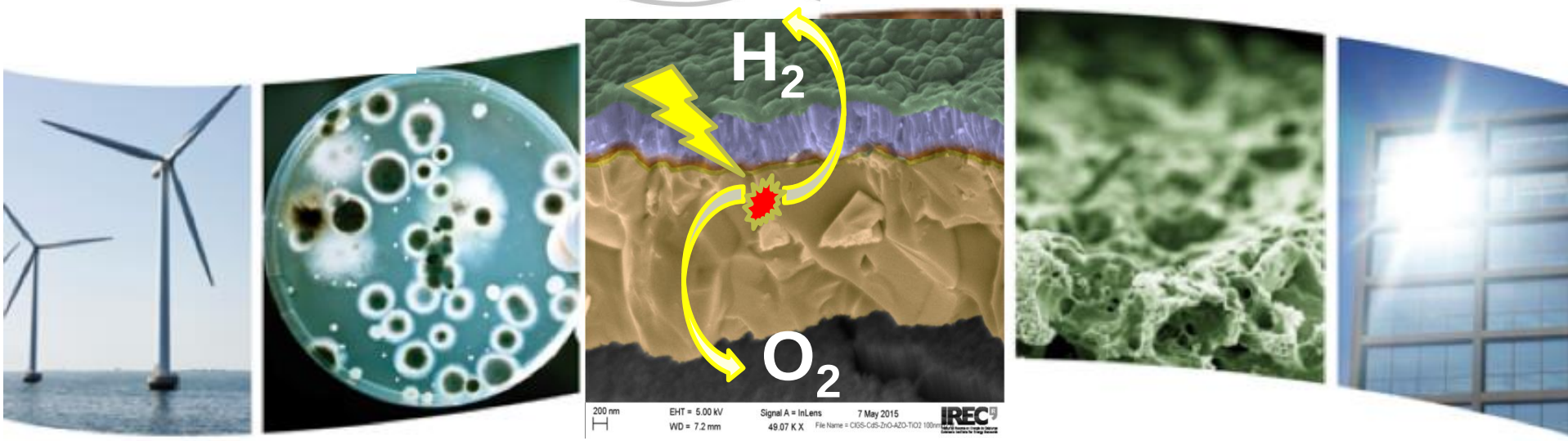


Seguridad, impacto, oportunidaded por el hidrogeno como vector energético y barreras para su implementación

J.R. Morante & M. Torrell

IREC, Catalonia Institute for Energy Research, Plaça de les Dones de Negre,1.
Sant Adrià del Besòs, 08930. Spain.

Vehicles

CONTROLLING AUTHORITIES:
DOT/NHTS (crashworthiness)
EPA (emissions)

General FC Vehicle Safety:

Fuel Cell Vehicle Systems:

Fuel System Components:

Containers:

Reformers:

Emissions:

Recycling:

Service/Repair:

Dispensing

CONTROLLING AUTHORITIES:
State and Local Government
(zoning, building permits)

Storage Tanks:

Piping:

Dispensers:

On-site H2 Production:

Codes for the Environment:

Storage

CONTROLLING AUTHORITIES:
DOT/PHMSA (over-road transport, pipeline safety)

Composite Containers:

Pipelines:

Equipment:

Fuel Transfer:

Infrastructure

Fuel Specs:

Weights/Measures:

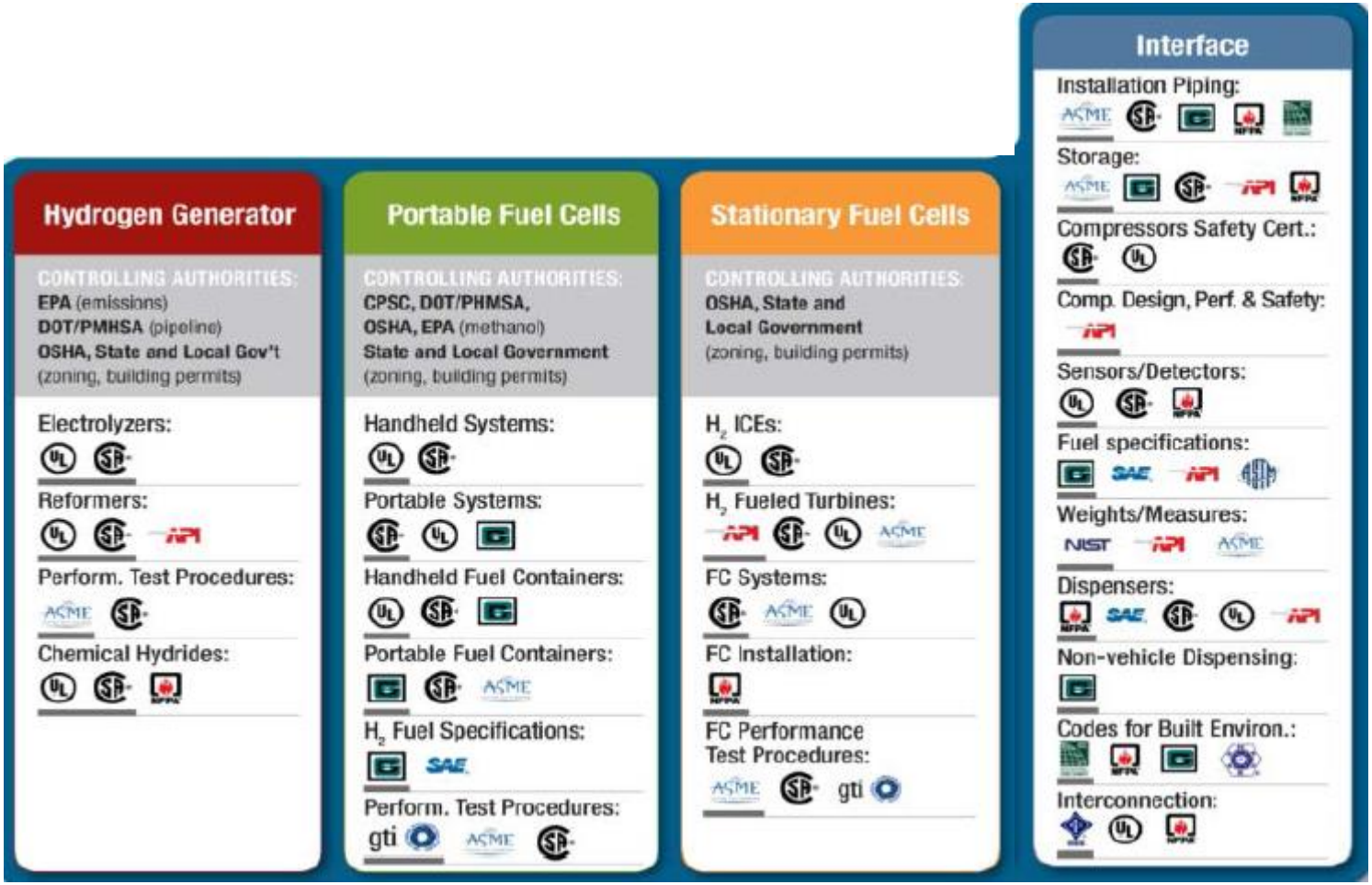
Fueling:

