HYDROGEN
Emergency Response
Training Resources

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

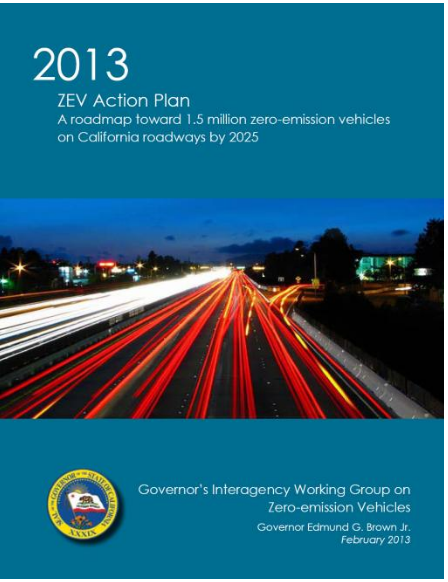
U.S. DEPARTMENT OF
ENERGY
Energy Efficiency &
Renewable Energy

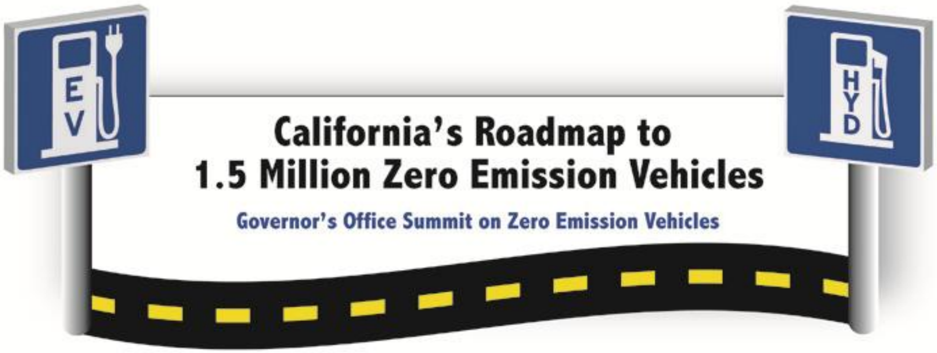
California
FUEL CELL PARTNERSHIP
DRIVING FOR THE FUTURE

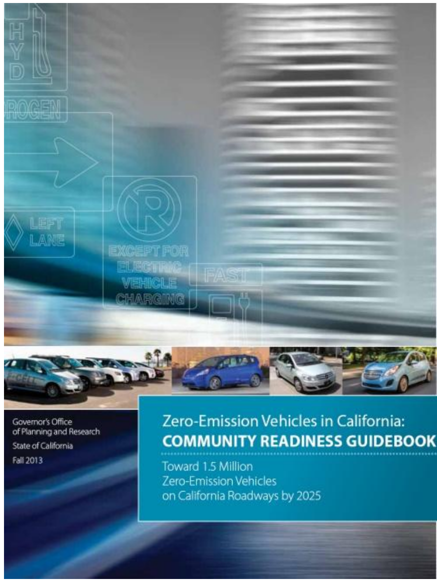
National
Hydrogen and Fuel Cells Emergency Response
TRAINING

California ZEV Action Plan

- By 2015: California major metropolitan areas “ZEV-ready” with infrastructure and streamlined permitting
- By 2020: California ZEV infrastructure can support up to 1 million vehicles
  - Including widespread use of ZEVs for freight and public transit
- By 2025: Over 1.5 million ZEVs in California





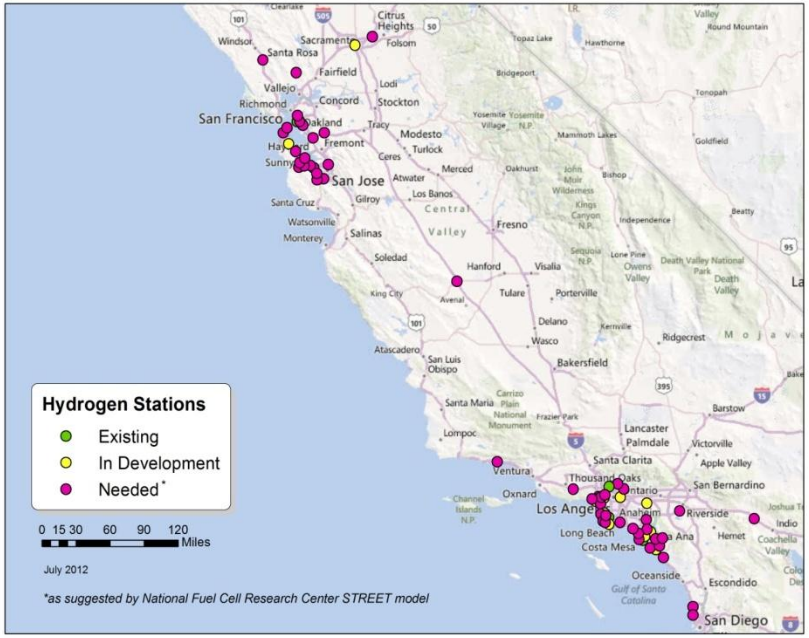


Visit www.cafcp.org/toolkits/cities to download the ZEV Action Plan

Stations must come first

- 68 stations provide coverage to enable market launch
  - Supports customer convenient fueling in early markets
  - Enables travel throughout early market regions and state
- 100 stations to support market growth

Map of 68 Hydrogen Fueling Stations: Existing, In Development and Needed



November 2015

Northern CA Hydrogen Stations

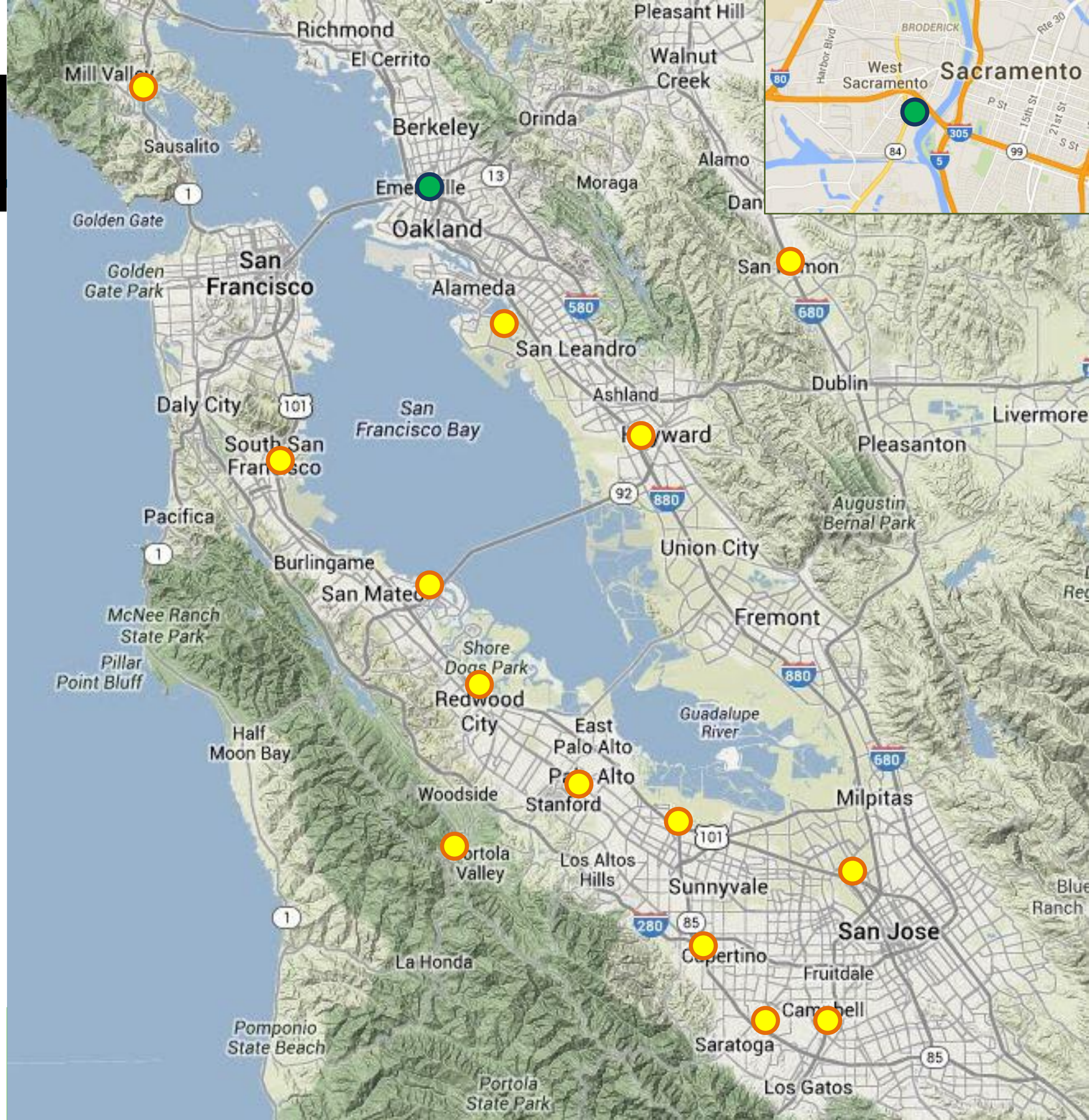
Open

Emeryville – AC Transit
West Sacramento

In Development

Campbell
Cupertino
Foster City
Hayward
Mill Valley
Mountain View
Oakland
Palo Alto
Redwood City
*Rohnert Park
San Jose
San Ramon
Saratoga
South San Francisco
*Truckee
Woodside

Not shown on map



November 2015

Southern CA Hydrogen Stations

Open

Burbank
Diamond Bar
Fountain Valley – OCSD
Los Angeles - Harbor City
Newport Beach
*Thousand Palms – SunLine Transit
Torrance
Los Angeles - West LA 2

