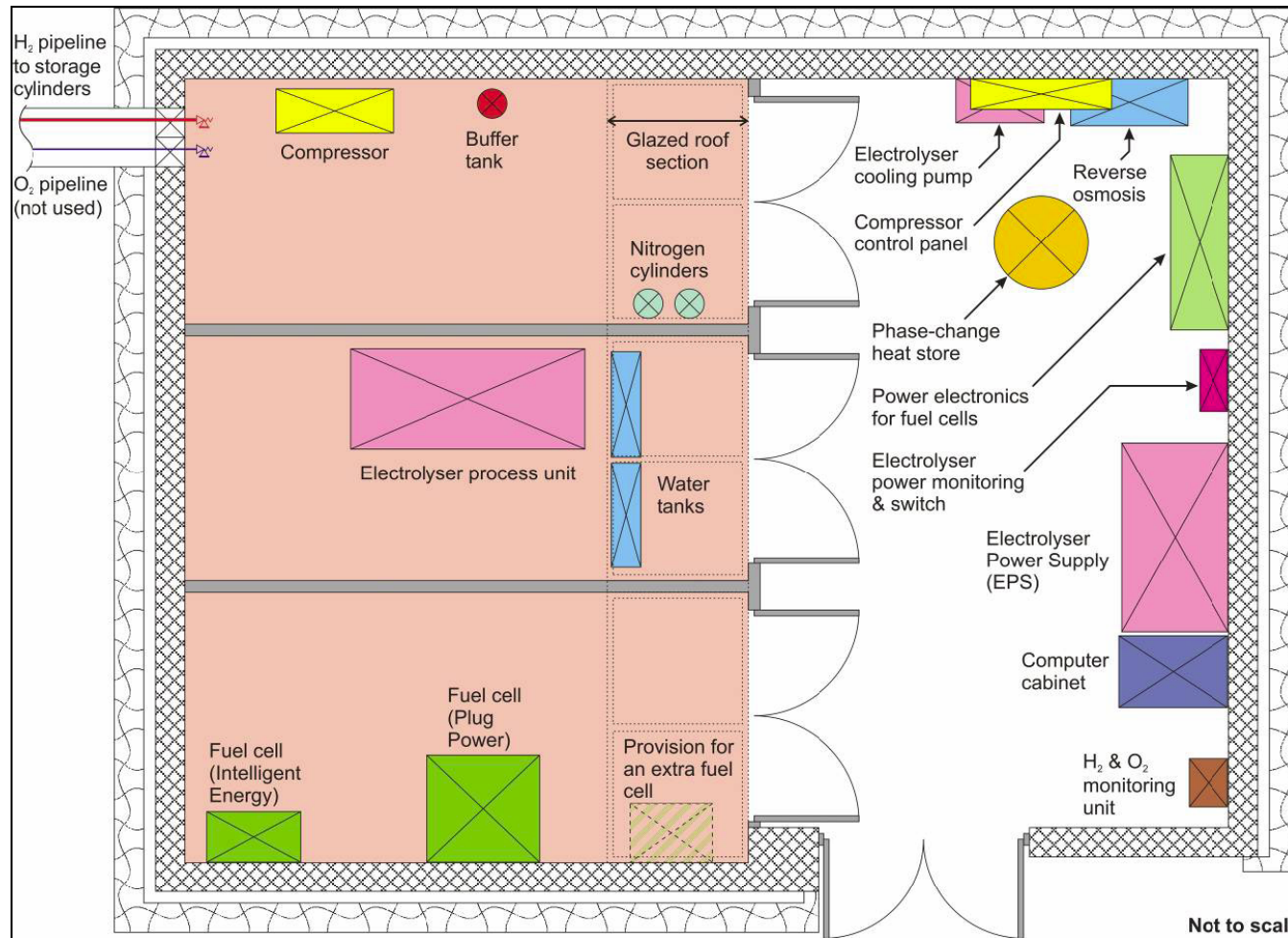


Objective: To make West Beacon Facility Energy Independent

Permitting and Safety at HARI

- The project is built on private property. There are no formal regulations. *“We had to devise our own.”*
- A Health and Safety Executive overviews operations and HAZOP procedures are in place.
- The fire brigade was consulted as hydrogen components were installed.
- The hydrogen building is divided into hazardous and safe zones.

