MOVES Review Work Group Recommendations to MSTRS *Process Outline*

SEPTEMBER 14, 2021

What's the purpose of these recommendations?

We are a work group of the Mobile Source Technical Review Subcommittee (MSTRS), chartered to "work collaboratively" to provide input and "timely recommendations" to EPA via the MSTRS and the Clean Air Act Advisory Committee (CAAAC) on:

- Evaluating data sources and analysis methods proposed for use in developing **emission rates** to be used in the MOVES model.
- Evaluating data sources and analysis methods proposed for use in developing **fleet and activity inputs** to be used in the MOVES model.
- Evaluating data sources and analysis methods proposed for use in developing **emission adjustment factors** to be used in the MOVES model.
- Evaluating the format of MOVES **input and output structures** and the usefulness of these formats in meeting the needs of modelers developing State Implementation Plans (SIPs) and transportation conformity determinations.

CAAAC recommendations on MOVES can help establish MOVES team priorities for future work and can help direct EPA resources to specific modeling and data-collection efforts

What form will this take?

- We will deliver a report and a presentation for the MSTRS fall meeting on October 14, 2021
  - Will include information about workgroup membership and presentations
  - The core will be the workgroup recommendations
  - Similar format to MOVES2010 report
- Best if the recommendations are meaningful and actionable (SMART)
  - Specific
  - Measurable
  - Achievable -- with realistic assumptions about EPA budget and staffing
  - Relevant-- the rationale for each recommendation should be explained
  - Time-bound-- at least clarify if recommendation is short-term or long-term

Who are the recommendations from?

- While the MOVES Review Work Group meetings are open to the public --and we greatly benefit from the regular participation of many non-members-- the recommendations themselves will come from the **workgroup members**
- These members have been selected due to their expertise in modeling emissions from highway and nonroad vehicles and to represent a spectrum of stakeholders
  - Including vehicle and engine manufacturers, fuel producers, state and local emission modelers, academic researchers, environmental advocates, and affected federal agencies.

Recommendation Process

- Discuss potential recommendations-- **Today**
  - Informed, but not limited by, previous recommendations
  - **Megan** will share screen with notes on draft list during meeting
  - Raise hand in Teams to be recognized by **Sarah** or **Matt**
  - Members can also text suggestions to the chat
  - Please limit speaking to 3 minutes
  - We will pause occasionally to make sure we get comments from members participating only by phone
- Members send follow up suggestions via email by **COB Sept. 17**.
  - Email to co-chairs Beardsley.megan@epa.gov, barth@ucr.edu
  - CC mobile@epa.gov
- Chairs will compile a ballot and send to members
  - Members reply with **top three** recommendations by **Oct 1**
- Chairs compile top recommendations into a final report for MSTRS, share with workgroup members, and post on MRWG web page

Timing

Date	Action
Tuesday, September 14	Discuss process Discuss potential recommendations
Friday, September 17	Members send any additional thoughts on recommendations
Thursday, September 23	Co-chairs finish compiling recommendations
Friday, September 24	Ballots sent to work group members
Friday, October 1	Last date to return ballots
Wednesday, October 6	Co-chairs finalize presentation and report explaining recommendations to MSTRS
Thursday, October 14	Co-chairs present to MSTRS meeting
Later October	EPA posts presentation on MRWG website

Previous Recommendations

The following tables summarize the MRWG “long-term” recommendations to MSTRS from May 2017 and May 2018. The year in parentheses indicates the year of the recommendation to MSTRS.

The work group also presented “short-term” recommendations. These were mostly addressed with the release of the MOVES3 model in 2020. See supplemental slides.

