Building Infrastructure for Zero Emission Buses

California Transit Association
53rd Annual Fall Conference

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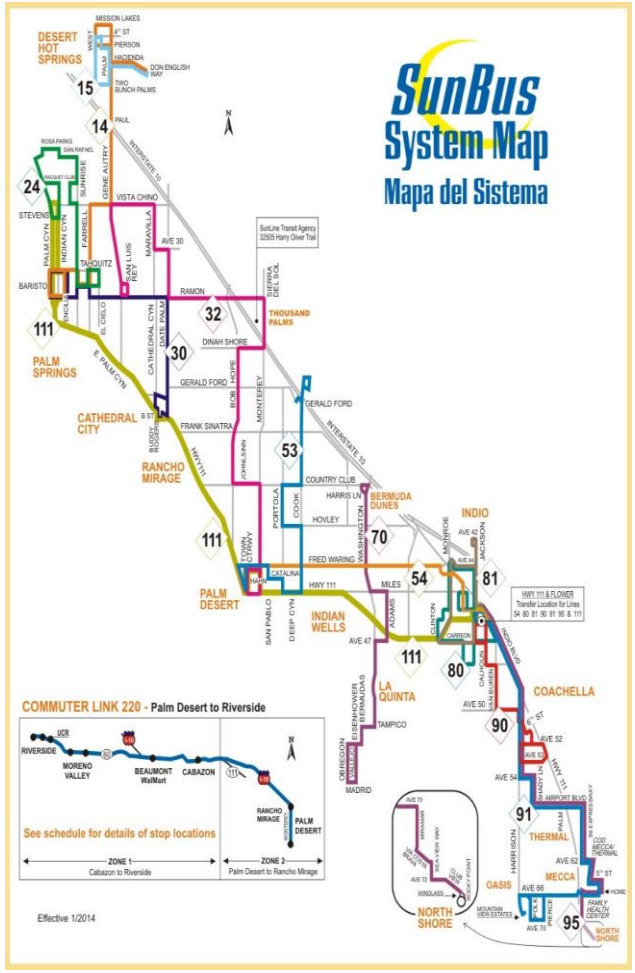
Chief Performance Officer
SunLine Transit Agency

SunLine Facts

SunLine Operations

- Fourteen (14) local SunBus fixed routes,
  (1) express line,
  (1) Riverside Commuter Link, ADA Paratransit
- **66 CNG buses**
- **10 Electric Hydrogen Fuel Cell buses**
- **3 All Electric Battery buses**
- **39 CNG Paratransit Vehicles**
- Operated 4.4 million revenue miles for 4.3 million passenger trips
- 365 Employees



SunLine Board Policy

- **Policy Language**

Actions to be Followed

"The State of California has established four categories of alternate fuel vehicles: 1) Zero Emission Vehicles; 2) Ultra Low Emission Vehicles; 3) Low Emission Vehicles; 4) Transitional Low Emission Vehicles. SunLine will, whenever possible, purchase vehicles in the same order as listed above. We do recognize that it may not always be possible to buy a vehicle from these categories as alternate fueled vehicles are still relatively new and are not always available. We also have to be practical and take into consideration the cost of the vehicle, and the cost of the continued use and maintenance"