Sensors/Detectors:

Connectors:

Communications:

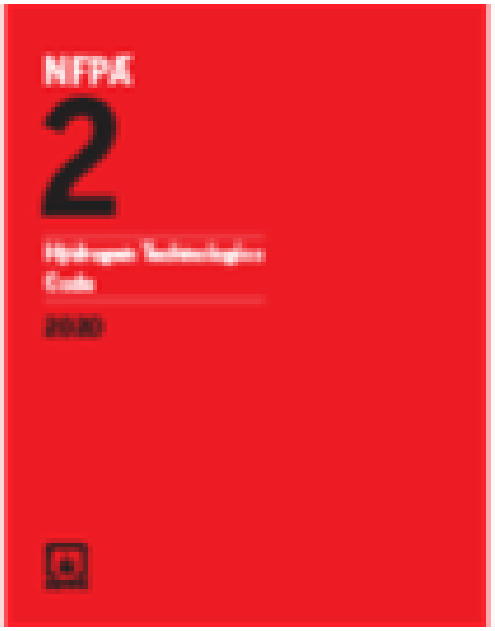
Building and Fire Code Requirements:


Hydrogen Generator
CONTROLLING AUTHORITIES:
EPA (emissions)
DOT/PMHSA (pipeline)
OSHA, State and Local Gov't
(zoning, building permits)
Electrolyzers:
Reformers:
Perform. Test Procedures:
Chemical Hydrides:
Portable Fuel Cells
CONTROLLING AUTHORITIES:
CPSC, DOT/PHMSA,
OSHA, EPA (methanol)
State and Local Government
(zoning, building permits)
Handheld Systems:
Portable Systems:
Handheld Fuel Containers:
Portable Fuel Containers:
H2 Fuel Specifications:
Perform. Test Procedures:
Stationary Fuel Cells
CONTROLLING AUTHORITIES:
OSHA, State and
Local Government
(zoning, building permits)
H2 ICEs:
H2 Fueled Turbines:
FC Systems:
FC Installation:
FC Performance
Test Procedures:
Interface
Installation Piping:
Storage:
Compressors Safety Cert.:
Comp. Design, Perf. & Safety:
Sensors/Detectors:
Fuel specifications:
Weights/Measures:
Dispensers:
Non-vehicle Dispensing:
Codes for Built Environ.:
Interconnection:

Organization Name			Standards Development Areas
	AGA	American Gas Association	Materials testing standards
	API	American Petroleum Institute	Equipment standards for petroleum production, storage and handling
	ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers	Promoting sustainability through research, standards writing, publishing, and education
	ASME	American Society of Mechanical Engineers	Mechanical and multidisciplinary engineering, design codes and standards
	ASTM	American Society for Testing and Materials	Technical test standards for materials, products, systems
	CGA	Compressed Gas Association	Equipment design and performance standards for compressed gas systems and components
	CSA	CSA Standards	US and Canadian equipment standards
	DOT	Department of Transportation	Federal transportation regulatory agency
	FERC	Federal Energy Regulatory Commission	Regulates interstate transmission of electricity, gas, and oil
gti	GTI	Gas Technology Institute	Supplies technical support and training for the energy industry
	ICC	International Code Council	Family of model building codes, including the International Fire Code
	IEEE	Institute of Electrical and Electronics Engineers	Electrical standards
	NERC	North American Electric Reliability Corporation	Produces standards for electric grid operation
	NFPA	National Fire Protection Association	Model codes and standards, including the National Electric Code
NIST	NIST	National Institute of Standards and Technology	Measurement standards
SAE	SAE	Society of Automotive Engineers	Vehicle standards
	NARUC	National Association of Regulatory Utility Commissioners	Represents state public service commissions
	UL	Underwriters Laboratory	Equipment and performance testing standards

