Updates to Onroad Vehicle Population and Activity Data in MOVES2014

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US EPA/OAR/Office of Transportation & Air Quality Assessment and Standards Division
MOVES2014

• EPA’s mobile source air pollution emission model
• Estimates emissions and energy use from onroad sources at the national, county, and project scales
• Adds nonroad emissions by incorporating of NONROAD2008
• Contains new rules, emission rates and activity data for onroad vehicles
• Updates onroad fuel effects and other correction factors
• Replaces MOVES2010b
Major Updates to Onroad Vehicle Population and Activity

- Updated *historical* vehicle populations and miles (VMT)
- Updated *projected* vehicle populations and VMT
- Better described vehicle mix and heavy truck characteristics
- Improved default speed distributions and driving cycles
- Improved default activity for long-haul truck hotelling
- Accounted for multi-day parking
Historical VMT and Population from FHWA

• MOVES relies on FHWA for historical VMT and vehicle population defaults

• In 2011, FHWA changed their vehicle categories
  – Based on updated vehicle classification approach
  – Intended to improve VMT estimates for light-duty vehicles

• This methodology change
  – No longer separates light-duty cars and trucks
  – Conserved total VMT
    • decreased light-duty VMT slightly;
    • increased heavy-duty VMT substantially
## Old Classifications

### ANNUAL VEHICLE DISTANCE TRAVELED IN MILES AND RELATED DATA - 2006

**BY HIGHWAY CATEGORY AND VEHICLE TYPE**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ITEM</th>
<th>PASSENGER CARS</th>
<th>MOTORCYCLES /3</th>
<th>BUSES</th>
<th>OTHER 2-AXLE 4-TIRE VEHICLES /4/</th>
<th>SINGLE-UNIT 2-AXLE 8-TIRE OR MORE TRUCKS /5/</th>
<th>COMBINATION TRUCKS</th>
<th>SUBTOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ALL MOTOR VEHICLES /6/</td>
</tr>
<tr>
<td>2006</td>
<td>Motor-Vehicle Travel: (millions of vehicle-miles)</td>
<td>123,847</td>
<td>1,367</td>
<td>950</td>
<td>81,548</td>
<td>7,125</td>
<td>43,079</td>
<td>205,395</td>
</tr>
<tr>
<td>2006</td>
<td>Interstate Rural</td>
<td>123,847</td>
<td>1,367</td>
<td>950</td>
<td>81,548</td>
<td>7,125</td>
<td>43,079</td>
<td>205,395</td>
</tr>
<tr>
<td>2006</td>
<td>Other Arterial Rural</td>
<td>207,029</td>
<td>1,602</td>
<td>959</td>
<td>145,716</td>
<td>13,847</td>
<td>25,430</td>
<td>352,744</td>
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<tr>
<td>2006</td>
<td>Other Rural</td>
<td>206,732</td>
<td>1,666</td>
<td>1,612</td>
<td>145,773</td>
<td>15,154</td>
<td>13,711</td>
<td>352,505</td>
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<tr>
<td>2006</td>
<td>All Rural</td>
<td>537,607</td>
<td>4,635</td>
<td>3,521</td>
<td>373,036</td>
<td>36,125</td>
<td>82,221</td>
<td>910,644</td>
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<tr>
<td>2006</td>
<td>Interstate Urban</td>
<td>267,106</td>
<td>2,379</td>
<td>1,024</td>
<td>166,660</td>
<td>10,033</td>
<td>50,085</td>
<td>433,768</td>
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<tr>
<td>2006</td>
<td>Other Urban</td>
<td>865,821</td>
<td>5,035</td>
<td>2,239</td>
<td>542,794</td>
<td>34,186</td>
<td>29,863</td>
<td>1,428,515</td>
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<tr>
<td>2006</td>
<td>All Urban</td>
<td>1,152,927</td>
<td>7,414</td>
<td>3,263</td>
<td>709,454</td>
<td>44,219</td>
<td>59,948</td>
<td>1,862,381</td>
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<tr>
<td>2006</td>
<td>Total Rural and Urban</td>
<td>1,660,534</td>
<td>12,049</td>
<td>6,793</td>
<td>1,082,490</td>
<td>80,344</td>
<td>142,169</td>
<td>2,773,325</td>
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<tr>
<td>2006</td>
<td>Number of motor vehicles registered /6/</td>
<td>135,399,945</td>
<td>6,678,958</td>
<td>821,959</td>
<td>99,124,775</td>
<td>6,649,337</td>
<td>2,169,670</td>
<td>234,524,720</td>
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<tr>
<td>2006</td>
<td>Average miles traveled per vehicle</td>
<td>12,485</td>
<td>1,804</td>
<td>8,253</td>
<td>10,920</td>
<td>12,083</td>
<td>65,526</td>
<td>11,824</td>
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<tr>
<td>2006</td>
<td>Person-miles of travel /7/ (millions)</td>
<td>2,671,044</td>
<td>15,303</td>
<td>143,816</td>
<td>1,876,690</td>
<td>80,344</td>
<td>142,169</td>
<td>4,547,734</td>
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<tr>
<td>2006</td>
<td>Fuel consumed /8/ (thousand gallons)</td>
<td>75,008,960</td>
<td>221,030</td>
<td>1,148,409</td>
<td>60,885,249</td>
<td>9,882,373</td>
<td>28,106,544</td>
<td>135,694,199</td>
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<tr>
<td>2006</td>
<td>Average fuel consumption per vehicle (gallons) /8/</td>
<td>554</td>
<td>33</td>
<td>1,307</td>
<td>612</td>
<td>1,482</td>
<td>12,954</td>
<td>579</td>
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<tr>
<td>2006</td>
<td>Average miles traveled per gallon of fuel consumed /8/</td>
<td>22.5</td>
<td>54.5</td>
<td>5.9</td>
<td>17.8</td>
<td>8.2</td>
<td>5.1</td>
<td>20.4</td>
</tr>
</tbody>
</table>