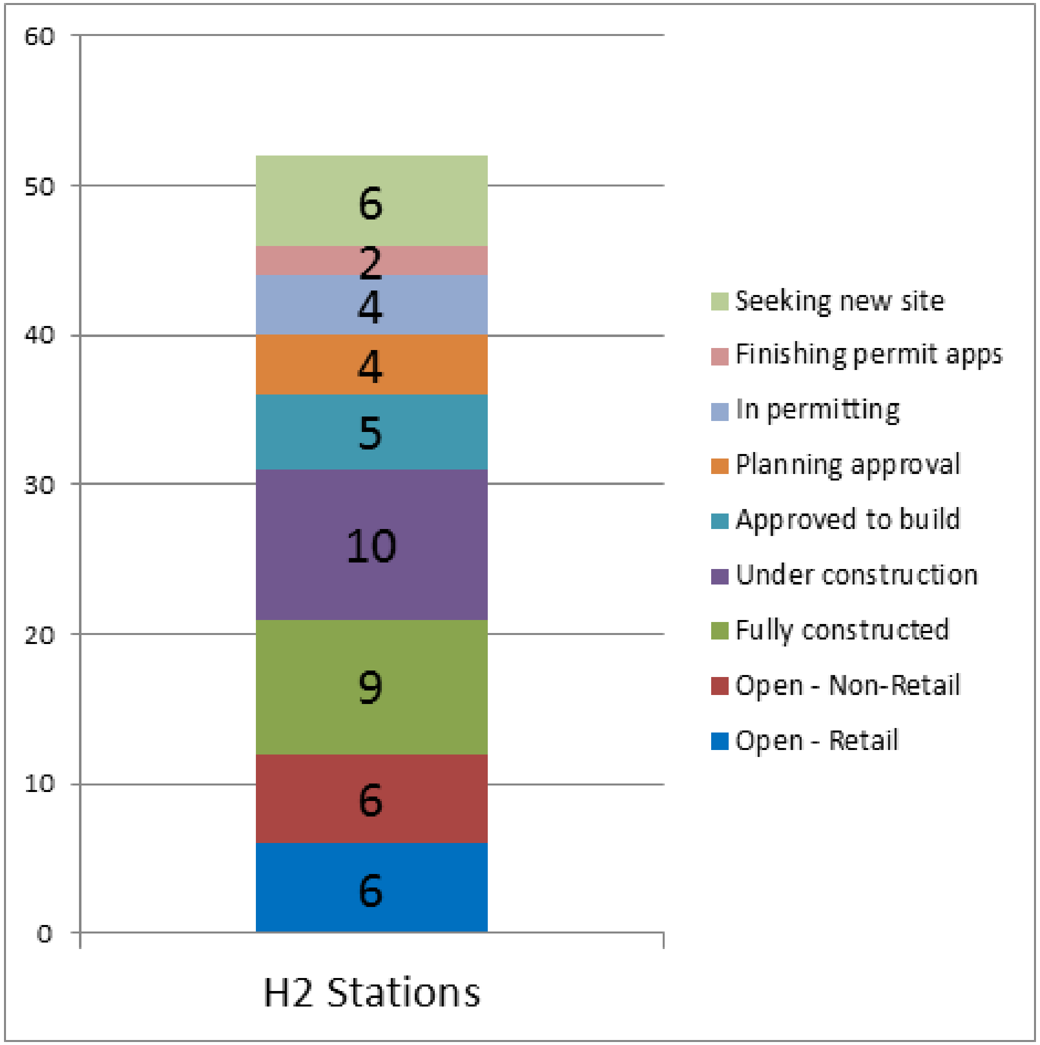
In Development

Anaheim
Burbank (upgrade)
Chino (upgrade)
*Coalinga
Costa Mesa
Irvine – UC Irvine
Irvine - Walnut Ave.
La Canada Flintridge
Laguna Niguel
Lake Forest
Lawndale
Long Beach
Los Angeles - Beverly Blvd.
Los Angeles – Cal State LA
Los Angeles – LAX (upgrade)
Los Angeles - Lincoln Blvd.
Los Angeles - Hollywood Blvd.
Los Angeles - Woodland Hills
Mission Viejo
Ontario
Orange
Pacific Palisades
Redondo Beach
*Riverside
*San Diego
*Santa Barbara
San Juan Capistrano
Santa Monica
South Pasadena

Not shown on map

California Fuel Cell Partnership
www.cafcp.org/stationmap

Status as of December, 2015



- 40 stations with planning approval or better
- 36 with approval to build or better

San Jose station received its weights & measures seal

Thanks to Santa Clara County for serving as the Registered Service Agency

Where are they coming next?

Primary Priority	Secondary Priority
Berkeley/Richmond/Oakland	Culver City
Beverly Hills/Westwood	Dublin/Pleasanton
Fremont	Encino/Sherman Oaks/ Van Nuys
Lebec	Granada Hills
Manhattan Beach	Irvine South
Sacramento	Los Banos
San Diego #2	Palm Springs
San Diego #3	Ventura/Oxnard
San Francisco	
Thousand Oaks/Agoura Hills	
Torrance/Palos Verdes	

http://cafcp.org/getinvolved/stayconnected/blog/automakers_release_list_station_priority_locations

Fuel Cells
Where are We Today?

Fuel Cells for Stationary Power, Auxiliary Power, and Specialty Vehicles

The largest markets for fuel cells today are in stationary power, portable power, auxiliary power units, and material handling

More than 50,000 fuel cells shipped worldwide in 2014 (~a global increase of 37% over 2013)

More than 50,000 fuel cells, totaling over 180 MW, were shipped worldwide in 2014

Fuel cells can be a cost-competitive option for critical-load facilities, backup power, and forklifts

Source: US DOE Fuel Cell Technologies Market Report 2014

Where are We Today?

Production & Delivery of Hydrogen

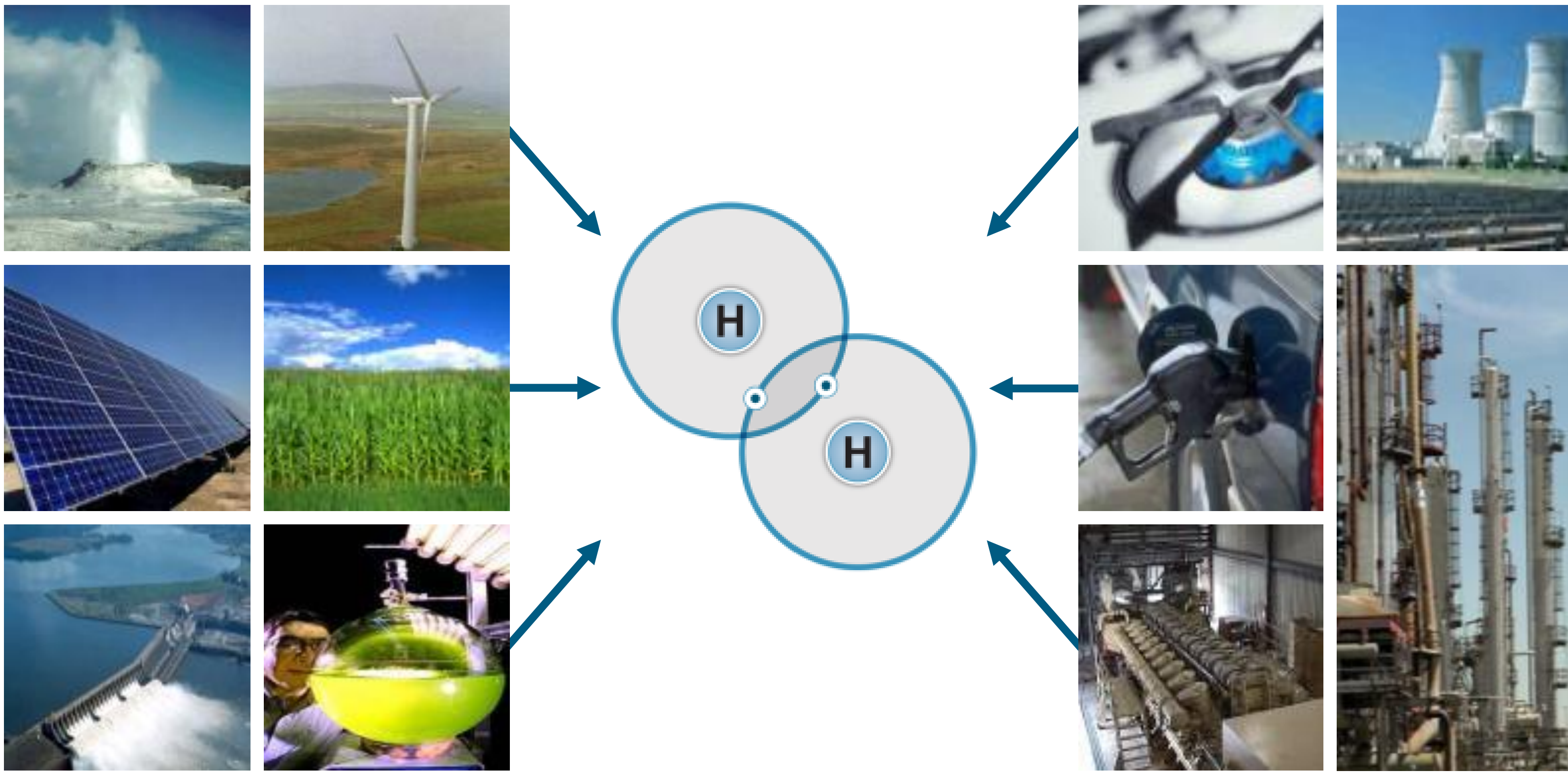
In the U.S., there are currently:

- ~9 million metric tons of H_2 produced annually
- > 1,500 miles of H_2 pipelines
- Primary use in petroleum refining
- Many other industrial uses

Source: US Department of Energy 2009/2010

Where Do We Get Hydrogen?

Renewable Sources | **Traditional Sources**



Solar, wind, geothermal, hydro, biomass, algae

Natural gas, gasoline, nuclear, coal

Hydrogen Uses

The use of hydrogen is not new; private industry has used it safely for many decades. Nine million tons of hydrogen are safely produced and used in the United States every year. 56 billion kg/yr are produced globally. For example, H_2 is used for:

- Petroleum refining
- Glass purification
- Aerospace applications
- Fertilizers
- Annealing and heat treating metals
- Pharmaceutical products

The Air Products and Chemicals hydrogen production facilities in Port Arthur, Texas, is funded by the Energy Department through the 2009 Recovery Act. | Photo credit Air Products and Chemicals hydrogen production facilities.

- Petrochemical manufacturing
- Semiconductor industry
- Hydrogenation of unsaturated fatty acids in vegetable oil
- Welding
- Coolant in power generators

Hydrogen Distribution

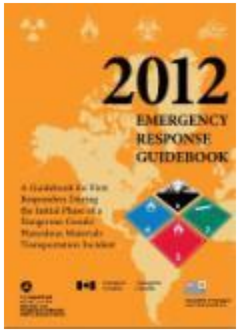
- DOT regulated transportation…
- Cryogenic liquid transport
  - -423°F (-253°C)
  - Low pressure (<100 psi)
- Pressurized gas trailers
  - ~2,000-6,500 psi
- Truck, rail, barge and pipeline

Photo: Praxair, Inc.

Photo: Ovonics

Photo: Air Products & Chemicals, Inc.

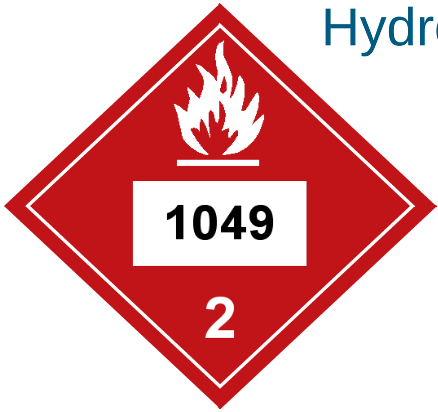
Transporting Hydrogen Today



DOT placards for commercial transport of hydrogen

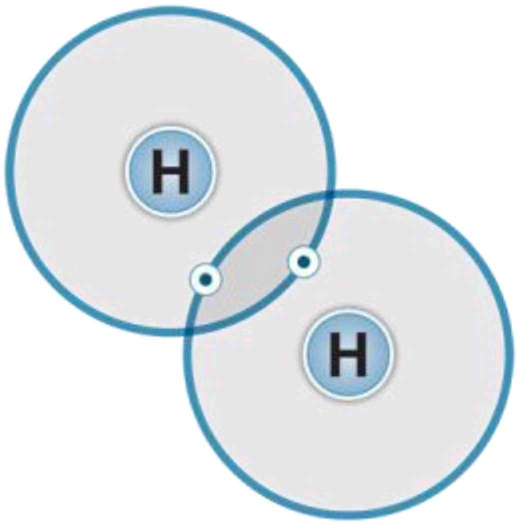
Liquid
Hydrogen

Gaseous
Hydrogen



Hydrogen Properties and Behavior

- A gas at ambient conditions
- Hydrogen is a cryogen: exists as a liquid at -423°F (-253°C).
  - Compressing the gas does not liquefy it
  - No liquid phase in a compressed gaseous hydrogen storage tanks
- LH2 storage at relatively low pressure (50 psi)
- Double walled, vacuum insulated tanks with burst disks, vents, and PRDs
- Volumetric ratio of liquid to gas is 1:848
  - Compare water to steam (1:1700)
- Energy content of 1kg of H_2 is approximately equal to 1 gal of gasoline (in BTUs)