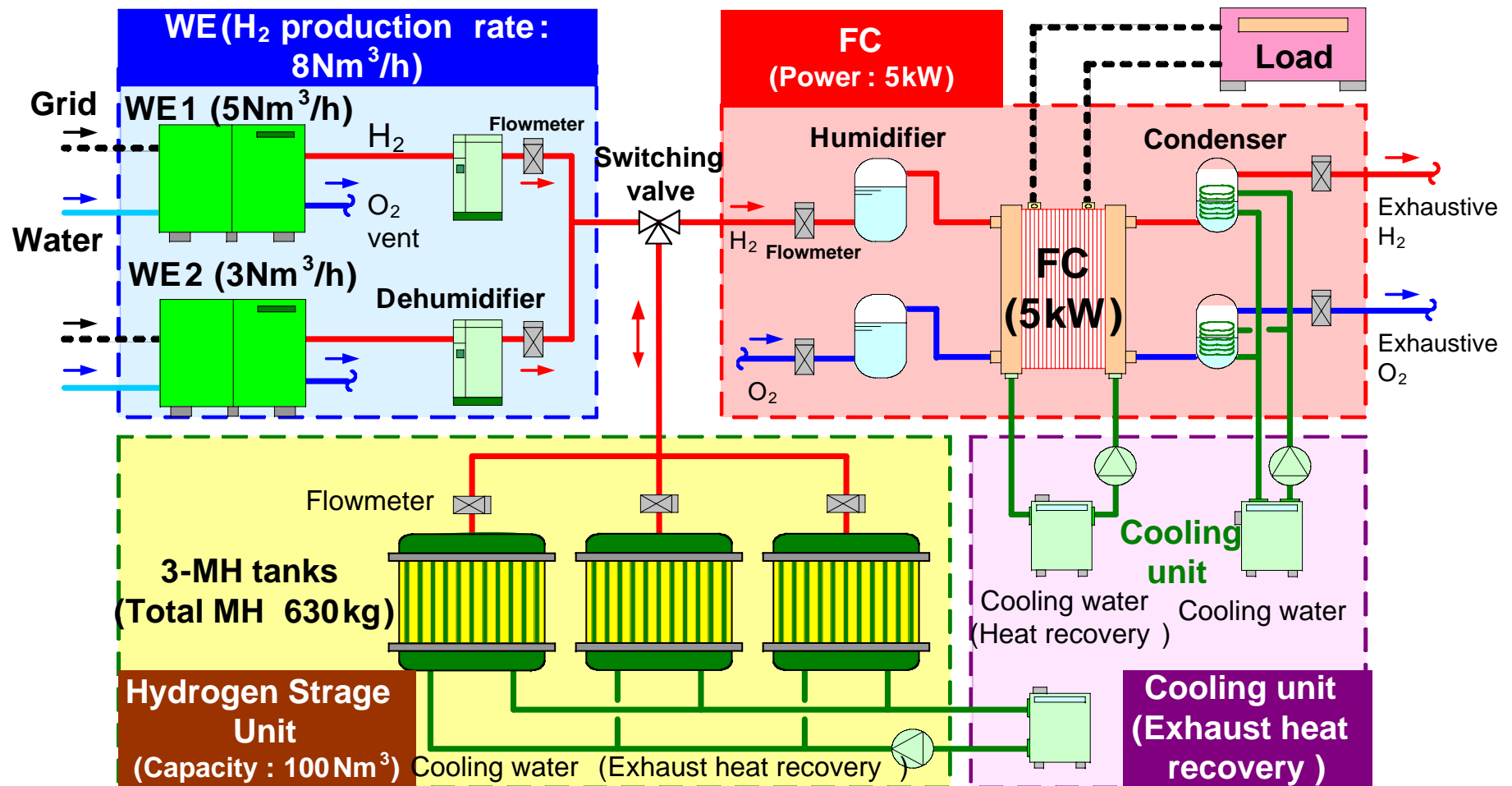
HARI Hydrogen Energy System



Layout of the West Beacon Farm 'Hydrogen building'

