Tracking Costs of Alternatively Fueled Buses in Florida

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Summary

- **Client:** Florida Department of Transportation (FDOT)
- **Duration:** 18 Months
- **Budget:** $100K
- **Objective:**
  - Establish recoding and reporting mechanism for performance and costs of alternative fuel public transit vehicles in Florida
  - Research costs of modifying transit maintenance facilities to make them suitable for servicing alternative fuel buses

Project Background

- Many transit agencies introduced AFV into their fleets
  - to reduce fuel consumption => save $
  - to reduce GHG emissions => environmental benefits
- Hybrid-Electric technology is particularly popular
- TIGGER grants and regular transit capital funds help with AVF acquisitions

Project Background

- FDOT funds 50% of non-federal share of bus capital
- AFV buses are currently significantly more expensive ($150,000 more per unit)
- Often do not provide desired efficiency gains and cost benefits

Project Goals

- FDOT is interested to track transit AFV lifecycle costs to make more educated capital funding/policy decisions
- Investigate costs of modifying transit maintenance facilities to accommodate AFV
- Most importantly - establish a process for on-going assessment of benefits and costs of advanced transit technologies

Previous Analysis – AFV Buses

- Similar analysis previously funded by FDOT
- Bus Fuels Fleet Evaluation Tool (BuFFeT model) developed by CUTR
- Model provides a tool for estimating fleet costs at a sketch-planning level
- Data on thousands of buses in the U.S.
- Old data (2007)
- Model needs to be updated with new data

Research Approach

- Approached transit agencies with data request
- All fixed-route agencies in Florida contacted
- Attended Paratransit Maintenance Consortium Meeting to inform operators of demand response service about the project
- Data requested from 12 paratransit agencies
- Analysis of data records available from statewide transit vehicle procurement database (TRIPS)

Type of Data Requested

- Vehicle length
- Power plant
- Fuel type
- Date placed in service
- Vehicle acquisition cost
- Life-to-date mileage
- Life-to-date fuel usage
- Life-to-date labor costs
- Life-to-date parts costs
- Etc.

Early Challenges

- Low Response rate:
  - Five fixed-route agencies provided meaningful data
  - None of the paratransit agencies responded to data requests
- Difficulty with on-going (quarterly) reporting
- Different agencies treat (and report) some cost categories slightly differently
- Despite low response rate, the data covers **over 70 percent** of Florida fixed-route fleet

Cost Analysis - Fixed Route Buses

- Five agencies provided cost data:
  1. Broward County Transit – Broward County
  2. RTS – Gainesville
  3. MDT – Miami
  4. PalmTran – Palm Beach
  5. StarMetro – Tallahassee
- Data for over 1,300 vehicles, 70% of the fixed-route transit fleet
- Agencies were asked to report on entire fleet (both diesel and AFV)

Fixed-Route Fleet Summary

Diesel Vehicles (95 % of fleet):

- Over 88% of diesel buses are 40-foot buses
- 6% - 31-foot buses
- 3% - 35-foot buses

AFV Vehicles (5% of fleet):

- All AFV – diesel hybrids
- Almost half of all AFV buses are articulated (48%)
- 30% of AFV transit fleet are 40-foot buses

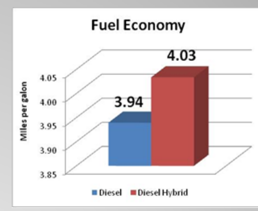
Performance Comparison Fixed-Route Fleet

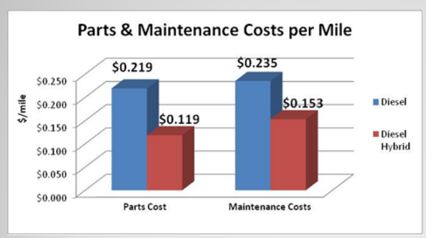
- AFV buses have significantly higher acquisition costs and slightly better gas mileage
- Results vary for buses of different sizes
- For 40-foot bus:

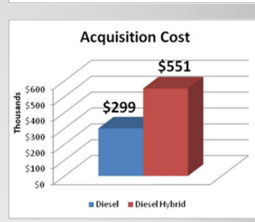
	Diesel	Diesel Hybrid
Acquisition	$299,153	$550,863
Fuel Economy	3.94 mpg	4.03 mpg
Parts cost/mile	21.1 cents	11.9 cents
Maintenance cost/mile	23.5 cents	15.3 cents