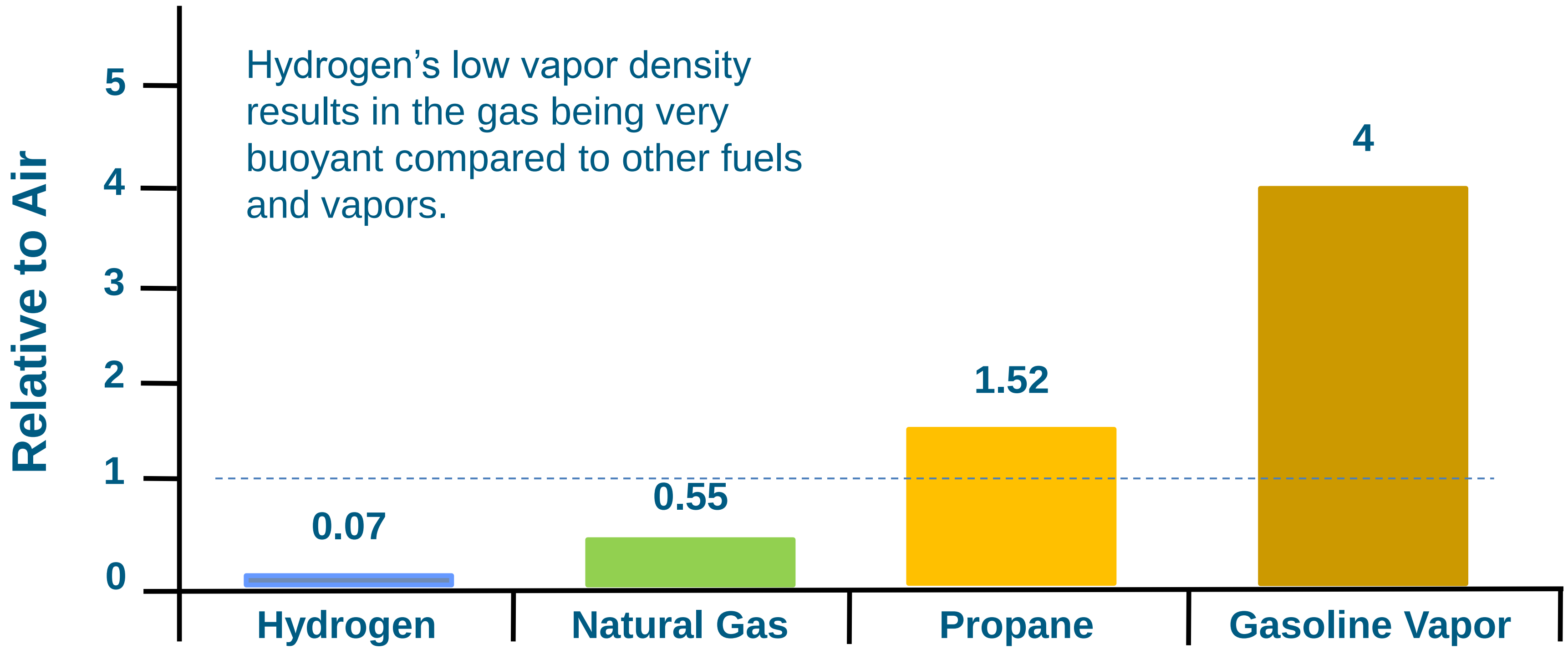
Molecular Hydrogen

Hydrogen Properties: A Comparison

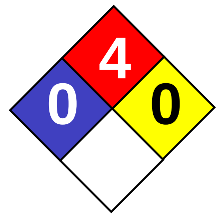
	Hydrogen	Natural Gas	Gasoline
Color	**No**	**No**	**Yes**
Toxicity	**None**	**Some**	**High**
Odor	**Odorless**	**Mercaptan**	**Yes**
Buoyancy Relative to Air	**14X** Lighter	**2X** Lighter	**3.75X** Heavier
Energy by Weight	**2.8X** > Gasoline	**~1.2X** > Gasoline	**43** MJ/kg
Energy by Volume	**4X** < Gasoline	**1.5X** < Gasoline	**120** MJ/Gallon

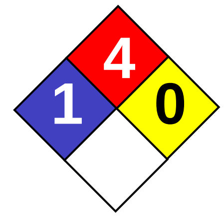
Source: California Fuel Cell Partnership

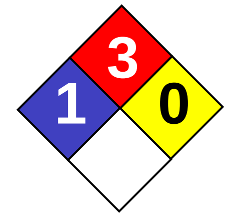
Relative Vapor Density



Comparison of Flammability

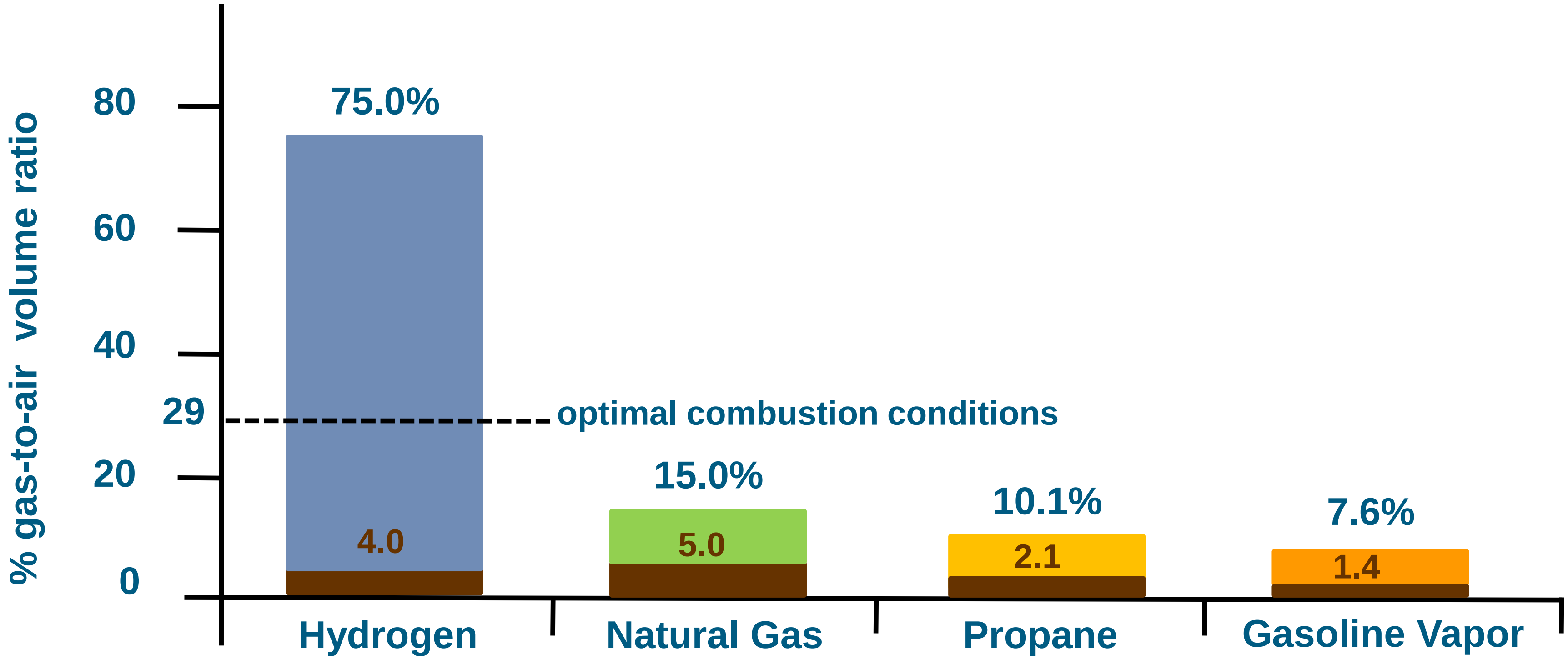




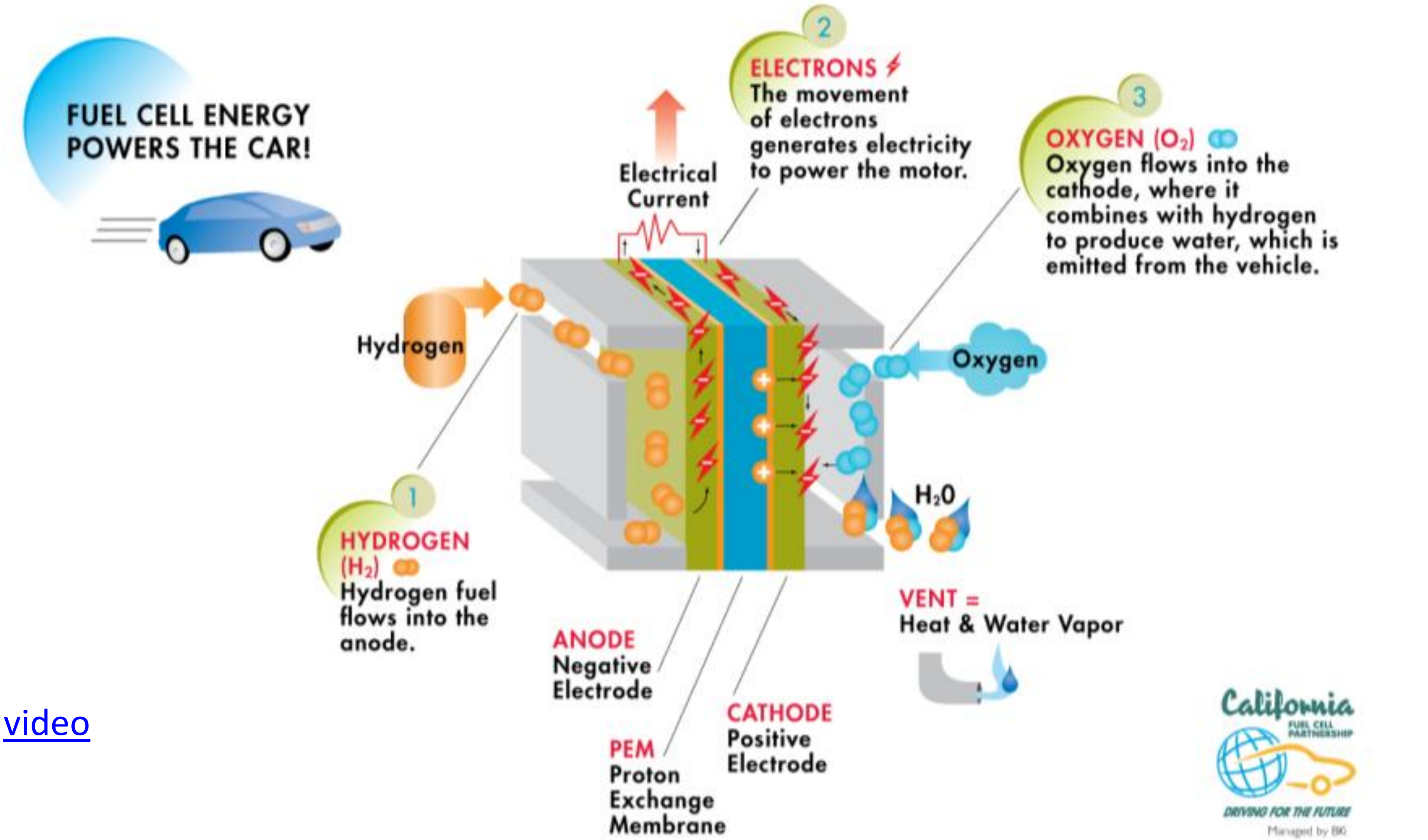


	Hydrogen	Natural Gas	Gasoline
Flammability in air (LFL – UFL)	4.1% - 74%	5.3% - 15%	1.4% - 7.6%
Most easily ignited mixture in air	29%	9%	2%
Flame temperature (°F)	4010	3562	3591

Flammability Range



How a Fuel Cell Works



[video]

Fuel Cell Applications

Fuel cells have a broad range of applications:

- Transportation
  - Light and medium duty
  - Heavy duty and transit
  - Auxiliary power for refrigeration trailers and trucks
  - Forklifts
  - Maritime
- Stationary power
  - Backup power for cell tower sites
  - Combined heat and power
  - Data centers, etc.
- Portable power

Photo: Cellcom

Photo: Nuvera

Fuel Cell Electric Vehicles (FCEV)

- Run on hydrogen
- Use a fuel cell and electric motor, no engine
- Quiet, mostly air compressor and valves
- Emit zero pollutants

Mercedes-Benz

Nissan

General Motors

Hyundai / Kia

Honda

AC Transit

Volkswagen / Audi

Toyota

Standard Components of All Vehicles

- Similarities between hydrogen vehicles and other vehicles:
  - Outward appearance is the same
  - Vehicles share a number of the same components
- If an incident occurs with any vehicle, some of the following components may pose a potential hazard:
  - Bumpers
  - Shock absorbers
  - Tires
  - Hood and trunk struts
  - Airbags
  - Seat belt pre-tensioners
  - Air-conditioning system
  - Batteries

Example:

12-volt battery in an FCEV

Photo: Honda Motor Company

FCEV vs. Gasoline Hybrid-electric Vehicle

Similar components include:

- Electrical storage devices (batteries, capacitors)
- Electric motors
- High-voltage electrical cables
- Regenerative braking

Example:

High-voltage battery location in an FCV

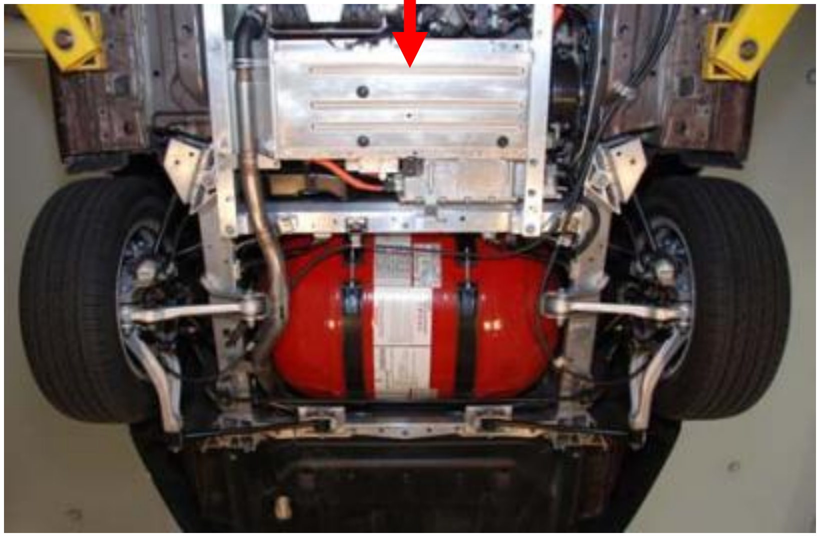


Photo: Honda Motor Company

FCEV vs. Compressed Natural Gas (CNG) Vehicle

Similar components include:

- High-pressure tanks (typically 3,600 psi for CNG and 5,000 psi or 10,000 psi for hydrogen gas)
- Low- and high-pressure fuel lines
- Pressure-relief device on tank (thermally activated)
- Pressure vent line (usually)
- Pressure in piping is reduced to typically <150 psig

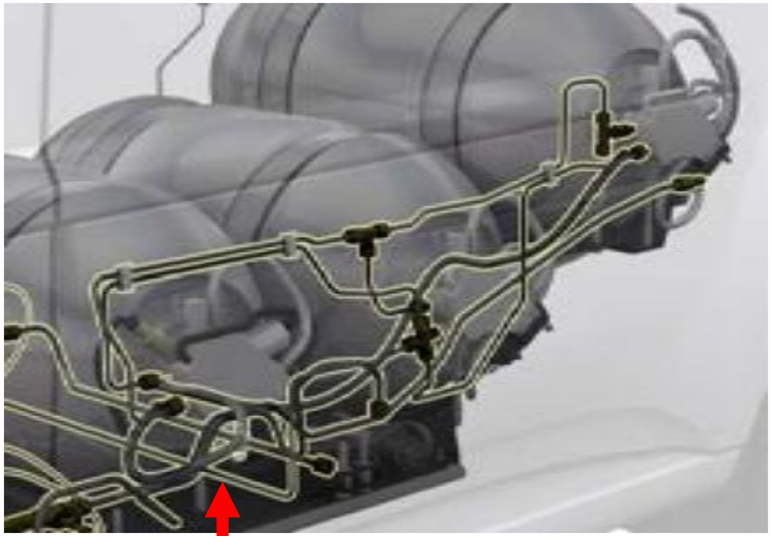
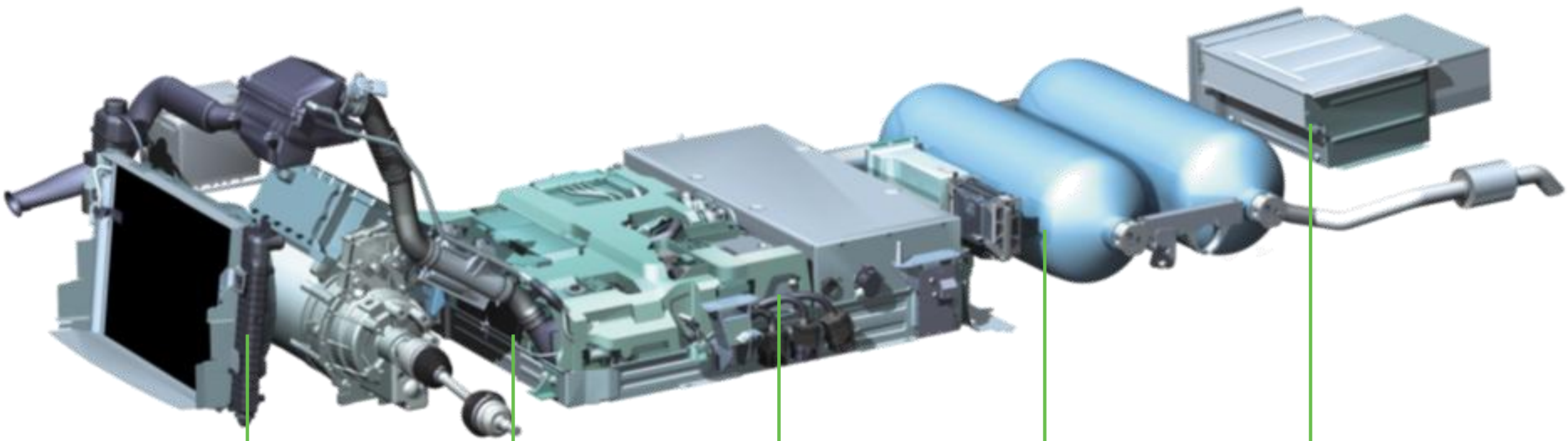


Image: General Motors

Example:

Hydrogen lines

FCEV System Layout



Cooling System
Typically, slightly larger radiators than conventional

Electric Motor
Electrical component; drives vehicle by electricity

Power Electronics
Electrical component; distributes electricity

Fuel Cell
Electrical component; generates electricity from hydrogen

Hydrogen Tanks
Compressed, gaseous fuel; vehicle fueled with hydrogen

High Voltage Battery
Electrical component; captures regen braking, supports acceleration

Source: California Fuel Cell Partnership

Fuel Cell Component Location

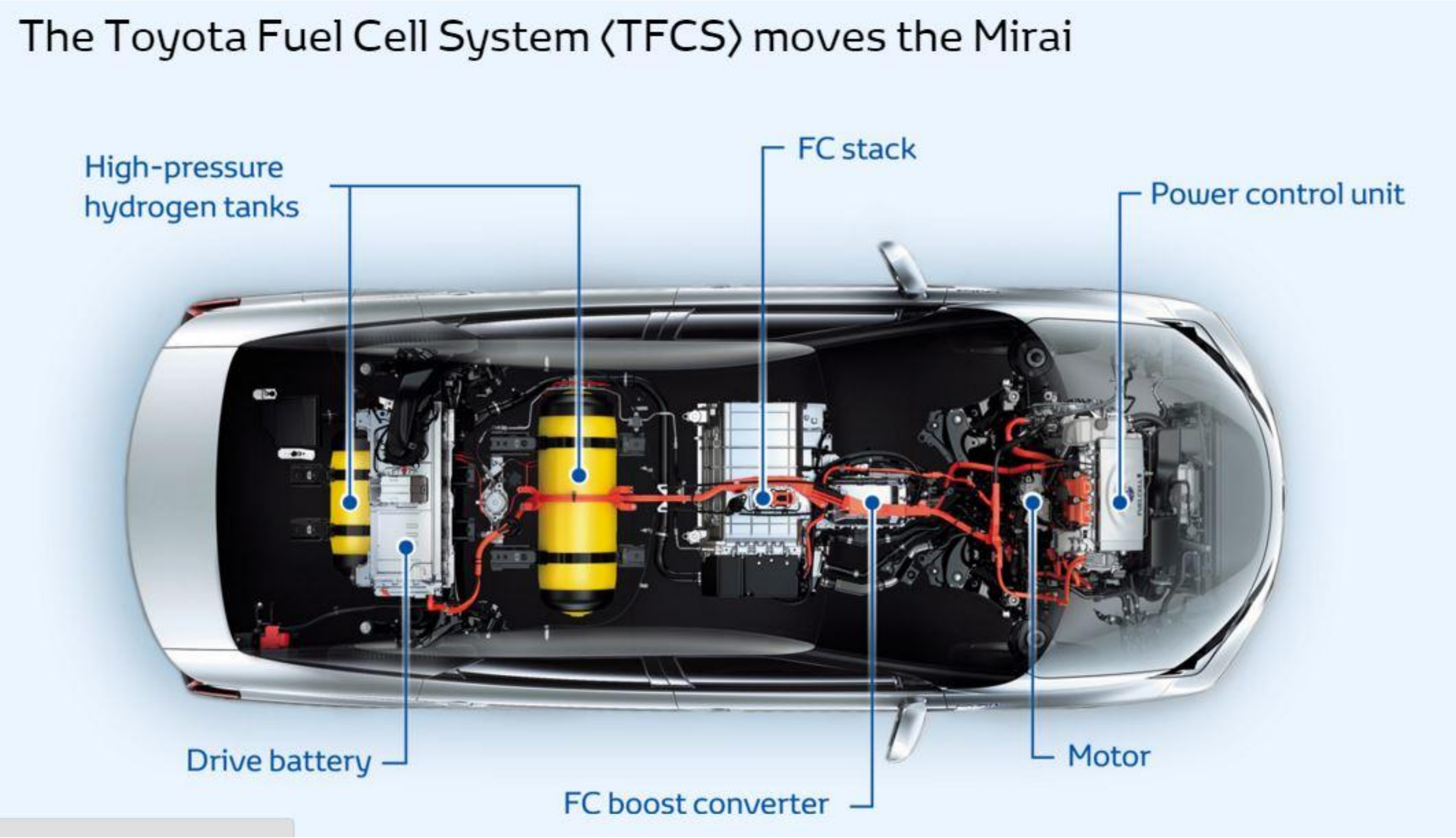
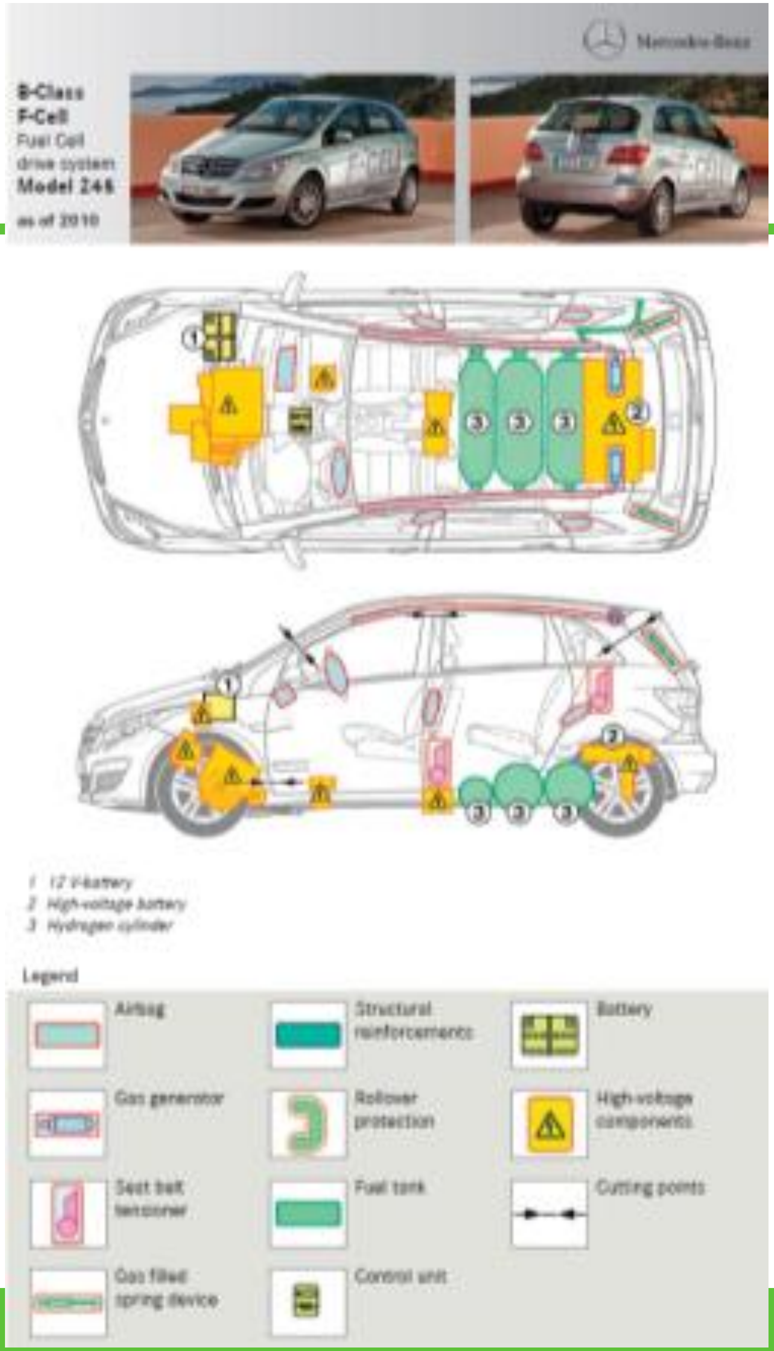