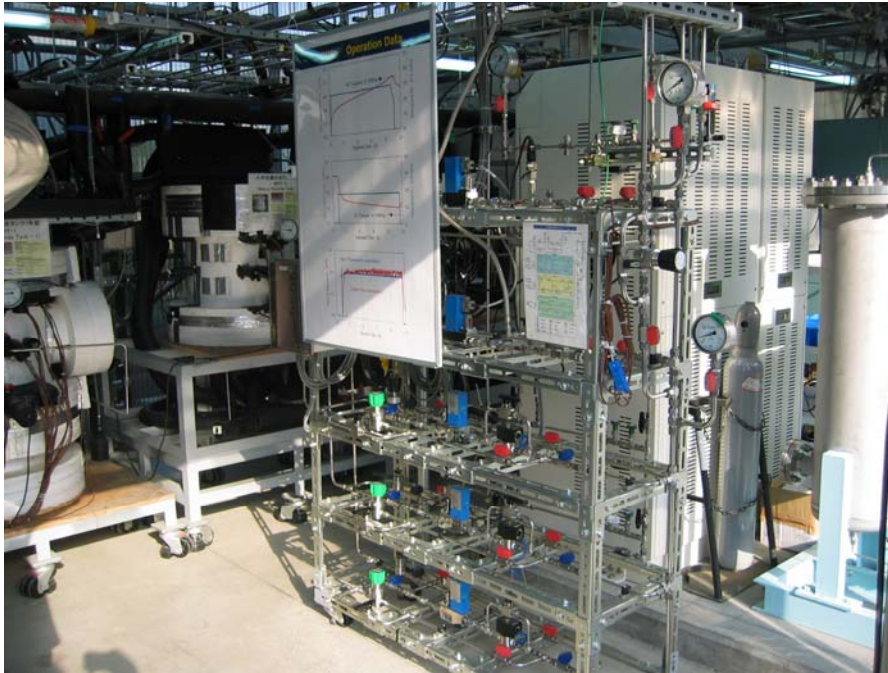
The pink shaded area is the hazardous zone and the white area the safe zone.