Also, in response to a request sent to the group in April and repeated in August, we received written recommendations by email from:

- Gil Grodzinsky– Georgia Department of Natural Resources (representing AAPCA)
- Wei Zhang—Idaho Department of Environmental Quality (representing NACAA)
- Steven Vander Griend—Urban Air Initiative
- Chris Voigt—Virginia Department of Transportation (representing AASHTO)

Improve MOVES Current Capabilities with Updated Data & Analysis

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Update modeling of Heavy Duty Diesel vehicles in MOVES: • Activity – incorporate latest heavy-duty vehicle project data sets, modify operating modes, and add road grade (2017, 2018) • Emissions – update with latest real-world data, including tampering, malfunction, and mal-maintenance (2017,2018)
Invest in a robust data collection program to gather information on how vehicles are actually used, and associated emissions and emission control technology. (2017,2018) • Collect more data on light-duty & heavy-duty starts, including particulate matter and LD diesel. (2018) • Improve IM and non-IM rates (2018) • Make use of huge vehicle activity datasets that are becoming available (connected vehicle data, telematics) to improve driving cycles, starts activity and other defaults (2017, 2018)
More detailed handling of air conditioning usage. (2017) Update modeling of air conditioning impacts (2018)
Improved handling of road dust and brake and tire wear. (2017) Improve modeling of brake and tire wear (2018)
Update MOVES default fuel parameters and fuel effects, including ethanol effects in Tier 3 and GDI vehicles (2018)
Evaluate MOVES estimates with comparisons to real-world data. (2017) (2018)

Expand MOVES Capabilities by Collecting New Data and Adding New Features

Expand MOVES Capabilities by Collecting New Data and Adding New Features
• Improve handling of alternative fuels and technology (ethanol, natural gas, electric vehicles, hybrid electric vehicle), for both tailpipe and evaporative emissions. (2017) • Improve modeling of alternative fuels and technology (ethanol, biodiesel, natural gas, electric vehicles, hybrid electric vehicles, gas direct injection, flex fuels), for both tailpipe and evaporative emissions. (2018)
Better account for secondary organic aerosol (SOA)-precursors and ultra-fine particles (2018)
Account for role of lubricating oil with respect to particle emissions (2018)
Allow additional user inputs such as vehicle load or weight (2018)
Improve MOVES capabilities for project level analyses: • Consider incorporating a true modal emissions model (2017 & 2018) • Improve linkages with traffic models (2017 & 2018) • Limit modeling of road grades to realistic levels (2017 & 2018) • Continue improving the MOVES Ramp Tool, and create similar tools for acceleration and deceleration links for congested (arterial street) intersections (2018) • Consider adding libraries of vocational duty cycles (2018) • Make vehicle load a user input variable in MOVES (2018) • Add tools to help model project level activity, such as tools to calculate travel fraction by model year (2018)

Make MOVES Easier to Use

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Simplify MOVES Onroad Source Types: e.g., combine some source types, converge with FHWA vehicle types. (2017, 2018)
Provide explicit output of diesel particulate matter (2018)
Consider different interfaces for different uses (multiple graphical user interfaces). (2017, 2018)
Create a “Scenario Manager” to allow users to better manage modeling multiple runs, compare incremental results, and automate post-processing. (2017, 2018)
Establish better methods of interfacing MOVES to other models (SMOKE, etc.) (2018)
Incorporate new options for improving processing time: e.g., consider pre-calculating look-up tables for cities or regions. (2017, 2018))
Provide documentation on how MOVES can be used for Life-Cycle Emissions Analysis (2017, 2018)
Improve software installation and update processes, including providing test files that users can run to ensure that they have MOVES installed correctly and are generating valid results (2017, 2018)

Discussion Questions

Of the previous long-term recommendations, which are the most important to relay to MSTRS and CAAAC?

What additional recommendations are important?

- Raise hand in Teams to be recognized by **Sarah** or **Matt**
- Members can also text suggestions to the chat
- Please limit speaking to 3 minutes
- We will pause occasionally to make sure we get comments from members participating only by phone

Additional Information

Short-term Recommendations (1 of 2)

