Mobile Sources Technical Review Subcommittee (MSTRS) MOVES Review Work Group: Meeting Summary

October 9, 2019
U.S. EPA Office of Transportation & Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105

Welcome from the Chairs

Dr. Matt Barth and Ms. Megan Beardsley welcomed the Clean Air Act Advisory Committee (CAAAC), Mobile Sources Technical Review Subcommittee (MSTRS) MOVES Review Work Group to the meeting. Ms. Beardsley presented the meeting agenda (see Table 1).

Table 1. MOVES Review Work Group Meeting Agenda:
October 9, 2019 (1 pm to 3 pm)

Topic
Welcome from the Chairs
Member Roll Call
General Announcements
Presentations: • Megan Beardsley (EPA): MOVES Update: Excerpts from the EPA International Emissions Inventory Conference • Christopher Voigt (Virginia Department of Transportation): Project-level analyses • Prof. Matthew Barth (University of California, Riverside): Adapting MOVES to better model autonomous and connected vehicles • Prof. Randall Guensler (Georgia Institute of Technology): MOVES-Matrix system for storing MOVES rates in a large look-up matrix
Future Meetings/Wrap-up

Member Roll Call

Ms. Beardsley conducted a Work Group member roll call. A list of Work Group members and others in attendance is presented in an Attachment to these meeting minutes.

General Announcements

Dr. Sarah Roberts made general announcements regarding meeting procedures, including how participants should signal when they had questions (i.e., by using the raised hand feature in Skype). Dr. Roberts stated that the meeting minutes will be submitted to the Work Group members for review before posting to the website and that any additional questions about the technical content of today's presentations should be sent to her at her e-mail address: Roberts.sarah@epa.gov.

Presentation: MOVES Update: Excerpts from the IEIC – Presented by Megan Beardsley, U.S. EPA

Ms. Beardsley presented excerpts from three onroad and nonroad presentations made by EPA staff at the International Emission Inventory Conference (IEIC) that was held July 29 – August 2, 2019. From the presentation, "Planned Updates to EPA MOVES Emission Model for Heavy Duty Onroad Vehicles," presented by Jaehoon Han et al., Ms. Beardsley noted that the preliminary estimates of the impact of the planned MOVES updates on heavy-duty emissions of NOx and PM2.5 is an overall decrease in emission estimates for calendar years (CYs) 2015 and 2020, with very little change for CY 2010. In addition, compared to MOVES2014b, the updates are likely to result in a significant increase in the estimate of HD running emissions of NOx from MY 2010+ vehicles, a significant decrease in HD extended idle emissions of NOx, an increase in running emissions of NOx due to gliders, the addition of new "off network idle" emissions, and a decrease HD running emissions of PM from MY 2010+ vehicles. From the presentation, "Advancing Nonroad Model Development through Data Partnerships," presented by Sarah Roberts et al., Dr. Roberts mentioned that the EPA will be collaborating with state and local agencies, academic institutions, and private fleets to obtain additional nonroad data. As partners, they will be working together to gather data, develop data and testing procedures and protocols, develop new sampling methodologies, test/develop measurement equipment and perform modeling. From the "Developing Updated Activity Inputs for Nonroad Equipment," presentation by James Warila and Kathryn Dotzel, Dr. Roberts pointed out that the EPA is planning to evaluate equipment activity for selected nonroad diesel equipment, including wheel loaders, skid-steer loaders, excavators, agricultural tractors and combines. She also noted that activity varies by region, equipment type and equipment size, and that it is too early to determine the potential impacts of this activity update on the emissions inventory.

Discussion

There were no comments or questions.

Presentation: Project-Level Analyses – Presented by Christopher Voigt, Virginia Department of Transportation, Vice-Chair, AASHTO CES Air Quality, Climate Change and Energy Subcommittee

Mr. Voigt began with an overview of key regulatory project-level modeling requirements and priorities for state DOTs, identifying PM$_{2.5}$ as the highest priority for state DOTs for emission and dispersion model improvements given typically small margins in project-level analyses between background concentrations and the annual NAAQS for this pollutant that place a premium on model accuracy.

