

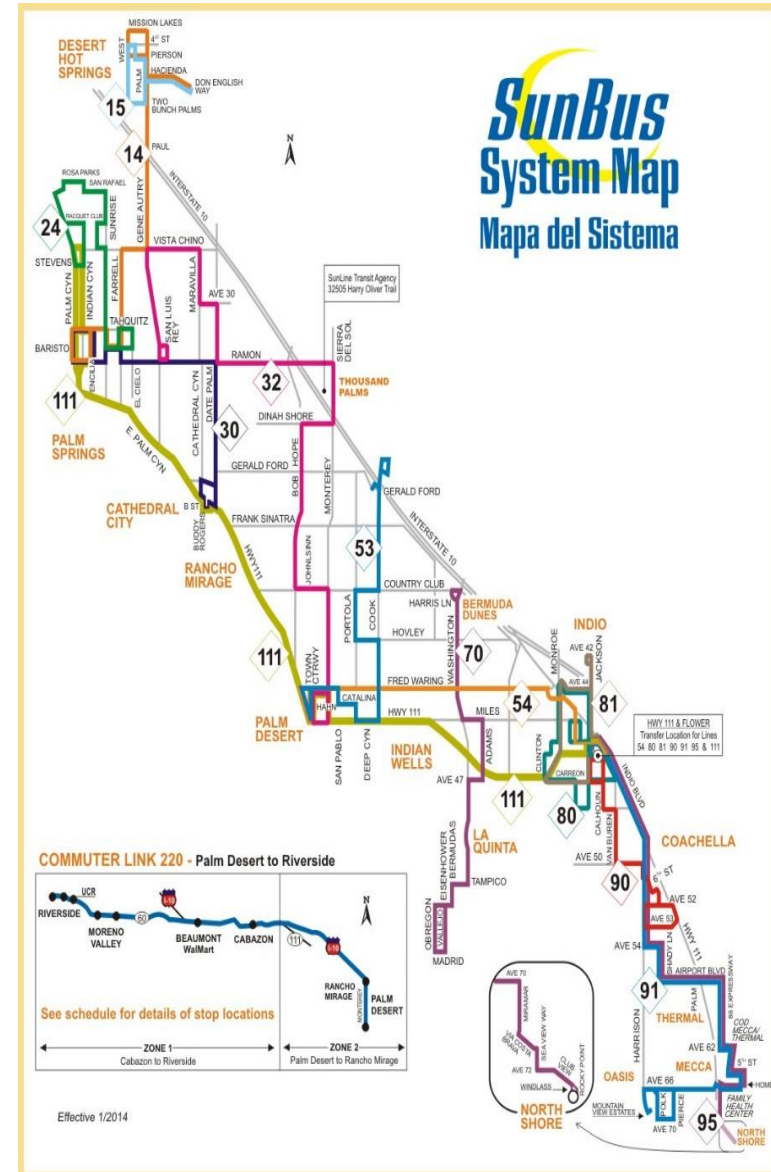
SunLine Hydrogen Program

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SunLine Facts

SunLine Operations

- Fourteen (14) local SunBus fixed routes, (1) express line, (1) Riverside Commuter Link, and ADA Paratransit
- **66 CNG buses**
- **10 Electric Hydrogen Fuel Cell buses**
- **3 All Electric Battery BYD buses**
- **39 CNG Paratransit Vehicles**
- Operated 4.3 million revenue miles for 4.5 million passenger trips
- 365 Employees



Research and Development

- Need Owners Representative with Subject Matter Expertise
- Systems Development Approach Must be Adopted
- Cannot Underestimate Value of Estimates
- Cannot Underestimate Value of Statements of Work that include Solid Acceptance and Rejection Criteria



Zero Emission Bus Resource Alliance

- Membership
 - Micro Transit < 9 fixed route buses: \$1,000
 - Small Transit 10-99 fixed route buses: \$3,000
 - Large Transit >100 fixed route buses: \$5,000
 - Accredited Colleges and Universities: \$1,500
- Started in 2015
- Benefits
 - Research, Discussions, and Best Practices in Zero Emissions Deployments
 - West Coast Center of Excellence Training
 - Development of Materials to support Planning and Deployment of Zero Emissions Technologies

