FHWA Initiatives Addressing Energy and Emissions Analysis

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Overview

• What is unique about energy and CO2 analysis?
• A few relevant projects supported by FHWA and its partners...
  • Infrastructure Carbon Estimator (ICE)
  • Strategic policy analysis tools (EERPAT and VisionEval)
  • Addressing institutional capacity (NCHRP 25-25 56)
Baseline Forecast of On-Road Energy Consumption, 2017 to 2050

Reflects the impact of:
- Federal fuel economy standards (light-duty and medium/ heavy-duty)
- State ZEV standards
- Market-driven changes in vehicle efficiency
- Change in travel activity

Light-duty vehicles: -27%
Medium- and heavy-duty vehicles: +10%

Source, Annual Energy Outlook 2019 Table 7
DISRUPTIVE TECHNOLOGIES COULD HAVE A SIGNIFICANT IMPACT BEYOND BASELINE CONDITIONS AND POLICIES

“Bookend” Forecast of the Energy and CO2 Impacts of Connected and Automated Vehicles

Factors that could *increase* energy consumption and associated emissions
- Reduced travel costs
- Increased VMT
- Zero-occupancy vehicles
- Access for New User Groups
- Faster driving speeds
- Increased freight movement
- Increased vehicle features

Factors that could *decrease* energy consumption and associated emissions
- Platooning, drafting and eco-driving
- Congestion management
- Emerging mobility service models
- Improved crash avoidance
- Zero-emission vehicles and power train efficiencies
- Less hunting for parking
- Vehicle right-sizing

Current Energy Consumption Levels

Source: U.S. Department of Energy, Smart Mobility Program
Lifecycle Energy / CO2 Considerations are also important in understanding impacts

On-road energy
- Vehicle operating energy consumption and emissions

Upstream fuel cycle
- Extracting petroleum, mining for electricity, growing and harvesting biofuel plants, transport, refining, and distribution
- Disposal of products

Infrastructure
- Upstream energy and fuel used in raw material extraction & production of construction materials
- Energy and fuel used by construction vehicles
- Fuel used by maintenance vehicles

Vehicle Cycle
- Raw material extraction, processing, transport; manufacture; assembly, distribution
- Maintenance
- Disposal of vehicles
Infrastructure Carbon Estimator (ICE)

• Simple tool for estimating the energy consumption and CO2 emissions from
  – building and maintaining transportation infrastructure,
  – Implementing sustainable pavements and construction practices
• Being used by NYSDOT, WSDOT and MNDOT to estimate energy and CO2 impacts in NEPA.
• Available at
Infrastructure Types Covered by the Tool

- Roadways and parking facilities
- Bridges
- Bicycle and pedestrian facilities
- Public transportation
- Construction
- Resurfacing
- Rehabilitation
- Routine Maintenance
Construction and Maintenance Activities Covered by the Tool

Materials
- Raw materials extraction
- Raw materials transport
- Raw materials production

Construction Equipment
- Transport of materials to site
- Construction equipment

Direct Energy & Emissions
- Routine Maintenance
  - Vegetation management
  - Snow removal
  - Sweeping, striping, litter, bridge deck repair

Upstream Energy & Emissions
- Energy & Emissions
- Chemical reactions-materials production
## Project Inputs

### Roadway Projects

<table>
<thead>
<tr>
<th>Facility type</th>
<th>Roadway Construction</th>
<th>Roadway Rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Roadway (lane miles)</td>
<td>Construct Additional Lane (lane miles)</td>
</tr>
<tr>
<td>Rural Interstates</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rural Principal Arterials</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Rural Minor Arterials</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rural Collectors</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Urban Interstates / Expressways</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Urban Principal Arterials</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Urban Minor Arterials / Collectors</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## Mitigation Strategies (pavement)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Baseline deployment</th>
<th>Planned deployment</th>
<th>Maximum potential deployment</th>
<th>Applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-place roadway recycling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold In-place recycling</td>
<td>0%</td>
<td>0%</td>
<td>99%</td>
<td>Asphalt and fuel use by construction equipment in roadway resurfacing and BRT conversions</td>
</tr>
<tr>
<td>Full depth reclamation</td>
<td>0%</td>
<td>0%</td>
<td>99%</td>
<td>Base stone and fuel use by construction equipment in roadway reconstruction and BRT conversions</td>
</tr>
<tr>
<td>Warm-mix asphalt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warm-mix asphalt</td>
<td>45%</td>
<td>90%</td>
<td>100%</td>
<td>Asphalt use in all projects</td>
</tr>
<tr>
<td>Recycled and reclaimed materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use recycled asphalt pavement as a substitute for virgin asphalt aggregate</td>
<td>0%</td>
<td>0%</td>
<td>25%</td>
<td>Asphalt use in all projects</td>
</tr>
<tr>
<td>Use recycled asphalt pavement as a substitute for virgin asphalt bitumen</td>
<td>0%</td>
<td>0%</td>
<td>40%</td>
<td>Asphalt use in all projects</td>
</tr>
<tr>
<td>Use industrial byproducts as substitutes for Portland cement</td>
<td>0%</td>
<td>0%</td>
<td>33%</td>
<td>Concrete use in all projects</td>
</tr>
<tr>
<td>Use recycled concrete aggregate as a substitute for base stone</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>Base stone use in all projects</td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>Materials and construction fuel use in roadway resurfacing and reconstruction projects</td>
</tr>
</tbody>
</table>
## Energy and CO2 Estimates

