

Trending to Zero: Battery Electric Buses in Public Transit



Incumbent Technologies

- Diesel
- CNG
- Diesel-hybrid



Foothill Transit Ecoliner Program History



2009

\$6.5 million ARRA
award to launch
Ecoliner Program

2011

\$10.2M TIGGER 2
award for 12 buses

2015

Orders placed for 2
fast-charge and 13
extended range buses

2010

First three buses
deployed

2014

12 electric buses
deployed on
Line 291; fully
electrified

Charging Profile



- 1 in-route fast-charge station
- Two 500 Kw overhead chargers
- 79,000 charge cycles to-date
- 10-90% state of charge in under 10 minutes



Fast Charge Process



Ecoliner Program Benefits



- Reliability comparable to CNG
- PM is cheaper, no oil or consumables
- Less noise
- Fewer parts
- Zero tailpipe emissions

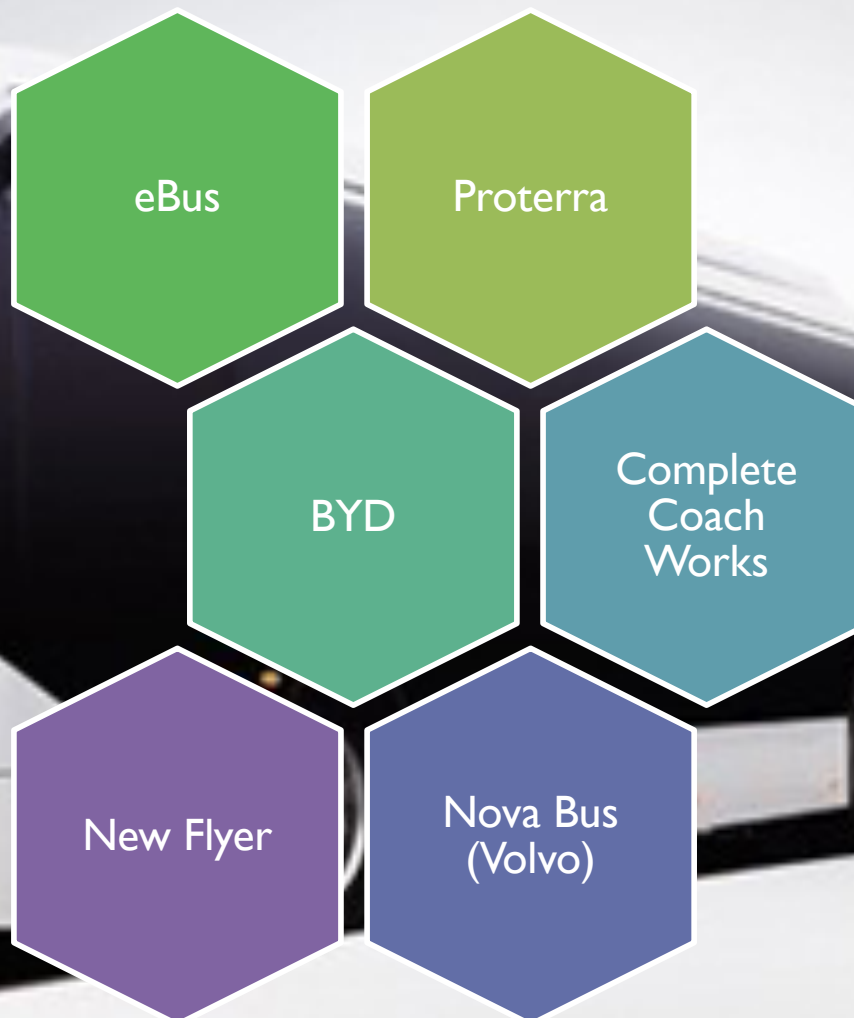
Ecoliner Program Challenges



- Upfront capital cost
 - Lessened with grant
- Demand charges
 - 35% of Foothill Transit's bill is demand charges
- “Bus” issues (doors, window)
 - vs. charging technology

	Electric	CNG	Diesel
Fuel price	\$0.18/kWh	\$0.93/gal	\$3.00/gal
MPG	2.16 kWh/mi	4.04 MPG	4.25 MPG
\$/mi	\$0.38/mi	\$0.23/mi	\$0.71/mi

US Battery- Electric Bus Manufacturers



Electric Buses in Urban Areas



Market Penetration

TABLE 18

U.S. VEHICLES BY POWER SOURCE

(ACTIVE, BUILT IN 2015, ORDERED, POTENTIAL ORDERS)

Ordered vehicles include vehicles currently under contract.

