PennDOT’s and NJDOT’s Experience with MOVES

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Discussion Outline

1. Context of emissions analysis and MOVES in PA and NJ
2. A manager’s view of the MOVES process
3. Observations on technical issues
Context of Emissions Analysis and MOVES in PA and NJ
Pennsylvania Context

- **Jurisdictions**
  - 67 Counties
  - 15 MPOs 32 counties
  - 8 RPOs 35 counties

- **PennDOT Central Office provides extensive technical support as needed**
  - RPOs All technical activities
  - 7 “small” MPOs, no travel model Most technical activities
  - 6 “small” MPOs, with travel model Range of technical support
  - Philadelphia, Pittsburgh MPOs Self sufficient

- **Comprehensive consultant support by PennDOT (Baker/AECOM team)**

- **Support for air agency (PaDEP)**
**PA Non-Attainment Status**

**8-hr Ozone Non-Attainment:**
- 18 counties non-attainment
- 19 counties maintenance

**PM-2.5 Non-Attainment:**
- 20 counties non-attainment
- 8 other jurisdictions non-attainment
New Jersey Context

- **Jurisdictions**
  - 21 counties
  - 3 MPOs  All 21 counties

- **NJDOT Central Office provides technical coordination and technology development**
  - NJTPA  (North Jersey)  Self sufficient
  - DVRPC  (Philadelphia)  Self sufficient
  - SJTPO  (South Jersey)  More support

- **Consultant support on technical issues and tool development by NJDOT (AECOM, Baker)**

- **Support for air agency (NJDEP)**

- **NJTPA and SJTPO retain AECOM, DVRPC is independent**
NJ Non-Attainment Status

1-hr Ozone Non-Attainment:
- 21 counties non-attainment and maintenance

PM-2.5 Non-Attainment:
- 13 counties non-attainment
NJ and PA have jointly (with NYMTC) supported development of post-processing and off-model tools

- PPSUITE: Travel model post-processor (AECOM)
- AQONE family: Off-model travel and emissions estimator

PPSUITE is the basic tool for emissions analysis for both states, except the DVRPC region (78 of 88 counties)
A Manager’s View of MOVES
“I went to the training and it scared the hell out of me....”
Schedule Implications: When must it be done?

- **Conformity grace period through March, 2012**
  - Reality: Immediate pressures (possible SIP revisions)
  - Possible 1-year extension to March, 2013

- **Complicated:**
  - Long data development effort (Months of preparation)
  - Long run times (Days of runs)
  - QA/QC crucial

- **Inter-relationships**
  - Ongoing TIP / Plan cycles
  - Existing SIP MVEBs
  - New SIP requirements
  - GHG mitigation goals
MOVES Production Times

- Setup, run & output time many times MOBILE

- How long is dependent on multiple factors
  - Hardware setup: Dedicated vs. shared, master / worker
  - File storage: Many times more, depends on context
  - Size of the area: 1-2 counties OK; More, difficult
  - Complexity of the area: Limits on aggregation / representation
  - Input file creation: Batch processing
  - Run automation: Batch processing, pre/post processors
  - Output automation
  - QA/QC at every step

- MOVES is fragile – Allow a buffer
MOVES Production Times

- **Consumes more resources over a longer period**
  - Managers, staff, consultants

- **Adds to critical path for key products**
  - Regional conformity
  - Project level conformity (future)
  - SIPS on tight deadlines
How Long Does It Take?

Conformity Example:
6 scenarios  6 scenarios
5 counties  1 county
145 hours  29 hours

Plus setup,
Pre-processing,
Post-processing

MOVES run time to Process 1 scenario (INVENTORY)

Assumes high-end processors and one master/worker setup,
well practiced analyst, supporting software,
batch processing
Risk Management

- What happens if something is missed?
  - What if false positive? False negative?
  - Conformity lapse or sanctions?
  - How will we know this?

- What can we do to minimize risk?