Recommendation	Status
Update MOVES-NONROAD portion of the model with better data and better documentation. (2017) Use the best data available to estimate nonroad equipment populations and technologies. (2018)	MOVES2014b (August 2018) improved emission estimates for nonroad mobile sources updating nonroad engine population growth indices (EPA-420-R-18-010); nonroad Tier 4 engine populations and rates (EPA-420-R-18-009) and speciation (EPA-420-R-18-011)); and sulfur levels of nonroad diesel fuels (EPA-420-R-18-008). These updates were carried into MOVES3. EPA is continuing to collect and analyze nonroad data for future model updates.
Simplify Ramps in MOVES (2017)	MOVES3 removed "ramps" as a separate road type. Ramp driving activity is now incorporated in rural and urban freeway driving. Ramps can still be modeled separately at Project Scale.
Update MOVES Onroad Population and Activity (2017)	MOVES3 updated historic and projected VMT based on 2019 Highway Statistics and Annual Energy Outlook (AEO). Updated vehicle age distributions. Updated default speed distributions.
Update Hotelling Hours in MOVES (2017)	MOVES3 updated HD hotelling assumptions (extended idling for diesel long-haul combination trucks at truck stops) based on new information.
Update Running Exhaust Criteria Pollutant Emission Rates for Model Year 2010+ Heavy-Duty Diesel Vehicles (2017)	MOVES3 updated the heavy-duty (HD) diesel running emission rates based on manufacturer-run in-use testing data from hundreds of HD trucks.
Update Emission Rates for Extended Idle and Auxiliary Power Units (2017)	MOVES3 updated HD diesel emission rates for extended idling and auxiliary power units.
Update Light-Duty Particulate Matter Emission Rates (2017)	MOVES3 included new data from GDI (Gasoline Direct Injection) vehicles, and updated PM temperature adjustments.

Short-term Recommendations (2 of 2)

Recommendation	Status
Incorporate Heavy-Duty Greenhouse Gas Phase 2 in MOVES (2017)	MOVES3 incorporated the effects of the HD GHG Phase 2 rule.
Incorporate additional data on LD & HD starts, including GDI PM and LD diesel (CARB data, etc.) (2018)	MOVES3 includes a number of updates for start emissions: • updated particulate matter (PM) rates for starts based on data gasoline direct injection (GDI) vehicles. • updated heavy-duty (HD) diesel start rates for hydocarbon (THC), carbon monoxide (CO), oxides of nitrogen (NOx) and PM. • because there are relatively few light-duty (LD) diesel vehicles, MOVES3 did not update LD diesel start rates based on data from LD diesel vehicles; instead these rates were set equal to the rates for LD gasoline vehicles. • included updates to start activity based on instrumented vehicle data, and updates to start emission adjustments based on time parked before the start ("soak" time).
Add more options for CNG vehicles. (2018)	MOVES3 allows modeling of CNG fuel for most HD source types: school buses, transit buses, other buses, refuse trucks, short-haul single-unit trucks, long-haul single-unit trucks, and short-haul combination trucks.
Maximize use of emerging telematics data wherever possible. (2018)	MOVES3 used LD and HD telematics data to estimate activity for vehicle speed distributions, start activity, and idle time.
Reconsider how to handle Fixed Mass Factors for different model year groups. (Having different values for different MY groups is confusing.) (2018)	In MOVES3, the Fixed Mass Factors (fscale) used in the MOVES calculation of Scaled Tractive Power (STP) for HD vehicles were updated for model years (MY) 2010-and-later.
Use certification data to decide how to model pre-MY2010 particulate matter from HD vehicles (to address concern about using MY 2010+ data for pre-MY2010 emission rates). (2018)	EPA certification data was used to develop PM emission rates for HD diesel MY2006-2009. PM emission rates for earlier HD diesel vehicles are based on data from the CRC E-55/59 research program

Recommendations received by email

In response to a request sent to the group in April and repeated in August, we received written recommendations by email from:

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- Wei Zhang—Idaho Department of Environmental Quality (representing NACAA)
- Steven Vander Griend—Urban Air Initiative
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From Gil Grodzinsky (1 of 3)

Hi all: Matt Barth sent these questions to help for next MRWG meeting. I have compiled some thoughts. As I continue to use MOVES I might have some more but likely I have the major stuff covered so sending now..
What is working well in MOVES3?
1.MOVES3 runs much quicker.
2.Installation was routine, in some ways easier than MOVES2014b.
3.MariaDB is easy to learn and use. There are a few variations but can work around them.
4.It now contains the best update on fuels, especially for Atlanta area (as requested from our state agency, GA EPD).
5.Better treatment of extended idling.
6.Option to add fuel other than diesel and gasoline for heavy duty vehicles besides transit buses will be useful for future work (e.g., NEI) as it is more realistic.
7.With new system where all the panels of the GUI need to be checked to access the input county database (everything else is green checked) along with the input county database manager as well, once you get to run MOVES you have a better chance of success and less hidden errors because of the checks and balance.
8.Seems to better treat regular idling. When making emission factor tables for general behavior I will need to remember there are running emissions in road type 1. For air quality studies of road ways and intersections I will not include it any of roadtype 1 in final analysis.
9.Positive but comment: I think github is a way to be updated on new information versus constantly updating user manuals or guidance documents. However it will be good too to have some manual/guidance documents which seem to be coming soon I think. So the best of both worlds. The git hub is great for experienced users. Thanks for making it.

