MOVES Update and Workgroup Recommendations

Presentation to Mobile Source Technical Review Subcommittee

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MOVES

EPA

Outline

- **MOVES background & process**
  - **MO**tor **V**ehicle **E**missions **S**imulator
- **MOVES data and validation**
- **MOVES2014 Update**
- **MOVES2014 FACA review**

MOVES

EPA

EPA's Mobile Source Emission Models - Background

- **Used to support state implementation plans, transportation conformity, NEPA assessment, EPA regulations, etc.**
  - Some States & Regions need updated MOVES model by early 2014 in order to prepare their Ozone SIPs due in mid-2015
- **CAA requires EPA to review and (if necessary) revise emission factors at least every 3 years**
  - The goal is to employ the most up-to-date scientific data and processes as well as the most recent controlling regulations
- **EPA goes through a fully transparent review process with FACA culminating in peer review/publication and MSTRS**

An Open Process for Informing Users and Getting Feedback

- Through 2012/13, EPA reconvened FACA workgroup to review MOVES development
- Conducted peer-review of MOVES technical documents
- Together with DOT, provided 26 hands-on training events to almost 700 users since release of MOVES2010
- Provided over 2500 responses to user questions submitted via e-mail
- Held a 2-day MOVES workshop in Ann Arbor attended by 230 state and local agency staff and contractors
- Provided ongoing support to AQ and transportation agencies about using MOVES in SIP development and conformity
- Continued to work on model improvements based on user feedback from all of these sources

MOVES is a Rigorous Science-Based Tool

- **Emissions are built up from the "bottom-up"**
- **Emission rates are tied directly to the physical processes (and failures if appropriate) that create those emissions**
  - Linked to the activity and technology
  - E.g. VSP-based (Vehicle Specific Power) running emissions, permeation/vapor venting/leak processes for evap, etc
- **Model is data-driven, where emissions are empirically derived**
  - Testing programs are designed with modeling end-goal in mind
  - Reliance on peer reviewed literature
- **Data holes in the model are more easily filled**
- **Model results are validated using a variety of data**

Ongoing Process for Updating MOVES

- **Collect**
  - Data from new relevant research programs
  - User concerns, recommendations, suggestions
  - Problems, potential errors, inaccuracies
- **Analyze**
  - New data, determine appropriateness of inclusion into MOVES
  - Confirm issues and/or evaluate recommendations
- **Develop Code**
- **Prioritize**
  - Based upon impact to user, data accuracy, impact on results
- **Test Code, Document and Peer Review**
- **Release**
- **Validation**
- **Repeat!**

What Is In MOVES?

- **Pollutants**
  - HC, CO, NO_x, NH_3, SO_2, $PM_{10,2.5}$, GHG (CO_2, CH_4, N_2O), Toxics
  - Energy (total, petroleum, fossil)
- **Emission processes**
  - Running, Start, Extended Idle ("hoteling")
  - Evaporative
    - Permeation, Vapor Venting, Liquid Leaks
  - Refueling
    - Vapor loss, Spillage
  - Crankcase (running, start, and extended idle)
  - Tire Wear
  - Brake Wear

What Is In MOVES?

- **Vehicle classes ("source types")**
  - Motorcycle
  - Passenger Car, Passenger Truck (SUV etc.), Light Commercial Truck
  - Buses
    - Intercity, Transit, School
  - Heavy Trucks
    - Single Unit / Combination: Short Haul / Long Haul
    - Refuse Truck, Motorhome

What is in MOVES?