- Risk Management Steps
  - Staff resources / training
  - Sufficient calendar
  - Good guidance
  - Active QA/QC process
Keys to Success

Computers networks: Make the commitment

- Multiple master and worker computers work well
- AECOM: 4 masters, 6 workers
- NJDEP: 3 masters, 4 workers
- MINIMUM: 1 master, 3 workers

Staff preparation

- Staff training
  - MOVES
  - MYSQL data management
  - Computer network setup and management
- IT staff involvement
Early start and advance planning are critical

- Schedule carefully, realistically.
  - Self, planning partners, sister agencies
- Start Early
- Allow for EXPECTED and *UNEXPECTED glitches, delays*
- Allow sufficient time – especially for first products
- Practice, practice, practice

Robust QA/QC process

- Standardized naming conventions and folder management are crucial
  - MOVES requires and generates thousands of files
  - Enforced conventions lead to error-free applications
Observations on Technical Issues
Things that are VERY DIFFERENT from MOBILE
MOVES Run Components

**Activity Data:**
- VMT / Speeds
- Temporal
- Topological

**Non-Activity Data**
- Meteorology
- Policies
- Fuel Supply
- I/M Program

**Activity Data:**
- Vehicle Population

**ON-ROAD**
- (Running)

**OFF-ROAD**
- (Evap/Start)

- Inventory Quantities
- VMT-based Rates
- Population Based Rates
SOURCE TYPE VMT

- **VMT input as ANNUAL total for the domain (typically county)**
  - INVENTORY: Leads to calculated emission quantities
  - RATE METHOD: Calculated emissions / VMT = Rate
  - Beware: Even for Rate Method, accurate/consistent VMT is needed

- **MONTH and DAY fractions:**
  - Most critical for PM$_{2.5}$ analysis (12-months / annual)
  - Source: Permanent count station data (4-year average)
    - Should address 12 months, weekday vs. weekend
    - Separately derived by county, freeways / arterials
  - Static: Do not change with scenario / year
  - Be careful of consistency:
    - Travel model represents one typical weekday (typically)
    - Factor UP to annual, back DOWN (within MOVES) to the analysis day
    - Establish the Annual total VMT once from travel model run, then (for various months/days) apply factors
    - Be sure to always use the same factors for UP and DOWN, and that input/output VMTs match
SOURCE TYPE POPULATION

SOURCE TYPE POPULATION drives “off-road” emissions:

- Starts / soaks / evaporatives
- Can be a dominant portion of total emissions in comparison to running emissions:
  - Currently 30%+  Future reaching 50%+

Source Type Population represents the number of vehicles that are present and emitting sometime during the analysis day

- “Registered vehicles” is a surrogate
- Advanced travel modeling methods could estimate this quantity
- NOT travel model trip ends:
  Allocation to productions vs. attractions needed
Current Options for SOURCE TYPE POPULATION

1. **Direct Use of Registration Data**
   - Convert M6.2 weight categories to MOVES types using EPA Guidance
   - Apply growth rates to get future years
   - May over-estimate evap/start emissions in urban areas; heavy vehicle issues

2. **Adjusted Registration Data**
   - Account for expected local vehicle starts per day (Surveys?)
   - Starts per Day assumptions not easily altered in MOVES

3. **Calculate from VMT**
   - Similar to MOBILE6.2 approach
   - VMT x 1 / (MOVES Default Miles/Veh) = # Vehicles
   - May not equate directly to # of starts; Thru traffic issues

4. **Combination (1 + 3)**
   - Recommend initial conservative approach
   - Light-Duty Vehicles – Use Registration Data
   - Heavy Vehicles – Base off VMT
   - (Very conservative approach)

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### 2008 PA Statewide Emissions Method 1 vs. Method 3

<table>
<thead>
<tr>
<th>Vehicle Group</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-Duty</td>
<td>+ 13%</td>
</tr>
<tr>
<td>Heavy-Duty</td>
<td>- 37%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>+ 11%</strong></td>
</tr>
</tbody>
</table>
MOVES Calculation Methods

- **INVENTORY Method**
  - MOVES produces emission quantities

- **EMISSION RATES Method**
  - MOVES produces a rate lookup table which user applies to VMT
Benefits of Inventory vs. Emission Rate Analysis

