Cobb County School District: Reducing School Bus Fleet Diesel Emissions and Idling

Chris Rome, Randall Guensler Vetri Elango, and Sara Khoeini

http://transportation.ce.gatech.edu/busemissions
Outline

- Project background
- Project objective and strategies
- Data collection methods
- Data analysis to date
- Baseline idling results
- Estimated diesel fuel savings
- Estimated emission reductions
- Next steps
- Summary
Idling Activity

- Thirty seconds of idling can use more fuel than turning off the engine and restarting
  - “Idling gets you nowhere”
- Idling = 0 MPG
- 1 hour of idling typically burns 0.5 – 1.0 gallons of fuel
- Idling for 10 minutes uses as much fuel as traveling five miles
- 1 gallon of gas produces about 20 pounds of CO$_2$, a major contributor to climate change

Source: my safetysign.com
Exposure to Idling

- Idling activity emits CO, VOCs, NOx and diesel particulate matter
- Breathing diesel exhaust fumes increases the risk of cancer, heart and lung disease, asthma, and allergies (especially in children)
- Exposure to most auto pollutants can be higher inside a vehicle than outside

Source: platinum.matthey.com
Project Purpose

- Approximately 500 Cobb County School District buses are currently being outfitted with GPS tracking, idle detection circuits, and cellular communication systems.

- The baseline data obtained from the system are being used to quantify engine idling, fuel consumption and emissions savings.
CCSD Combined School Bus Emission Reduction Strategy

- Tailpipe emissions controls
  - CCSD is installing diesel oxidation catalysts (DOC) and crankcase filters to reduce emissions from onroad fleet activity

- Idle control
  - GT is monitoring vehicle idling activity and implementing real-time driver feedback systems to reduce idling where children’s exposure is highest

- Engine load mitigation
  - GT is monitoring hard acceleration and high speed activity and implementing driver feedback systems to reduce emissions from high engine load events
Idle Reduction Strategy

- Establish maximum idle time thresholds for specific anti-idle zones
  - School property and neighborhood parking areas
  - Bus yards and bus staging areas
- When idle time exceeds the established threshold, a warning message is sent to the dispatcher
  - Web page alert, plus e-mail/messaging
- When idle time exceeds the second idle threshold, the engine will be powered down (summer/fall)
- Daily idle reports for each vehicle and summary reports for subfleets are generated for fleet managers
Baseline Monitoring Systems

- 480 GPS systems in buses
  - Idle-detection circuit
  - Oil pressure sensor
  - GPS/cellular antenna

- Circuits manufactured by GT team of researchers and undergraduates

- Systems are installed by CCSD fleet maintenance mechanics

Source: Georgia Tech – Chris Rome
Bus Deployment

- Baseline deployments began in December 2010
  - Baseline monitoring systems are all constructed
  - CCSD is installing units (240+ installed to date)
- QA/QC logs reviewed online to identify connectivity issues
- Troubleshooting completed in field for buses with problems
Cobb County School District Transportation Facts

- 180 school days
- 114 schools
- 96,547 bus-eligible students
- 943 bus drivers
- 1150 buses
  - 869 conventional buses
  - 281 special needs buses
- 887 routes served per day
  - 21,596 bus stops
- 12,600,000 bus-miles/year
- 1,900,000 gallons of diesel/year
Data Processing

- SPSS statistical software used to process the idle events reported from the tracking system server
- Daily figures for diesel fuel consumption and VMT from CCSD FuelMaster® records
- Emissions estimates from EPA DEQ online software
- Potential diesel fuel savings calculated by hand
Bus Idle Activity

- In our research, an idle event is defined when a bus sits stationary with engine on for 120+ seconds
  - Excludes bus stops and intersection delay
- Idle threshold will be refined through GIS analysis to ensure bus stop and intersection activity is excluded
  - Must consider cycle length times and bus unloading times at school
- Baseline Data: December 2010 – March 2011
- Number of buses installed in the CCSD fleet during that period increases over time from 0 to 184
Baseline Idling Results
Monitored Buses for March 2011

- Of the buses reporting to the server, only 63% idle per day
- Some buses did not idle at all during March
Baseline Idling Results

Heavy Idling

- Average idle time (for idling buses):
  - 0.52 hours/bus/day
  - lower than the original 0.70 hour estimate
  - Likely affected by seasonality issues

- 308 bus-days of ‘heavy idling’
Baseline Idling Results
Idling Variance

- 160 of 184 buses reported idling
- Almost all buses average 15-60 minutes of idling per day
- Only 5 ‘heavy idlers’
  - 60+ minutes/day
- 18 ‘low idlers’
  - 2 to 15 minutes/day
Baseline Idling Results
Average Idle Results

- Average duration of an idle event
  - 5.9 minutes
- Average number of daily events
  - 5.4 idle events/bus/day
- Average AM start time for idle events
  - 7:33 AM
- Average PM start time for idle events
  - 3:06 PM
Heaviest Day of Idling to Date
March 29, 2011