Performance Comparison Fixed-Route Fleet

- 40' Hybrid vs. 40' Diesel:
  - 2.3% better gas mileage
  - 45.7% lower parts cost
  - 34.9% lower maintenance costs
  - 84.3% more expensive







Performance Comparison Fixed-Route Fleet

- Hybrid vs. Diesel for entire fleet (all-size buses):
  - Hybrid buses have 5% better fuel economy
  - 57% lower parts cost per mile
  - 36% lower maintenance costs per mile
  - Hybrids cost <u>more than double</u> compared to diesel

Power Plant	No. of Buses	Average Bus Age (years)	Average Acquisition Cost ($)	Gas Mileage (mpg)	Parts Cost per Mile ($)	Maintenance Cost per Mile ($)
Diesel	1,253	6.4	$299,179	3.94	$0.218	$0.235
Diesel Hybrid	66	0.8	$720,569	4.14	$0.093	$0.149
Fleet Total:	**1,319**	**6.1**	**$315,759**	**3.94**	**$0.217**	**$0.234**

- Average age of hybrid buses is less than 1 year, compared to over 6 years for diesel buses; this can explain some of the better performance

Demand Response Vehicles

- No performance data for demand response vehicles were available
- All fleet data was obtained from Transit Research Inspection Procurement Services (TRIPS) database
- TRIPS contains inventory of paratransit vehicles acquired by transit agencies
- Vehicle reliability records are also available in TRIPS, but no operating and cost data
- Vehicles acquired with federal assistance (FTA's Section 5310 Program) are reported separately from vehicles acquired without federal participation (Non-5310)

Vehicles Acquired with Federal Assistance (Section 5310)

- Twice as many gasoline-powered demand response vehicles than diesel
- Data on annual vehicle purchase over the period of 2007-2011 reveals a trend of increasing percentage of gasoline-powered vehicles
- In 2007, purchases were split fifty-fifty between gasoline and diesel vehicles
- In 2011, the purchases of gasoline and diesel vehicles were split eight to one
- Possible explanations:
  - Lower acquisition costs of gasoline paratransit vehicles
  - Differences in operating, maintenance costs, or reliability (no solid data to support this assumption)

Paratransit Fleet Summary

Vehicles acquired with federal financial assistance (Section 5310)

Fuel Type	Number of Vehicles	Average Acquisition Cost
Diesel	416	$73,684
Gas	907	$72,540
Unknown	192	$72,401

- Gasoline-powered vehicles cost slightly less than diesel (1.6% less)
- Large “unknown” category can skew results

Vehicles Acquired Without Federal Assistance (Non-5310)

- Gasoline vehicles are more popular than diesel (twice as popular)
- Higher share of vehicle purchases every year goes to gasoline-powered vehicles (similar to Section 5310)
- Similar trend in purchases suggests that it is unlikely that federal assistance is a determining factor in the choice of gasoline propulsion vs. diesel

Paratransit Fleet Summary

Vehicles acquired without federal financial assistance (Non-5310)

Fuel Type	Number of Vehicles	Average Acquisition Cost
Diesel	1,279	$83,000
Gas	2,364	$80,899
Unknown	293	$83,146

- There are almost twice as many paratransit vehicles running on gas than on diesel
- Gasoline-powered vehicles cost 2.5% less than diesel

Paratransit Fleet by Vehicle Size

1. Vehicles acquired with federal assistance:

- Vehicles range in size from 17' to 31'
- Most popular sizes (overall): 22-foot and 23-foot vehicles
- For diesel vehicles – 23-foot was most popular size of vehicle, followed by 22-foot vehicles
- For gasoline vehicles – 22-foot buses were the most popular, followed by 26-foot and 23-foot vehicles

Paratransit Fleet by Vehicle Size

2. Vehicles acquired without federal assistance:

- Most popular vehicle size (overall): 23-foot and 20-foot vehicles, followed by 31-foot and 22-foot buses
- Most popular size for diesel buses: 31-foot, followed by 20-foot and 23-foot vehicles
- Most popular size for gasoline-powered vehicles: 23-foot, followed by 20-foot and 22-foot buses

Maintenance Facilities Costs

- Operating AFV may require modifications to transit maintenance facilities
- Typical modifications may include: better ventilation, classified (explosion-proof) electrical wiring, leak detection systems, fire suppression systems, etc.
- Many transit agencies also prefer to have fueling facility on site
- All these modification represent additional costs to operate AFV in transit fleet