- PPSUITE provides transparent switch-hitting between the methods
- Benefits are dependent on context:
  - Small jurisdictions (<5 counties) INVENTORY simpler and faster
  - Large jurisdictions, with staff skills INVENTORY simpler and equivalent time
  - Large jurisdictions, constrained resources RATES can be simpler, prepared in advance

- NJ will use Inventory for both SIPs and Conformity
  - Computer clusters, consultant team and NJDEP staff resources in place, run time not an issue

- PA will use Emission Rates for SIPs due to number of counties
  - Ability to pre-calculate emission rate tables is important
  - Smaller MPO staffs will have less direct involvement with MOVES
# Emission Differences: Inventory vs. Rate Methods

## 2018 Summer Weekday Test Runs

<table>
<thead>
<tr>
<th>County</th>
<th>% Difference*</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VOC</td>
<td>NOX</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Allegheny</td>
<td>0 %</td>
<td>+3 %</td>
<td>-2 %</td>
</tr>
<tr>
<td>Blair</td>
<td>0 %</td>
<td>0 %</td>
<td>-2 %</td>
</tr>
<tr>
<td>Centre</td>
<td>-1 %</td>
<td>+1 %</td>
<td>-3 %</td>
</tr>
<tr>
<td>Lancaster</td>
<td>0 %</td>
<td>+4 %</td>
<td>+1 %</td>
</tr>
<tr>
<td>Lehigh</td>
<td>0 %</td>
<td>+4 %</td>
<td>+1 %</td>
</tr>
<tr>
<td>Mercer</td>
<td>0 %</td>
<td>0 %</td>
<td>-2 %</td>
</tr>
<tr>
<td>Montgomery</td>
<td>0 %</td>
<td>+4 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Northampton</td>
<td>0 %</td>
<td>+3 %</td>
<td>+1 %</td>
</tr>
<tr>
<td>York</td>
<td>0 %</td>
<td>+3 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

*Difference Range* | 0-1% | 0-4% | 0-3% |

* - % = Inventory is Lower than Rate Method  
+ % = Inventory is Higher than Rate Method
Things that are similar to MOBILE
HOUR fractions

- **Source:** Travel model, post processor, pattern data
- **Dynamic:** SHOULD change with model scenario / year
- **Post-processing of model outputs needed to transform volumes from 4 periods (typical) to hour volumes and fractions of daily VMT**

(Period Volumes can vary from run to run)

*Model Periods* → *24-Hour Pattern* → *Period Peak Spread*
**Vehicle Type distribution**

- **Dynamic:** Should change with model scenario/year
- **Source:** Travel model auto/truck/bus volumes

Vehicle type pattern data

<table>
<thead>
<tr>
<th>Model</th>
<th>HPMS Class</th>
<th>NJDOT Traffic Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td></td>
<td>1 Motorcycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class ID 1</td>
</tr>
<tr>
<td>Auto</td>
<td></td>
<td>2 Passenger Car</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class ID 2</td>
</tr>
<tr>
<td>Comml</td>
<td></td>
<td>3 Other 2 axle-4 tire vehicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class ID 3</td>
</tr>
<tr>
<td>Bus</td>
<td></td>
<td>4 Bus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class ID 4</td>
</tr>
<tr>
<td>Truck</td>
<td></td>
<td>5 Single Unit Truck</td>
</tr>
<tr>
<td>+ 6 + 7</td>
<td></td>
<td>Class ID 5</td>
</tr>
<tr>
<td>Truck</td>
<td></td>
<td>6 Combination Truck</td>
</tr>
<tr>
<td>+ 9 + 10 + 11 + 12 + 13</td>
<td></td>
<td>Class ID 8</td>
</tr>
</tbody>
</table>
Model-calculated speeds are insufficient for MOVES analysis

- Hourly distribution of speeds typically not available (period at best)
- Less opportunity for VMT adjustments
  - Daily/seasonal variation
  - HPMS VMT reconciliation
  - Off-model projects
- Model validation issues