Code Change	Impact
2003 International Fire Code adds chapter on hydrogen fueling stations	This was the first hydrogen fueling information available in the fire codes
2005 NFPA forms Hydrogen Technologies Technical Committee	With the support of DOE NFPA forms the first Fire Code Committee specifically devoted to hydrogen technologies safety
2006 NFPA 52 Vehicular Alternative Fuels codes adds multiple chapters on hydrogen vehicle fueling	First detailed set of requirements for both hydrogen vehicle fueling and hydrogen storage at stations
2009 SAE J2719 Fuel Quality published	First US standard for hydrogen fuel quality for passenger vehicles

Code Change	Impact
2010 SAE 2601 Fueling Protocol published	First US standard for fueling passenger vehicles at retail stations
2011 NFPA 2 Hydrogen Technologies Code first edition published	First National Fire specifically for hydrogen including risk-informed setback distances for bulk gaseous storage systems
2012 CSA Hydrogen Component Standards published	Comprehensive set of listing standards for hydrogen components
2015 International Fire Code references NFPA 2	Reference to NFPA 2 hydrogen technologies Code effectively makes NFPA2 the national code for hydrogen
2016 NFPA 2 Hydrogen Technologies Codes incorporates fueling material from NFPA 52	Further consolidation of NFPA hydrogen requirements into what is now the national code for hydrogen technologies



http://catalog.nfpa.org/NFPA-2-Hydrogen-Technologies-Code-P1144.aspx

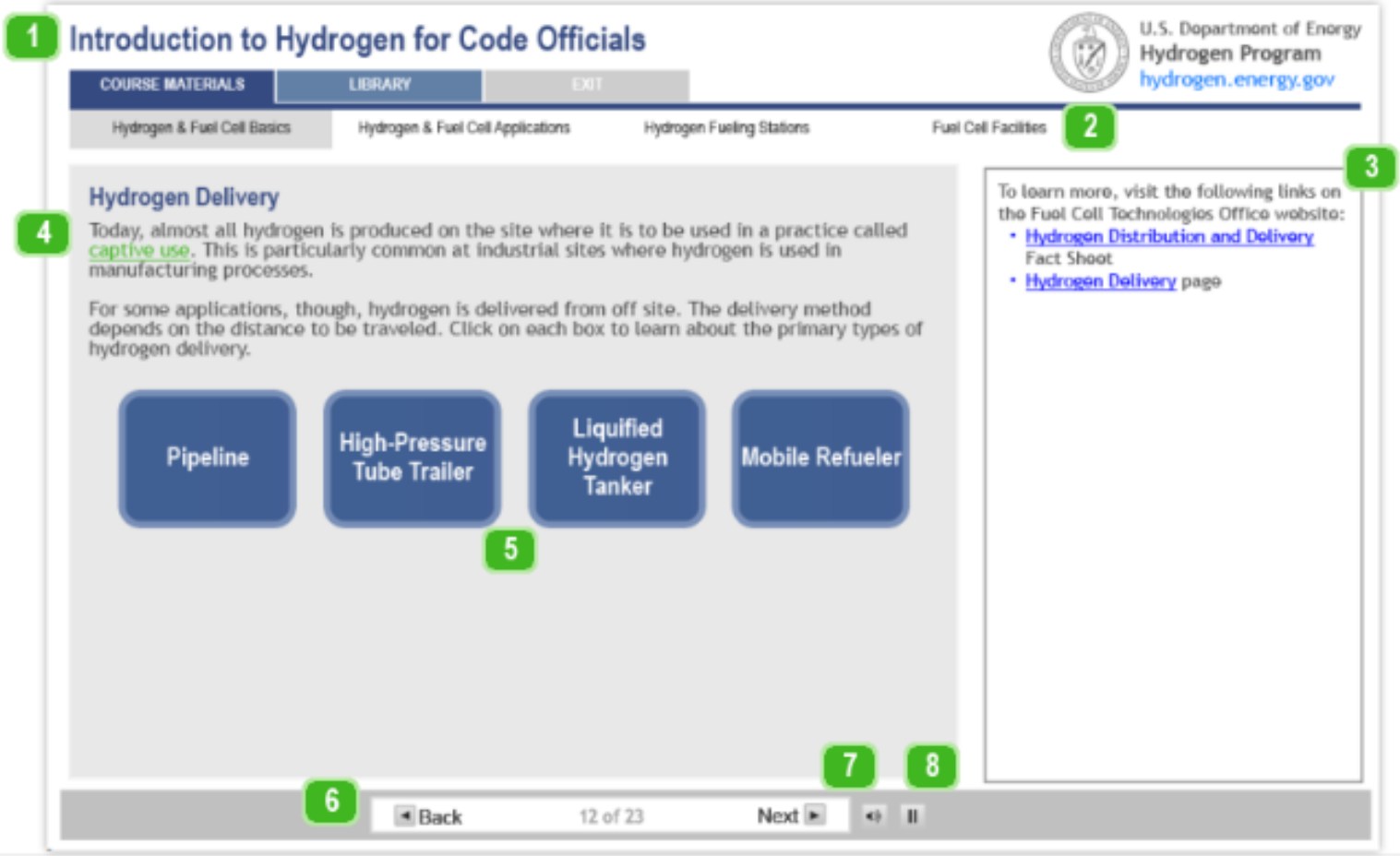
H2 Tools is intended for public use. It was built, and is maintained, by the Pacific Northwest National Laboratory with funding from the DOE Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office.