After reviewing 2011 AASHTO Green Book guidance on road grades (noting an update has recently been issued) and how it provided a preliminary basis for determining an appropriate range of road grades to test for highway projects, he presented MOVES2014a modeling results for fleet average emission factors for 2020 by road grade for both urban unrestricted and urban restricted access facilities, for speeds from 5 to 75 mph in 5 mph increments, and for running emissions only. He noted the modeling results were relatively similar between urban and rural facilities, and would only be presenting results therefore for urban. For reference, he began with results for CO2E, which were generally good but showed some anomalous behavior at higher road grades, which differed to some extent for urban restricted and unrestricted access facilities. He noted similar results, which are included in the trailer to the presentation, were obtained for NOx and VOC.

He then presented fleet average emission factors for PM2.5 (total running exhaust and crankcase running exhaust), which showed much more anomalous behavior at high road grades, and differed substantially between urban restricted and unrestricted access facilities. He noted similar results (included in the trailer to the presentation) were obtained for CO. He contrasted results for PM2.5 for gasoline and diesel-powered vehicles, showing that the anomalous behavior of the emission factor curves at higher road grades was much more pronounced for gasoline than diesel-powered vehicles, although both were affected, with the curves for gasoline-powered vehicles for restricted access facilities differing to a significant degree from those for unrestricted access facilities. He noted modeling results by source type (not presented) for passenger cars versus combination long-haul trucks were similar to the curves for gasoline versus diesel-powered vehicles.

He raised a number of questions, including importantly what subset of the curves for PM2.5 (at lower road grades and speeds) should be considered reliable for use in regulatory project-level modeling, given the anomalous modeling results for higher road grades and speeds. Mr. Voigt then made recommendations for project-level improvements for MOVES, ranking them from critical to medium-high priority and noting that additional (lower-priority) recommendations were provided in the trailer to the presentation.

The critical priority recommendations included: (#1a) develop & implement an "*Interim Policy on Limitations on Applications for MOVES for Higher Road Grades*" with supporting charts by pollutant, facility type, etc. as well as a statement on limitations in emission modeling and potential uncertainties that state DOTs can include in NEPA documentation for purposes of transparency and disclosure; and (#1b) validate MOVES emission factors (EFs) for higher road grades and speeds, covering the full range of road grades expected in practice and at a minimum those specified in the AASHTO Green Book, with priorities for PM2.5, PM10, CO and MSATs. He noted the interim policy could be implemented in the near-term, while updates to MOVES road grades would be in the medium- to long-term.

High priority recommendations included: (#2) adjust project-level EFs based on mileage accumulation rates, which MOVES does already for regional analyses. For streamlining, recommended improvements that could be implemented in the near term as new research would not be needed (only coding changes): (#3a) provide check boxes for all MOVES inputs for which defaults are available; (#3b) provide check boxes for selecting running emissions; and (#3c) provide check boxes for selecting Federal Highway Administration (FHWA)-specified mobile source air toxics (MSATs) and processes (running emissions only). Research studies were recommended (#4) to prioritize inputs that contribute most cost-effectively to accuracy and reductions in uncertainty, and (separately) to address the 2007 NRC report (Models in Environmental Regulatory Decision-Making) recommendation to assess & communicate uncertainty, Recommendation #5 was continue consultation with departments of transportation and their consultants on needed model improvements, including placing a priority on project-level modeling needs. As medium-high priorities, recommendation #6 was to review and implement as appropriate the recommendations of NCHRP Research Report 909 (on truck activity), and #7 was to converge MOVES source types with the FHWA highway performance monitoring system (HPMS) vehicle types.

Discussion

Dr. Barth commented that the road grade effects shown here have been seen before, and he agrees that a sensitivity analysis should be done. He also noted that there are concerns about high speeds, and California is working to get additional data for high speed emission effects for the 85-95 miles per hour range for input into the EMFAC model. He mentioned that it may be possible to use that data for MOVES also.