Crucial variable in MOVES’ calculation of emissions

- Speed bin distribution (AVERAGE SPEED DISTRIBUTION file) is allocated according to VHT, not VMT

Some form of Post Processing is necessary:

- Simpler method:
  - Link-level aggregate analysis
- More robust method (PPSUITE)
  - Link and Intersection based
  - Toll plaza (ETC) analysis
  - Incident delays
ROAD TYPE DISTRIBUTION

- Fraction of **VMT** on each MOVES Road Type, by Source Type ID
- **Mapping Scheme Required**
  - Model Facility Type
  - Model Area Type
  - To Road Type
  - ROAD TYPE DISTRIBUTION fractions are computed on the fly, based on % of:
    - Calculated VMT on links
    - By facility type
    - By area types

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**Model Facility Type**

1) Freeway  
2) Expressway  
3) Principal Arterial Divided  
4) Principal Arterial Undivided  
5) Arterial Divided  
6) Arterial Undivided  
7) Minor Arterial  
8) Collectors / Local  
9) High-Speed Ramp  
10) Medium-Speed Ramp  
11) Low-Speed Ramp  
12) Centroid Connector

**Model Area Type**

1) CBD  
2) Urban  
3) Urban Fringe  
4) Suburban  
5) Exurban

**MOVES Road Type**

2) Urban Restricted  
3) Urban Unrestricted  
4) Rural Restricted  
5) Rural Unrestricted
Activity Data: RAMP FRACTION

- **Fraction of VHT driving on ramps vs. limited access roadways (“Restricted”)**

- **Two values only for entire domain:**
  - Rural Restricted Access
  - Urban Restricted Access

- **Calculated on the fly from model network facility types and travel times on ramp**
  - Post processing typically required
  - Most current models include ramp detail in network coding
  - Could reasonably be calculated once, given the level of abstraction
  - Scenario-specific calculation provides sensitivity to TIP ramp improvement projects
Age distributions are tabulated separately for each county
- Developed by county due to economic differences
- Based on NJMVC registration data, prepared by NJDEP

Distributions are prepared for one current (base) year and applied to future years without modification


**OTHER DATA**

- **Inspection / Maintenance Programs**
  - Single statewide program and file (NJ).
  - I/M is unique to each model year, so I/M files were prepared for each analysis year with model year sliding.

- **Fuel Supply and Programs**
  - Complex: 5 fuel mixes in each county due to the variety of suppliers and seasonal variants.
  - Changes in future years reflecting policies.

- **Meteorology**
  - Average temperature and average humidity for each hour, by month and across 10 years.
  - For NJ, data was obtained for 6 airports and 10 years from WeatherBank, Inc.
Speed & VMT Post Processing

PPSUITE Post Processing Software

Analysis

Patterns

Travel Model or Database

Off-Model Adjustments

PPNET Network Analysis

PPEVENT Incident Delay

Detailed Network Operations

MOBILE6

PREMOBILE PREMOVES Pre-processing

POSTMOBILE POSTMOVES Post-processing

MOVES

Emissions

Performance

System Performance

Emissions
Batch Processor Support

- Large number of runs suggests need for batch control and scripting
  - NJTPA = 845 runs per conformity determination (13 counties)
  - Error-free run setups are critical (MOVES input files including run specifications)
  - Replicable results

- CENTRAL process control software
  - Batch process controller and scripting tool
  - Fully integrated with PPSUITE and MOVES
SUMMARY

- Current version of MOVES (MOVES2010a) is performing well
- Run times are significantly decreased from earlier versions and appear manageable
- Be careful while choosing and preparing input data
  - Opportunity to “start over” with data
  - Setting up travel model outputs and links
  - Other Activity and Non-Activity sources
- Be organized and prepare well in advance
  - Data preparation
  - Data management
  - Staff training
  - Computer cluster
  - Software setups and support tools
- Contemplate some form of batch processing
- Allow ample time for the first Conformity Analysis runs
  - Conformity “dry run” several months before actual conformity runs
- Prepare staff training and quality control
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