- 118 idling buses
- 77.5 hours of idle
- 0.66 hours/bus
  - (40 minutes)
- 4 idle events per bus
- Cold Day
  - 40° F in AM
  - 45° F in PM
Mapping Bus Fleet Idling Events

- Idle events in Cobb County
- Categorized using GIS geo-fencing and proximity to certain features
- Size of circle represents duration of the event
Idle Zone Categorization

- Out of Cobb County
- School area
  - Within School Designed Parking Area
  - Within 500 ft Parking Area
  - Within 600 ft of school center point
- Bus Stops
  - Within 300 ft of bus stop point in the street boundary
- Intersections
  - Within 500 ft of intersection center within street boundary
- On Street
  - Within 60 ft of centerline
- Off Street
  - Out of 60 ft from centerline
## Idling Stats by Location

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Events</th>
<th>Out of Total Idle Events (%)</th>
<th>Min (5% percentile) In minutes</th>
<th>Max (95% percentile) In Minutes</th>
<th>Mean (Minutes)</th>
<th>Standard Deviation (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Idling events</td>
<td>16601</td>
<td>100%</td>
<td>2.1</td>
<td>15.5</td>
<td>5.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Out of Cobb County</td>
<td>1111</td>
<td>7%</td>
<td>2.1</td>
<td>15.5</td>
<td>5.7</td>
<td>6.2</td>
</tr>
<tr>
<td>School Area</td>
<td>9841</td>
<td>59%</td>
<td>2.1</td>
<td>17.6</td>
<td>6.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Bus stops</td>
<td>704</td>
<td>4%</td>
<td>2.1</td>
<td>8.8</td>
<td>3.8</td>
<td>2.7</td>
</tr>
<tr>
<td>Intersection</td>
<td>2974</td>
<td>18%</td>
<td>2.0</td>
<td>11.6</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Non of the above (On road)</td>
<td>373</td>
<td>2%</td>
<td>2.1</td>
<td>10.0</td>
<td>4.4</td>
<td>3.3</td>
</tr>
<tr>
<td>None of the above (Off road)</td>
<td>1598</td>
<td>10%</td>
<td>2.1</td>
<td>14.3</td>
<td>6.1</td>
<td>4.6</td>
</tr>
</tbody>
</table>
Diesel Consumption Savings Quantification

- 480 instrumented buses, 1150 bus fleet
- Bus idling consumes at least 0.5 gal per hour
- With engine shut-off technologies, idle will be reduced by 0.52 hours per bus per day
  - Strategy saves 22,000 gallons of diesel per year for the 500-bus monitored fleet
  - 53,000 gallons of diesel saved for the entire fleet
- At a cost of $4.12 / gallon of diesel
  - $92,500 fuel savings for instrumented vehicles
  - $221,700 savings if applied to entire fleet
- System is self-sustaining
Estimated Emission Reductions

- EPA’s Diesel Emissions Quantifier (online DEQ)
  - Fleet characteristics – fleet size, model years, fuel types (ULSD), emission strategies
  - But idle emission rate is constant across vehicle model years anyway
- 480 idle shut-off vehicles
- 108 vehicles with Diesel Oxidation Catalyst (DOC) and closed crankcase ventilation (summer 2011)
Estimated Emission Reductions

- 480-bus monitored fleet
- Reductions per year from Idle Control:
  - PM – 3.15 tons/year
  - NOx – 116 tons/year
  - CO$_2$ – 4071 tons/year
- Reductions per year from DOC:
  - PM – 1.3 tons
  - HC – 6.7 tons
  - CO - 13.7 tons
Estimated Value of Health Benefits

- “The benefits are presented as the dollar value of avoiding health effects that result from exposure to PM2.5, such as premature mortality, chronic bronchitis, asthma attacks, non-fatal heart attacks, and others. These dollar values are based on a number of studies that EPA uses when estimating the health benefits of environmental rules.” - EPA DEQ

- $210,000 from idle control
- $90,000 from DOC and closed crankcase
Next Steps

- Idle warning system implementation May/June 2011
  - Online idle notifications for bus dispatchers
  - Dispatcher to driver voice warning
  - Driver training
- Idle shutoff implementation August/September 2011
  - Install idle shut-off units and determine idling reduction over baseline and notification only
- Further emissions quantification research:
  - MOBILE6, MOVES, and GT’s Heavy Duty Diesel Vehicle Modal Emissions Model (HDDV-MEM)
Summary

- First truly comprehensive before and after study to assess the joint impacts of diesel emissions control technology and idle reduction programs over time
- Application of cutting edge technologies
  - Real-time GPS monitoring and notifications
  - Advanced emissions modeling and real-world data
- The archive of vehicle data provides significant additional benefits for the school district
- Reduces emissions and diesel consumption for health improvements for children (and saves money)