SunLine's Hydrogen Program

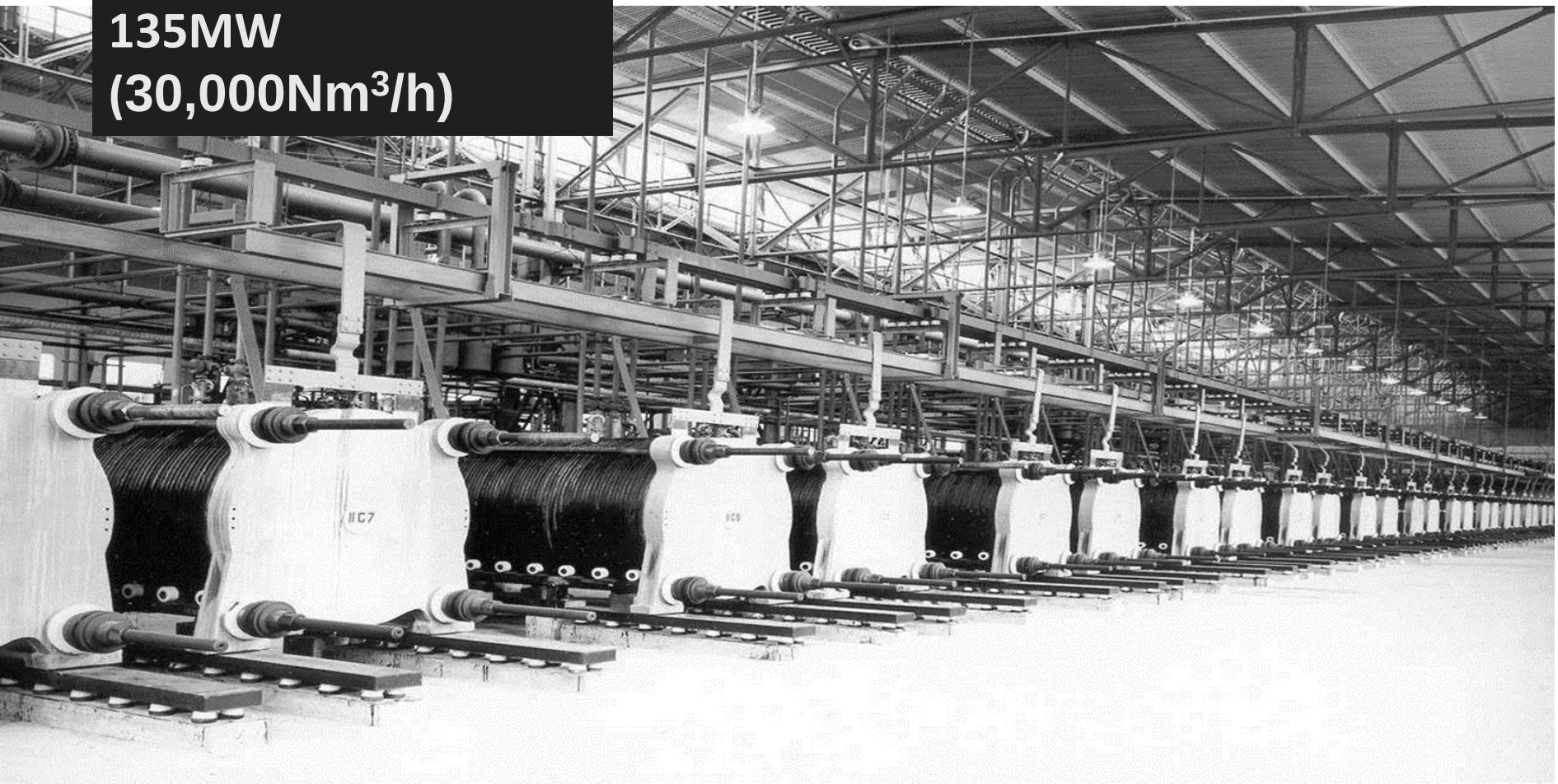
Current H_2 Fueling

- 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.