Navigating the Course

COURSE MATERIALS | LIBRARY | EXIT

U.S. Department of Energy
Hydrogen Program
hydrogen.energy.gov

Click any of the indicators below to learn more about each section.



-https://www.hydrogen.energy.gov/training/code_official_training/

Telecommunications Industry Association

A Fuel Cell Guide

REGULATIONS, CODES, AND STANDARDS FOR THE DEPLOYMENT OF

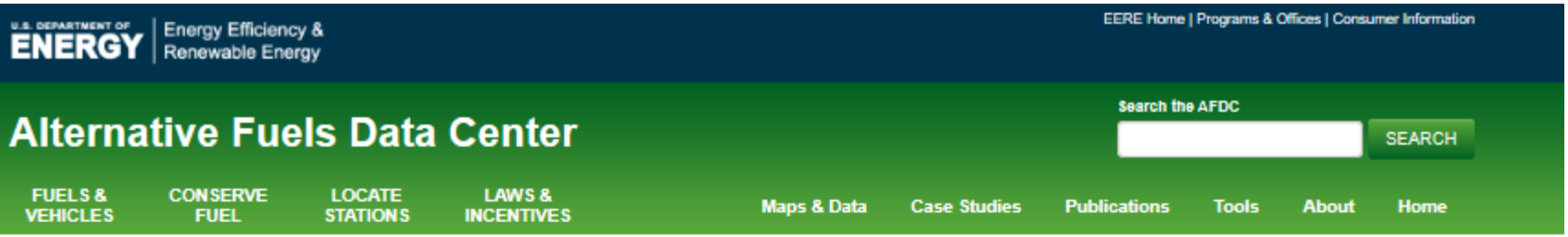
http://www.tiaonline.org/resources/tia-fuel-cell-reference-guide

Guide to Permitting Hydrogen Motor Fuel Dispensing Facilities

Hydrogen Technologies Safety Guide

http://www.nrel.gov/docs/fy16osti/64042.pdf

*http://*www.nrel.gov/docs/fy15osti/60948.pdf



Codes and Standards Resources

The codes and standards resources linked below help project developers and code officials prepare and review code-compliant projects.

Standards Development Organizations

Standards development organizations (SDOs) are responsible for leading the support and development of key codes and standards for alternative fuel vehicles, dispensing, storage, and infrastructure. The following charts show the SDOs responsible for these alternative fuel codes and standards.

- Biodiesel Vehicle and Infrastructure Codes and Standards Chart
- Electric Vehicle and Infrastructure Codes and Standards Chart
- Ethanol Vehicle and Infrastructure Codes and Standards Chart
- Natural Gas Vehicle and Infrastructure Codes and Standards Chart
- Propane Vehicle and Infrastructure Codes and Standards Chart