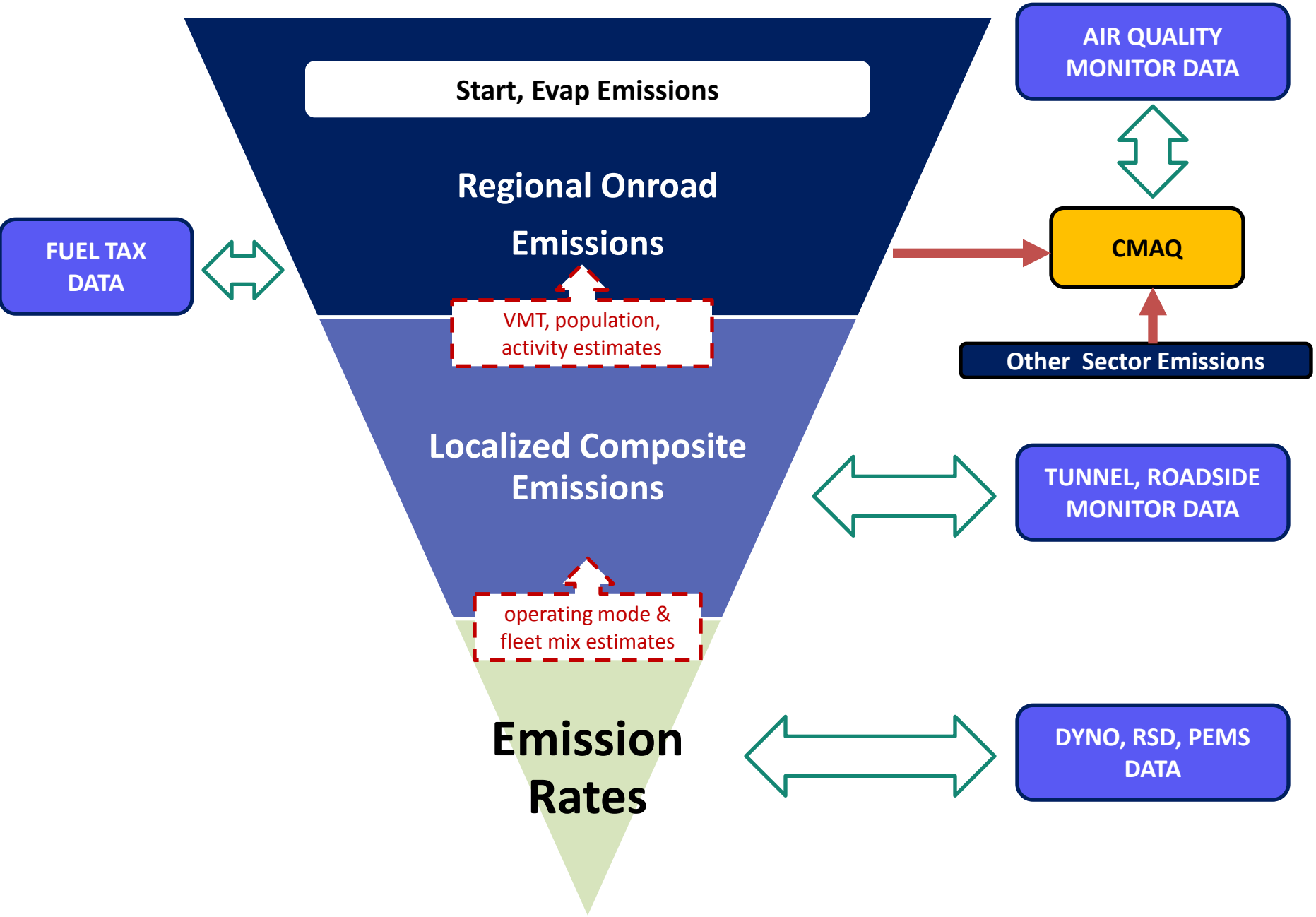
- **Four road types for running emissions:**
  - Rural Restricted Access (freeways and Interstates)
  - Rural Unrestricted Access
  - Urban Restricted Access (freeways and Interstates)
  - Urban Unrestricted Access
  - Database has drive patterns by road type and average speed
- **Separate road type called Off-Network**
  - Captures start, evaporative, and extended idle emissions
  - Database includes default start, idle, and parking activity information

Database is the “heart” of MOVES

- **State-of-the-art database methodology and coding**
- **MySQL database has over 100 tables that store:**
  - Emission rates
  - Fleet and activity data
  - Fuel and meteorology data
  - Conversion/adjustment factors
- **User can (and should) develop custom databases that replace defaults where local data are available**
- **All changes are table driven**
  - Even fundamental structural items, like vehicle classes, road types, emission rates, etc.
  - “Data Managers” allow easy customization of many variables