Presentation: Enhancing MOVES for Connected and Automated Vehicle Analysis – Presented by Matt Barth, University of California, Riverside

Dr. Barth began by remarking that transportation is undergoing four major revolutions – shared mobility, electrification, connectivity and automation. Transportation emissions inventories are based on emission factors, vehicle activity and fleet composition, and these transportation revolutions will have an impact on each of these inventory development components. For instance, these revolutions could reduce congestion and stop-and-go driving, and platooning may reduce aerodynamic drag. These changes would need to be reflected through updated emission factors and vehicle activity data. In a recently conducted MOVES sensitivity analysis, it was found that MOVES under-predicted the beneficial effects of connected and automated driving on emissions. However, developing sub-bins of the current MOVES bins for vehicle operation mode (op mode) and emission factors reduced the under-prediction of emissions with MOVES. Dr. Barth recommended that sub-bins could be incorporated in MOVES to preserve the traffic smoothing effects associated with the four revolutions that tend to get washed out with the larger bins. Alternatively, a bin-pyramid approach could be used that would use different bin resolutions, depending on the goal of the modeling exercise being performed. He also suggested that a complementary physical modal or instantaneous emission model could be adopted to improve the modeled emission estimates for connected and automated vehicles.

Discussion

In response to a question about whether operating mode is an input in project mode, Dr. Barth and Ms. Beardsley replied that yes, op mode can be an input.

Dr. Gurdas Sandhu asked whether the calibration process for MOVES was performed for each vehicle. Dr. Barth explained that the calibration was done for one vehicle, a Nissan Altima, and then the emission factor for that vehicle was used for all vehicles of that type, and the calibration was based on the average of the actual data.

Dr. Sandhu suggested that MOVES is built more for the fleet average, so it would be better to get three Nissan Altimas to determine if there is between-car variation. He mentioned that there could be more variation between cars than the variation of the model. He also suggested that the calibrated data could be tried on a different car to determine how they compare. Dr. Barth responded that the primary goal of the research was to see if bin size had an effect on the emission estimates while the other factors were held steady. He agreed that it would be best to test more vehicles and get fleet averages.

Dr. Sandhu stated that there is little data available for the higher number bins and remarked that there could be differences seen if comparing data for the higher number bins that have fewer data points.

Dr. Randy Guensler asked if Dr. Barth planned to investigate the sub-bins for different applications. Dr. Barth replied that he did plan to try to optimize the sub-bins, and the resulting sub-bin sizes may not be linear.

Presentation: Integrating Models at Multiple Scales for Transportation Energy and Emissions Assessment – Presented by Randall Guensler, Georgia Institute of Technology

Dr. Guensler began by noting that traditional MOVES modeling of complicated and dynamic networks is time consuming and requires the generation of many link emission rates, which leads many users to generate lookup tables to support modeling. A goal of a study by Georgia Tech was to pre-run MOVES for all combinations of input data and compile emission rates into a multi-dimensional matrix. So far, they have completed over a million MOVES runs, and from these results, they have generated regional matrices of emission rates. For a given region, sub-matrices were built for each calendar year, fuel type, inspection/maintenance program, and meteorology. These matrices include emissions rates based on source type, model year, and speed/vehicle specific power operating mode bin. When tested, the use of a matrix has been shown to provide the same results as the standard MOVES model. Dr. Guensler states that the development and use of the matrices provides tremendous flexibility for use in scenario analysis, such as regional travel demand models, corridor/scenario analysis, microscale pollutant dispersion models, and other applications. He also noted that the matrices can be applied at any spatial and temporal scale, but he cautioned that the matrices are very large, and the use of Python scripts are required.

Discussion

Mr. Debbie Wilson and Dale Wells asked whether MOVES would need to be re-run to develop new matrices every time a new version is released or when the age distribution or vehicle mix changes. Dr. Guensler replied that yes, it would need to be re-run.

Mr. Mark Janssen asked how many person hours and how much money it took to do this study. Mr. Guensler responded that about $500,000 total was spent, or about $300,000 per year, and graduate students did a lot of the work for the study.

Dr. Sandhu asked that for any factors that go on the right side of the matrix, would it be possible to re-run the model for only the part that has changed. Dr. Guensler answered that it was possible, as it would only be necessary to know which equations would be impacted and re-run that part of the model. Dr. Sandhu asked whether temperature effects would be an example of a variable change that would not require a total model re-run. Dr. Guensler replied that yes, that would be an example, but for something like temperature effects, it would be easier to compare metrics and adjust the results to match the change made.

Ms. Beardsley asked what the interactions would be between the changes made and bin size and other factors. Dr. Guensler noted that the advantages of binning are that it would be possible to answer policy questions with less effort, but the model user would need to be sure that there is enough data available to sufficiently answer the question. In some instances, more data may need to be collected, and the MOVES model would be the convergence between the data and answering the policy question at hand.