# New Classifications

**ANNUAL VEHICLE DISTANCE TRAVELED IN MILES AND RELATED DATA - 2006 1/**

**BY HIGHWAY CATEGORY AND VEHICLE TYPE**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ITEM</th>
<th>LIGHT DUTY VEHICLES SHORT WB 2/</th>
<th>MOTORCYCLES</th>
<th>BUSES</th>
<th>LIGHT DUTY VEHICLES LONG WB 2/</th>
<th>SINGLE-UNIT TRUCKS 3/</th>
<th>COMBINATION TRUCKS</th>
<th>ALL LIGHT DUTY VEHICLES 2/</th>
<th>SINGLE-UNIT 2-AXLE 6-TIRE OR MORE AND COMBINATION TRUCKS</th>
<th>ALL MOTOR VEHICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Motor-Vehicle Travel: (millions of vehicle-miles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interstate Rural</td>
<td>145,528</td>
<td>1,399</td>
<td>1,410</td>
<td>45,217</td>
<td>10,201</td>
<td>54,161</td>
<td>190,745</td>
<td>64,361</td>
<td>257,915</td>
</tr>
<tr>
<td></td>
<td>Other Arterial Rural</td>
<td>244,948</td>
<td>2,681</td>
<td>1,982</td>
<td>93,525</td>
<td>19,999</td>
<td>31,247</td>
<td>338,473</td>
<td>51,246</td>
<td>384,882</td>
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<tr>
<td></td>
<td>Other Rural</td>
<td>237,699</td>
<td>2,721</td>
<td>1,933</td>
<td>105,356</td>
<td>20,530</td>
<td>17,010</td>
<td>342,455</td>
<td>37,540</td>
<td>394,644</td>
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<tr>
<td>2006</td>
<td>All Rural</td>
<td>627,575</td>
<td>7,001</td>
<td>5,324</td>
<td>244,066</td>
<td>50,730</td>
<td>102,418</td>
<td>871,672</td>
<td>153,148</td>
<td>1,037,146</td>
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<tr>
<td></td>
<td>Interstate Urban</td>
<td>334,688</td>
<td>2,150</td>
<td>1,812</td>
<td>64,882</td>
<td>17,004</td>
<td>38,741</td>
<td>419,560</td>
<td>53,745</td>
<td>477,257</td>
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<tr>
<td></td>
<td>Other Urban</td>
<td>1,065,472</td>
<td>10,005</td>
<td>6,902</td>
<td>303,813</td>
<td>55,564</td>
<td>38,162</td>
<td>1,389,205</td>
<td>93,746</td>
<td>1,498,958</td>
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<tr>
<td>2006</td>
<td>All Urban</td>
<td>1,420,370</td>
<td>12,155</td>
<td>8,714</td>
<td>388,455</td>
<td>72,588</td>
<td>74,903</td>
<td>1,688,865</td>
<td>147,491</td>
<td>1,847,225</td>
</tr>
<tr>
<td></td>
<td>Total Rural and Urban 5/</td>
<td>2,047,945</td>
<td>19,157</td>
<td>14,038</td>
<td>632,593</td>
