

Moving from cylinder replacement to on-site refueling

Simpler, safer, more reliable

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NASFM & U.S. DOE/NREL
Hydrogen Permitting Workshop

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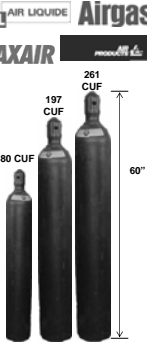
Hydrogen Storage / Delivery – Current Model

Advantages of Current Model:

- Large distribution infrastructure
 - 3000+ locations in the US
- Proven technology
 - Standards established for siting & delivery
- Hydrogen available in compressed cylinders
 - Certified containers
 - Capacity / run time dependent on tank size and pressure

Limitations of Current Model:

- Labor intensive to exchange heavy cylinders
 - Weight & size ~ 140 lb. each
- Residual hydrogen "lost" in exchange
- Limited scale for extended run times
 - More run time = more cylinders
 - 200 kW-hr → 24 Cylinders; 300 kW-hr → 36 Cylinders



Logos for AIR LIQUIDE, Airgas, and PRAXAIR are visible in the background of the slide.

Hydrogen Development Goals

Hydrogen storage/delivery development goals:

- Maintain reliability and ensure commercial readiness
- Refill vs. cylinder exchange
 - Utilize hydrogen mobile refueler and deliver to fixed storage (propane model)
 - Mitigate labor of cylinder exchange
- Higher volume refillable storage system
 - Telcos require >48 hours run-time to allow re-fueling multiple sites during long widespread outages.
 - Example: ~35 scf/kWhr; 7000 scf = 200 kW-hr of hydrogen energy storage
 - ~ 50 hrs of runtime @ 4kW
 - ~ 34 hrs of runtime @ 6kW

Why focus on compressed gas development vs. fuel processors?

- High reliability, low maintenance
- Independent of system power requirements (scalable)
- Infinite storage time (no fuel degradation)
- No environmental spill hazard
- No air emissions
- No waste product

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Advantages of refill vs. exchange

- Refilling offers several advantages over cylinder exchange
- Cylinder exchange requires:
 - disconnecting and reconnecting cylinders; every connection cycle is a chance for a leak, and damage to cylinder valve
 - Moving and maneuvering heavy tanks; difficult access even in outdoor installations (gravel/dirt, above-ground conduit, etc.)
 - Inefficient volumetric storage (cylinders can't be closely packed because access is required)
 - Cylinders exchanged by lay persons
- Refilling offers:
 - Single connection point designed for refueling
 - Maneuvering a hose vs. cylinders
 - Denser storage volume
 - Trained personnel/operators
 - Already a standard method at volume H2 consumers (hydrogenation, semiconductor, metal treatment)
 - Already validated for propane
 - Propane = 2520 Btu/scf
 - H2 = 270 Btu/scf

Storage allowances for Infrastructure Fuels

Fuel Type	Allowable onsite Storage Quantity/ BTU	References/Special Conditions
Diesel	275 gallons 139,000 BTUs/gallon 38,225,000 BTUs/site	NFPA 30 Flammable Liquids Code 2006, Table 4.3.2.1.1(a) and (b) : 2.5 ft to exposures
Gasoline	275 gallons 124,000 BTUs/gallon 34,100,000 BTUs/site	NFPA 30 Flammable Liquids Code 2006; Table 4.3.2.1.1(a) and (b) : 2.5 ft to exposures
LPG	1200 gallons 91,600 BTUs/gallon 109,120,000 BTUs/site	2006 IFC Table 3804.3 : 10ft to exposures, 10 foot minimum between fill connection & vent from liquid-level gauge to external source of ignition (air conditioner), direct vent appliances, or mechanical ventilation air intake.
Hydrogen	3500cuft 270 BTUs/cu. ft. 945,000 BTUs/site	2006 IFC Table 3504.2.1 0 ft for >=2 hour construction/no openings within 25 ft; 5 ft otherwise to non-rated construction, public streets, alleys & ways, lot lines and other storage areas

Allowable Hydrogen on site storage is at least one order of magnitude lower than other fuels by BTU content.

2006 IFC 3005.7 Transfer.
Transfer of gases between containers, cylinders and tanks shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1.
Exception: Fueling of vehicles with compressed natural gas (CNG).

Discussion/Questions