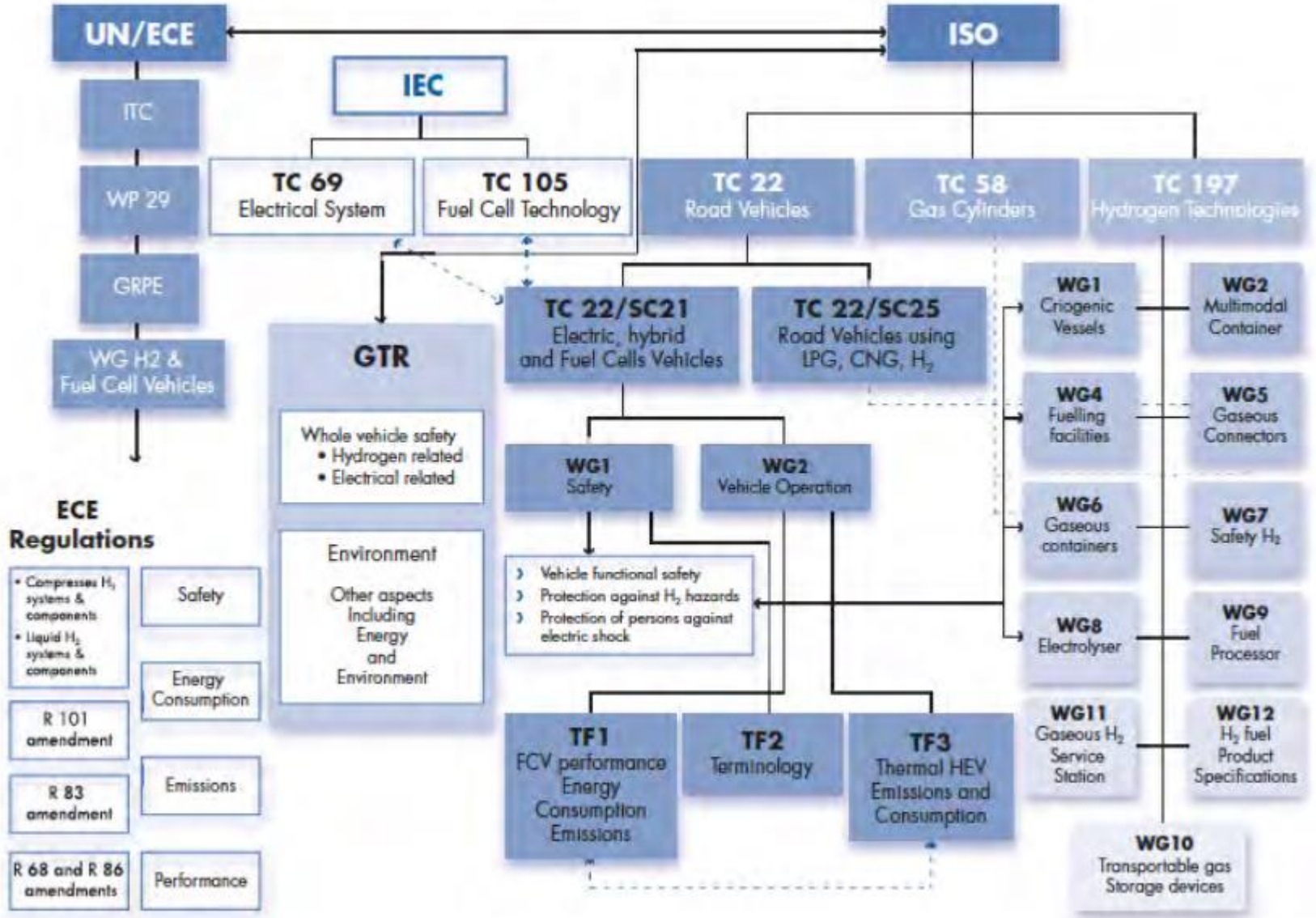
Codes and Standards

The following documents are lists of nationally recognized codes and standards related to vehicles and infrastructure used for fuel projects. Additional codes and standards might exist for some jurisdictions.

- Biodiesel Vehicle and Infrastructure Codes and Standards Citations
- Ethanol Vehicle and Infrastructure Codes and Standards Citations
- Natural Gas Vehicle and Infrastructure Codes and Standards Citations
- Propane Vehicle and Infrastructure Codes and Standards Citations

Learn about codes and standards basics.

https://www.afdc.energy.gov/codes_standards.html


UN/ECE
ISO
IEC
ITC
WP 29
GRPE
WG H2 & Fuel Cell Vehicles
TC 69 Electrical System
TC 105 Fuel Cell Technology
TC 22 Road Vehicles
TC 58 Gas Cylinders
TC 197 Hydrogen Technologies
GTR
Whole vehicle safety
• Hydrogen related
• Electrical related
Environment
Other aspects Including Energy and Environment
TC 22/SC21 Electric, hybrid and Fuel Cells Vehicles
TC 22/SC25 Road Vehicles using LPG, CNG, H2
WG1 Safety
WG2 Vehicle Operation
› Vehicle functional safety
› Protection against H2 hazards
› Protection of persons against electric shock
TF1 FCV performance Energy Consumption Emissions
TF2 Terminology
TF3 Thermal HEV Emissions and Consumption
WG1 Criogenic Vessels
WG2 Multimodal Container
WG4 Fuelling facilities
WG5 Gaseous Connectors
WG6 Gaseous containers
WG7 Safety H2
WG8 Electrolyser
WG9 Fuel Processor
WG11 Gaseous H2 Service Station
WG12 H2 fuel Product Specifications
WG10 Transportable gas Storage devices
ECE Regulations
• Compressed H2 systems & components
• Liquid H2 systems & components
Safety
Energy Consumption
R 101 amendment
R 83 amendment
Emissions
R 68 and R 86 amendments
Performance

ISO standards

The International Standardisation Organisation (ISO) is actively engaged in the development of international standards for hydrogen equipment and technologies through the following technical committees (TC):

- ISO/TC 197 – Hydrogen technologies;
- ISO/TC 22 – Road vehicles; and
- ISO/TC 58 – Gas cylinders.

IEC standards

The International Electrotechnical Commission (IEC) is actively engaged in the development of international standards relevant to hydrogen equipment and technologies through the following technical committees (TC):

- IEC/TC 105 – Fuel cell technologies;
- ISO/TC 69 – Electric road vehicles and electric industrial trucks; and
- IEC/TC 31 – Equipment for explosive atmospheres.

EIGA Codes

The European Industrial Gases Association (EIGA) is an organization representing the majority of European (and some non-European) companies producing and distributing industrial, medical and food gases. The activities of the organization are focused on the technical, safety and environmental aspects concerning the handling of gases. Since 2002, EIGA has been a major contributor to the development of international standards and the dissemination of knowledge related to hydrogen-energy systems.

To date 5 Industrial Gas Codes (IGC) code of practice documents have been published by EIGA related to various aspects of hydrogen delivery covering general safety aspects, hydrogen and syngas pipelines, hydrogen production plants, cylinders and vessels for hydrogen transport and refuelling station designs.