Size matters! Scale drives down cost…

Largest single electrolysis plant ever built

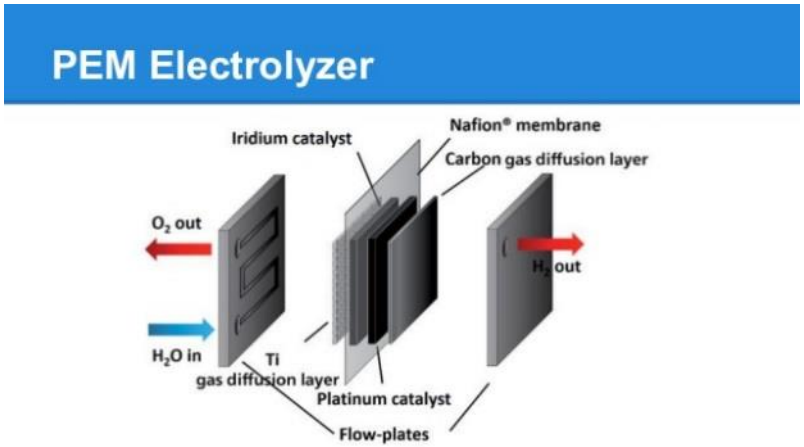
Nel (Norsk Hydro)
Glomfjord / Norway
1953 – 1991
135MW
(30,000Nm³/h)



SunLine's Hydrogen Program

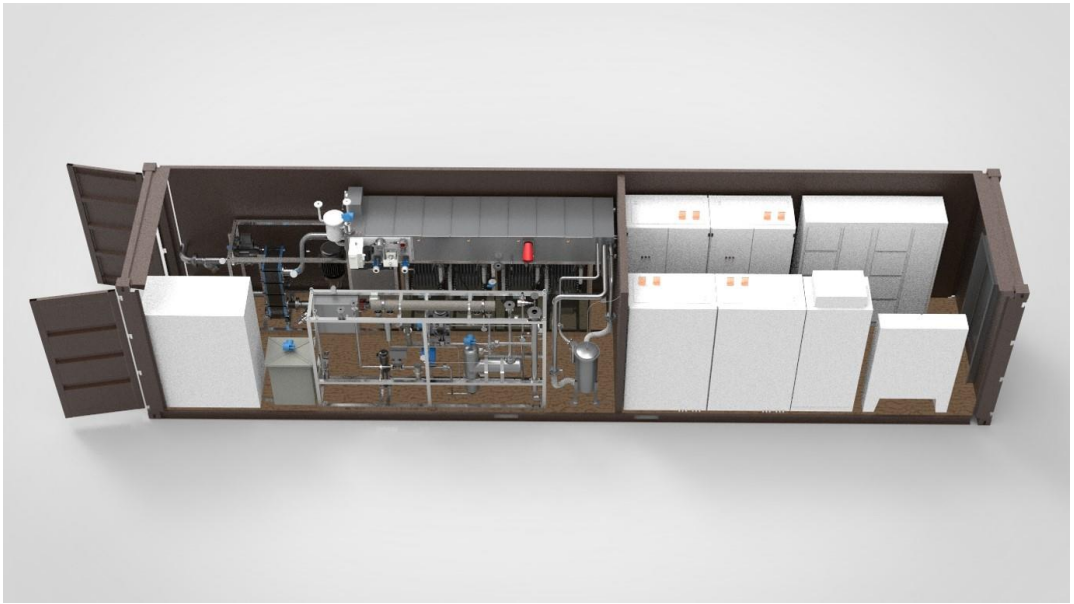
Future Fueling – In Construction

- Electrolyzer
- 902 Kg per day capacity
- 2.2 MW
- Kg price is $10Kg estimated before rebates



PEM system configuration lends itself to containerization

- Reduces site work requirements
- Installation time reduced significantly
- Makes system more deployable
- 2.2 MW containerized system available