<td>123,318</td>
<td>177,321</td>
<td>2,680,537</td>
<td>300,639</td>
<td>3,314,271</td>
</tr>
<tr>
<td>2006</td>
<td>Number of motor vehicles registered 2/</td>
<td>194,294,855</td>
<td>6,678,958</td>
<td>621,959</td>
<td>38,714,951</td>
<td>7,755,933</td>
<td>2,577,983</td>
<td>233,009,805</td>
<td>10,333,922</td>
<td>250,344,644</td>
</tr>
<tr>
<td></td>
<td>Average miles traveled per vehicle</td>
<td>10,540</td>
<td>2,968</td>
<td>17,079</td>
<td>16,349</td>
<td>15,900</td>
<td>58,783</td>
<td>11,504</td>
<td>29,092</td>
<td>12,017</td>
</tr>
<tr>
<td></td>
<td>Fuel consumed (thousand gallons)</td>
<td>86,590,015</td>
<td>445,917</td>
<td>1,875,536</td>
<td>36,874,459</td>
<td>16,781,174</td>
<td>26,613,396</td>
<td>125,564,475</td>
<td>46,374,480</td>
<td>174,939,342</td>
</tr>
<tr>
<td>2006</td>
<td>Average fuel consumption per vehicle (gallons)</td>
<td>458</td>
<td>47</td>
<td>2,403</td>
<td>955</td>
<td>2,161</td>
<td>11,487</td>
<td>539</td>
<td>4,483</td>
<td>697</td>
</tr>
<tr>
<td></td>
<td>Average miles traveled per gallon of fuel consumed</td>
<td>23.1</td>
<td>43.0</td>
<td>7.1</td>
<td>17.1</td>
<td>7.4</td>
<td>6.0</td>
<td>21.3</td>
<td>6.5</td>
<td>17.2</td>
</tr>
</tbody>
</table>
Future Year Projections from DOE

• MOVES2014 uses DOE’s Annual Energy Outlook 2014 projections for 2012-and-later
  – Vehicle miles traveled
  – Vehicle population
  – Fuel consumption

• MOVES sales projections are based on relative annual VMT growth
VMT Growth in MOVES 2010b and MOVES 2014
Vehicle Mix

• Vehicle mix is important for emissions:
  – Fuel Types
    • Fraction of Gasoline & Diesel
    • Availability of Flexible Fueled (E85) Vehicles
  – Regulatory Classes
    • Emission standards depend mostly on vehicle weight ratings (GVWR) and model year
  – Age Distributions
    • Model-year distribution
    • Deterioration of controls
    • Activity varies with age
New Data on Vehicle Mix

Polk 2011
- Vehicle Category
- Model Year
- Fuel Type
- GVWR
- Household Units
- Work Units

Interim Polk
- modelYearID
- fuelTypeID
- regClassID
- totalCounts

Sample Vehicle Counts

Interim VIUS
- sourceTypeID
- modelYearID
- fuelTypeID
- regClassID
- sourceTypeFractions

VIUS 2002
- SAMPLE_ID
- AXLE_CONFIG
- TRIP_PRIMARY
- OPCLASS
- FUEL_CID
- FUEL
- VIUS_GVW
- ADM_MODELEYEAR
- ADM_GVW
- TAB_TRUCKS