Photo-http://www.toyota-global.com/innovation/environmental_technology/fuelcell_vehicle/

Low and High Voltage Systems



- Fuel cells produce:
  - 200 – 450V (light duty)
  - 400 – 600V (buses)
- High-voltage batteries or ultra-capacitors
  - Additional power, braking regeneration
- 12V (light duty)/24V (bus) systems
  - Startup and running accessories

High Voltage System

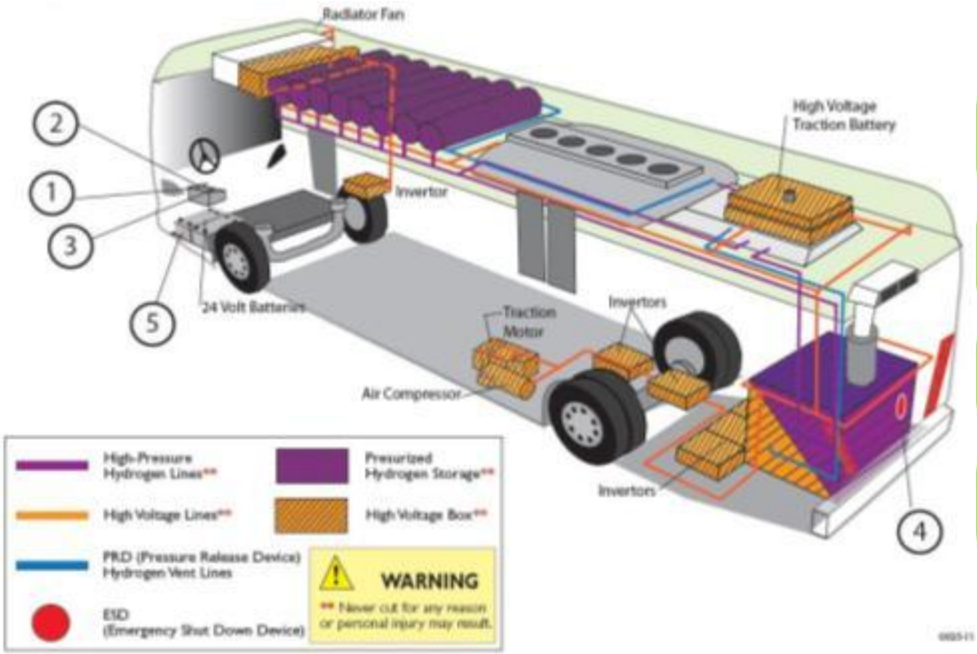
- Same technology as other alt fuel vehicles (gas/electric hybrids)
- Orange high-voltage wiring per SAE
- Isolated + and – sides (not grounded to the chassis)
- Automatic high voltage system disconnect
  - Inertia switch
  - Ground fault monitoring

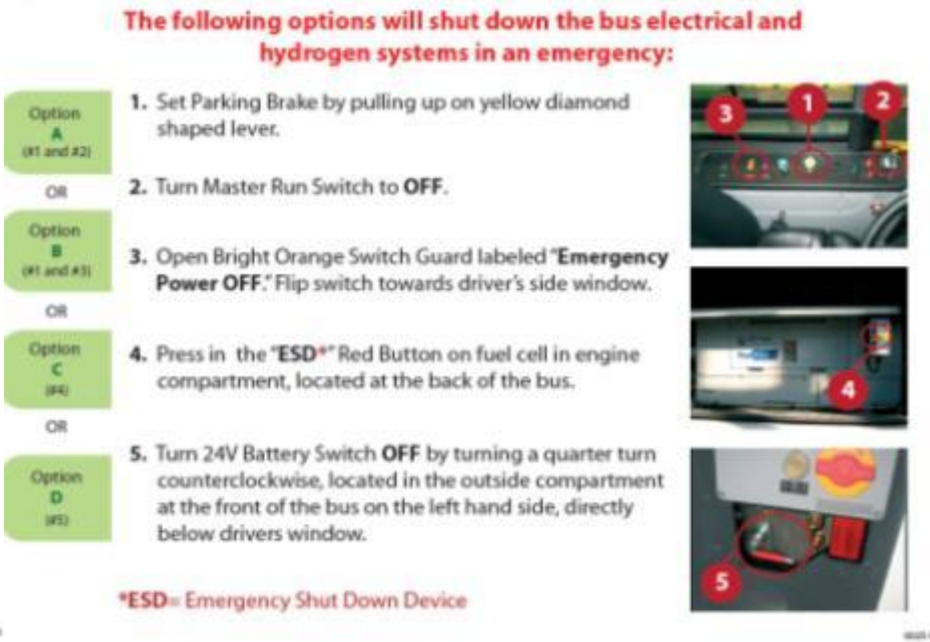
Light Duty Vehicle

Transit Bus

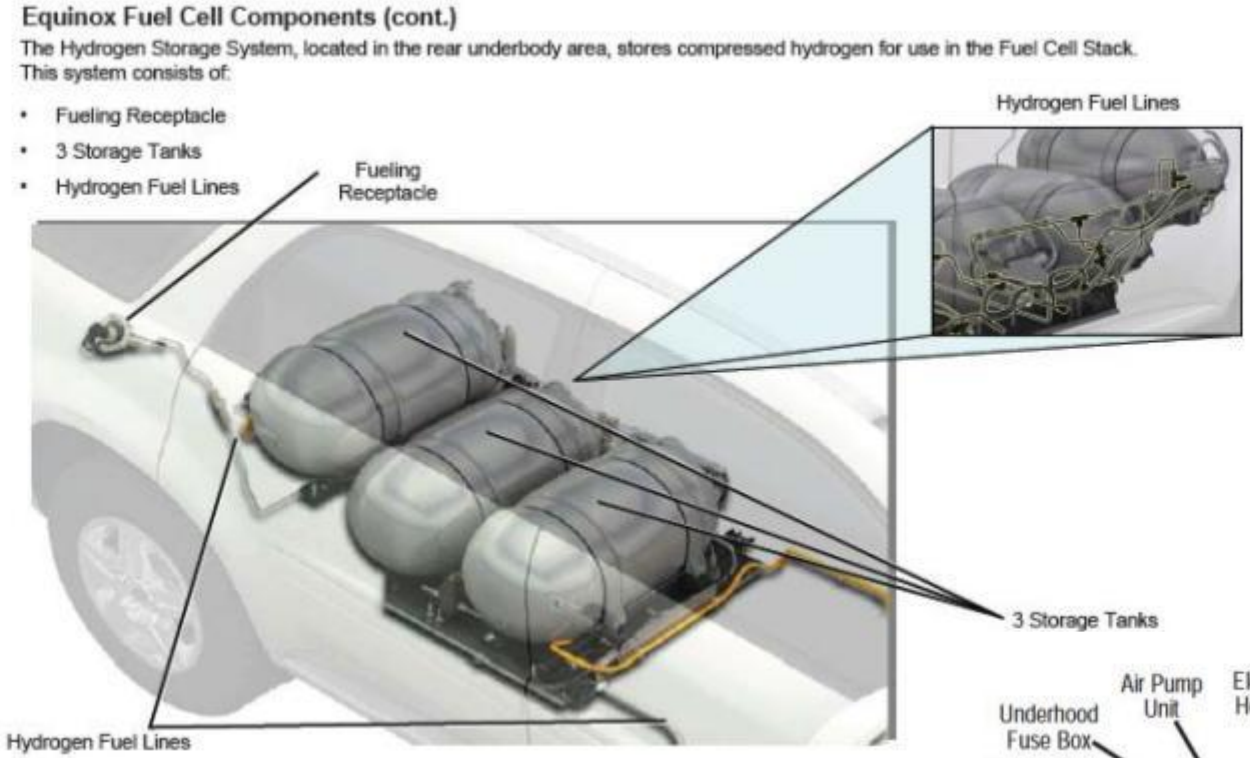
Bus Low and High-voltage Systems

- 24V (bus) systems
  - Startup and running accessories
- Fuel cells produce:
  - 400 – 600V (buses)
- High-voltage batteries or ultra-capacitors
  - Additional power, braking regeneration

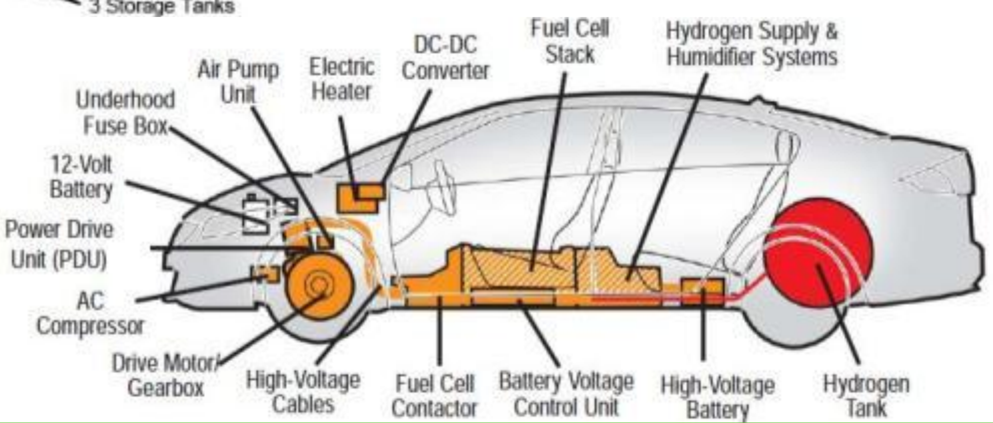




Hydrogen Delivery System



- Single tank and multi-tank set-ups
- Distribution lines contain lower pressures than tanks
- Tank PRDs/TRDs vent directly or are connected to fuel vent line(s)

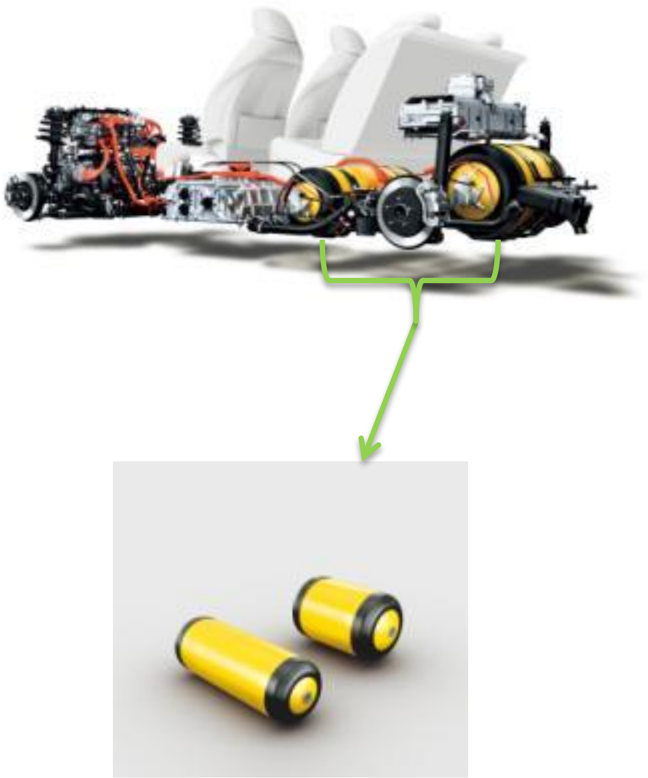


Hydrogen Delivery System – Bus

- Bus fuel tanks on roof
- All equipped with PRDs and vent lines
- Larger capacity storage

