



Hydrogen Fueling Stations

IEEE – April 25, 2023



Introduction - Bio



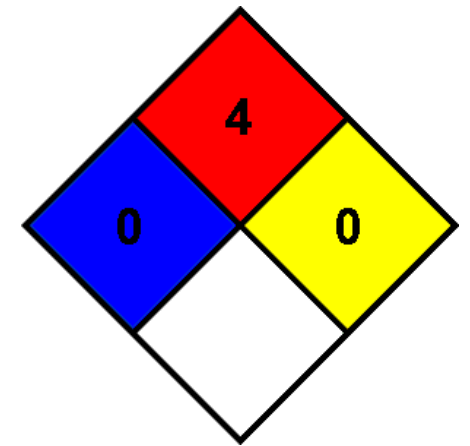
- Electrical Engineer with 30+ years in EPC
- Semi-Retired
 - Author of *An Inconvenient Purpose*
 - Green Stewardship, LLC
- Passion for Hydrogen and Fuel Cells



HYDROGEN SAFETY MOMENT

FIRE FIGHTING INSTRUCTIONS:

1. The only safe way to extinguish a flammable gas fire is to stop the flow of gas.
2. If the flow cannot be stopped, allow the entire contents of the cylinder to burn.
3. Cool the vessel and surroundings with water from a suitable distance.
4. Extinguishing the fire without stopping the flow of gas may permit the formation of ignitable or explosive mixtures with air. These mixtures may propagate to a source of ignition.



CARBON-FIBER TANKS ARE DURABLE

- Ballistics tests
- Drop and crash tests
- Fire tests

IN TANK COMBUSTION NEARLY IMPOSSIBLE

- Air (oxidant) and fuel (hydrogen) must be present in tank simultaneously, not possible due to pressurization

RADIANT HEAT

- Radiant heat of H₂ flame is low
- Risk of secondary fires is lower

Why Hydrogen Fuel Cell EV?

- Faster fill times
- Better vehicle range
- 1 gal = 1 kg (but 2x+ miles)
- More familiar fueling expertise
- Better cold weather performance & range
- Actually safer? (H₂ disperses quickly)
- Lighter vehicle weight
- Great for Heavy Duty and Long Haul
- Still a DC motor



Hydrogen – Gaseous vs. Liquid



- Gaseous
 - Standard dispensing pressures, 350 Bar & 700 Bar
 - Storage (pressurized, LH₂, liquid carrier, solid)
 - Safety - Fire walls, vent stacks, safety shutoffs, setbacks
- Liquid
 - Cryogenic (minus 423 deg F)
 - Controlling boil-off (approx. 1% loss per day)
 - Safety – greater setbacks

Site Delivery Modes

- HP tube trailer truck
- Liquid H₂ tanker
- Other
 - Ammonia
 - Methanol
 - Bioethanol
- On-site Generation
 - SBI-Bioenergy [Golu H₂ | sbibioenergy](https://sbibioenergy.com)
 - NEL – On Site electrolysis
 - GKN Hydrogen- Metal Hydride storage
 - Plug Power
 - Tecnicas Reunidas RNG-SMR
 - Fuel Cell Energy – Tri-Gen System