MOVES2010 Validation Was a Driver For Improvements

- **Ongoing validation has been an important element of MOVES design and implementation**
- **EPA's validation work on MOVES began with MOVES2004, focused on fuel consumption**
- **Validation of criteria pollutant version (MOVES2010a) has evaluated model performance using several methods**
  - Validation report in process
- **Goal is to inform improvements to MOVES2014, and identify data gaps**


Start, Evap Emissions
Regional Onroad Emissions
VMT, population, activity estimates
Localized Composite Emissions
operating mode & fleet mix estimates
Emission Rates
FUEL TAX DATA
AIR QUALITY MONITOR DATA
CMAQ
Other Sector Emissions
TUNNEL, ROADSIDE MONITOR DATA
DYNO, RSD, PEMS DATA

Overview of Validation Results

- **EPA has evaluated MOVES2010a predictions using several methodologies**
- **Emission rate comparison generally favorable, though areas where discrepancy was found were updated**
  - e.g. evaporative emissions
- **Tunnel comparisons show consistent trends**
- **Air quality model evaluations using MOVES show low bias, improved performance vs. MOBILE6**
- **Validation work is ongoing – helps define improvements for next version of MOVES and further research needs**

MOVES2014 Data Updates

- **New rules**
  - New regulations since MOVES2010b
- **New data**
  - New test programs and analyses
- **Data updates**
  - Future forecasts (VMT, population, sales)
- **Data bug fixes**

MOVES2014 Updates: New Rules

- **MOVES2014 will include**
  - Heavy Duty (HD) Greenhouse Gas MY 2014-2018
    - Decrease in heavy duty energy consumption rates
    - Decrease in criteria pollutant emissions as a result of improved aerodynamics and rolling resistance.
    - Increase in criteria emissions from auxiliary power units
  - Light Duty Greenhouse Gas MY 2017-2025
    - Decrease in light duty energy consumption rates
    - Decreased fuel consumption results in
      - Decrease in sulfur-related (SO2, SO4) emissions
      - Decreased refueling emissions
  - Tier 3 (MYs 2017-2025)
    - Changes to vehicle emission rates & fuels.

New Data, Analysis & Updates

- **Heavy Duty**
  - HD GHG rule
  - In-Use Compliance Program PEMS data
  - Houston Port Drayage Study
  - New CNG data
- **Light Duty**
  - LD GHG, LEVIII, Tier 3
  - Evaporative Emissions
    - Adding multi-day diurnals
    - Leak data from Colorado field study
    - Improvements to running loss emissions
    - Altitude effects
  - Cold Temperature
    - Test data on newer gasoline vehicles

New Data, Analysis & Updates (cont'd)

- **Fuel Effects**
  - Gasoline (EPAct) Analysis
  - Gasoline Sulfur Effects
  - E85
  - Fuel supply
- **Speciation**
  - Total Organic Gases (TOG), PM, Hazardous Air Pollutants
- **Activity**
  - Sales, population and VMT
  - Distribution of VMT and starts
    - Instrumented vehicle studies

MOVES2014 “Functional” Improvements

- **Improved evaporative emission processing (e.g. multi day diurnal)**
- **Incorporation of TOG and PM Speciation in MOVES**
  - TOG and PM species to be directly compatible with air quality models (CMAQ, CAMx) (i.e. no post-processing required)
  - Historically done by SMOKE
- **Addition of NONROAD model (Draft) into MOVES**
- **Better performance**
- **Improved documentation**
  - Upgraded technical documentation, user manuals, etc
- **Improved SMOKE-MOVES**

SMOKE-MOVES

- Processes emissions for air quality modeling
- Spatially allocates MOVES outputs into “grids”
- Maps MOVES emissions into chemical mechanism species
- Uses “representative” counties and lookup factors to make runs computationally feasible
- Shifts most mapping of chemical mechanism species from SMOKE to MOVES to improve accuracy by model year, fuel, and technology

MOVES Review Workgroup

- Created as part of the peer-review process to provide guidance to the MOVES development team
- Workgroup originally created and in service from April 2007 to October 2010
- Workgroup reconstituted in July 2012 to provide guidance to MOVES2014 development

