U.S. Department of Transportation
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Greenhouse Gas Emissions Analysis of Regional Transportation Plans with EPA's MOVES Model

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Greenhouse Gas Emissions & Transportation Planning

- **Some metropolitan planning organizations (MPOs) and state DOTs have begun GHG analysis for their transportation plans**
- **Pending Federal legislation (climate and transportation bills) would require this analysis for larger MPOs and state DOTs**
- **Some existing state legislation, and state climate action plans, also require this type of analysis**

Factors that Influence GHGs from Surface Transportation

- **Direct (operational) energy**
  - VMT, fleet mix (vehicle types and ages), speed, fuels used
- **Indirect energy**
  - Changes in travel activity on other roadways, mode shift
  - Induced/displaced land use
- **Construction and maintenance energy**
  - Extent of activity (earthwork, tunneling, grade reduction)
  - Materials (amount of steel and concrete, recycled vs virtual materials)
- **Upstream/downstream energy**
  - Well-to-pump emissions for fuels
  - Manufacture and disposal emissions for vehicles

VMT as a surrogate for GHGs?

- **Some areas use VMT as a surrogate for energy consumption and/or GHG emissions**
  - More VMT = more emissions or energy, and vice versa
  - This is not very accurate and can provide misleading results

- **Variations: use conversion factors or mpg estimates to convert VMT to energy use or emissions**
  - FTA's New Starts guidance or state/national inventories can be used for GHG emissions rates
  - MPG estimates from EPA, DOE, etc. can be used to convert VMT to fuel consumption
  - Both approaches ignore impacts of speed changes, etc.

MOBILE6.2

- **EPA's MOBILE6.2 emission factor model generates CO2 and MPG estimates by vehicle age and type, so local fleet data can be used to calculate differences**
  - E.g., if transportation plan Alternative A has more trucks than Alternative B, can calculate impacts of this

- **MOBILE6.2 emissions/energy rates are not sensitive to speed, and are inaccurate after 2005 (new fuel economy standards not incorporated)**

Why Is Speed Important?

- **Fuel consumption (fuel economy) varies with speed, so projects that increase (or decrease) speeds impact energy use even if VMT stays the same**

Source: MOVES Demo

EPA's MOVES model

- **Replacement for MOBILE6.2, released December 2009**
  - www.epa.gov/otaq/models/moves/index.htm

- **Performs energy and GHG analysis**
- **Far greater capabilities than MOBILE6.2**

- **FHWA/EPA MOVES training workshops available**

Using MOVES for GHG Analysis

- **MOVES can model multiple forms of energy:**
  - Total energy consumption
  - Fossil fuel energy consumption
  - Petroleum energy consumption
- **and multiple GHGs:**
  - Carbon dioxide (CO2)
  - Methane (CH4)
  - Nitrous oxide (N2O)
  - CO2 Equivalent
  - Black carbon (elemental carbon)

Using MOVES for GHG Analysis: Two Options

- **Emission Inventory**
  - MOVES, unlike MOBILE6.2, is an inventory model
  - Can calculate total energy consumption and/or GHG emissions for a selected geographic area and fleet
- **Emission Rates**
  - A look-up table output option allows users to produce running emission rates in grams per mile in order to post-process results, as some agencies currently do with MOBILE
  - In a lookup run, MOVES produces running emissions rates (grams/mile, BTU/mile, etc.) for each speed bin (5 mph increments)
    - Start emissions reported on a gram/vehicle basis

Using MOVES for GHG Analysis: Limitations

- **MOVES2010 has some limitations related to energy/GHG analysis that will be addressed in future versions:**
  - Energy/GHG effects of biofuels (E85, biodiesel) not fully accounted for
  - Some vehicle types (hybrid, fuel cell) present in the model but not active

- **Even with these limitations, MOVES is much more capable than any other available tool**

