

Federal Advisory Committee Act
Clean Air Act Advisory Committee

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

December 6, 2017
U.S. EPA Office of Transportation & Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105

Welcome from the Chairs

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

**Table 1. MOVES Review Work Group Meeting Agenda:
December 6, 2017 (1 pm to 4 pm)**

Topic
Welcome from the Chairs
General Announcements
Member Roll Call
Presentations: <ul style="list-style-type: none">• Update of Engine Categories, Emission Rates, and Speciation Profiles for Tier-4 Nonroad Compression Ignition Engines• Draft Tool to Model Ramps in Project Scale• Recommended Updates to MOVES Heavy-Duty Source Masses Using VTRIS Data• Recommended Updates to MY 2010+ Heavy-Duty Vehicles: Fixed Mass Factor and Diesel Particulate Matter Rates• Coordinating Research Council 2017 and 2018 MOVES related Projects
Future Meetings/Wrap-up

General Announcements

Dr. 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 Adobe Connect). 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 by January 17, 2018 at her e-mail address: Roberts.sarah@epa.gov.

Member Roll Call

After the general announcements were made, Ms. Beardsley conducted a Work Group member roll call. A list of Work Group members in attendance is presented in an Attachment to these meeting minutes.

Presentation: Update of Engine Categories, Emission Rates and Speciation Profiles for Tier-4 Nonroad Compression Ignition Engines – Jaehoon Han and Darrell Sonntag

Dr. Han began by reviewing the emission standards for Tier 1 through Tier 4 engines, noting that for Tier 4, emission rates vary depending on the compliance technology used. In MOVES2014a, engine technology categories (ETCs) for nonroad compression ignition (NRCI) equipment were not differentiated by control technology. The EPA is updating the ETCs for Tier 4 considering the control technology used, based primarily on the EPA engine certification database. The EPA is recommending eight Tier 4 ETCs, based on whether the engine is in compliance with the Transitional (Interim) or Final Tier 4 standards and whether diesel particulate filters (DPF) or selective catalytic reduction (SCR) technology, or a combination of both technologies, is used. Using the engine certification database (VERIFY), fractions of the engine population in each of the eight ETCs were developed. Dr. Han presented several charts showing the population fraction in each category by model year and for different engine horsepower ranges. Dr. Han noted that there is an exemption in the rules that allows equipment manufacturers to delay installing Tier 4- compliant engines for up to seven years, and the population of engines in this exemption needs to be accounted for in the total engine population. The EPA is currently analyzing this population using a database developed from manufacturer reports. The EPA has also developed recommended emission factors for NO_x, PM, and non-methane hydrocarbons (NMHC) for each ETC. Dr. Han presented several charts showing these emissions factors for different horsepower ranges. The EPA is also recommending an update to the speciation of toxics for Tier 4 engines based on control technology used.

Discussion

Ms. Julie McDill asked whether this update would address engine activity or just the number of engines in the population. Dr. Han responded that the goal has been to get the population fraction in each category right based on the population and fraction in use, and that the activity of each engine type should be reflected in those categories.

Ms. McDill requested clarification about whether this update was designed to get the emission factors correct for Tier 4 after the EPA had decided what Tier 4 categories there should be. Dr. Han replied that this is correct.

Ms. McDill referred to a note in the presentation stating that stationary engines were excluded from the certification data set and asked how mobile engines were defined. Dr. Han clarified that they use the legal definition for mobile engines, which states that an engine needs to be moved at least once per year to be considered “mobile”, and if they are not moved at least that often, they

are considered stationary engines. Since MOVES only addresses mobile engines, engines that are considered to be stationary are excluded from the mobile engine population.

Mr. Dale Wells asked whether any real-world data had been used to check or verify the accuracy of the certification data. Dr. Han responded that the EPA just received the certification data, and this is the best and only available data at this time. He stated that the EPA would consider using further data, including real-world data, if it becomes available.

Mr. Jeremy Heiken noted that this update is a wonderful improvement to the model. He commented that there would likely be new catalyst technology used for Tier 4 engines and that extrapolating the toxics fraction for Tier 4 from the Tier 2 engine technologies may not provide a realistic profile of toxics. He also noted that SCR warm-up takes time, and emissions during this warm-up period are not fully controlled. He asked whether the EPA had investigated emissions during this warm-up period for the purposes of MOVES. Dr. Han responded that the emission factor is for steady-state conditions based on information received from manufacturers, and this may be something that could be analyzed in the future.