Potential vehicle may not total to 100% as some potential orders have not specified power source at this time.

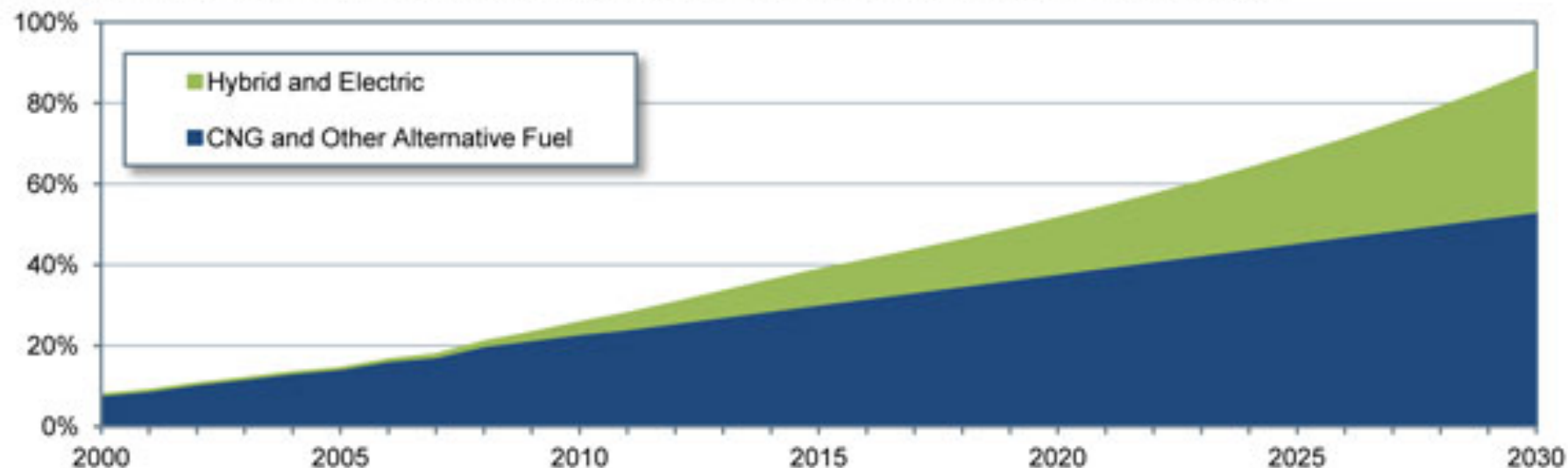
Power Source	Active	%	Built in 2015	%	Ordered	%	Potential	%
Bus								
Biodiesel	2,631	7.5%	93	4.4%	92	3.6%	68	2.0%
Compressed Natural Gas 31.2%								
Diesel & Elec Battery (Hybrid) 13.5%								
Gasoline	434	1.2%	61	2.9%	35	1.4%	11	0.3%
Gasoline & electric battery	125	0.4%	0	0.0%	0	0.0%	0	0.0%
Diesel Fuel 44.7%								
Liquified natural gas & diesel	7	0.0%	0	0.0%	0	0.0%	0	0.0%
Propane & gasoline	4	0.0%	0	0.0%	0	0.0%	0	0.0%
Propane (liquified petroleum gas)	42	0.1%	16	0.8%	31	1.2%	0	0.0%
Electric Battery 1.3%								
Bus Rapid Transit								
Compressed natural gas	8	4.3%	2	100.0%	0	0.0%	0	0.0%
Diesel and electric battery (Hybrid)	26	14.0%	0	0.0%	10	100.0%	0	0.0%
Diesel fuel	152	81.7%	0	0.0%	0	0.0%	0	0.0%
TOTAL	186		2		10		0	

On
Order



Projected Growth

Exhibit 9-19 Hybrid and Alternative Fuel Vehicles: Share of Total Bus Fleet, 2000–2030



Source: Transit Economic Requirements Model.