What is working not-so-well?
1. Very little especially after patch.
2.Realize the reason for this but still considered extra work versus MOVES2014: A little more work to use total starts per day inputs since have to split it by vehicle type unlike before with MOVES2014 you could just provide total starts per day (all vehicles). I used MOVES3 default starts per day per vehicle by vehicle type database to split our total startsperday into total startsperday by vehicle type.
3.Other was related to changes in NOx due to model change. Had to do my own studies to pinpoint the exact culprit of the NOx increases in urban areas with much of VMT from local roads and an abundance of large freight trucks (“long” and “short” haul combination trucks).
4.I do miss custom domain for a few applications but found a way around it. I am probably the only person who feels this way about it though! I also used the check off/on forward progress although don’t miss that one. Again you can easily work around it by running an early year and get same results. Sounds like won’t ever be able to run MOVES with and without certain rules and regulations although that would have been neat.

From Gil Grodzinsky (2 of 3)

What improvements would be most useful for future models?
1.Keep an eye on new regulations and possible removal of some provisions particularly with the SAFE rule. If that is not implemented, MOVES needs to updated with it. If a new rule implements a clean truck initiative with fleets replacing old trucks with new ones it should be accounted for as combination trucks have become the dominant source of NOx pollutant in the future. Why? Model would be overestimating emissions in reality.
2.Maybe adjusting the vehicle types to better match the way they can be identified via telemetrics and/or FHWA counters while keeping integrity of categorizing vehicles by emission factors based on driving behavior or "drive cycle".
3.Already happening, but…: Improvement to the nonroad model with better input data for better estimates of emissions with this elusive sector. Right now a lot of surrogates are used.
4.A way to more explicitly handle cheating and aftermarket bypassing of controls.
5.If there was a way to tweak MOVES to make SMOKE-MOVES easier for states to run by adding a module. We are trying an inventory MOVES approach, but maybe there is something that could be done to simplify SMOKE-MOVES within MOVES basic functioning.
6.While greatly improved in my experience, as new MOVES versions come out for various reasons, always strive to make MOVES run more quickly

What data is available to support recommended changes?
1.The EPA in the publication of new rules/regulations will identify any data supporting their decision and that would support any action regarding the MOVES model.
2.FHWA vehicle type categories, weight categories, telemetric data/FHWA counter data can be made available.
3.Emissions control requirements (like Tier 3 engine and fuel requirements and limits) and how the controls requirements are different by different vehicle types. Comparing all these vehicle splits with MOVES current vehicle splits.
4.Various reports on emissions being many times higher with emission controls bypassed, removed, or circumvented/cheated through software
5.SMOKE-MOVES: Various reports on how difficult it is to run and how few states can and desires to making it easier so all states could run the methodology.
6.Nonroad: EPA and MOVES Review Group is already aware of the issue.

General comment: MOVES in general has been great at helping us identify high priorities for targeting key mobile transportation sources of pollutants like NOx. For instance we need to look at combination trucks and how to prevent low speeds on our urban roads and replace/install systems to get emission controls to work and stay warmed up when operating at low speeds. Also for PM we have to look at reducing tire wear and brake wear as models show these sources dominating the emissions inventory in the future. Lastly non road sources become a larger part of the inventory in the future.

These comments are based on MOVES3. Just starting with MOVES3.0.1 but these comments designed to be MOVES3 version agnostic. Thanks for fixing non road issue and having QA inventory test tool within MOVES looks great.

From Gil Grodzinsky (3 of 3)

Hi Matt and Megan:

I had a few recommendations/additional thoughts, one that is likely thought about by many already:

MOVES and shifting policies: MOVES will likely have to be updated for the upcoming mid-term LD GHG rule for MY 2023-2026. It would be an interesting discussion in September regarding the shifting sands of policies and how MOVES has to keep up with it.