Onboard Hydrogen Storage

- Hydrogen can be stored as a gas or liquid
- To date, light duty vehicles use gaseous hydrogen
- Gaseous hydrogen: 35 or 70 MPa (approximately 5,000 or 10,000 psi, respectively)
- Passenger vehicles typically store up to 6 kg of hydrogen gas
- Buses with multiple tanks can store as much as 40 kg to 50 kg of hydrogen gas
- To date, buses carry gaseous hydrogen



Toyota Mirai fuel cell sedan power train, seats, and hydrogen tanks
Source: http://newsroom.toyota.co.jp/en/detail/4198334

Compressed Hydrogen Storage Systems

- Carbon fiber wrapped, metal or polymer lined tanks
- Equipped with temperature activated pressure relief devices (PRD/TRD)
- Stronger than conventional gasoline tanks
  - Absorb 5X crash energy of steel

Wall thickness comparison:
35 MPa vs. 70 MPa cylinders

(Photo courtesy of Powertech)

Compressed Hydrogen Tank Testing

- Bonfire
- Drop
- Gun fire
- Pressure cycling
- Overpressure
- Temperature
- Impact
- Permeation
- “Tank life” – at least 15 years
- Rated for 2.25x service pressure

Compressed Hydrogen Tank Testing

- In accordance with latest proposed hydrogen vehicle tank standards (SAE J2579, CSA HGV2)
- Tests conducted as part of the design qualification testing for new tanks
- Vent only, no rupture

High Strain Rate Impact Test

Gunfire test of 35 MPa hydrogen tank:

- Objective: penetrate tank while pressurized
- Tank filled with hydrogen to 5,000 psi
- 30 caliber armor piercing bullet, 45° angle
- Simulate a high-strain rate penetration event due to collision

video

Bonfire Test

Bonfire test of 70 MPa hydrogen tank:

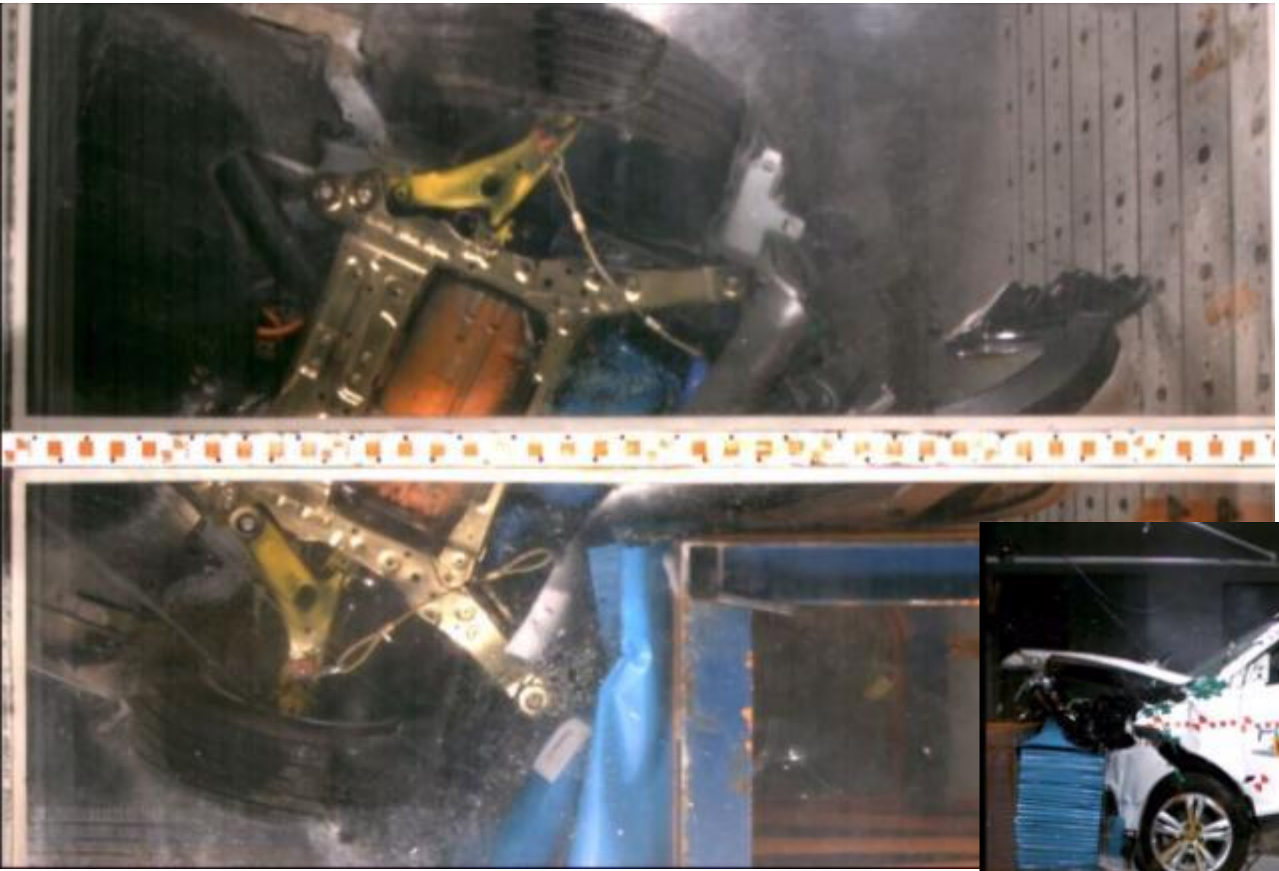
- Objective to simulate vehicle fire; entire tank engulfed
- Tank filled with hydrogen to 10,000 psi
- Subjected to a propane burner fire, 1.65m long
- PRD activated and hydrogen vented to atmosphere without incident

video

Equinox Fuel Cell – FMVSS 208 Certification (occupant protection)

Test With Operating Fuel Cell and Hydrogen Onboard Witnessed by NHTSA and Transport Canada

Hyundai ix35 FCEV- FMVSS 305 and ECE R94-25s Certification



Hyundai ix35 FCEV- FMVSS 305 and ECE R94-50s Certification

Fuel Isolation in Typical or Normal Operation

In typical operation of turning off the vehicle (key to "Off"):

- Cuts the 12 volt signal, therefore…
  - Closing the electrically activated solenoid(s) in the fuel storage system
  - Opening the electrically activated relays in the high voltage system
- This isolates the fuel to the tank and high voltage to the battery pack

Photo: GM Equinox FCV

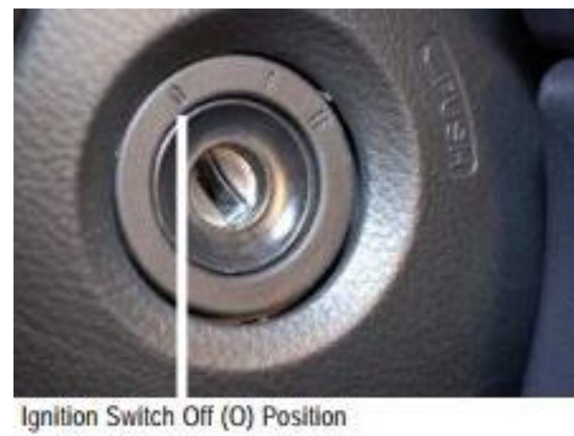


Photo: Honda FCX Clarity

Safety Systems

Safety System:

Hazard/ Action:

Vehicle Response:

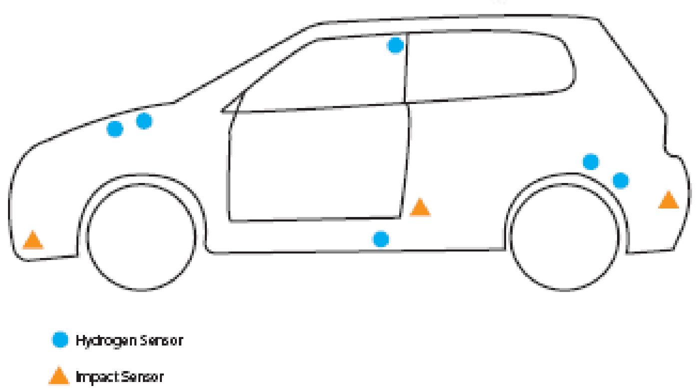
Disconnect/cut negative cable on 12-volt battery

Hydrogen sensors → Detect H_2 leak: in passenger cabin and/or throughout vehicle

Impact sensors → Detect collision, like air bag sensors

Emergency shutdown device (ESD) → Located in all FCBs

- In-tank solenoid(s) close (default position: closed) – isolate H2 in tanks
- Electrical relays open (default position: open) –shut down vehicle, isolate high voltage system, dissipate charge in high voltage lines



Types of Stationary Facilities

Stationary facilities include:

- Stationary fuel cells
- Bulk hydrogen storage
- Hydrogen fueling stations

Photo: Air Products and Chemicals, Inc.

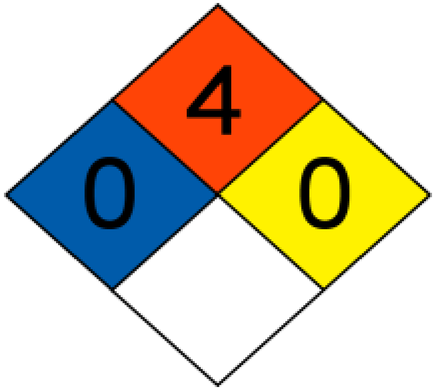
Photo: Plug Power, Inc.

Photo: California Fuel Cell Partnership

Identifying Stationary Facilities

NFPA 704 Hazard Placards

- Red = Flammability
- Blue = Health
- Yellow = Reactivity
- White = Special Precautions