Houston METRO Services

- Local Bus
- Park & Ride/Commuter Services
- METRORail
- METROLift
- HOV/HOT Lanes
- METRO Star Vanpool
- Motorist Assistance Program (MAP)
- Houston TranStar
- METRO Policy



METRO Electric Bus Demo Goals

1.

- Test reliability and durability in METRO operations

2.

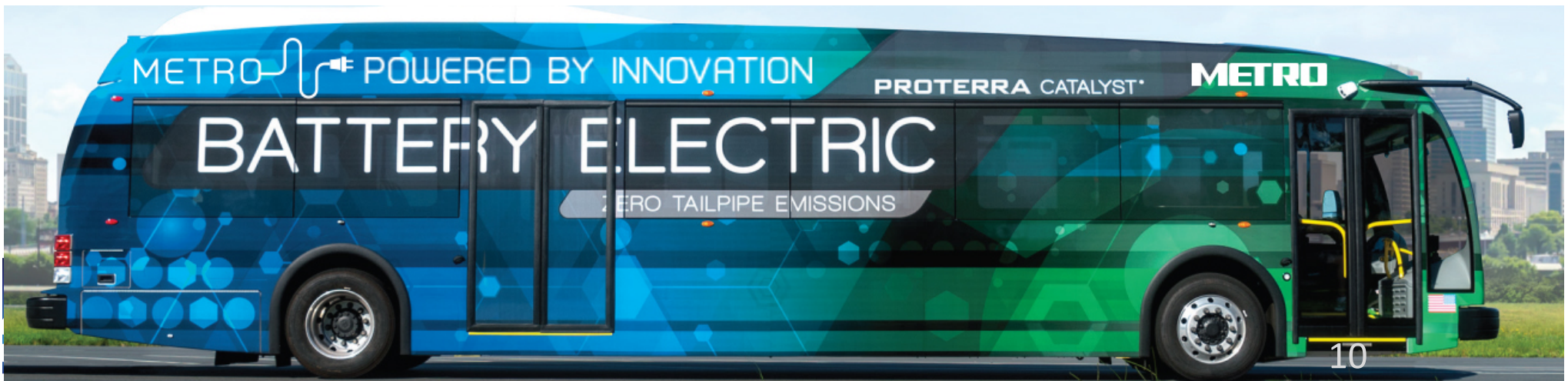
- Test HVAC operation in simulated Houston climate

3.

- Compare performance to other fleets (CNG, hybrid, diesel)

4.

- Gain feedback from customers, operators, and mechanics



Performance Summary

Miles driven	6,094
Average fuel economy (MPGe)	17.6
Average charge time (minutes)	11
Daily run time (hours)	20.2
Diesel fuel saved (gallons)	1,500
Greenhouse Gas emissions prevented (pounds)	37,800

Diesel fuel saved =
2 passenger vehicles driven
for 1 year



Bus & Charger Performance

Bus

- Ride height de-bonded
- Air compressor smoked
- Battery pack leak
- Overall: Fair/good performance



Charger

- Prototype, mobile charger
 - Overhead charge arm—bleed down
 - Longer than normal charge times
- Overall: Bugs with mobile charger

HVAC Test

Test

- Simulation in Fallbrook paint booth
- Chamber heated to 110F
- “Houston Pull Down”
 - 110F to 72 +/- 3F in 30 minutes
 - More stringent than APTA standard

Outcome

- Pulled down from 110F to 90F in 30 minutes
 - Did not meet Houston standard
- Designed with a 28KW peak output HVAC unit
- Proterra working to meet in the future



Customer Feedback

Internal Temperature	More comfortable	The Same	Less comfortable
	72%	27%	1%
Internal Temperature	More comfortable	The Same	Less comfortable
	72%	27%	1%
Ride smoothness	Smoother	The Same	Less smooth
	77%	21%	1%



Fast-Charge Electric Bus Summary

Strengths

- Technology is commercially available
- All day operation
- No range limits

Weaknesses

- Not compatible with all routes
- High electricity costs
- Portable charger (demo only)



Next Steps for Houston METRO

Meetings with
other electric
bus
manufacturers
scheduled
April 2017

Conduct a
cost analysis
and evaluation
protocol

Test during
summer
months

Visit transit
agencies and
manufacturers

Solicit grant
funding as
appropriate

Conduct a
multi-bus trial



Contact Information



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