MOVES-NONROAD Model Plans and Data Updates

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September 14, 2016
Overview

- NONROAD Model Summary
  - Model Coverage
  - Methodology
  - Default Data

- Near-Term Plans for NONROAD Model Updates
  - 2014-2040 Growth Factors
  - 1996-2014 Growth Factors
  - Additional Fixes and Improvements

- Long-Term Model Development Plans
  - Data Updates
  - Model Redesign
  - Model Prototype-Data Integration
Model Summary: Coverage

- First public release of stand-alone model in 1998
- Coded in FORTRAN95 and integrated into MOVES2014
- Temporal coverage: 1970-2050. Spatial coverage: county to national

Over 80 distinct equipment types. Excluded: locomotives, commercial marine vessels, aircraft

Over 200 fuel+equipment type combinations
Over 1200 fuel+equipment type+horsepower SCCs
Model Summary: Coverage

Pollutants

Processes

- Running Exhaust
- Crankcase Running Exhaust
- Refueling Displacement Vapor Loss
- Refueling Spillage Loss
- Evap. Tank Permeation
- Evap. Hose Permeation
- Diurnal Fuel Vapor Venting
- Hot Soak Fuel Vapor Venting
- Running Loss Fuel Vapor Venting

239 pollutant+process combinations
Power algorithm approach to calculating NONROAD exhaust emissions:

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Population</th>
<th>Activity</th>
<th>Emission Factor</th>
<th>Load Factor</th>
<th>Rated Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>(tons/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment population for a defined base year, to which growth factors and geographic and temporal allocations are applied</td>
<td>Annual activity (hrs/year)</td>
<td>In-use exhaust emission factor (g/hp-hr)</td>
<td>Fraction of available power (unitless)</td>
<td>Average rated horse-power (hp)</td>
</tr>
</tbody>
</table>
**INTEGRATION OF SOURCE DATA**

NONROAD utilizes data from a variety of industry and government sources:

- Power Systems Research
- U.S. Forest Service
- National Oceanic and Atmospheric Administration
- Motorcycle Industry Council
- U.S. Department of Agriculture
- Oak Ridge National Laboratory
- International Snowmobile Manufacturers Association
- U.S. EPA
- National Marine Manufacturers Association
- California Air Resources Board
- U.S. Energy Information Administration
- U.S. Census Bureau

<table>
<thead>
<tr>
<th>Source Data Incorporation</th>
<th>Equipment Population</th>
<th>Activity</th>
<th>Population Growth Rates</th>
<th>Emission Factors*</th>
<th>Average Horsepower</th>
<th>Geographic Allocation</th>
<th>Load Factor</th>
</tr>
</thead>
</table>

*Emission factors in the model have been adjusted to reflect post-2002 federal emissions standards (SI rules; Tiers 1-4)
Proposed Model Updates

Objective: improve the accuracy of nonroad emission inventories by developing a new comprehensive NONROAD model that combines state-of-the-science data with a user-friendly software platform.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Population and Activity</th>
<th>Equipment Scrappage</th>
<th>Population Growth</th>
<th>Emission and Load Factors</th>
<th>Model Code</th>
<th>Graphical User Interface (GUI)</th>
<th>Model Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near-term updates (next MOVES release)</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
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<tr>
<td>Long-term updates (later MOVES releases)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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</tbody>
</table>
Near-Term Plans: Update Growth Factors

- Model currently fits historical engine population estimates from 1989 to 1996 with a linear regression, and then extrapolates to future years.
  - Does not account for yearly variations or large-scale economic trends
  - Concern that this approach overestimates projected populations
- EPA proposing to develop 2014-2040 growth indices using surrogates:

<table>
<thead>
<tr>
<th>Equipment Sector</th>
<th>Surrogate growth index data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawn and Garden (residential), Recreation</td>
<td>State-level human population (University of Virginia Weldon Cooper Center for Public Service)</td>
</tr>
<tr>
<td>Lawn and Garden (commercial), Industrial</td>
<td>State-level GDP (Moody’s Analytics)</td>
</tr>
<tr>
<td>Recreational Marine</td>
<td>National-level energy consumption (2016 Annual Energy Outlook (AEO))</td>
</tr>
<tr>
<td>Railroad Maintenance</td>
<td>National-level billion ton-miles traveled (2016 AEO)</td>
</tr>
<tr>
<td>Construction, Agricultural, Logging, Mining, Oil Field</td>
<td>Census region-level energy consumption (2016 AEO); state-level GDP (Moody’s Analytics)</td>
</tr>
<tr>
<td>Airport Service</td>
<td>Federal Aviation Administration Terminal Area Forecast Model</td>
</tr>
</tbody>
</table>
Near-Term Plans: Update Growth Factors (2014-2040)

