

Cryotank for storage of hydrogen as a vehicle fuel

Lighter, smaller, safer, cheaper!

J. Raymond Smith

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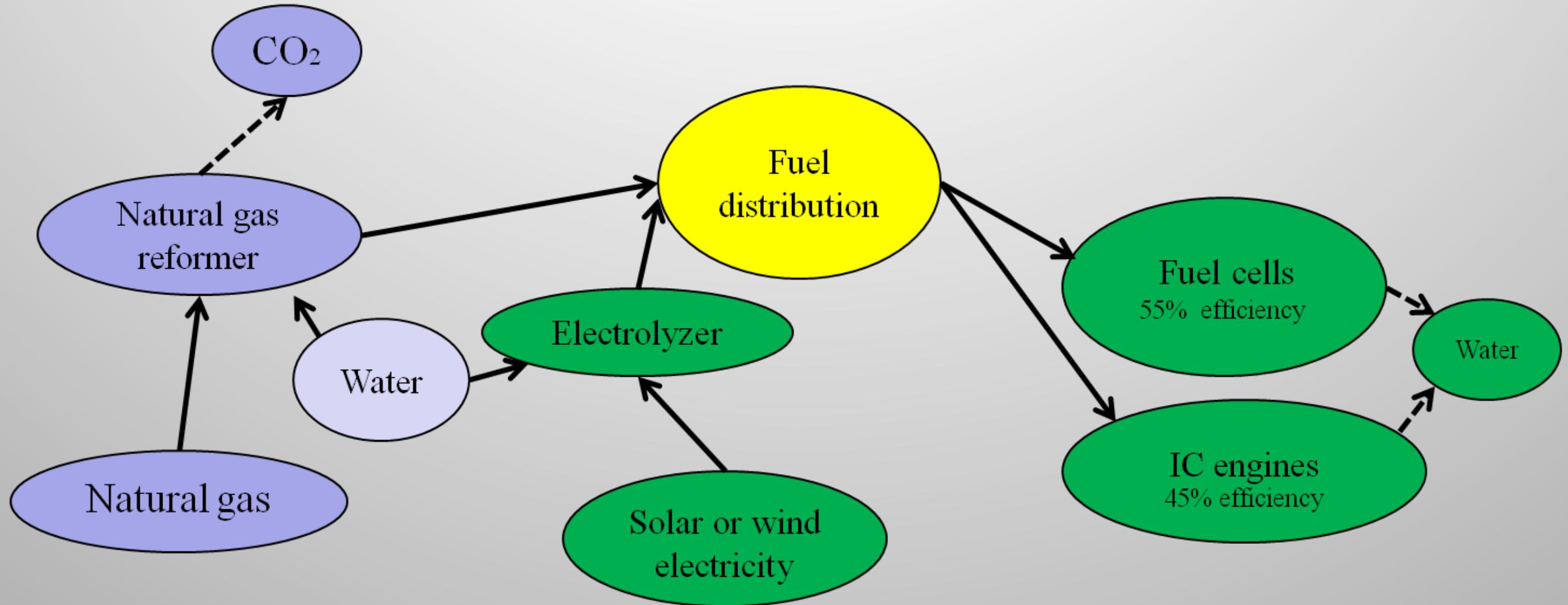


LLNL Hydrogen powered Prius – 650 mile range!



Why hydrogen as a mobile fuel?

