Tracking Costs of Alternatively Fueled Buses in Florida

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CUTR Webcast
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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

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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 ongoing 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:

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>Diesel Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition</td>
<td>$299,153</td>
<td>$550,863</td>
</tr>
<tr>
<td>Fuel Economy</td>
<td>3.94 mpg</td>
<td>4.03 mpg</td>
</tr>
<tr>
<td>Parts cost/mile</td>
<td>21.1 cents</td>
<td>11.9 cents</td>
</tr>
<tr>
<td>Maintenance cost/mile</td>
<td>23.5 cents</td>
<td>15.3 cents</td>
</tr>
</tbody>
</table>
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

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

- **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 more than double compared to diesel
  
- 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)

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

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Number of Vehicles</th>
<th>Average Acquisition Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>416</td>
<td>$73,684</td>
</tr>
<tr>
<td>Gas</td>
<td>907</td>
<td>$72,540</td>
</tr>
<tr>
<td>Unknown</td>
<td>192</td>
<td>$72,401</td>
</tr>
</tbody>
</table>

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)

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

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Number of Vehicles</th>
<th>Average Acquisition Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>1,279</td>
<td>$83,000</td>
</tr>
<tr>
<td>Gas</td>
<td>2,364</td>
<td>$80,899</td>
</tr>
<tr>
<td>Unknown</td>
<td>293</td>
<td>$83,146</td>
</tr>
</tbody>
</table>

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

- **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

- **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

- **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)

- 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?