Gaseous Hydrogen

Liquid Hydrogen

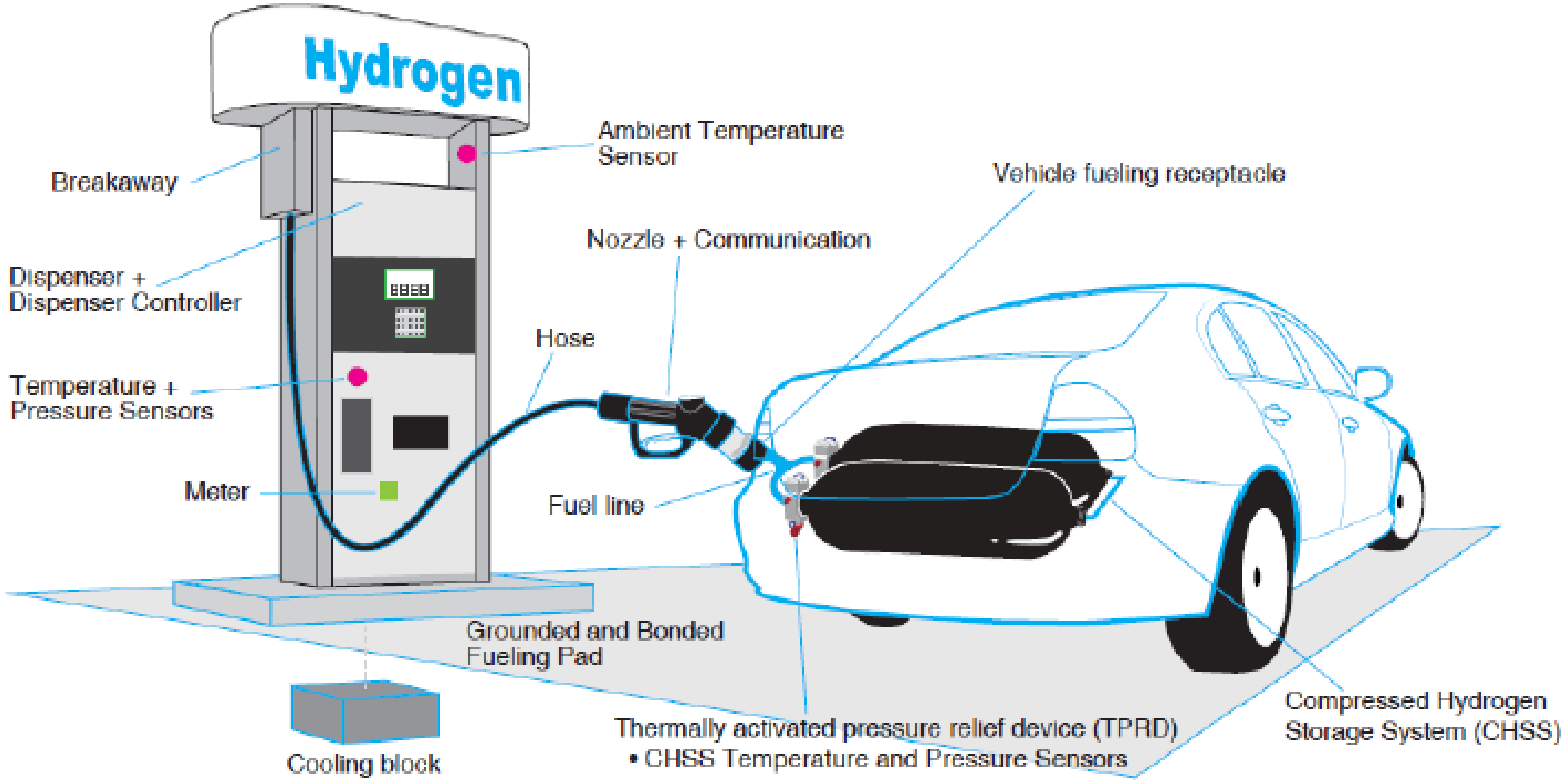
Hydrogen Fueling

- Closed-loop design, no leaks or vapors
- Experienced suppliers and providers: Linde, Shell Hydrogen, Air Products, Air Liquide, Hydrogen Frontiers, ProtonOnsite, First Element, HTEC**,** HyGen Industries and others

35 MPa Nozzle **(H35)**

70 MPa Nozzle **(H70)**

Hydrogen Fueling Diagram



General Station Safety Systems

- Pressure relief systems
  - Burst disks
  - Pressure relief valves/devices (PRV/PRD)
  - Safety vents
- Fire and leak detection systems
  - Telemetric monitoring
  - Hydrogen gas detectors
  - UV/IR cameras
  - Fueling line leak check on nozzle connect

ASME steel and composite stationary storage tubes

General Station Safety Systems

- Design elements
  - Engineering safety margins and analysis (HAZOP, etc.)
  - Hydrogen compatible materials
  - Siting to established regulations
  - Cross-hatched areas for user attention
- Other systems
  - Emergency stops
  - Dispenser hose break-away devices
  - Impact sensors at dispenser
  - Controlled access
  - Excess flow control (fueling)
  - Pre-coolers (-40^{o}F)

Gaseous Hydrogen Delivery

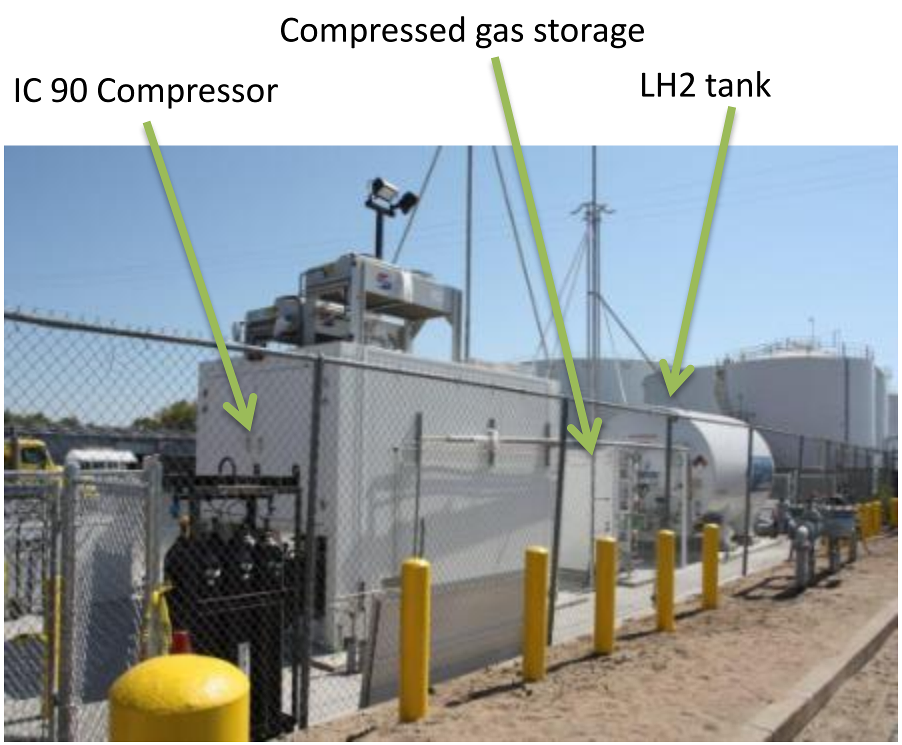
Gaseous hydrogen can be delivered to the fueling station by tube trailer or mobile refueler

Photo: National Renewable Energy Laboratory

Photo: U.S. Department of Energy

Hydrogen Fueling Stations
Liquid Hydrogen Delivery

Liquid hydrogen can be delivered to the fueling station by tanker truck, as is shown for this hydrogen and gasoline station



Fueling dispenser & canopy

Photos: California Fuel Cell Partnership and Linde.

Hydrogen Fueling Stations
Onsite Hydrogen Generation by Reforming

- Hydrogen can be generated onsite at the fueling station
- Photo shows a station in Newport Beach, California
- Natural gas is piped to the station and converted to hydrogen in a reformer

Photos: California Fuel Cell Partnership

Onsite Hydrogen Generation by Electrolysis

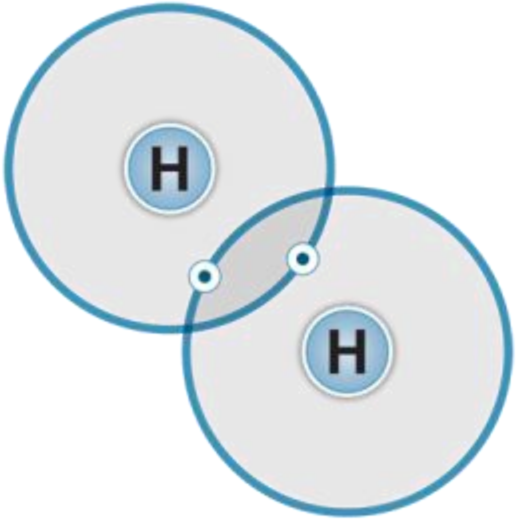
- Hydrogen can be generated onsite by electrolysis of water as at Emeryville, CA with this Proton OnSite electrolyzer
- Using 100% renewable solar-powered electricity, it produces 65 kg/day of hydrogen for dispensing to passenger vehicles

Photos: CaFCP

Considerations for Managing Hydrogen-related Emergencies

Buoyancy of hydrogen gas:

- It's 14 times lighter than air
- When released outside, it rises at ~45 mph
- It's a small molecule and very difficult to confine
- When released inside, it quickly finds its way through most materials
- Due to an inverse Joule-Thomson effect, hydrogen does not cool the surrounding environment (won't cause ice on the valve)



Molecular Hydrogen

Hydrogen Vehicles

SIZE-UP

The hazards encountered with hydrogen vehicles are similar to those of other vehicles. Questions to ask during size up should consider:

- Types of vehicles involved (cars, small trucks, buses)
- Fuels and quantities (gasoline, diesel, E85, LPG, hydrogen, hybrids)
- Closed compartments (drive shafts, batteries, LPG tanks, hood or trunk struts, passenger compartments, tires, fuel tanks)
- Exposures (including other vehicles, structures, cargo)

Hydrogen Vehicles

SIZE-UP

Additional considerations during vehicle incident size up:

- Hydrogen fuel tank
  - Is there fire?
  - If so, is it impinging the hydrogen tank?
  - Is the tank currently venting?
  - Has the tank already vented?
- Hydrogen fuel
  - If the hydrogen is venting, is it burning?
  - If the hydrogen is not burning, are there potential ignition sources?
  - Can the hydrogen be dispersed to levels below the LFL?

Hydrogen Vehicles

SIZE-UP

High-Voltage System, Potential Ignition and Shock Hazard:

- Has the key been turned off and removed from the ignition? If key is unreachable, consider disconnecting or cutting the low-voltage battery cables
- Are any of the high-voltage components exposed? Avoid these until fully deactivated

  Note: Power remains in system for 5 minutes after deactivation
- Is the high-voltage battery on fire?

  Note: Nickel metal hydride batteries, common in these vehicles, may reignite if left smoldering

Formal Identification

PLAN

May have decals and graphics identifying car/bus as an FCEV

Formal Identification

PLAN

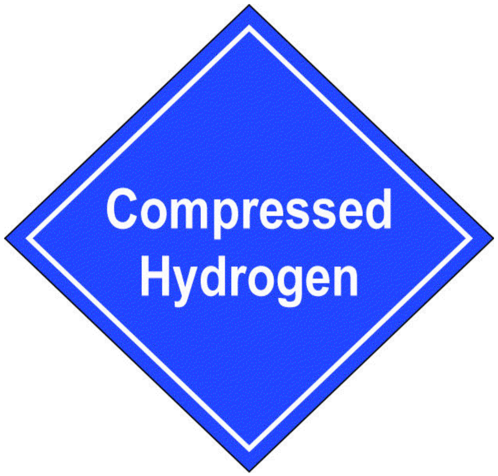
Vehicle badging, per SAE International

Formal Identification

For vehicles greater than 19,500 lbs (8845 kg) GVWR (Heavy duty)

Blue diamond sticker on rear

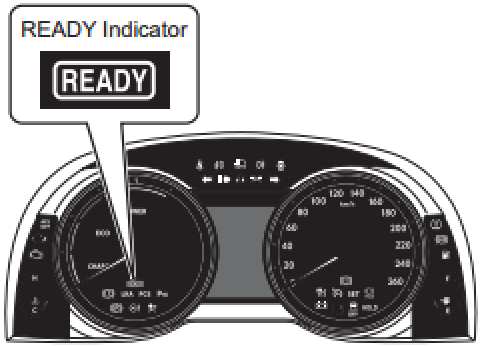
- SAE J2578 example
  (follows NFPA 53 for CNG)



Informal Identification

PLAN

- Never assume the vehicle is off
- Be aware that vehicle is quieter than a typical internal combustion engine vehicle during start up and shut down
- Check the driver instrumentation panel for indication of vehicle operation



Informal Identification

PLAN

Graphics displayed are typical of what you will see on vehicles, but can vary by vehicle.

Informal Identification

PLAN

Fueling receptacle

Design clues

Interior

SIZE-UP → PLAN

Hydrogen Release Indicators

Compressed H_2

- Very loud hissing (almost all leaks will be audible)
- TPRD[1] release ⟶ controlled high-pressure hydrogen rapid release through safety vent
  - Occurs if tanks are exposed to high-temperature heat (e.g., fire)
  - Avoid cutting into hydrogen lines

[1] TPRD – Thermally activated pressure relief device

Hydrogen Lines and High Voltage Systems

SIZE-UP → PLAN

- **Avoid** cutting into hydrogen lines, storage tanks or PRD vent lines
  - No standard markings
  - Most hydrogen fuel lines are silver, stainless steel
- **Do not** cut high-voltage cables
  - **Orange** in color per SAE standard
  - 200 to 500 volts; 200 to 300 amps

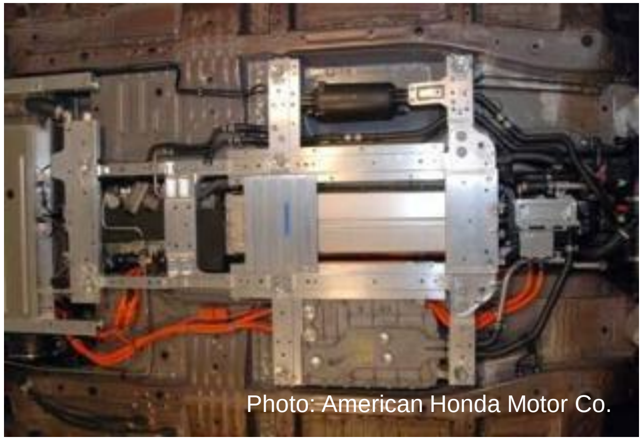


Photo: American Honda Motor Co.