Integrated H₂ System, Takasago, Japan



Objective: Building thermal and electrical load-leveling

Integrated H₂ System, Takasago

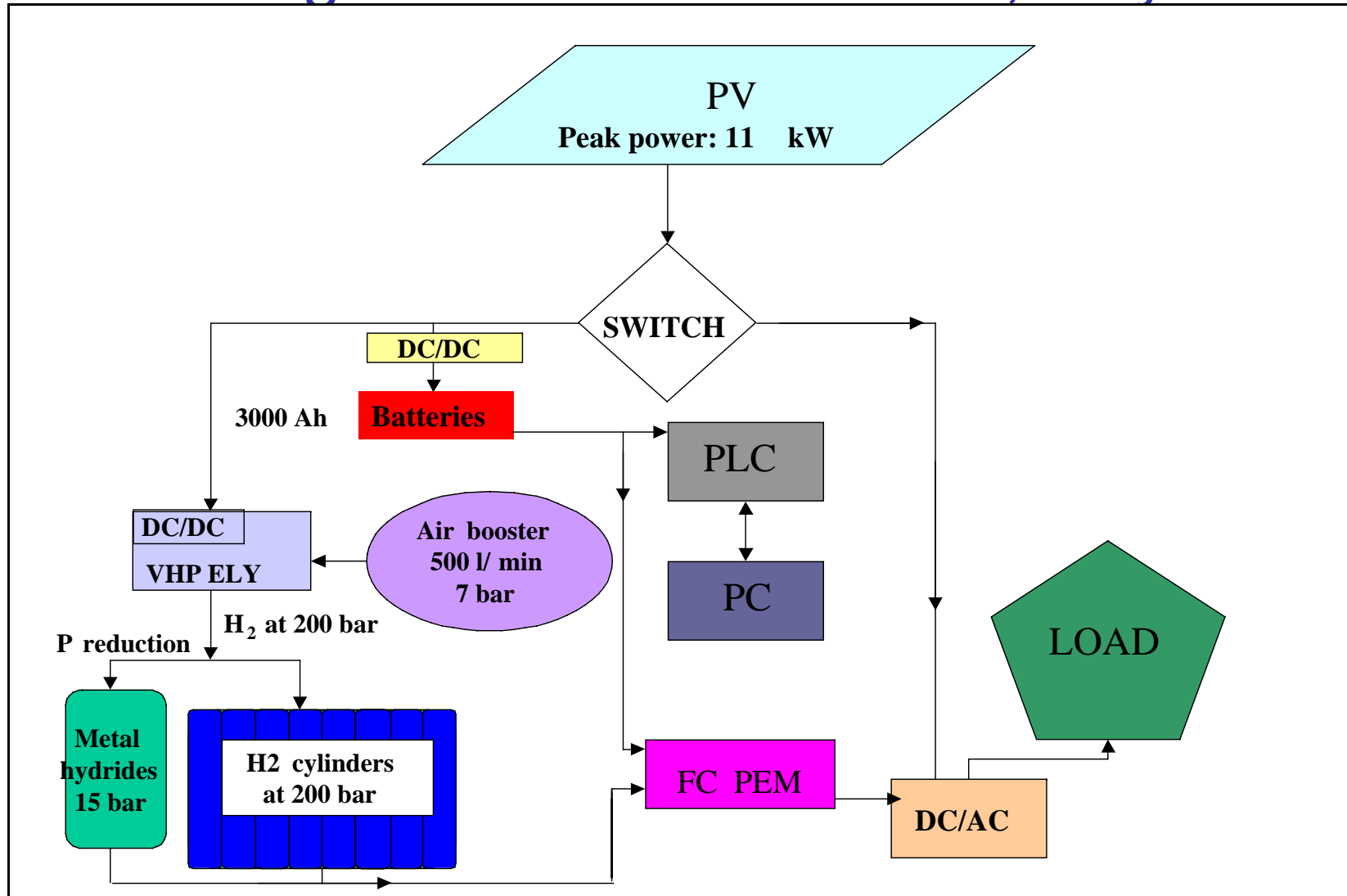


Reversible Fuel Cell System and Metal Hydride Storage

Permitting at Takasago Site in Japan

- In Japan, *“there is no special regulation only for hydrogen systems.”*
- The integrated hydrogen system is located in a company laboratory.
- Industrial Safety and Health Law for ventilation applies. Dust removal to prevent explosion or fire.
- The “Hydrogen Gas Guidebook” applies.
- High pressure and industrial electric codes apply.