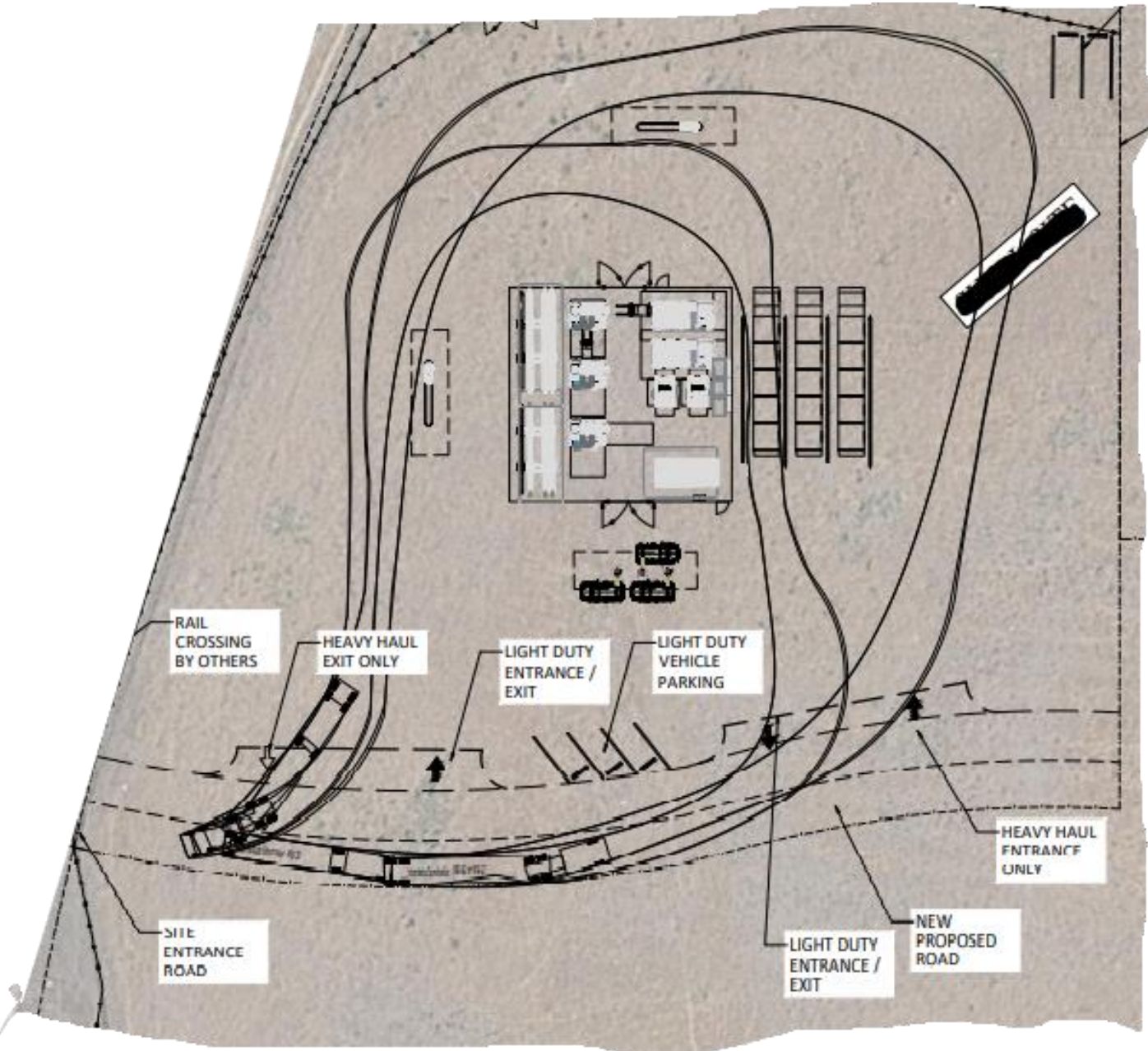


Typical H₂ Gaseous Station Components

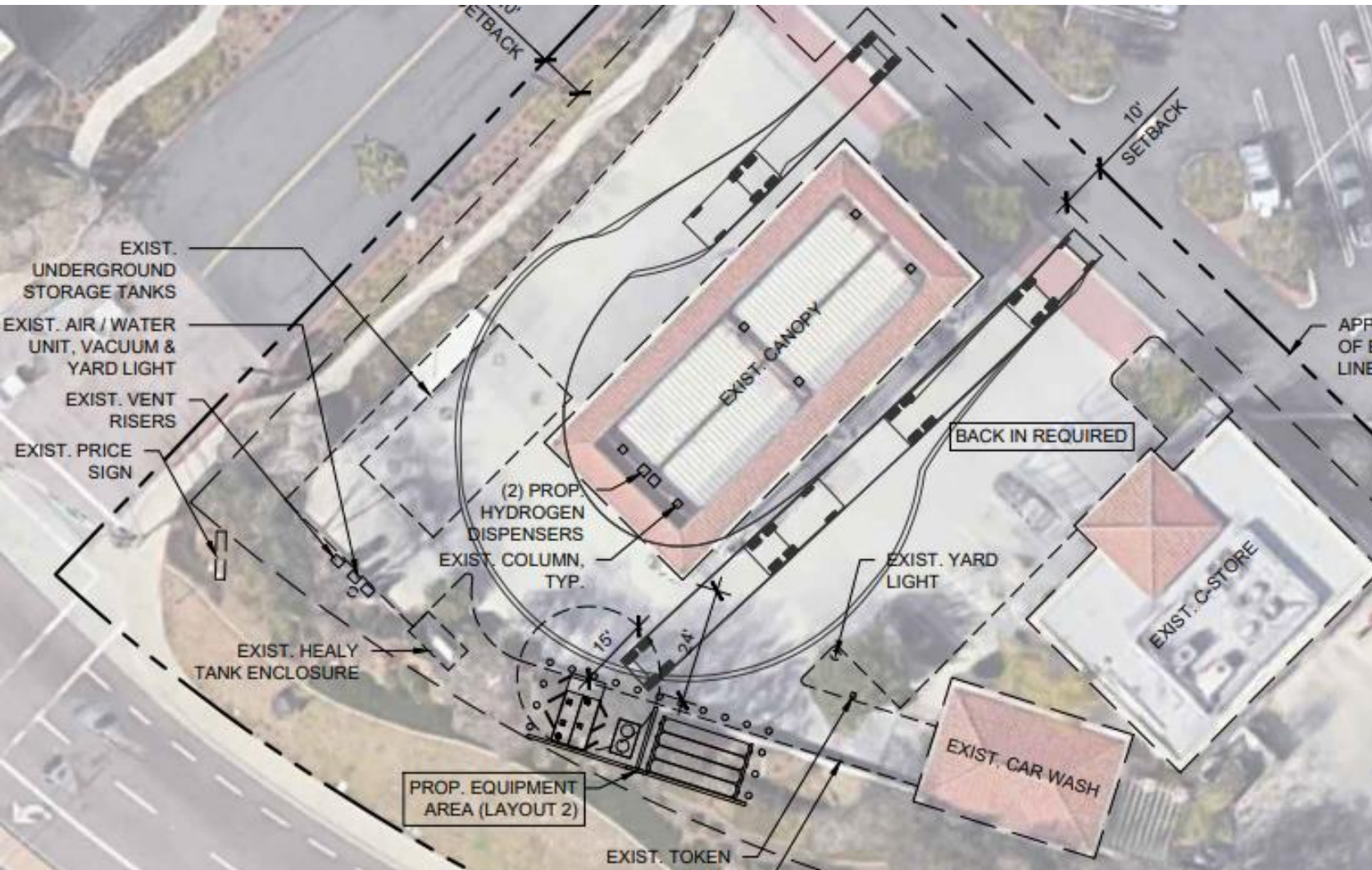
- Unloading station
- Transformer / power feed upgrade
- Lower pressure storage
- High pressure storage/ buffer tank
- Compressors
- Chillers
- Piping to dispensers
- Physical barriers / bollards
- Vent stacks, safety features

Example of Hydrogen Fueling Station

- Gaseous Hydrogen – 350 Bar & 700 Bar
- On site storage tubes and tube trailer truck unloading and extra storage parking
- Central location chillers, compressors, site storage
- Distances important to dispensers
- Truck path turn radii important
- Avoid need for trucks to reverse if possible



