




**ACTransit for the Environment**




## ZEBAs Demo Program - Lessons Learned

Doug Byrne, Fuel Cell Operations Manager



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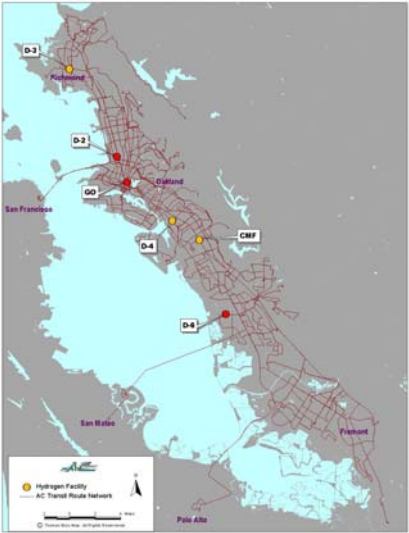
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## AC Transit

- **Serving 1.5 million people in 13 cities**
- **61 million passengers**
- **600 buses**
- 1,800 employees
- \$325 million budget
- 105 lines (26 Transbay)



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## Getting Started with Fuel Cells

- Under Development Since November 1999
- Member of **California Fuel Cell Partnership**
- Member of **The Climate Registry**


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## ZEBA Program

- Fuel Cell Bus Fleet
- Hydrogen Fueling Stations
- Solar Installations
- Stationary Fuel Cells
- Carbon Inventory and Climate Action Plan

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## Policy Drivers


- **Public Health:** urban centers/people at risk
- **Quality of Life:** quiet buses
- **Cost Savings:** Reduced life cycle costs

**Hydrogen's Global Value** ( a piece of the puzzle) —

- **Sustainability:** Diversified and Renewable Energy Supply
- **Energy Independence** (National Security)
- Reduction in **Global Warming**




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## 1<sup>st</sup> Generation Bus

- >267,000 Miles
- >700,000 Passengers
- 65% Better Fuel Economy
- 43% GHG Reductions  
(Reforming Natural Gas;  
100% reduction with solar or wind hydrogen)



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## Phase 2 – Bay Area Demo

- \$67 Million
- 12-13 Next-Gen Buses
- 5 Transit Agencies (>2,500 vehicles)
- Shared Service
- Shared Training

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## Vehicle Improvements in Efficiency

- **5,000 lbs. Lighter than 1<sup>st</sup> Generation Bus!**
- All-Electric Drive Rooftop Cooling
- All Electric HVAC System
- Electric-Drive Power Steering and Air Compressor
- Active Regenerative Braking
- Liquid Cooled Lithium-Ion Battery System
- Rooftop 40 Kg H<sub>2</sub> Storage
- Two 85 kW Siemens Drive Motors



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## Next-Generation Bus

- > Over 500,000 miles
- > 88% to 100% Better Fuel Economy
- >760,000 Miles – AC Transit F/C Fleet - 1<sup>st</sup> & 2<sup>nd</sup> Gen
- Over 2 million passengers in the Bay Area (120k/Month)





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## Performance

Metric	Fuel Cell Sep 2011 thru Apr 2012	Fuel Cell Feb thru July 2013	Fuel Cell August 2013	GGT Service April Thru Aug 2013
Availability	56%	77.96%	81.45%	96.77%
Miles per Diesel Gallon Equivalent	7.55 (8.32 High)	N/A	N/A	N/A
Fleet Average – MBCRC	2,014 Miles	7031 Miles	7019 Miles	Bus FC5 10814 Miles
Fleet Total Miles	146111	169613 Miles	35093 Miles	GGT Service Miles = 10814
Brake Wear	15% @ 43k Miles	N/A	Less Than 20% @ 60K Miles	Less Than 20% @ 50K Miles

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## Benefits

- **Passengers**
  - Quiet (Neighborhoods)
  - Smooth
  - No Vibration
  - Clean and Odorless
- **Drivers**
  - Range
  - Sustained Power
  - Smooth
  - Handling
- **Mechanics**
  - Clean
  - Fewer Parts
  - Durability

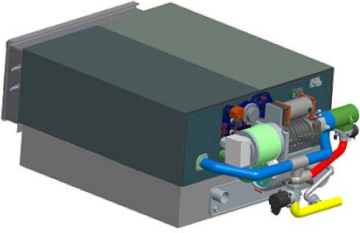
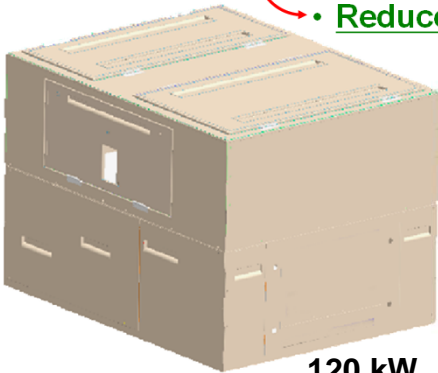


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## Transportation Fuel Cells – 120 kW and 150 kW

- **Increase** power density, efficiency, and durability
- **Reduce** weight, size, and **cost**



**120 kW** **150 kW**

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## Earlier Stations – 85,109 kg



**Electrolyzer – 7,000 kg**



**Mobile: Liquid to Gas w/  
Cryogenic Pump – 23,000 kg**



**Onsite Reformer – 55,109 kg**


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## Emeryville Station – 600 Kg/Day

- Solar Electrolysis (65 Kg/day)
- Liquid Hydrogen from Steam Methane Reforming
- Fast Fueling
- Buses @ 360 Kg/day
- Cars @ 240 Kg/day
- August 2011 to August 2013 (50,000 + kg)







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## ACT Solar Power – 1.5 Megawatts

AC Transit solar system will provide **2,000 MWh/Year** of renewable power to the Emeryville Hydrogen Station and our other facilities




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## Seminary Energy Station




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## Stationary Fuel Cell – 420 kW








- Stationary Solid Oxide Fuel Cell system fueled with BP Energy Biogas
- Generates 3,399 MWh/year @ 52-55% efficiency (35-39% for California Grid)
- Powers electrolyzer that produces 65 kg of green hydrogen/day for 2-3 buses



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## Fuel Cell Buses - Moving Forward

- **Vehicles**
  - Capital cost of buses
  - Operating cost for fuel cell engine replacement
  - Long term durability still under review
- **Fueling Infrastructure**
  - Current stations limited to fueling 12 buses
  - Scalability to larger fleets needs to be evaluated

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