Replacing Buses Upon Retirement Will Allow Electrification of Port Authority Buses by 2032

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MOTIVATION
• Transportation is the largest greenhouse gas emissions contributor in the U.S.¹
• Port Authority has worked towards better sustainability in its Pittsburgh public transportation over the past 30 years, using the cleanest diesel possible since 1991 and introducing biodiesel fuel buses since 2009²
• As of 2018, the company has 741 buses that use mostly diesel and biodiesel at an efficiency of 3.91 miles/gallon³
• Electric buses can save over 55% of energy use compared to diesel.

OBJECTIVES
• Analyze the energy savings of replacing all Port Authority buses with New Flyer electric buses by 2031
• Determine the logistics of the changes in infrastructure necessary for the switch
• Identify the optimal path to electrification

METHODS

Major Cases:

Base Case
• Replace buses 1:1 as they retire
• Charging stations in all garages

Route Prioritization
• Replace buses as they retire in only the East Liberty and West Mifflin garages (430 buses)
• Charging stations in those two garages only

Increased Adoption
• Replace 20% of the fleet each year, allowing electrification in 5 years
• Charging stations in all garages

Research Steps:
Collect data about diesel and electric buses
Current Port Authority bus statistics Run Flyer electric bus statistics
Assess reductions in energy consumption Increase in electricity demand vs. decrease in diesel demand
Model differences in costs Raw costs vs. factoring social costs and benefits
Identify optimal pathway to electrification Choose the case that would provide the most benefits for a feasible cost

RESULTS & DISCUSSION
• The system can have fully electric buses by 2032 in the base case and by 2025 in the increased adoption case
• Increased adoption provides the greatest reductions in energy demand in the shortest amount of time.
• Increased adoption has highest decrease in energy demand

SENSITIVITY ANALYSIS
• NPV is most sensitive to changes in maintenance cost rate
• Capital cost of an electric bus would need to be $650,000 to breakeven
• Breakeven carbon price is lowest for the base case

<table>
<thead>
<tr>
<th>Case</th>
<th>Breakeven Carbon Price ($/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>$178</td>
</tr>
<tr>
<td>Route Prioritization</td>
<td>$185</td>
</tr>
<tr>
<td>Increased Adoption</td>
<td>$1,182</td>
</tr>
</tbody>
</table>

CONCLUSIONS
• The base case is the most feasible route to full electrification of Port Authority buses because of the lower yearly expenditures and lower breakeven carbon cost
• Despite the greater benefits of increased adoption, the case is too costly during the time period of the switch
• If there are not enough funds for full electrification, route prioritization will still reduce energy demand by 28%
• The ultimate choice will depend on how much the government is willing to subsidize the project

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REFERENCES
1. EPA, 2016, “Carbon Pollution from Transportation.”