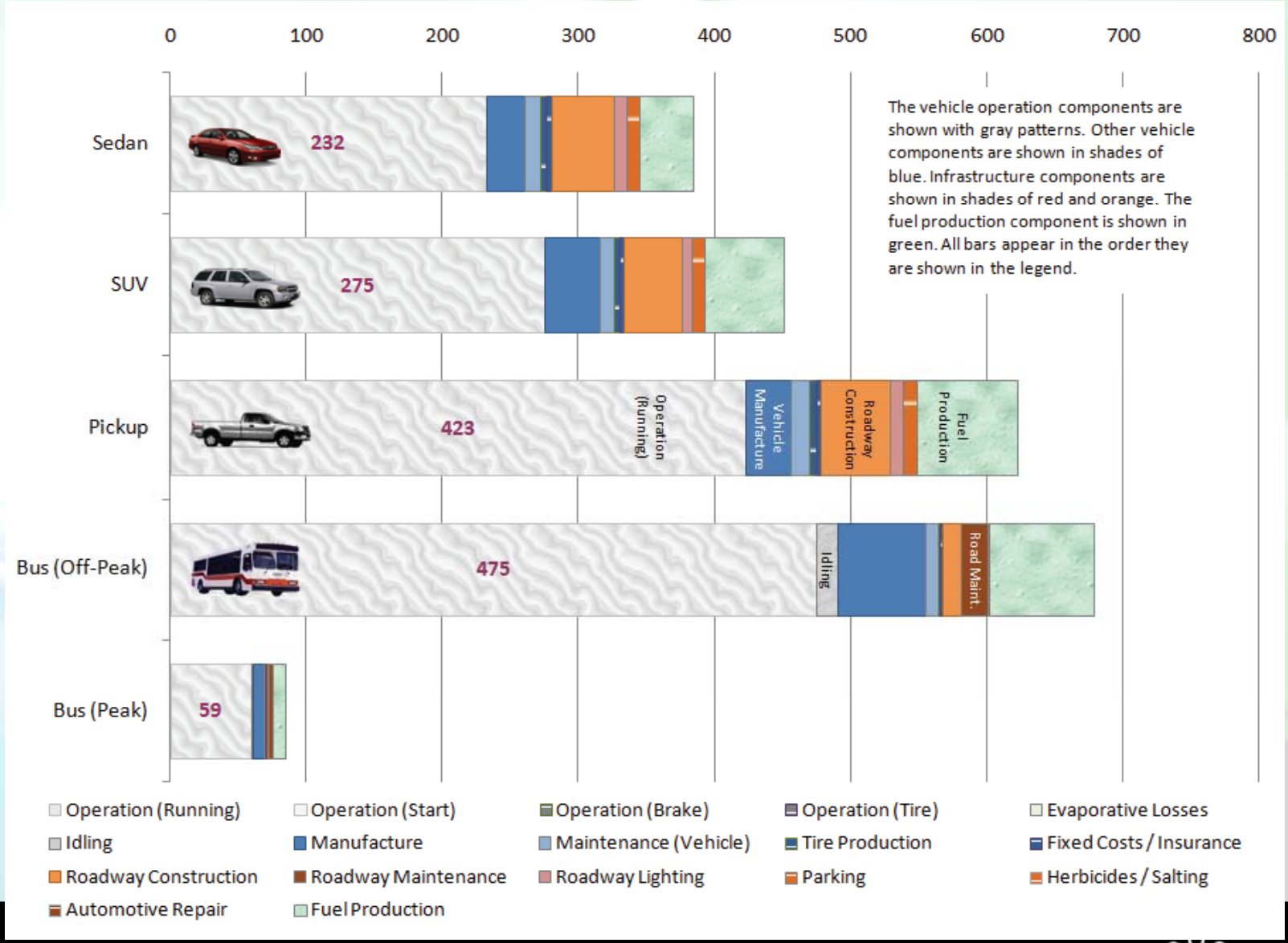
Life-cycle Analysis

- **Since GHG reduction strategies are being evaluated over very long timeframes (2050 and beyond), LCA is an ideal approach for comprehensive analysis of long-term plan or project impacts**

- **Some transportation projects may not reduce GHG emissions on a lifecycle basis, or may not provide reductions in a useful timeframe**
  - Some projects that reduce *operational* energy/GHGs have very long payback periods (50 years or more) when construction energy/emissions are taken into account

Life-cycle Analysis

- **Life-cycle analysis can answer questions like:**
  - How long does it take before the energy savings from operational improvements offset the energy associated with construction equipment, materials, and delay created by the work zones?
  - Is a transit-oriented plan alternative more efficient than a HOV-oriented alternative if the energy associated with construction is considered?
  - Would a more congested plan alternative still result in lower overall energy use if it results in more compact land use over time?