Membership

- **Industry Trade Groups**
  - AAM, Global Automakers, AEM, API, EMA, MECA
- **Environmental Groups**
  - NRDC, Environmental Defense
- **State and Local Government**
  - NACAA, AASHTO, CARB, AMPO, CARB
- **Federal Government**
  - EPA, FHWA
- **Research Consortiums**
  - Coordinating Research Council, TRB
- **Academia**
  - UC Riverside, Georgia Tech, NC State, UC Berkeley, WVU

MOVES Review Workgroup Process

- From July 2012 – July 2013, EPA held six, ½ day meetings where proposed updates to MOVES was presented in detail, including underlying data and analyses as appropriate
- Meeting notes are taken and distributed
- Workgroup members coordinated within their organizations and with their constituents to solicit ***specific*** comments on EPA's proposals prior to the next meeting
- In addition, Workgroup developed ***general recommendations*** to the MSTRS based on proceedings of workgroup meetings

MOVES Review Workgroup – 2012/13

- **Meetings were conducted live and via webinar, open to public (typically had 20 – 30 non members participating)**
- **Some key topics covered**
  - MOVES Validation
  - MOVES2014 Plans and Directions
  - MOVES draft NONROAD Plans
  - HD GHG Rule Implementation
  - CNG Buses
  - Evaporative Emissions (Covered in two sessions)
  - Fuels – EPAct, E85, sulfur, Fuel Supplies
  - EPA Test programs
  - Activity Updates
  - Speciation into MOVES
  - SCC Revision Proposal

MOVES Review Workgroup – 2012/13

- **Comments/questions and responses documented in the meeting summaries posted on the MOVES FACA website**
- **Comment topics**
  - Testing for emissions in cold temperatures
  - Improving documentation e.g. mapping source type to source bins
  - Integrating NONROAD into MOVES
  - Understanding how temperature affects emission rates
  - Integrating academic testing results into MOVES
  - Improving activity data for NONROAD
  - Including devices such as block heaters in colder climates
  - Using state data 2011 EIS to improve MOVES default data

MOVES2014 Review Workgroup General Recommendations (1 of 2)

- **The overall updates and improvements of MOVES2014 are well founded and have significantly moved the model forward. The model continues to provide a good deal of flexibility for a variety of mobile source emissions modeling applications**
- **Validation is an important step in any kind of model development. With the time and resources available, the MOVES2014 team has done a reasonably good job of validating different parts of the model.**
  - ***EPA should consider more in-depth validation with new data sets coming on-line, such as the Tier-II PEMS dataset, and the California Air Resources Board datasets***
  - ***EPA should continue to seek out other datasets (those not used for model development) that can be used for further validation***
- **A long-term plan should be developed for future MOVES updates. The next version of MOVES should be planned now, identifying new features, components, and data (particularly emissions rate data) that can support the model.**

MOVES2014 Review Workgroup General Recommendations (2 of 2)

- **A diverse set of data is critical to any major model development. EPA should continue to:**
  - ***identify data gaps and prioritizing data collection efforts***
  - ***Seek out existing data sets that can be used for developing new features and for validation; sources would come from the private sector, academia, state research programs (e.g., CARB) and other sources***
  - ***Consider developing a data-sharing plan with other organizations (e.g., CARB, SCAQMD); as part of this effort, develop a consistent method of data organization***
  - ***Develop a plan for long-term data collection in critical areas where the MOVES model needs improvement. Examples would be to continue with large scale PEMS studies in multiple cities across the U.S. (e.g., Denver, Atlanta, etc.)***
- **Some data and model comparisons should be conducted by organizations outside of EPA (e.g., Coordinated Research Council)**
- **Continuous funding is critical for any major modeling effort; EPA should budget funds for an ongoing effort to identify areas for model improvement**

Further Information

- **Presentations made to the FACA MOVES Review Work Group (July 31, 2012 – July 9, 2013) available at:**

http://www.epa.gov/otaq/models/moves/faca.htm

- **Specific questions on model should be posted to the MOBILE inbox (mobile@epa.gov)**
- **Upon release, MOVES model and reports (including peer reviews) will be posted on MOVES website**

http://www.epa.gov/otaq/models/moves/

- **Information on SMOKE and SMOKE-MOVES:**

http://www.smoke.model.org/version3.1/html/Release_Notes_v31.html