SAE J2600 - Compressed Hydrogen Surface Vehicle Fueling Connection Devices
http://standards.sae.org/j2600_201211/

SAE J2601/2 - Hydrogen Bus Fueling Technical Information Report
http://www.sae.org/technical/standards/J2601/2_201409

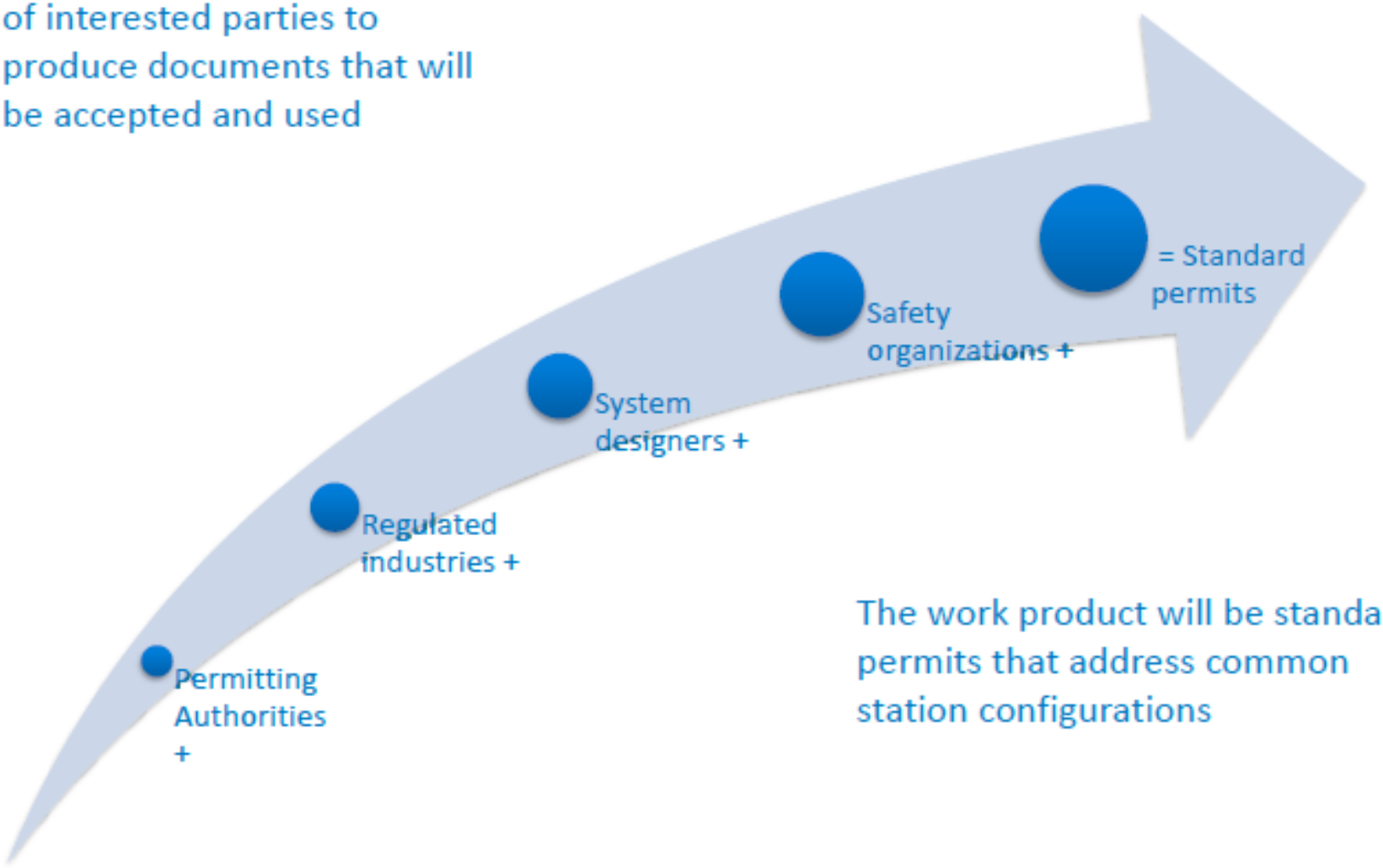
SAE J2601/3 - Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles
http://standards.sae.org/j2601/3_201306/

SAE J2578 - Recommended Practice for General Fuel Cell Vehicle Safety
http://standards.sae.org/j2578_201408/

SAE J2579 - Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles
http://standards.sae.org/j2579_201303/

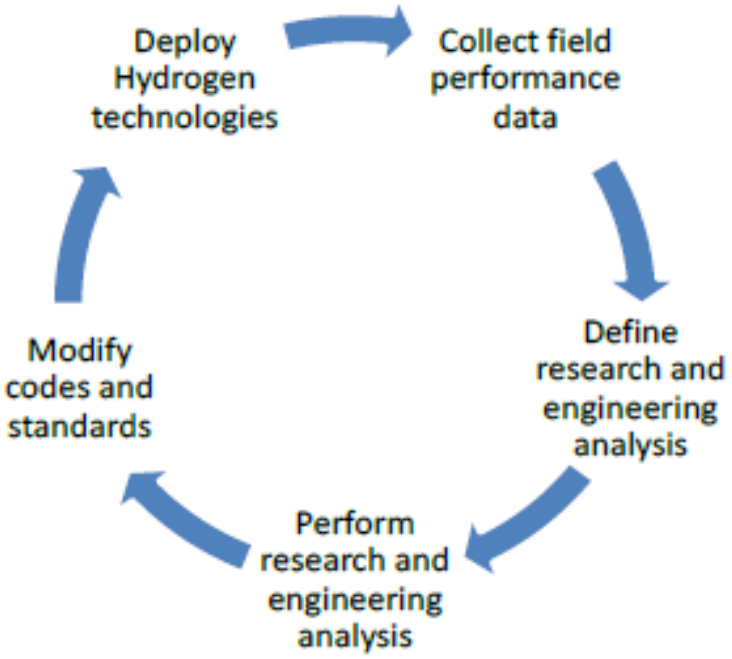
SAE J2719 - Hydrogen Fuel Quality for Fuel Cell Vehicles.
http://standards.sae.org/j2719_201109/