Draft national-scale growth factors derived from projections of human population (U.S. Census) and energy consumption (Annual Energy Outlook) (assumes 2014 population base year)
Near-Term Plans: Update Growth Factors (2014-2040)

Draft national-scale growth factors derived from GDP and FAA projections (assumes 2014 population base year)
Near-Term Plans: Update Growth Factors (1996-2014)

- Existing population base years are 1996, 1998, 1999, or 2000 (depending on equipment type)
- EPA updating equipment population data for 2014 (not expected to be ready for next model release)
- Start with existing base year populations \(\rightarrow\) apply updated growth factors for the period 1996-2014 \(\rightarrow\) arrive at estimated 2014 population \(\rightarrow\) apply 2014-2040 growth factors to the estimated 2014 population
- Candidate data sources: Energy Information Administration (AEO, fuel sales), U.S. Census Bureau, USDA Census of Agriculture, Army Corps of Engineers
Near-Term Plans: Additional Fixes and Improvements

- Nonroad Importer Technical Guidance to assist users in importing the best available local data:
  - fuels
  - meteorology
  - equipment population
  - activity and load factor
  - retrofits
  - month, day, hour allocations

- Streamline the metal and dioxin calculator to remove a redundant fuel volume conversion calculation

- Database updates to reflect changes to Alaska, Virginia, and Montana counties
Long-Term Plans: Data Updates

- Extensive efforts underway to update population and activity data for the major nonroad engine categories: small spark-ignition, large spark-ignition, recreational equipment, recreational marine, and compression-ignition.

- Identify and acquire nonroad engine sales data
- Develop scrappage curves
- Develop national equipment population dataset
- Develop equipment population growth projections

- Identify and acquire equipment activity data
- Nonroad fuel consumption validation
- Develop geographic allocation factors

- Multiple data sources are vetted according to three areas of evaluation:
  1. Data contents
  2. Data quality
  3. Data source characteristics

- Longer-term plans to update nonroad emission factors
Long-Term Plans: Data Updates (Population)

### Sales Data

- > 100 equipment types from all 12 categories
- Classified by fuel type, engine size, equipment type, model year
- Minimum coverage: 2000-2014
- Extensive QA to compare data sources

### Scrappage Curves
Show the percentage of equipment remaining in use over successive years

- Used to determine the age distribution of in-use equipment for a given CY
- Requires representative in-use model year distributions and corresponding time series sales data
- Exploring multiple data sources and strategies, including a 2-parameter Weibull function

### National Populations
National-scale in-use population dataset for 2014 (new base year)

- Estimates informed by sales data and scrappage curves
- Population estimates for > 100 equipment types from all 12 categories
- Classified by fuel type, engine size, equipment type, model year
- Extensive QA against other national datasets (e.g., registrations, equipment censuses)

### Growth Projections
Sources: AEO, Moody’s Analytics, U.S. Census

- Projections of energy use, population, equipment activity, and economic indicators used as surrogates to project sector-specific equipment population growth
- Apply to 2014 base year equipment populations
- Coverage: 2014-2040
Long-Term Plans: Data Updates (Activity and Allocation)

**Activity Data**
Data on how frequently nonroad equipment is used on an annual or seasonal basis (total operating time, hr/year)

Sources: national, state, and local field surveys (e.g., California Air Resources Board, Texas Commission on Environmental Quality, USDA), commercial vendors

Level of available detail varies by source, so extensive QA required to assess the engine, equipment, and activity information as well as the temporal and geographic applicability of the data

**Fuel Consumption**
Nonroad diesel and gasoline consumption can be used to validate equipment population and activity estimates

Sources: FHWA (Highway Statistics Annual Reports non-highway gasoline use), U.S. Dept. of Energy (state-level fuel consumption), nonroad fuel tax revenues, state surveys, U.S. Energy Information Administration (Fuel Oil and Kerosene Sales)

Must ensure data source estimates can be properly attributed to nonroad equipment categories

**Geographic Allocation**
Must allocate national-scale populations and total activity of nonroad engines to the state and county levels

Requires the use of surrogate statistics that correlate with population or total activity in a particular geographic area

Currently identifying candidate surrogate statistics, as well as independent county-level datasets that could be used as validation test data
Long-Term Plans: Model Redesign

• Priorities in new model design:
  
  • Use widely available data → facilitates more frequent updates
  
  • Minimize impact on users → continue to use MOVES structure – MySQL tables and output, graphical user interface, shared tables (meteorology, counties)
  
  • Improve model performance → underlying calculations to be done in fast, flexible GO language
  
  • Revisit equipment categories → consider consolidating or removing some equipment types
Long-Term Plans: Prototype-Data Integration

Newly-acquired population and activity data to be integrated into prototype testing

- Population and Activity Data
- QA/QC and Format
- Document
- Test
- Add to Prototype
- Release

Promotes iterative refinements that will ultimately be folded into the final model