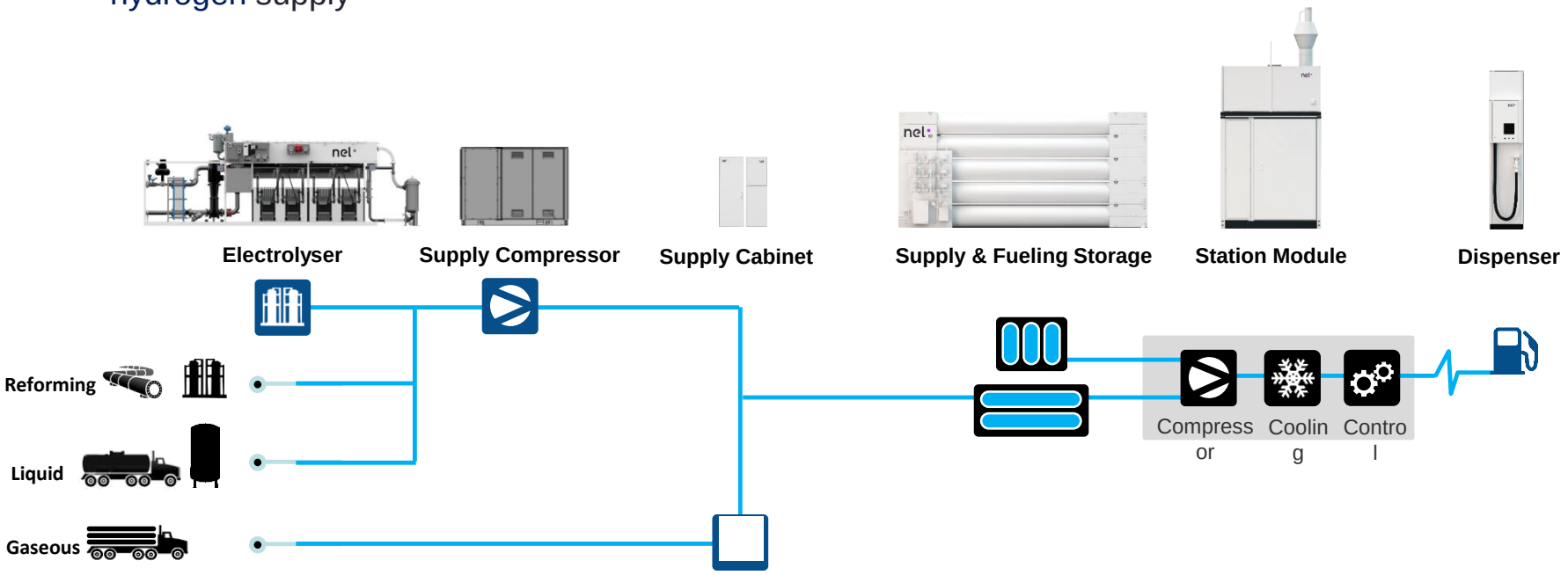


nel Hydrogen©

H2 Station connects to any hydrogen source

H2Station® is designed to connect to any hydrogen source ranging from onsite production to trucked-in delivery

- H2Station® fueling equipment is standardized and always the same regardless of hydrogen supply.
- Only storage and supply compression and connections are customized depending of the hydrogen supply



Main objective is to ensure that customer achieves the lowest hydrogen price possible and the preferred renewable content.

Hydrogen price parity with diesel/CNG for Buses

Achieving hydrogen price parity with diesel/hybrid and CNG will be important for the TCO experienced by Transit Agencies.

FCEB consumption ranging from 0.13 – 0.16 mile/kg results in the following fossil parity price with Diesel/Hybrid and CNG:

- Diesel: $4.5 - $5.6 per kg hydrogen
- Diesel hybrid: $3.6 - $4.5 per kg hydrogen
- CNG: $3.5 - $4.3 per kg hydrogen

Price parity with diesel is within reach today.

Diesel hybrid and CNG price parity requires scale.

