Fuel Savings Potential from Future In-motion Wireless Power Transfer (WPT)

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Regional Road Usage

- 1% of roads are used for 25% of the vehicle miles traveled
- Extensive overlap in road usage apparent across regional vehicle population
- Overlap occurs on high capacity roads
In-Motion Power Transfer

**Potential:** Road electrification could remove range restrictions of EVs, and increase the fuel savings of PHEVs or HEVs if implemented on a large scale

- ~1% of all roads nationally to be electrified
- Full build out is a major endeavor, so what might incremental benefit be?
- Who might benefit most a state, an urban area?
  - What would be the incentive?

**Question:** If a government entity wanted to deploy In-Motion WPT what is the fuel savings potential for the regional hybrid personal vehicle population?

- **Metrics:**
  - Cost: Infrastructure Mileage
  - Benefit: Fuel Displaced

- **Assumptions:**
  - Only hybrid vehicle benefits considered
  - Incremental roll out of infrastructure
  - All fuel is displaced during time spent on infrastructure

**BEV:** Battery Electric Vehicles  **PHEV:** Plug in Hybrid Vehicles  **HEV:** Hybrid Electric Vehicles

*NATIONAL RENEWABLE ENERGY LABORATORY*
WPT Fuel Savings Estimation

**Workflow**

**Step 1: Spatial Indexing**
- Match drive cycles to census geographies
- Match drive cycles to road network

**Step 2: Simulation**
- Identify vehicle fuel use through simulation across vehicle models using approximately 1 million miles of on road data

**Step 3: Data Fusion**
- Merge result from step 1 & 2 to quantify fuel use by road segment across a variety of vehicle models
- Assign priority for roll out based on potential fuel displacement

**Resources & Tools**

**Transportation Secure Data Center (TSDC)**
Warehouse of personal vehicle drive cycles collected as part of household travel surveys

**Future Automotive Systems Technology Simulator (FASTSim)**
Drive cycle simulation tool

**High Performance Computing**
Census Geographies

- **Consolidated Statistical Area (CSA):**
  - CSAs represent groupings of metropolitan and/or micropolitan statistical areas

- **GPS data divided by In-CSA and Out of CSA**

- **GPS In-CSA divided on high capacity, and not on high capacity roads using map match**
Drive Cycle Match

- Interstates and Highways make up between 2.5% and 4% of the total roads within the CSAs
- The mileage traveled on the interstates and highways ranges from 54% in California to 24% in Chicago
- Consistent with previous observations

<table>
<thead>
<tr>
<th>Region</th>
<th>In-CSA Interstate\Highway Miles</th>
<th>% Of Travel Captured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>1,489 (3.6%)</td>
<td>24%</td>
</tr>
<tr>
<td>California</td>
<td>6,494 (4%)</td>
<td>54%</td>
</tr>
<tr>
<td>Chicago</td>
<td>1,367 (2.78%)</td>
<td>24%</td>
</tr>
<tr>
<td>Kansas City</td>
<td>222 (2.72%)</td>
<td>28%</td>
</tr>
</tbody>
</table>

Source: Transportation Secure Data Center
Atlanta interstate speed profiles
Google Earth
Simulations Using GPS data

- Simulator takes speed profiles and simulates fuel consumption
- Merging the TSDC data, FASTSim and the HPC we can simulate millions of vehicle miles as dozens of vehicle models
- Merge with drive cycle match to identify where fuel is being consumed
Data Fusion

- Each urban interstate and highway road segment is given a priority using the total fuel displaced per road segment
  - Increased fuel consumption higher priority, and earlier deployment
- Variation in mileage, but similar trends when regional totals are normalized
Prioritization

Top 1%
Results

- If 1% of the road miles within a geography are electrified 25% of the fuel used by a ‘fleet’ of vehicles enabled with the technology could be displaced.

<table>
<thead>
<tr>
<th>Region</th>
<th>1% Mileage</th>
<th>Cost $3 Million/Mile</th>
<th>% Fuel Displaced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>413</td>
<td>1.2 Billion</td>
<td>25%</td>
</tr>
<tr>
<td>California</td>
<td>1803</td>
<td>5.4 Billion</td>
<td>25%</td>
</tr>
<tr>
<td>Chicago</td>
<td>491</td>
<td>1.4 Billion</td>
<td>25%</td>
</tr>
<tr>
<td>Kansas City</td>
<td>55</td>
<td>166 Million</td>
<td>25%</td>
</tr>
</tbody>
</table>
Considerations – Further Exploration

**Geography**
- Other census geographies
- Road Segmentation – Needs better normalization to eliminate weighting by segment length
- Defines the denominator of the % Roads metrics
  - Can have significant impact if comparisons are not made appropriately (used to normalize across regions)

**Vehicle Drivetrain**
- How does vehicle interact with infrastructure
  - Hybrid: Accept charge or direct power to the motor
  - Electric: Accept charge or direct power to the motor
- Charging efficiencies at high speed
- Metrics that can optimize for EVs

**Exploration into suitability modeling to better assess costs and generalize fuel savings using capacity, speed, grade, flow, etc.**

**Expand HPC Implementation**
- After first segment placed re-run simulation to place the second, and third