Answer: **A pathway to greener mobility!**



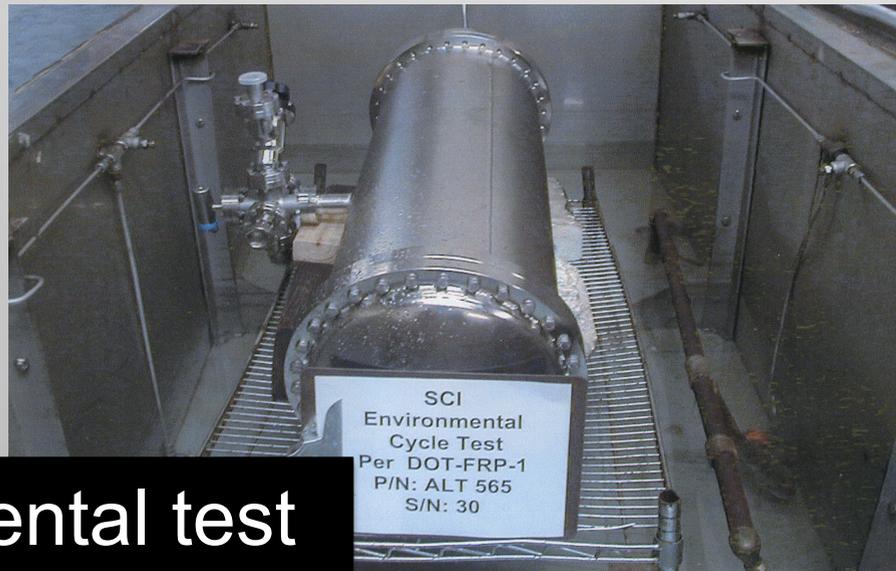
Why hydrogen as a mobile fuel?

- Renewable hydrogen has no toxic or greenhouse gas emissions
- Fuel cells using hydrogen achieve greater than 50% efficiency
- Cost per mile will be comparable to gasoline
- Hydrogen has more energy per pound than any other fuel



The technology

- Hydrogen at low temperature and high pressure reduces weight, volume and cost of storage
- Prototypes have passed Department of Transportation and International Organization for Standardization (ISO) tests (fire & bullet)



Environmental test
-40F → 120F



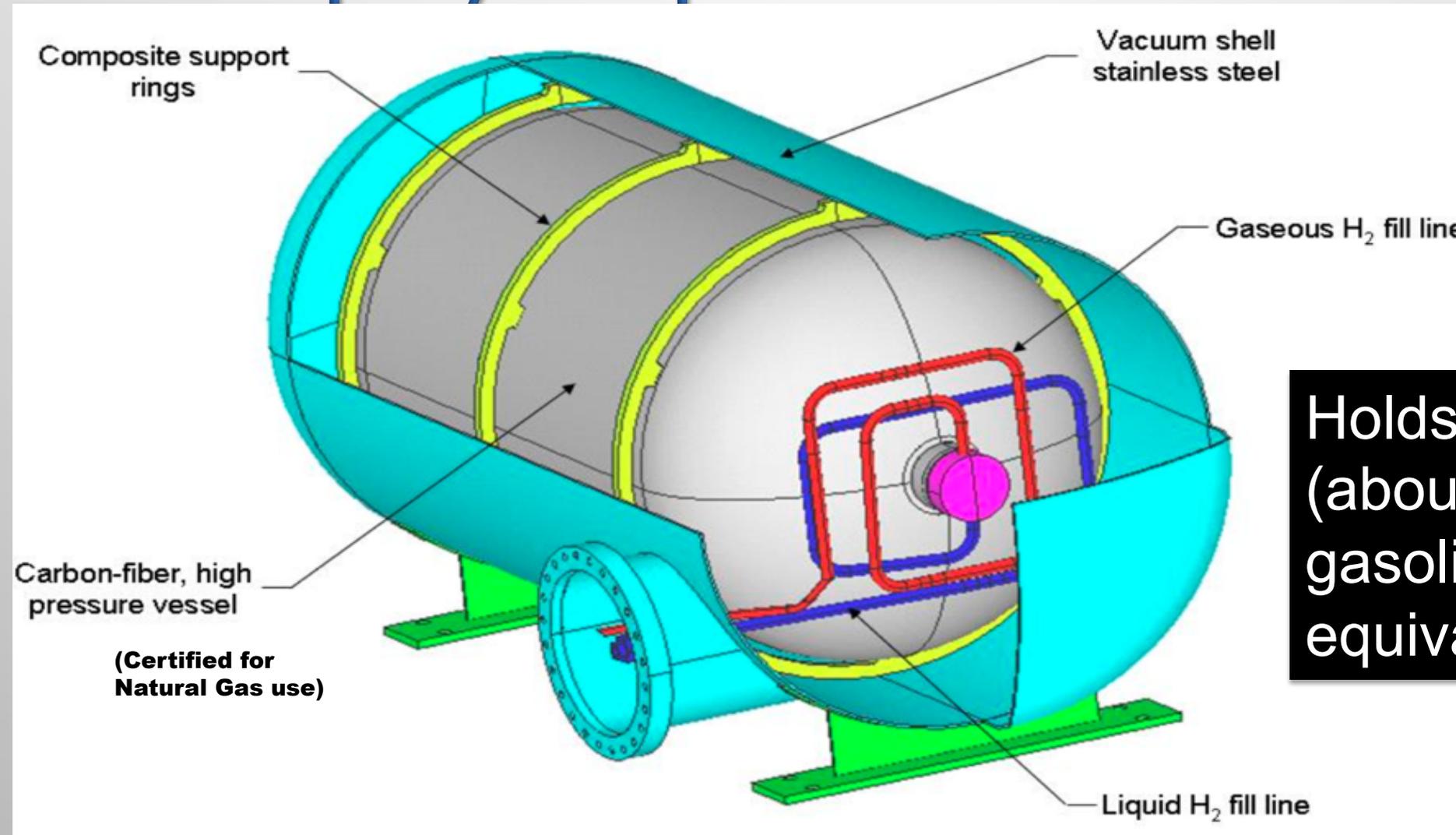
The cryotank will store either gaseous or liquid hydrogen