0
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Sedan
232
SUV
275
Pickup
423
Operation (Running)
Vehicle Manufacture
Roadway Construction
Fuel Production
Bus (Off-Peak)
475
Idling
Road Maint.
Bus (Peak)
59
The vehicle operation components are shown with gray patterns. Other vehicle components are shown in shades of blue. Infrastructure components are shown in shades of red and orange. The fuel production component is shown in green. All bars appear in the order they are shown in the legend.
Operation (Running)
Operation (Start)
Operation (Brake)
Operation (Tire)
Evaporative Losses
Idling
Manufacture
Maintenance (Vehicle)
Tire Production
Fixed Costs / Insurance
Roadway Construction
Roadway Maintenance
Roadway Lighting
Parking
Herbicides / Salting
Automotive Repair
Fuel Production

Framework for a planning-level energy/GHG analysis

- **State-of-the-practice framework for an energy/GHG analysis protocol that incorporates:**
  - Operational energy/emissions, including some lifecycle adjustments
  - Construction energy/emissions
  - Maintenance energy/emissions

- **Sufficient to provide credible information for decisionmaking (net energy/GHG benefits, payback period) without going as far as full LCA**

Operational energy/emissions

- **Use MOVES to develop energy and emissions rates or emissions inventories by year (maybe in 5-year increments)**
  - Use state- or area-specific fleet, fuel and meteorological information (follow MOVES guidance for County-level analysis)
  - Express emissions in CO2 equivalent (incorporates all MOVES GHGs except for black carbon)
- **Incorporate upstream/downstream adjustments for vehicles and fuels (using data available from EPA national inventories)**

Operational energy/emissions

- **Develop operational emissions rates for transit vehicles**
  - Transit buses can be modeled in MOVES
  - Need to develop rates for electric rail/bus based on energy consumption records (maybe from other states or FTA) and information on state electricity sources (coal/oil/gas/hydro/nuclear/renewable)
  - Need to develop rates for diesel rail based on the NONROAD model, manufacturer information, or FTA information
  - Other modes (ferries?)

Construction energy/emissions

- **Need energy/emissions rates for highway and transit construction**
- **Some simple values available from other states (CA, NY), past projects, literature for near-term use**
- **Mid- to long-term: develop state-specific information**
  - Review detailed project construction logs for energy (fuel) use information
  - Break out by project elements
    - Lane miles for roadway, lanes and length for bridge
    - Parking lots (park and rides) by acre
  - Consider state practices for construction (concrete vs asphalt, recycled vs virgin materials)
- **Can also quantify effects of delays/detours during construction, if data or model results are available**

Maintenance energy/emissions

- **Routine maintenance (mowing, restriping, snow and ice removal, drainage maintenance, etc.): use state/local maintenance fleet logs of fuel consumption and/or vehicle mileage/hours**
  - Calculate on a per-lane-mile basis
- **New lanes miles in the transportation plan = additional maintenance energy/GHGs**
- **Need maintenance factors for transit too**

Reporting emissions

- **Can be summarized on an annual basis or cumulative basis**
- **Annual basis: report total emissions from implementing plan for the horizon year (last year of the transportation plan) and compare to current year emissions**
- **Cumulative basis: report total emissions by adding the annual emissions over the life of the plan**
  - This approach provides a more realistic view of transportation plan impacts

Resources

- **NCHRP 25-25 Task 17 report, "Assessment of Greenhouse Gas Analysis Techniques for Transportation Projects"**
  - www.trb.org/NotesDocs/25-25%2817%29_FR.pdf
- **NCHRP 25-25 Task 58 report, "Greenhouse Gas Mitigation Measures for Transportation Construction, Maintenance, and Operations Activities"**
  - http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(58)_FR.pdf
- **FHWA Report, "Integrating Climate Change into the Transportation Planning Process." July 2008**
  - www.fhwa.dot.gov/hep/climatechange/index.htm
- **DOT Center for Climate Change and Environmental Forecasting**
  - http://climate.dot.gov/