Process requires collaboration of interested parties to produce documents that will be accepted and used



The work product will be standard permits that address common station configurations

- With baseline set of codes and standards in place the next step is to improve those documents through lessons learned
- This is the CCSI process
- Field data indicates:
  - Component reliability
  - Equipment Enclosures
  - Alternative fueling
  - Transit infrastructure



hydrogenandfuelcells.energy.gov

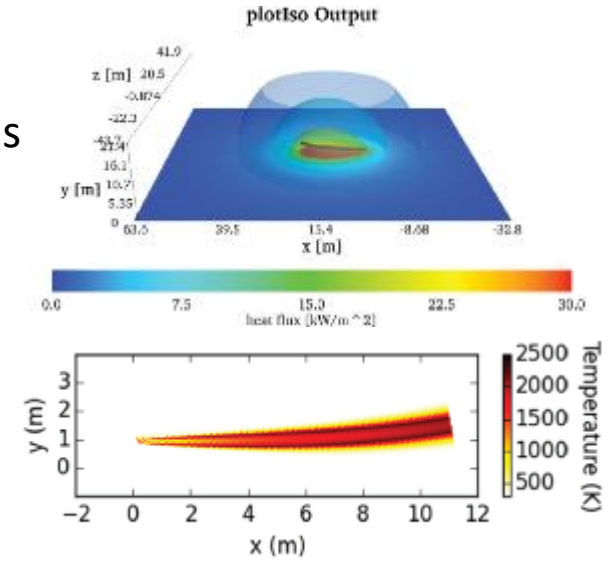
RISK ASSESSMENT

Hydrogen Risk Assessment Model (HyRAM)

El kit de herramientas HyRAM es el primer kit de herramientas de software que integra modelos deterministas y probabilísticos para cuantificar escenarios de accidentes, predecir efectos físicos y caracterizar el impacto de los riesgos de hidrógeno en las personas y las estructuras. HyRAM incorpora probabilidades genéricas para fallas de equipos y modelos probabilísticos para el impacto del flujo de calor en humanos y estructuras, con modelos validados computacional y experimentalmente de liberación de hidrógeno y física de llamas.

La importancia de la gestión de riesgos proporciona valiosas aportaciones sobre:

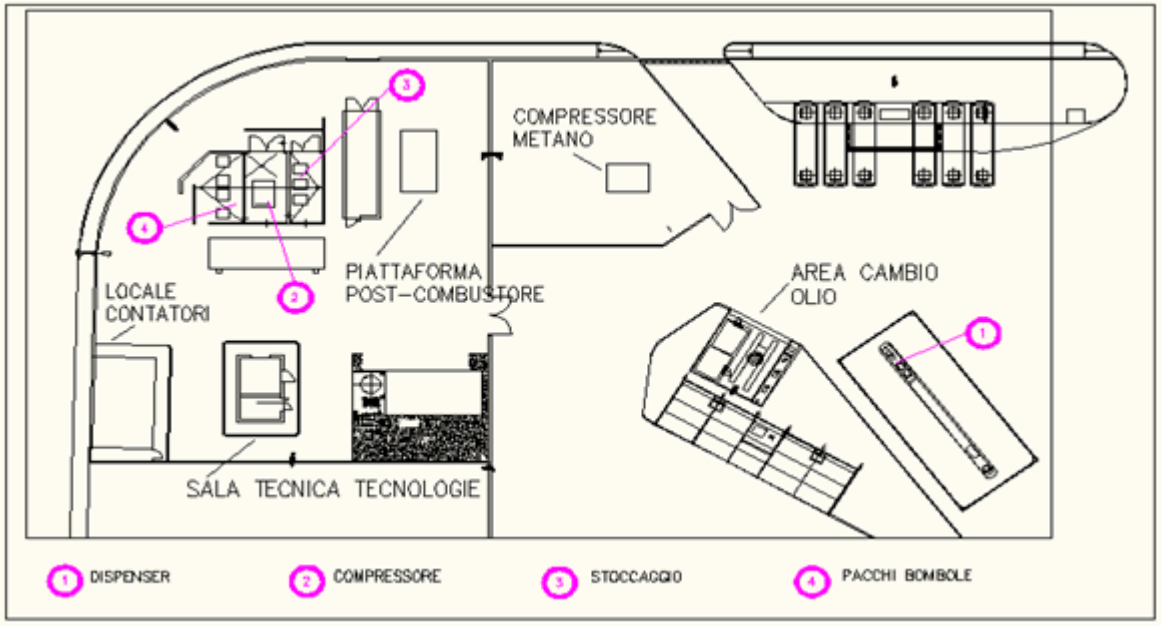
- Fuentes de riesgo.
- Estrategias para reducir riesgos
- Prioridades



https://energy.sandia.gov/transportation-energy/hydrogen/quantitative-risk-assessment/hydrogen-risk-assessment-model-hyram/

RISK ASSESSMENT

CASE STUDY:



El case study analizado se refiere a una planta piloto, planeada para ser instalada, para el suministro de hidrógeno para vehículos de pilas de combustible. Se ha formulado la hipótesis de una estación de reabastecimiento de hidrógeno de 50 m x 20 m, que opera 300 días al año y donde se reaprovisionan 50 vehículos por día una vez al día, para un total de 15,000 reabastecimientos por año.