Stationary Facilities

SIZE-UP

Stationary hydrogen facilities will have hazards similar to facilities with other compressed and/or cryogenic gas processing or storage systems

- Gas or liquid storage?
  - High-pressure cylinder storage
  - Cryogenic liquid storage
- Is there a leak or flame present?
  - Gaseous hydrogen: use combustible gas/hydrogen detector and thermal-imaging cameras
  - Liquid hydrogen: look for ice crystals/frozen water vapor
- Is the leak confined by a structure? Ventilation adequate?
- Onsite reforming? Is a methane source present?
- Presence of other fuels (e.g., CNG, propane, gasoline)
- Identify potential ignition sources

Stationary Facilities

PLAN

- Isolate and deny public entry
- Approach from upwind
- Eliminate ignition sources, activate emergency stops if accessible
- Use leak-detection devices and thermal-imaging cameras to assess hazard potential
- Use water fog to dissipate/control escaping gas
- Do not touch/walk through product
- Allow hydrogen to burn if safe to do so
- Deploy master streams to protect exposures
- Do not spray water into pressure relief vents

The Code Landscape

Primary Building and Fire Codes	Hydrogen Specific Codes and Standards	Component Listing and Design Standards
California Fire Code	NFPA 2 Hydrogen Technologies Code	ASME Boiler and Pressure Vessel Code
California Building Code	NFPA 55 Compressed Gas and Cryogenic Fluids Code	ASME B31.12 Hydrogen Pipelines and Piping
California Mechanical Code	NFPA 853 Installation Standard for Stationary Fuel Cell Power Systems	CGA S-1.1-3 (PRDs) CGA-G-5.5 Hydrogen Vent Systems
California Electrical Code	NFPA 70 National Electrical Code	UL 2075 Sensors
		ASME A13.1 Color Coding
		SAE J2600 Compressed Hydrogen Surface Refueling Connection Devices
		Component Listing Standards such as CSA H series of documents and UL listing documents

IFC and NFPA 2

- California adopted the 2011 NFPA 2 and language from the 2015 IFC effective July 1, 2015
  - Per the CA OSFM IB 14-010 issued Nov. 14, 2014

- Per OSFM, an IB is expected to be issued late January, 2016 re: adoption of the 2015 IFC and 2016 NFPA 2

HYDROGEN
Safety Panel

Hydrogen Equipment Certification Guide: Introduction and Kickoff for the Stakeholder Review

Nick Barilo
PNNL Hydrogen Safety Program Manager

Webinar – December 10, 2015

Hydrogen Safety Panel Membership

Name	Affiliation
Nick Barilo, Manager	Pacific Northwest National Laboratory
Richard Kallman, Chair	City of Santa Fe Springs, CA
David Farese	Air Products and Chemicals
Larry Fluer	Fluer, Inc.
Bill Fort	Consultant
Donald Frikken	Becht Engineering
Aaron Harris	Air Liquide
Chris LaFleur	Sandia National Laboratories
Miguel Maes	NASA-JSC White Sands Test Facility
Steve Mathison	Honda Motor Company
Larry Moulthrop	Proton OnSite
Glenn Scheffler	GWS Solutions of Tolland
Steven Weiner	Excelsior Design, Inc.
Robert Zalosh	Firexplo

Formed in 2003 to support U.S. DOE Hydrogen and Fuel Cells Program, the Hydrogen Safety Panel:

- has a combined 400+ years of experience, representing many hydrogen sectors and technical areas of expertise
- reviewed 281 projects (427 reviews) covering a broad portfolio
- includes committee members from NFPA 2 and 55, and technical committees of ASME, SAE and ISO

Codes and Standards

Safe practices in the production, storage, distribution and use of hydrogen are well established and essential for developing hydrogen and fuel cell technologies.

- Codes and standards have progressively evolved to address public safety and acceptance of these new technologies.
- **Inherent in the provisions of codes and standards are requirements for the use of *approved, certified, listed,* and *labeled* methods and equipment.**

Certification Presents Challenges

- In the early market the availability of systems or equipment that are listed, labeled or certified is limited
- Significant cost can be involved since the technology and products are still rapidly changing and each new iteration can require recertification
- When equipment is not listed or available, “approval” by the code official is required before installation occurs

The scarcity of listed hydrogen equipment places an extraordinary burden on code officials to ensure (approve) that the products employed include the appropriate inherent or automatic safety measures.

What’s the Criteria for Approval?

The *Guide* has been developed to assist code officials, designers, owners, evaluators and others with the application of the listing and approval requirements pertinent to the design and/or installation of hydrogen equipment as regulated by the model codes.

How is This *Guide* Different from Other Guides or Commentaries?

- The *Hydrogen Equipment Certification Guide* focuses on the use of the terms:
  - *Listed*
  - *Labeled*
  - *Approved*
  - *Certified*
- Requirements that do not use the above terms arecovered by other guides (NFPA , ICC, etc.).
- The *Guide* spans an array of codes expected to be encountered by users and code officials.
- The target users include designers, equipment manufacturers, and code officials where hydrogen systems are being installed or operated

Photo: h2tools.org

Codes & Standards Covered by the *Guide*

- *2015 International Fire Code*
- *2015 International Building Code*
- *2015 International Fuel Gas Code*
- *2015 International Residential Code*
- *2015 International Mechanical Code*
- *2011 NFPA 2 Hydrogen Technologies Code*
- *2015 NFPA 1 Fire Code* (as used by NFPA 2 as a source document for requirements relevant to hydrogen as established by NFPA 55)
- *2013 NFPA 55 Compressed Gases and Cryogenic Fluids Code* (as used by NFPA 2 as a source document for requirements relevant to hydrogen)

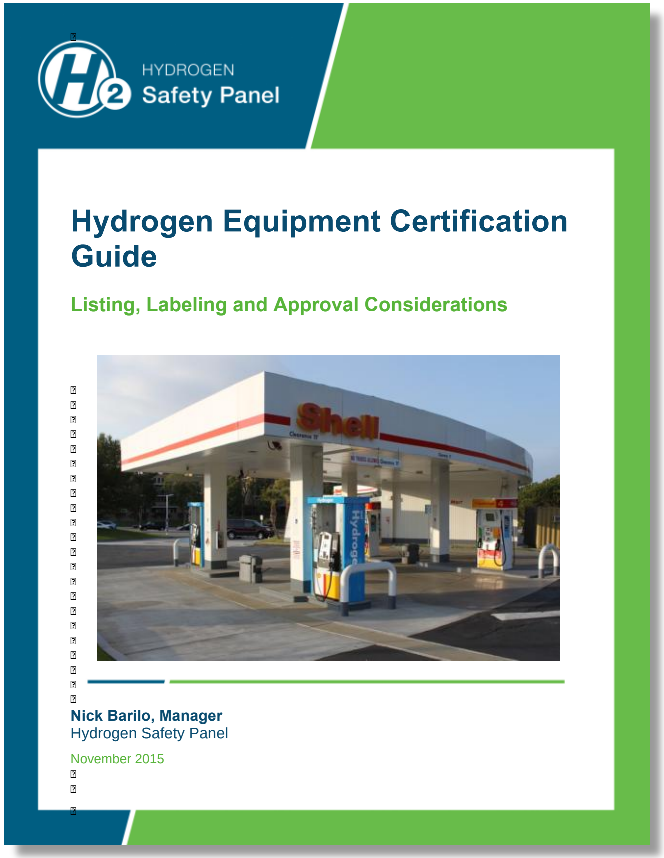
Value to Designers, Code Officials and Owners/Operators

- Where approvals are required, and listed equipment is not available the *Guide* provides direction and/or background to assist the users with elements of consideration needed to address the requirements for safety compatible with the requirements of the code.
- Resources in the form of informational documents and references are provided to aid the user where further research or background is needed in the approval process.
- “Required references” are identified when the referenced code section requires the use of a resource outside of the code itself. The required references comprise a library of documents that may be needed to interpret the requirements depending on the applicable code in use. The documents are code and section specific thereby limiting the need for outside resources to only those documents necessary for design or application.

Limitations on Use of the *Guide*

The *Guide* provides guidance only…

- It is **not** a regulatory document
- Is **not intended** to provide *formal interpretations* or positions on compliance with the codes and standards addressed therein, which can only be provided by the code development organizations or by the responsible regulatory official



Disclaimer

While the Guide provides methods for the AHJ to evaluate alternative approaches to certification, listing, and labeling requirements, it is not intent of the Guide to circumvent certification and listing if the AHJ determines it to be necessary for approval.

Expanding the Initial Review

- Review and comments are requested to ensure that the *Guide* is a quality document that meets the needs of those involved in the design, use or approval of hydrogen equipment.
- Send comments to hsp@h2tools.org
- Comments due No Later Than February 29, 2016.
- The final document will be made available on the Hydrogen Tools Portal in August/September 2016.

HYDROGEN
Safety Panel

Hydrogen Equipment Certification Guide - Stakeholder Comment Form

Submit comments to hsp@h2tools.org

Commenter's Name:
Commenter's Affiliation:
Commenter's Phone:
Commenter's Email:

Page and Paragraph	Subject or Code Section	Comment

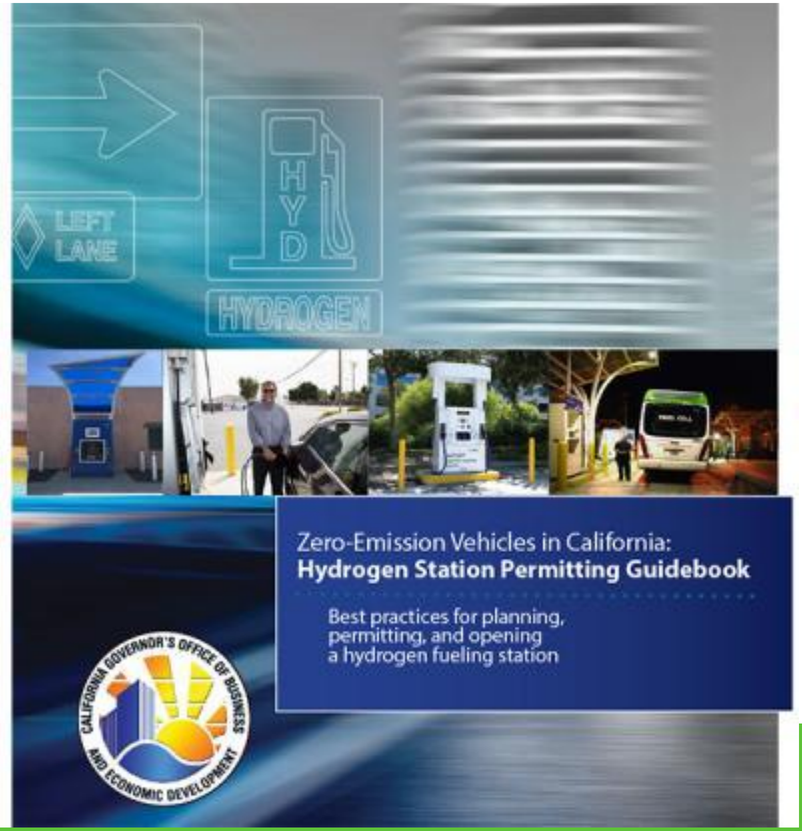
PLEASE NOTE: Contact information is only for discussing your comments with you if the need arises. There will be no attribution to individuals or organizations responding.

Download URL
https://h2tools.org/sites/default/files/Hydrogen_Equipment_Certification_Guide_20151210.zip

The comment form is part of the download for the draft certification guide. Submit comments to h2p@h2tools.org.

Additional resources

- www.cafcp.org
- www.h2tools.org
- http://business.ca.gov/Programs/Permits/HydrogenStationPermitting.aspx



Contact Information

Please let us know if you have any questions or comments!

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