Phase	Pressure	Temperature
Liquid	15 psi	20 K (-455 F)
Liquid+gas	< 5000 psi	< ambient
Gas	5,000 psi	ambient

- The amount of gas and hence pressure in the tank depends on duration of non-use (time parked). No hydrogen loss until after 10 days of parking. Vented gas can be catalytically reacted to water without hazard.



Cryotank is insulated using vacuum around “conventional” carbon fiber-epoxy composite tank vessel

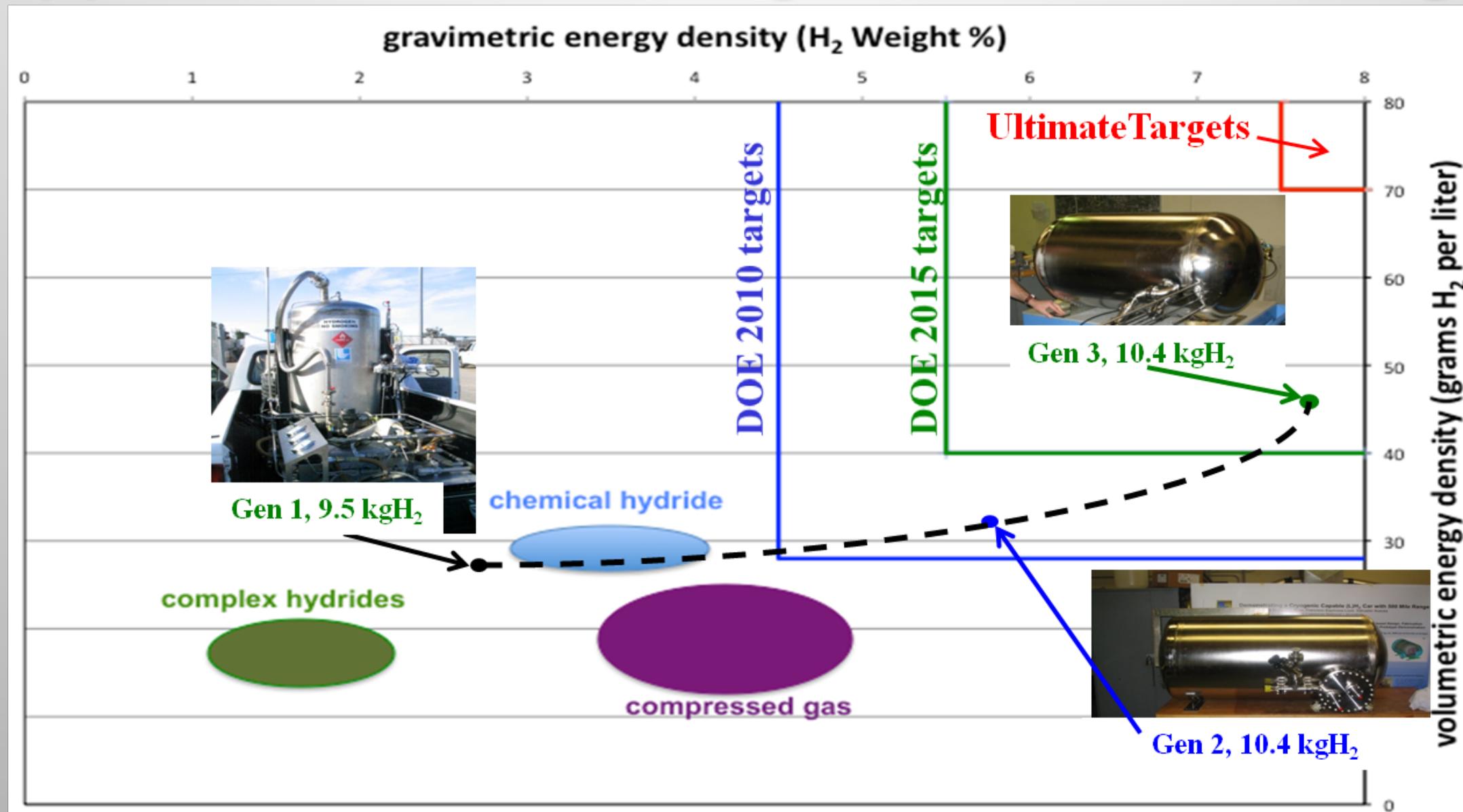


Holds 7.0 kg of H₂
(about 7 gallons of
gasoline
equivalent energy)

About 40 gallon external volume tank will cost about \$2,800



Cryotank exceeds DOE 2015 H₂ storage goals and can approach ultimate weight and volume targets



Cryogenic pressure vessels can enable H₂ autos

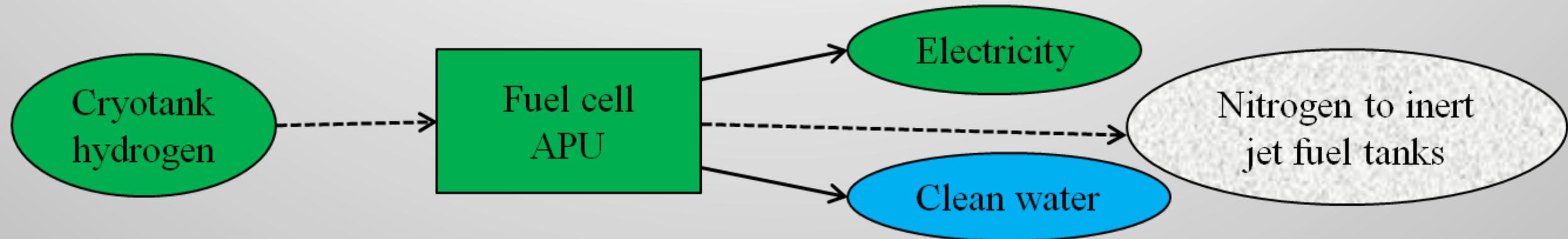


- **Lowest ownership cost:** Cryogenic vessels use 2- 4x less carbon fiber than high pressure gaseous H₂ tanks.
- **Rapid refueling at high density:** 5 minute high density refueling (74 -90 g/L) possible with LH₂ pump
- **Safe:** Low expansion energy, steel jacket provides secondary protection, low on-road operating pressure, fewer pressure cycles due to longer driving range
- LLNL vehicle drove 650 miles on one liquid 10 kilogram H₂ fill



Current projected uses of cryotank

- **Automobiles** – BMW will incorporate cryotank into their fuel cell test fleet in 2012
- **Aircraft** – Airbus discussing (with BMW) APU replacement



- **Forklifts** - indoor use with no emissions
- **Mining locomotives** – no emissions



Contact Information



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