La planta está constituida por sistemas de compresión de etapas múltiples, unidades de almacenamiento y de suministro.

*Quantitative Risk Assessment on a Hydrogen Refuelling Station, Chemical Engineering Transactions, Vol.67, 2018

RISK ASSESSMENT

Parámetros de entrada en HyRAM*:

Case	Unit	Pressure (bar)	Diameter (mm)	Probability leak detection	Exposure Time (s)
1	Dispenser	350	9.52	90%	60
2	Dispenser	350	9.52	90%	5
3	Dispenser	350	9.52	10%	60
4	Dispenser	350	9.52	10%	5
5	Compressor	600	9.52	90%	60
6	Compressor	600	9.52	90%	30
7	Compressor	600	9.52	10%	60
8	Compressor	600	9.52	10%	30
9	Storage	480	9.52	90%	60
10	Storage	480	9.52	90%	30
11	Storage	480	9.52	10%	60
12	Storage	480	9.52	10%	30

Comparación de resultados para el surtidor y compressor:

Table 4: Safety distances for hazard units of refuelling station

Dispenser	Safety distance (m)	Compressor	Safety distance (m)	Storage unit	Safety distance (m)
Case 1	21.8	Case 5	27.5	Case 9	-
Case 2	17	Case 6	22.5	Case 10	-
Case 3	24	Case 7	30	Case 11	7
Case 4	18.6	Case 8	28.5	Case 12	6

Reducción de distancias de seguridad tras análisis en HyRAM e identificación de medidas de mitigación – por medio de implementación de sistemas de apagado de emergencia autómatico.

*Quantitative Risk Assessment on a Hydrogen Refuelling Station, Chemical Engineering Transactions, Vol.67, 2018

IIT HYDROGEN REFUELLING STATION

BOLZANO, ITALY

OPERATOR	H2 Alto Adige/H2 South Tyrol

OMV INNSBRUCK HYDROGEN REFUELLING STATION

INNSBRUCK, AUSTRIA

OPERATOR	OMV Aktiengesellschaft

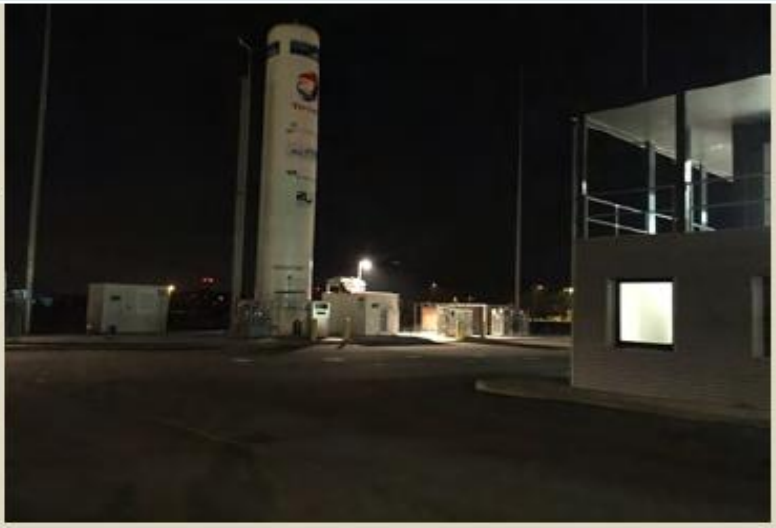
TOTAL SACHSENDAMM HYDROGEN REFUELLING STATION

BERLIN, GERMANY

OPERATOR	Total GmbH

TOTAL SCHÖNEFELD HYDROGEN REFUELLING STATION

BERLIN, GERMANY



OPERATOR	Total GmbH

VATTENFALL HAFEN CITY HYDROGEN REFUELLING STATION

HAMBURG, GERMANY

OPERATOR	Vattenfall/Shell

HySUT HANEDA HYDROGEN REFUELLING STATION

YOKOHAMA, JAPAN

OPERATOR	Tokyo Gas

SHIBA-KOEN HYDROGEN REFUELLING STATION

TOKYO, JAPAN

OPERATOR	Iwatani Corporation

NERIMA HYDROGEN REFUELLING STATION

TOKYO, JAPAN

OPERATOR	Tokyo Gas

TOYOTA-CITY ECOFUL HYDROGEN REFUELLING STATION

TOYOTA-CITY, JAPAN

OPERATOR	Toho Gas

AMAGASAKI HYDROGEN REFUELLING STATION

AMAGASAKI-CITY, JAPAN

OPERATOR	Iwatani Corporation