Hydrogen price parity with diesel/CNG for busses in California

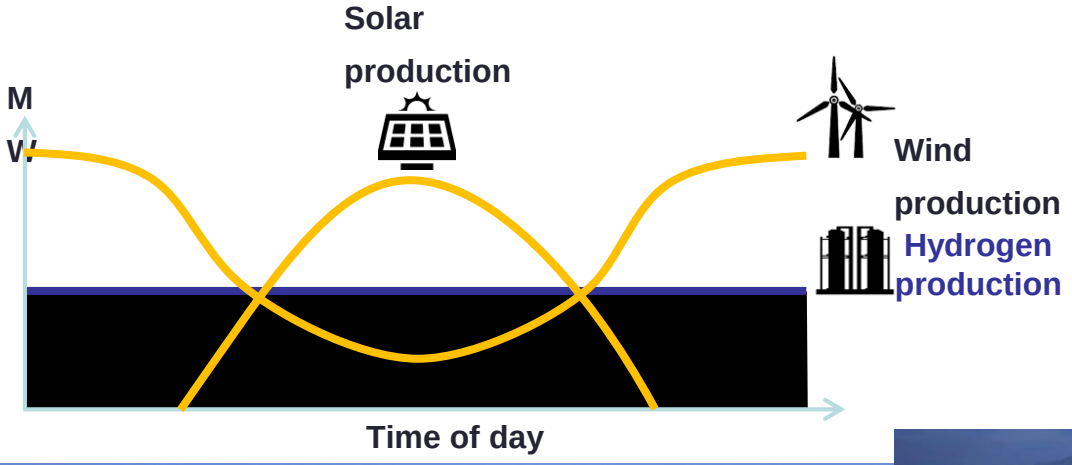
Fuel	Diesel	Unit	Diesel Hybrid	Unit	CNG	Unit
Fuel consumption	3.87	miles/DGE	4.84	miles/DGE	2.91	miles/DGE
Fuel price (incl. O&M)	$2.79	/DGE	$2.79	/DGE	$1.62	/DGE
Fuel cost per distance	$0.7	/mile	$0.6	/mile	$0.6	/mile
H2 parity price - 1	**$5.6**	**/kg**	**$4.5**	**/kg**	**$4.3**	**/kg**
H2 pariy price - 2	**$4.5**	**/kg**	**$3.6**	**/kg**	**$3.5**	**/kg**

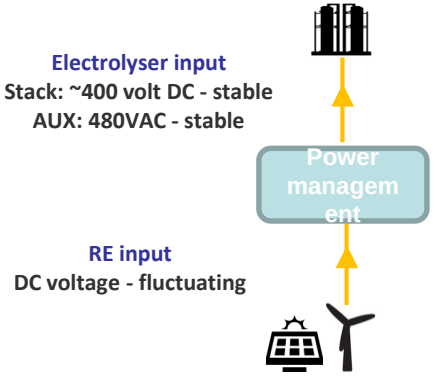
Hydrogen	1	2	Unit
Fuel consumption	8.00	9.85	kg/100km
	0.08	0.10	kg/1km
	0.13	0.16	kg/mile
	7.77	6.308	mile/kg

Data based on ARB: "Innovative Clean Transit - Cost Data and Sources - Update on 6/26/2017"

Combining solar and wind increases electrolyzer utilization

- Combining solar and wind may allow for a substantial increase in electrolyzer utilization – particularly for off-grid applications.
- Depending of site location – wind production typically happens during night and solar during day.
- Optimization of solar/wind and electrolyzer capacity may enable up to 65% electrolyzer utilization off-grid.
- Local power management will be required when operating off-grid – to ensure sufficiently stable power supply.





LEADERS IN ALTERNATIVE FUEL TECHNOLOGY

SunLine TRANSIT AGENCY

Leaders in Hydrogen Electric Fuel Cell Bus Technology for over 18 years

Battery Electric Bus Infrastructure

- Engage your utility provider at the beginning
- Understand the future energy needs
- Work closely with your planning team to establish routes that will support the technology

Definition of Opportunity

Commercialization of Zero Emission Technology must include the Transit Industry's perspective in three key areas:

- Risk associated with the investment in the technology
  - Purchase readily accepted vs. introductory technology
  - Infrastructure needed short term and in the future

- Performance associated with the reliability of the equipment
  - Mission focus and organization communication focused on Zero Emission Program that starts at the top but is routinely reinforced at all levels
  - OEM support, commitment, and communication that supports reliability

- Affordability of initial investment and support costs
  - Capex 

and Opex 

SunLine Center of Excellence

Thank You


Powering a Clean Tomorrow Today
SunBus


HYDROGEN FUEL CELL
Zero Emissions
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