Wrap-Up

In closing, Ms. Beardsley informed the meeting attendees that the next meeting date has not been scheduled yet, but the EPA will send out an email when more information is known. Dr. Roberts also noted that anyone interested in presenting at the next meeting should submit an abstract and title to her by email.

Ms. Beardsley thanked the meeting attendees for their participation.

A list of participants is provided as an attachment to this summary. This list is based on the participants who attended the meeting in person and the participants who joined the conference call as archived by the conference call software, which may not include every person attending the conference call. Copies of the presentations given during this meeting will be available at https://www.epa.gov/moves/moves-model-review-work-group.

Attachment – Work Group Meeting Attendance List

October 2019 MOVES Review Work Group Attendees

Name	Home Organization	Representing Organization
Giedrius Ambrozaitis	Alliance of Automobile Manufacturers	Alliance of Automobile Manufacturers
Matt Barth	University of California, Riverside (CE-CERT)	University of California, Riverside (CE-CERT), Work Group Co-chair
Megan Beardsley	U.S. Environmental Protection Agency (EPA)	EPA; Work Group Co-Chair
Britt Holmen	University of Vermont	University of Vermont
Joe Jakuta	Ozone Transport Commission (OTC)	Ozone Transport Commission (OTC)
Mark Janssen	Lake Michigan Air Directors Consortium (LADCO)	Lake Michigan Air Directors Consortium (LADCO)
Chris Kite	Texas Commission on Environmental Quality	Association of Air Pollution Control Agencies (AAPCA)
Lubna Shoaib	East-West Gateway Council of Governments	Association of Metropolitan Planning Organizations (AMPO)
Chris Voigt	Virginia Department of Transportation	Amer. Assoc. of State Highway and Transportation Officials (AASHTO)
Dale Wells	Colorado Department of Public Health and Environment	National Association of Clean Air Agencies (NACAA)

October 2019 MOVES Review Non-Work Group Attendees

Name	Organization	Representing Organization
Jiayi An	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Sudheer Ballare	U.S. Environmental Protection Agency/ORISE	U.S. Environmental Protection Agency/ORISE
Laura Berry	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Andrew Bollman	North Carolina Division of Air Quality	North Carolina Division of Air Quality
Marty Boardman	Texas A&M Transportation Institute	Texas A&M Transportation Institute
Andy Burnham	Argonne National Laboratory	Argonne National Laboratory
Weston Carloss	Colorado Department of Public Health and Environment	Colorado Department of Public Health and Environment
David Choi	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Angela Cullen	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
David D'Onofrio	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Alison Eyth	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Michael Gerhardt	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Janice Godfrey	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Randy Guensler	Georgia Institute of Technology (Georgia Tech)	Georgia Institute of Technology (Georgia Tech)
Jaehoon Han	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Joey Huang	North Carolina Department of Environmental Quality	North Carolina Department of Environmental Quality
Noh Hyunsoo	Pima Association of Governments	Pima Association of Governments
David Kall	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Natalie Liljenwall	Oregon Department of Transportation	Oregon Department of Transportation
Tom Malamakal	Washington Department of Ecology	Washington Department of Ecology
Tiffany Mo	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Evan Murray	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Todd Pasley	North Carolina Division of Air Quality	North Carolina Division of Air Quality
Sarah Roberts	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Gurdas Sandhu	U.S. Environmental Protection Agency/ORISE	U.S. Environmental Protection Agency/ORISE
Jolyon Shelton	Delaware Dept. of Natural Resources and Environmental Control	National Association of Clean Air Agencies (NACAA)
Kira Shonkwiler	Colorado Department of Public Health and Environment	Colorado Department of Public Health and Environment
James Smith	Tennessee Department of Environment and Conservation	Tennessee Department of Environment and Conservation

October 2019 MOVES Review Non-Work Group Attendees

Name	Organization	Representing Organization
Darrell Sonntag	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Lesley Stobert	SC&A, Inc.	EPA Contractor
Brian Sullins	Alabama Department of Environmental Management	Alabama Department of Environmental Management
Naima Swisz-Hall	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Claudia Toro	U.S. Environmental Protection Agency/ORISE	U.S. Environmental Protection Agency/ORISE
Benjamin VanGessel	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
James Warila	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency
Debbie Wilson	Mid-Atlantic Air Management Association (MARAMA)	Mid-Atlantic Air Management Association (MARAMA)