INTERCITY BUSES
TRANSIT BUSES
SCHOOL BUSES

MOTORCYCLES
MOTOR HOMES
Vehicle Characteristics

• Weight and aerodynamic characteristics of vehicles determine power needed at different speeds

• We used Weigh-in-Motion data to update mass characteristics of heavy-duty trucks

• HD GHG rule requires changes in HD truck characteristics—MOVES now reflects this.
Age Distributions

• Base year age distributions from Polk & VIUS data
• Projected to future using sales and scrappage assumptions
  – MOVES2010 used single scrappage curve
  – MOVES2014 uses a dynamic scrappage rate
Passenger Car Age Distributions

![Graph showing passenger car age distributions across different calendar years (2011, 2020, 2030, 2040). The graph plots age fraction against passenger car age, with a clear decline in age fraction as age increases.]
Average Combination Truck Age

Average Truck Age

2011

2018

Short Haul

Long Haul

Model
MOVES2010b
MOVES2014
Better Data on Speed

• MOVES2010b average speed distributions were based on travel demand models from a 1999 analysis

• Instrumented vehicles provided more up-to-date and detailed vehicle behavior

• New speed distributions based on TomTom summary GPS information with detail by:
  • road type
  • hour of the day
  • day of the week
Comparison of Example Average Speed

GPS data provides much smoother transitions between speed bins than previous defaults.
New driving cycles for high and low speeds

Modified HHDDT Creep mode cycle (1.8 mph)
# Driving Schedule Map

| Source | Min Speed (mph) | 0 | 2.5 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 |
|--------|----------------|----|-----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Type   | Max Speed (mph) | 2.5 | 5   | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 100|
| 11     | Motorcycle     |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 21     | Passenger Car  |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 31     | Passenger Truck|    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 32     | Light Commercial Truck | | | | | | | | | | | | | | | | | | |
| 41     | Intercity Bus  |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 42     | Transit Bus    |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 43     | School Bus     |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 51     | Refuse Truck   |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 52     | Single Unit Short-haul Truck | | | | | | | | | | | | | | | | | | |
| 53     | Single Unit Long-haul Truck | | | | | | | | | | | | | | | | | | |
| 54     | Motor Home     |    |     |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 61     | Combination Short-haul Truck | | | | | | | | | | | | | | | | | | |
| 62     | Combination Long-haul Truck | | | | | | | | | | | | | | | | | | |
Hotelling

- Long-haul combination trucks often operate even when they are not driving (hotelling).
- MOVES2014 can model two methods of hotelling on long-haul combination trucks:
  - Idling the main engine (Extended Idle)
  - Running an auxiliary power unit (APU)
    - National default APU penetration rate
      - MY <2010: 0%
      - MY ≥2010: 30%
    - APU mission rates are modelled as a small (6 hp) Tier IV nonroad diesel engine
- MOVES2014 defaults allocate hotelling activity to rural highways
Light Duty Parking/Trip Data

• Evaporative emissions are more likely to “break-through” canister when vehicles park more than three days

• Updated MOVES trip data adding information on multi-day parking episodes

• This also affected MOVES2014 default trip-per-day calculations.
NOTES FOR MODELERS
Use Local Data!!!

• MOVES default population and VMT are based on national data
• Local areas often have better local data:
  – VMT
  – Vehicle populations
  – Age distributions
  – Gas/diesel mix
  – Speed distributions
  – Information on starts, hotelling
  – Etc.
MOVES2014 Technical Guidance

Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity

Tools to make local inputs easier

- **MOVES County Data Manager**
  - Assists user in entering data at the county scale

- **MOVES Project Data Manager**
  - Assists user in entering data at the project scale

- **AADVMT converter**
  - Converts Average Annual Daily VMT to total annual VMT for use in MOVES

- **Age Distribution Projection Tool**
  - Creates projections of future age year distributions based on current local age distributions.
Questions?

Email the MOVES team at mobile@epa.gov

Read the technical report to be posted soon at

http://www.epa.gov/otaq/models/moves/moves-reports.htm
Acknowledgements

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