Example Integration at Existing Site



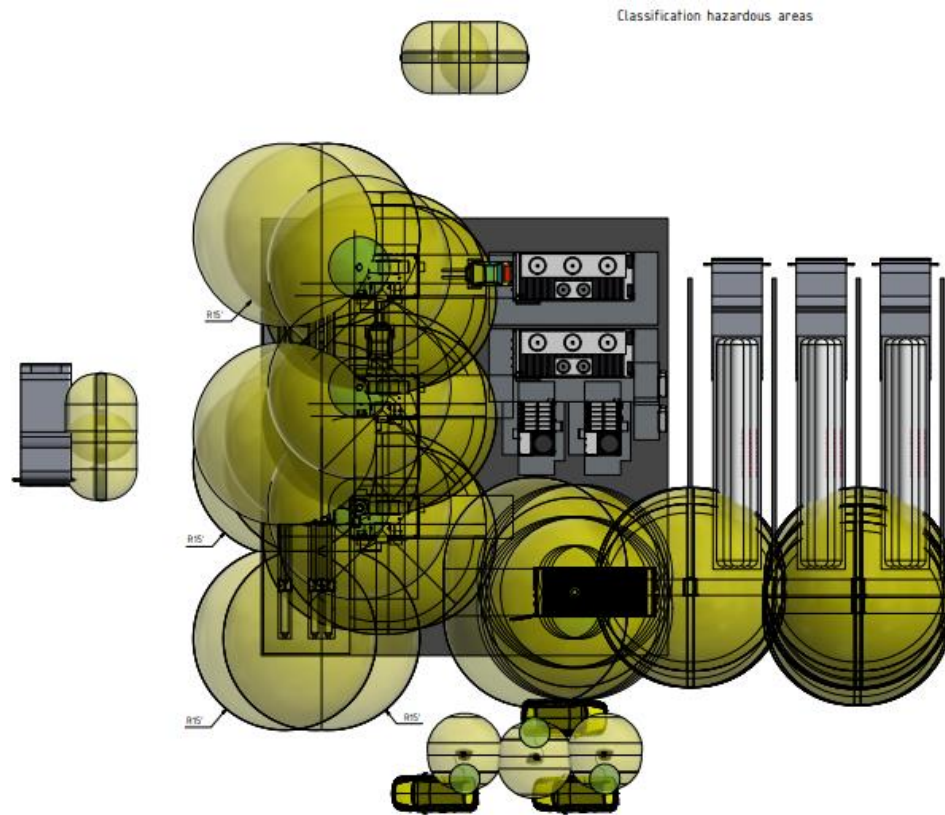
- Dispensers can integrate into existing fueling canopies
- Engage AHJ early
- Have a solid plan for permitting – answering questions
- Truck flow paths critical
- H₂ vent stack heights can be an issue

Resources for Codes, Safety, Lessons Learned, Info

- NFPA 2
 - [NFPA 2: Hydrogen Technologies Code](#)
- Fuel Cell and Hydrogen Energy Association
 - [Hydrogen and Fuel Cell Safety](#)
 - [Codes & Standards Overview — Hydrogen and Fuel Cell Safety](#)
- California Hydrogen Business Council
 - [CHBC-Hydrogen-Handbook-v3.pdf \(californiahydrogen.org\)](#)
- Center for Hydrogen Safety
 - [CHS | Center for Hydrogen Safety \(aiche.org\)](#)
 - [Best Practices Overview | Hydrogen Tools \(h2tools.org\)](#)



Safety



- Most hazardous areas for fueling stations fall in 5 ft or 15 ft radius
- Cameras, combination of sensors (Honeywell, Drager)
- Robust bollards – Fencing - Walls
- Awareness of freeze burn potential from nozzle temperature (minus 50 C)
- Grounding, avoiding sparks
- Training, training, training

What's Next?

- Heavy Duty to lead the way
 - Class 8 trucks, long haul
 - Drayage vehicles
 - Ports
 - Areas with poor air quality, Opportunity Zones
 - Buses
 - Mining
 - Trains
 - Ships / Ferries
- Light Duty vehicles not out of the question
 - Toyota, Honda, Hyundai
 - Diversity of technology is good





Discussion

gasaway@greenstewardshipllc.com