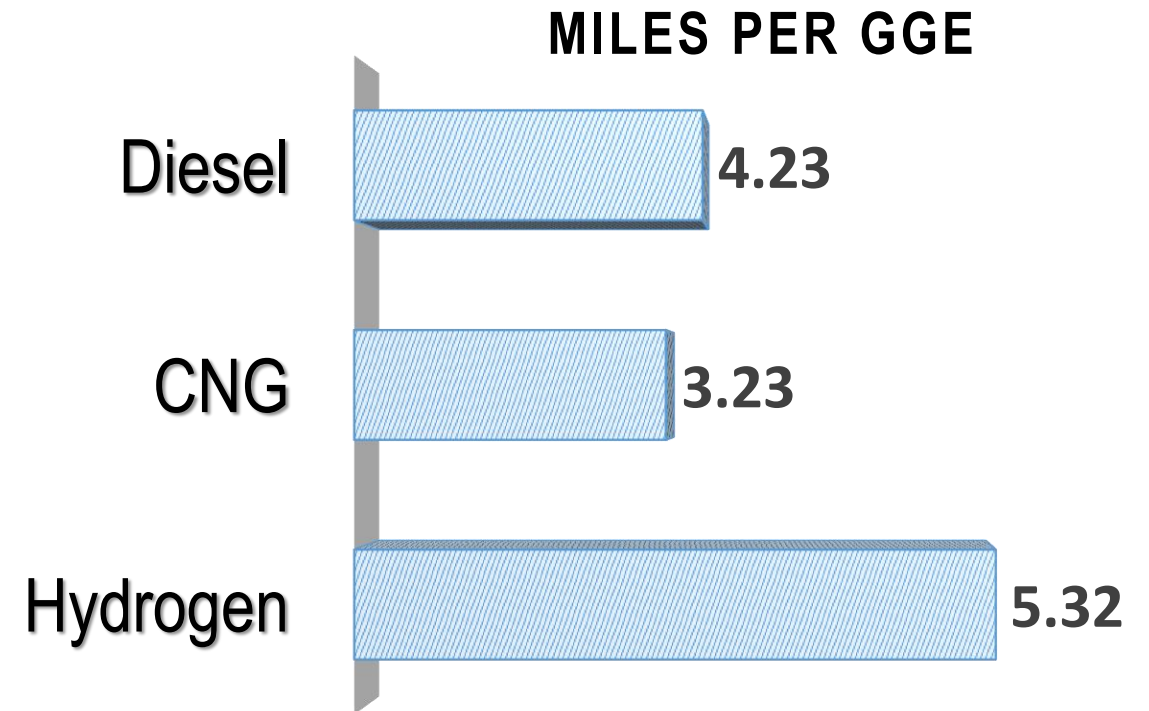
Hydrogen Reformer

- SunLine's Hydrogen Reformer has been in operation since 2006 (12 years)
 - Was assigned a useful life of 8 years, per Hyradix (Manufacturer)
- Hydrogen reformer creates fuel by converting methane and steam into hydrogen, through auto thermal reformation (hot high pressure).
- In Fiscal Year 2018 it hydrogen was produced at an average cost \$8.43 per KG. That does not factor in any rebates.



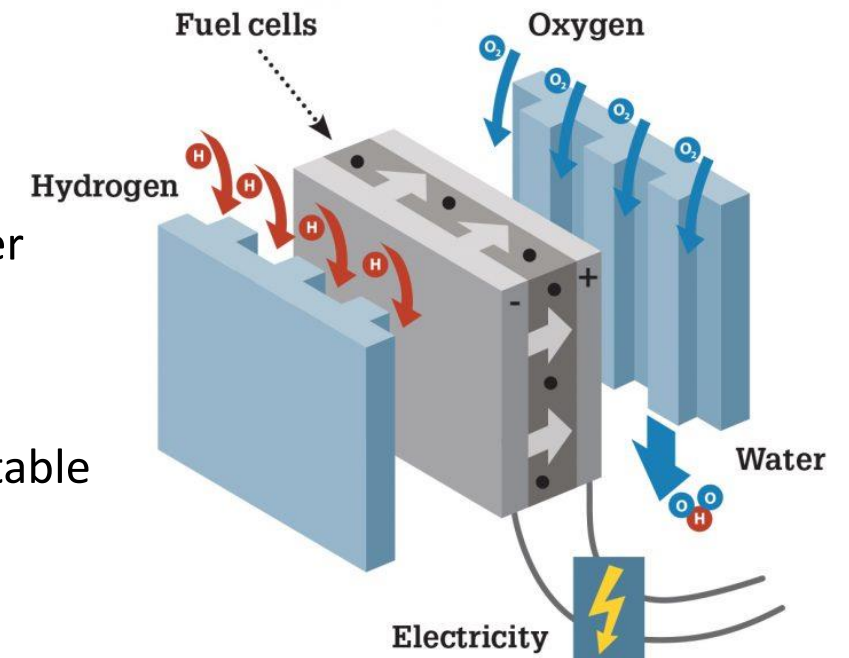
Bus Performance using Hydrogen

Bus Tank Holds



Hydrogen Electrolyzer

- How Electrolyzer works
 - Uses electricity to split the H molecule from H_2O
 - Will produce 900 kg in 24hrs (37.5 kg/hr)
- What are the different type of Fuel cells?
 - (PEM) Proton exchange membrane
 - proton exchange membrane fuel cells—deliver high power density and offer the advantages of low weight and volume compared with other fuel cells.
 - ✓ Direct methanol fuel cells- Portable Systems
 - ✓ Alkaline fuel cells-One of first types, environmentally unstable
 - ✓ Phosphoric acid fuel cells
 - ✓ Molten carbonate fuel cells
 - ✓ Solid oxide fuel cells
 - ✓ Reversible fuel cells



Reformer Lessons Learned

- SunLines Hyradix Adeo 100 unit runs with extremely low emissions.
- Very cost effective and efficient method of producing 99.999% H₂ purity
- Has met 98% up time of production, operation and life time expectancy
- Still in service
- Easy to maintain and operate

Reformer Lessons Learned

- Reformer was a revolutionary design with only a couple units produced before market falling out and company went out of business.
- Specialty maintenance items are hard to get due to low manufacturing of these unit items, company's still can produce most parts but at a high cost due to one off builds with a long lead time.
- Note perhaps knowing this unit was going to have an extended life cycle, purchasing some spare years ago would have been better before extended down times.

Electrolyzer Lessons Learned

- Fully understand capability and experience of grant partners
- Anticipate potential cost overruns
- Fully understand operational costs including any utility upgrades needed
- Meet with partners frequently