“Hydrogen from the Sun” Ecological House in Brunate, Italy

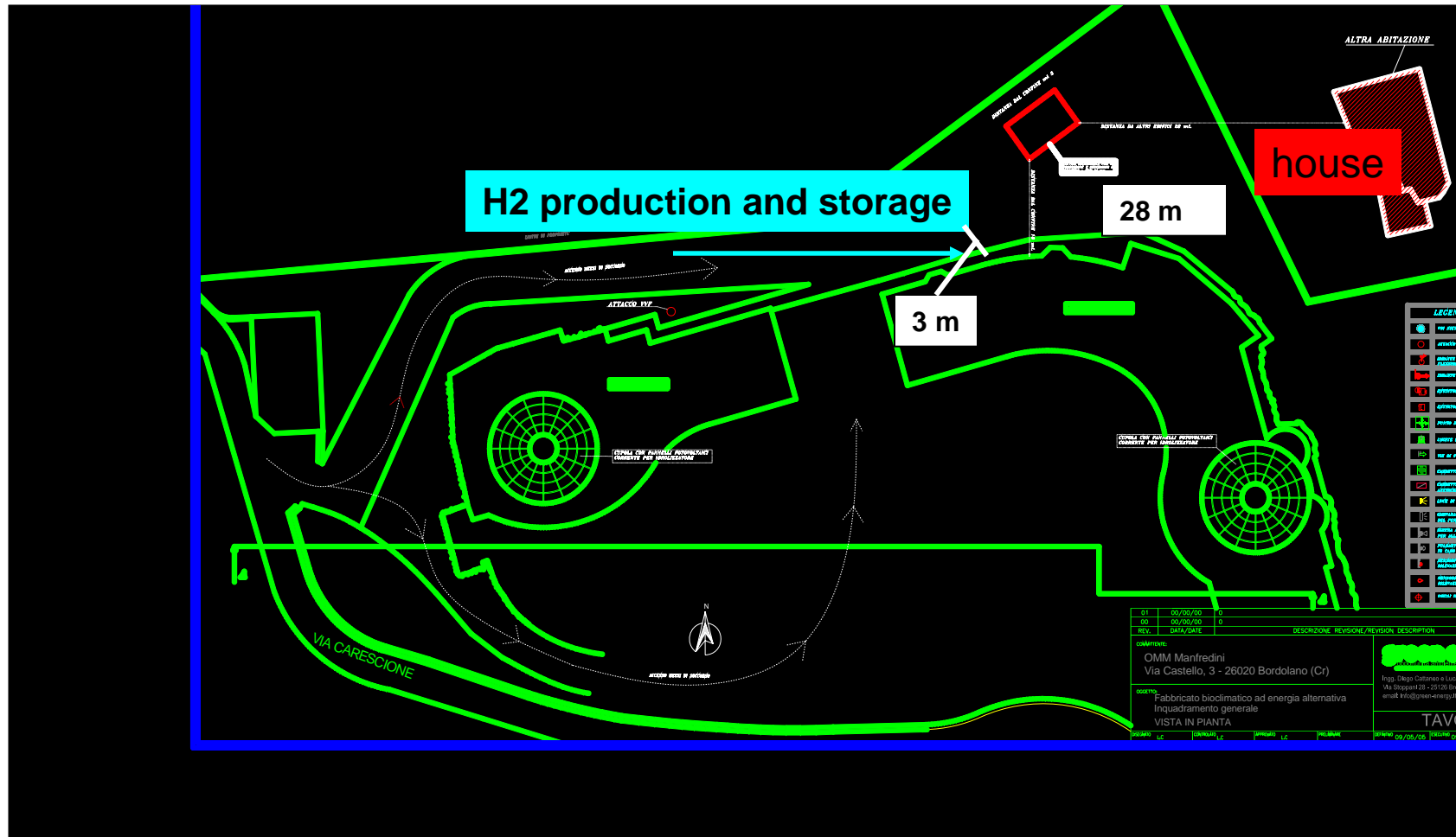


Objective: To make the estate fully powered by renewable energy

Permitting at Ecological House in Brunate

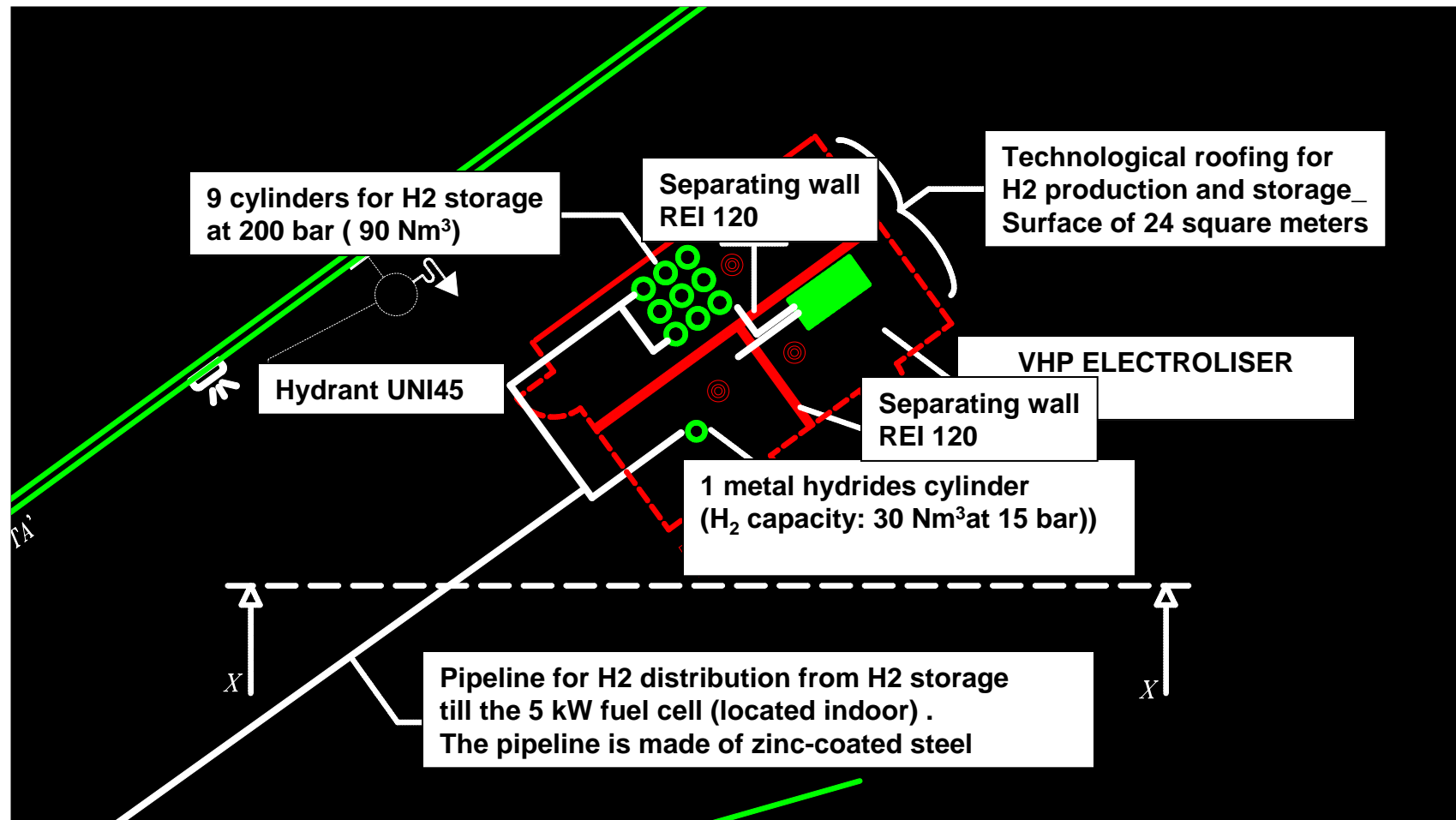
- Due to lack of Italian regulations for hydrogen systems, the local fire marshall (Fire Brigade of the Province of COMO) constrained the mass of hydrogen that could be stored on site and the location of subsystems.
- *“At first, the presence of another house nearby was a problem for the Fire Brigade. After a few months they decided to respect the limit of 15 meters between the site of the H₂ production and storage and that house.”*

Request of approval of the local Fire Brigade: Italian house



Request of approval of the local Fire Brigade

Distribution of the electrolyser and of the hydrogen storage



Las Vegas Energy Station



Safety review completed per US DOE procedures.

Las Vegas Energy Station: Safety Measures

- ASME code compliant steel (not composite) hydrogen storage vessels
- NFPA 50 used to determine keep-out distances for hydrogen storage.
- A hydrogen dispenser nozzle compliant with SAE J2600
- Distinctly different geometries for the hydrogen and blended-fuel dispenser nozzles so that they cannot be mistaken for one another
- Automatic pressure-loss checks prior to and during a fueling operation
- Concrete platforms in the fueling areas to promote grounding
- Third-party-certified electrical enclosures
- All systems subjected to detailed HAZOP review

Other Project Experiences

- H2 Truck - Denmark: CE certified

“Standardization is a subject that needs immediate attention, since this already puts restraints on products coming to the market.”

- EPACOp - France: based on European Conformity Standards

“In the absence of official regulations dealing especially with fuel cell technology, EC directives were used.”

- multiEnergy Station - Collesalvetti, Italy

The first “really” public hydrogen station in Italy

- Linde Hydrogen Center - Munich, Germany

“We expect to be filling on average of around 10 hydrogen vehicles a day - making the Linde Hydrogen Center one of the busiest hydrogen filling stations in the world.”