Maintenance Facilities Modification Needs

- **Battery Electric Vehicles**
  - Garage needs to conform to NFPA requirements regarding installing and handling high-voltage electrical wiring/equipment
  - Higher ventilation rates for battery storage/charging locations
  - Install smoke and heat detectors near charging locations
  - Upgrade fire detection and suppression systems to be compatible with electric fires
- **Biodiesel**
  - No modifications are necessary to accommodate biodiesel transit vehicles

Maintenance Facilities Modification Needs

- **Compressed Natural Gas (CNG)**
  - Improved ventilation rates (at least 6 air exchanges per hour) to disperse potential gas leaks
  - Gas leak detection and fire suppression systems
  - Roof ventilators are recommended
  - No accepted codes/building standards for CNG garages => difficult to estimate costs of modifications
  - Average cost to modify one maintenance garage for CNG is $600K (FTA, 1998), but may vary substantially
  - Average CNG fueling station for 200-bus fleet costs $1.7 million (FTA, 1998), but costs may vary significantly

Maintenance Facilities Modification Needs

- **Ethanol**
  - Improved ventilation to disperse potential leaks
  - Classified (explosion-proof) wiring at elevations lower than 18 inches above floor (Ethanol vapor is heavier than air, tends to stay close to the ground)
  - In general, same requirements as for methanol
  - Average cost to modify typical 200-bus maintenance facility for Ethanol vehicles is $300K (GAO, 1998)
  - Fuel station conversion to Ethanol may cost from $21K to $400K (GAO, 1998), depending on capacity and other factors

Maintenance Facilities Modification Needs

- **Hybrid Electric Vehicles**
  - Upgrade facilities with lifts and cranes to handle replacement of battery packs (every 3-5 years)
  - Older lead acid batteries need to be reconditioned regularly (every few months)
  - Charging/conditioning equipment can cost up to $50K (reported by NYC Transit)
  - Improved ventilation of maintenance areas
  - Heat and smoke detectors
  - Additional safety equipment (and training) to handle high-voltage electrical systems
  - Fueling facility does not need modifications

Maintenance Facilities Modification Needs

- **Hydrogen Fuel Cell**
  - Many requirements are similar to CNG vehicles
  - Gas leak sensors, explosion-proof wiring
  - Improved ventilation (in excess of 6 air changes per hour)
  - Recommended to direct hydrogen leaks to the outside of building (use of movable hoods)
  - Eliminate the use of open flame equipment, limit the use of hot element electrical heaters
  - Modification costs could not be estimated since fuel cell buses are still very rare

Maintenance Facilities Modification Needs

- **Liquefied Natural Gas (LNG)**
  - Similar requirements as for CNG
  - Classified (explosion-proof) wiring and equipment in maintenance areas at elevations less than 18 inches above floor (LNG tends to stay close to floor)
  - Median cost to modify 150-200 bus garage for LNG: $600K (TCRP, 1998)
  - Fueling facility cost will vary depending on capacity and other circumstances
  - Average cost to design and construct LNG fueling station: $2.5 million, additional $200K to have capability to fuel both LNG and CNG (GAO, 1998)

Maintenance Facilities Modification Needs

- **Liquefied Petroleum Gas (LPG)**
  - Propane storage/dispensing facilities must be located at a certain minimum safe distance from buildings, streets, underground tanks, etc.
  - Explosion-proof wiring and electrical equipment
  - Flammable gas detectors
  - Higher rate of ventilation
  - Average cost to modify a typical 200-bus maintenance garage for LPG: $300K (GAO, 1998)
  - Average construction cost of one LPG fueling station: $700K (GAO, 1998)

Maintenance Facilities Modification Needs

- **Methanol**
  - Facilities should be designed to eliminate ignition source gases (methanol is more volatile than diesel)
  - Higher rate of ventilation
  - In general, similar requirements as for Ethanol vehicles
  - Average cost to modify typical 200-bus garage for Methanol: $300K (GAO, 1998)
  - Average cost to modify one fueling station to make it suitable for Methanol: $400K (GAO, 1998)

Challenges and Limitations

- Data availability
- No periodic (quarterly) reporting
- Limited number of AFV in Florida fixed-route transit fleet
- Low variety of AFV in the fixed-route fleet
- Limited data on paratransit vehicles in TRIPS (no operating cost data)
- None of 5,400 demand response vehicles reported in TRIPS are AFV

Next Steps

- New Project - Tracking costs of alternatively fueled buses in Florida – Phase II (18 months)
- Continue on-going data collection and analysis
- Develop new strategies to ensure periodic reporting by agencies (web-based reporting, inform agencies on the use of data, etc.)
- As more field data is collected reliability and usefulness of the analysis will improve

Questions?

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