Energy and Emissions Implications of Transportation Modes

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GT Energy Series: Energy and Urbanization
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Mirror, mirror, on the wall,
What’s the best mode of them all?
Level of Influence

- Individual mode choice
- Policy making
  - Transportation
  - Fuel production and distribution
  - Utilities
- Multi-criteria evaluation at multiple scales
  - Energy
  - Emissions
  - Health
Question 1

DRIVE OR FLY?
Long-Distance Travel
Single Aisle (SA) Jet vs. SUV: GHGs
Question 2

**CAR, BUS, OR TRAIN?**

Vehicle and Propulsion Systems
Surface Modes:
Emissions per Passenger Mile

Passenger loading assumptions:
- Buses and vans:
  Peak—40; average—9; off-peak—5.
- AE heavy rail: Peak—80% full; average—37% full; off-peak—10% full.
  Number of cars per train: 10. Capacity per car: 45.
- DE commuter rail:
  Peak—80% full; average—32% full; off-peak—10% full.
  Number of cars per train: 15. Capacity per car: 90.
Question 3

WHICH BUS?

Type of Bus Operations
Urban Transit Route Duty Cycle

Number of Seconds Elapsed vs. Speed in Miles Per Hour

- Speed in Miles Per Hour ranges from 0 to 80
- Number of Seconds Elapsed ranges from 0 to 2500
Comparison for Local Bus: GHGs

- Well-to-pump
- Pump-to-wheel

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>CNG</th>
<th>B20</th>
<th>Parallel</th>
<th>Series</th>
<th>BEV</th>
<th>FCV</th>
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Cities:
- Atlanta, GA
- San Francisco, CA
- Phoenix, AZ
Comparison for Local Bus: NOx

- Diesel
- CNG
- B20
- Parallel
- Series
- BEV
- FCV

Emission Rate (g/km)

- Atlanta, GA
- San Francisco, CA
- Phoenix, AZ

Well-to-pump
Pump-to-wheel
Comparison for Local Bus: PM$_{2.5}$
Express Bus Route Duty Cycle
Comparison for Express Bus: GHGs

- **Well-to-pump**
- **Pump-to-wheel**

### Emission Rate (kg/km)

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<tr>
<td>Atlanta, GA</td>
<td>1.74</td>
<td>0.34</td>
<td>0.09</td>
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<td>San Francisco, CA</td>
<td>2.30</td>
<td>0.45</td>
<td>0.12</td>
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<tr>
<td>Phoenix, AZ</td>
<td>2.18</td>
<td>0.43</td>
<td>0.11</td>
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</table>

**Cities:**
- Atlanta, GA
- San Francisco, CA
- Phoenix, AZ
Comparison for Express Bus: NO\textsubscript{x}

- **Atlanta, GA**
  - Diesel: 1.04
  - CNG: 0.67
  - B20: 1.08

- **San Francisco, CA**
  - Diesel: 1.37
  - CNG: 5.02
  - B20: 1.42

- **Phoenix, AZ**
  - Diesel: 1.30
  - CNG: 4.23
  - B20: 1.35

**Legend**
- Well-to-pump
- Pump-to-wheel
Comparison for Express Bus: PM$_{2.5}$

![Graph showing emission rates for different cities and fuel types.]

- **Well-to-pump**
- **Pump-to-wheel**

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<tbody>
<tr>
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<td>0.09</td>
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<tr>
<td>San Francisco, CA</td>
<td>0.11</td>
<td>0.08</td>
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<tr>
<td>Phoenix, AZ</td>
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Geographic Context

This is a representational map; many of the boundaries shown on this map are approximate because they are based on companies, not on strictly geographical boundaries.

USEPA eGRID2010 Version 1.0
December 2010
Geographic Comparison

Duty cycle used in example: New York Bus Cycle
So...

WHAT’S THE ANSWER?
Summary

- Complexity and uncertainty
  - Type of application
  - Operational characteristics
  - Geographic context
  - Optimization objectives
- The broader picture: Sustainability & Resilience
- Need for decision support tools
  - Policy support tools
    - Fuel and Emissions Calculator (FEC)
  - Individual decision support tools
Questions and comments?
Please email yanzhi.xu@ce.gatech.edu
Model website: fec.ce.gatech.edu
THANK YOU!