I still think it would be nice in future MOVES, maybe long term, to have some vehicle types merged as the benefits of the splits might be outweighed by the efforts to delineate between types accurately. This was already listed as a possible recommendation, but reiterating that it is still relevant today. The use of “other buses” was a good idea vs. “intercity” with MOVES3. It is how R.L. Polk really did so our input data actually matches better now.

I think it would be neat to be able to run MOVES for more than “weekday” and “weekend” as traffic varies quite a bit from day to day (Friday is much different than Monday and Saturday from Sunday). However, I realize that adds a lot of complexity.

I would inquire on MariaDB and any improvements that people think for the tool specifically. A lot of people are opting for MySQL Workbench so was wondering. For me I have issues sometimes with extracting all that I need into a csv file, but I think at this point it is just something new and I keep figure it out if I have any issues due to lack of experience.

That is all I can think of at this point. If I think of anything else I will let you know and honestly, what I have listed probably isn’t all that new which is good news as you all seem to have the bases covered.

From Wei Zhang

Good improvement:

The installation process is cleaner and easier

The GUI is cleaner

Incorporated a lot of newer data set into the model

Need to improve:

The speed of model run

Suggestion on a new tool:

Currently the user can export county level MOVES default inputs through GUI but it is one category of input files at a time. I am wondering if MOVES can have a tool to export all MOVES default inputs files for one particular county in one shot.

From Steven Vander Griend

We have engaged our consultant to run the MOVES3 model and have several issues we would like to present on. Here are some of the key issues we found in MOVES3.

The fuel defaults for E10 do not represent real world fuel properties. In fact, 3 states have fuel parameters that are not even allowable in market fuels.

The Fuel Wizard makes some interesting changes to E200 based on T50. Changing E200 but not T50 in the fuel properties makes several emission calculations that are erroneous and this should raise questions since emissions modeling was never based on E200, just T50.

EPA has two very large vehicle studies showing E10 lowering NOx emissions compared to E0 yet if the fuel properties are entered into the MOVES3 model, NOx emissions are increased with E10.

Comparing E15 to E10 shows reduced tailpipe VOC's but evaporative emissions still increase, even with E15 having lower RVP.

Reducing aromatics in the fuel should lower aromatic emissions like toluene and Xylene. Some toxic emissions are based on total VOC emission rates and not changes to fuel properties.

We would like to present our results of MOVES3 emission results to the MOVES Review Group when time allows.

From Chris Voigt

Attached is a copy of the presentation on project-level analysis needs to the MRWG in October 2019, with copies of key slides below. Please consider recommendations that have not already been implemented for future MOVES3 updates, and in particular:

- 1a - Develop & implement as needed an "Interim Policy on Limitations on Applications for MOVES for Higher Road Grades." Provide supporting charts showing the road grades for each pollutant, facility type etc. for which the model may be applied. Provide a statement on limitations in emission modeling and potential uncertainties that state DOTs can include in NEPA documentation for purposes of transparency and disclosure.
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- 1b -Validate MOVES emission factors (EFs) for higher road grades and speeds, covering the range of road grades typically expected in practice, and at a minimum those specified in the AASHTO Green Book by road type. Provide supporting charts with the final documentation showing the road grades for each pollutant, facility type etc. for which the model may be applied and provide text explaining how and why the curves vary with each chart. Priority: PM2.5, PM10, CO and MSATs.
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- Note: This is directly related to one of the existing long-term recommendations for MOVES (in the attached file "MRWG presentations and past recommendations") that should also be a top priority, namely to "*Evaluate MOVES estimates with comparisons to real-world data. (2017) (2018)*"
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- 2 - Adjust project-level EFs based on mileage accumulation rates (MARs), as already done for regional modeling. Priorities: PM2.5, PM10 and CO, then other project-level pollutants.
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- 4 (modified) - Consider the creation of a pooled fund to work with state DOTs and FHWA on assessing uncertainty for the entire project-level modeling chain. Both EPA emission modeling and dispersion modeling staff would need to be involved.

October 2019 MRWG Presentation on Project-Level Analyses:

https://www.epa.gov/moves/october-2019-moves-model-review-work-group-meeting-materials