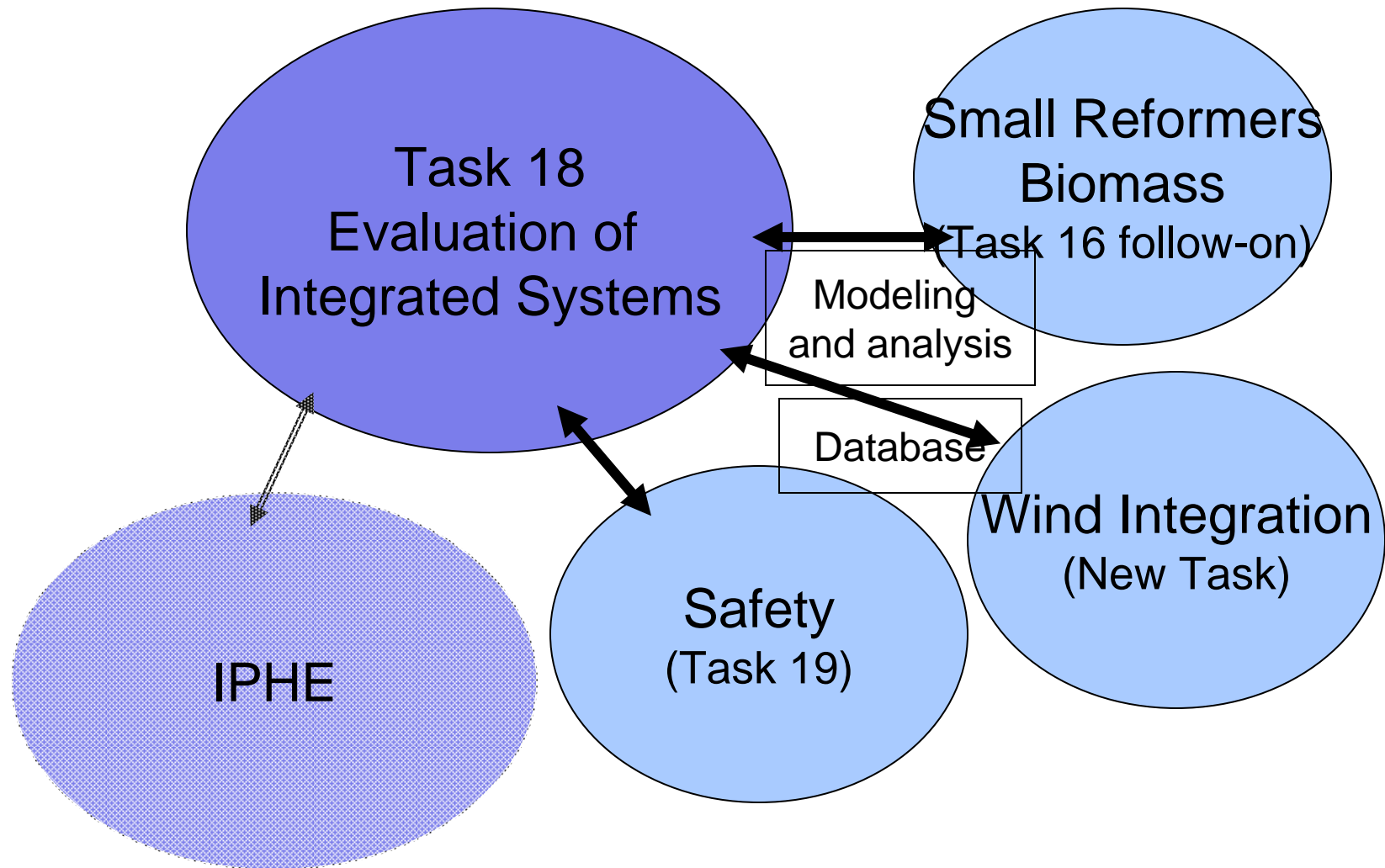


Status and Plans

- Task 18 has been extended through 2009.
- Subtasks A&B continue; new Subtask C to provide synthesis and lessons learned.
- Kick-off meeting for Phase 2 will be held at the Italian Ecological House in Brunate in April. Topics to include system performance and safety design.
- New projects to be selected for evaluation.
- Coordination with Task 19 (Safety) to continue.



Relationship to Other Activities



Task 18 Contact Information

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