### Annualized energy use (mmBTUs), per year over 20 years

<table>
<thead>
<tr>
<th></th>
<th>Roadway - new construction</th>
<th>Roadway-rehabilitation</th>
<th>Roadway-total</th>
<th>Bridges</th>
<th>Rail, bus, bicycle, ped.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upstream Energy Materials</strong></td>
<td>89,975</td>
<td>152,838</td>
<td>242,813</td>
<td>24,643</td>
<td>178,067</td>
<td>445,523</td>
</tr>
<tr>
<td><strong>Direct Energy Construction Equipment Routine Maintenance</strong></td>
<td>33,942</td>
<td>27,079</td>
<td>60,021</td>
<td>10,747</td>
<td>61,066</td>
<td>132,374</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>123,917</td>
<td>179,917</td>
<td>302,834</td>
<td>35,390</td>
<td>239,673</td>
<td>736,482</td>
</tr>
</tbody>
</table>

### Annualized greenhouse gas emissions (MT CO2e), per year over 20 years

<table>
<thead>
<tr>
<th></th>
<th>Roadway - new construction</th>
<th>Roadway-rehabilitation</th>
<th>Roadway-total</th>
<th>Bridges</th>
<th>Rail, bus, bicycle, ped.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upstream Emissions Materials</strong></td>
<td>5,626</td>
<td>9,276</td>
<td>14,902</td>
<td>2,065</td>
<td>12,507</td>
<td>29,474</td>
</tr>
<tr>
<td><strong>Direct Emissions Construction Equipment Routine Maintenance</strong></td>
<td>2,402</td>
<td>1,975</td>
<td>4,377</td>
<td>784</td>
<td>4,491</td>
<td>9,652</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8,028</td>
<td>11,251</td>
<td>19,279</td>
<td>2,849</td>
<td>16,998</td>
<td>50,690</td>
</tr>
</tbody>
</table>
ICE 2.0

• Pooled fund effort led by the Minnesota DOT, with participation from California, Colorado, Iowa, New York, Texas, Washington. FHWA is also supporting the project.

• What to expect:
  – New roadway elements
  – New research on infrastructure energy and embodied CO2e embodied emissions
  – Improvements to tool interface
  – Ability to estimate on-road operating energy / CO2 based on simple estimates of vehicle miles traveled and travel speed
  – Project expected to be completed in late 2019
Strategic Planning Models – Differences from Conventional Travel Demand Models

**Conventional Travel Demand Models**
(4-step and Activity-Based)
- Originally developed to evaluate transportation capacity (especially roads and capital-intensive transit projects)
- Detailed representation of the transportation system
- Very useful for evaluating incremental changes to a transportation system and related policies

**Strategic Planning Models**
- Detailed representation of households and factors influencing behavior (similar to activity-based)
- Simplified representation of transportation system
- Easier to develop and calibrate (but less precise)
- More flexible, and can address a broader policy space more easily
- Run quickly, and can be used to evaluate dozens of policy combinations

Graphics courtesy of Brian Gregor, Oregon System Analytics
Strategic Planning Models

• The Energy and Emissions Reduction Policy Analysis Tool
  – Based on the GreenSTEP model created by the Oregon Department of Transportation.
  – Enhanced to address well-to-pump energy and emissions and better represent freight flows and related strategies
  – FHWA is planning to pilot test the new freight component of EERPAT
  – Models have been developed in WA, UT, CO, VT MA, and MD

• VisionEval is a pooled fund effort intended to improve the GreenSTEP family of models
Thank you.

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