Presentation: Draft Tool to Model Ramps in Project Scale – Erin McCurry

To begin, Ms. Erin McCurry stated that the EPA is removing ramps as a separate emission calculation from the National and County Scales in MOVES, but ramps will continue to be accounted for as separate links in Project Scale analyses. On-ramps have more acceleration and higher emissions than highway driving, while off-ramps have comparatively more deceleration and lower emissions. In MOVES Project Scale, vehicle activity on a link, such as a ramp, can be defined by average speed, second-by-second drive schedule or operating mode distribution. Using operating mode distributions is the most precise option, but is the most data intensive. The EPA has created a ramp tool using data from the Detroit ramp study that can be used to estimate ramp operating mode distributions in Project Scale. To develop the tool, second-by-second passenger car portable activity monitoring system (PAMS) data from the 2012 Detroit study were used, in which ramp driving was isolated using global positioning system (GPS) data. For each ramp trip, emission rates were calculated based on the operating modes for the trip, and the operating modes were calculated and assigned for each second of the ramp trip based on vehicle specific power and source type (i.e., passenger car, passenger truck or light commercial truck) default characteristics. The average operating mode distribution for each ramp type, source type and average speed range was recorded. The Draft Ramp Tool will provide operating mode distributions and emissions based on user-provided average speed data. Additional details on the development and use of the ramp tool will be made available in a report and with MOVES peer-review materials. Based on feedback from the review of these materials, the EPA will determine whether to make the final version of the Ramp Tool publicly available on the MOVES website.

Discussion

Mr. Dale Wells commented that it would be good to consider ramp metering in further development of this tool. He also noted that remote sensing data could be used to refine the tool.

Dr. Chris Frey asked why operating mode data is considered to be better than second-by-second data. Mr. Gary Dolce explained that as a MOVES input, second-by-second drive schedule data can be input for a specific vehicle or several vehicles individually, and does not represent the mix of different vehicles traveling and accelerating at differing rates. The operating mode distribution represents the average of many vehicles and includes different types of vehicles traveling and accelerating at differing rates, so it is more representative of real-world vehicle population and driving.

Mr. Heiken commented that there was a lot of heterogeneity in the emission rates at differing speeds and that location and weather conditions can affect emissions. He asked what season it was when the Detroit data were collected. Ms. McCurry responded that the study took place in the summer.

Mr. Chris Voigt asked whether the EPA had compared emissions using average speed to the emissions estimated with the tool. Ms. McCurry replied that they had performed several comparisons, and information on the comparisons would be available in the technical documentation for the tool.

Mr. Voigt asked whether road grades were considered for the ramp tool. Ms. McCurry explained that road grade data for the individual ramps was not available, so it was assumed to be zero. Mr. Dolce noted that there are limitations to the tool, but the goal at this time is to improve upon the current defaults in MOVES.

Dr. Matt Barth commented that using operating mode average speeds is an improvement over the defaults and that smaller bins for the operating modes would be helpful for future development. He suggested that it may be that a complementary model could be developed.

Mr. Gil Grodzinsky commented that the tool is an improvement over what is currently in MOVES, but it should be clear what the purpose and limitations of the tool are when it is released. Ms. McCurry confirmed that the report includes a discussion on limitations of the tool.

Presentation: Recommended Updates to MOVES Heavy-Duty Source Masses Using VTRIS Data – Daniel Bizer-Cox and Angela Cullen

Mr. Daniel Bizer-Cox first presented background information on source mass and how it is used in MOVES. He noted that source mass represents the average weight of a given vehicle type, including the vehicle, occupants, fuel and payload. This information is used in calculating operating mode distributions, and ultimately, emissions in MOVES. In MOVES2014, these values vary by source type and model year and are based on 2002 Vehicle Inventory and Use Survey (VIUS) data. For the new version of MOVES, source masses can now also vary by regulatory class. To calculate source mass by regulatory class, a mapping between Federal Highway Administration (FHWA) vehicle classes and MOVES source types and regulatory classes was performed. The national average source masses were then calculated by weighting each state's average mass by vehicle-miles traveled (VMT) using FHWA VM-2 data. Vehicle weight information for 2013 from the FHWA vehicle travel information system (VTRIS) were used as the basis for all model years, and the masses for MY2014+ were then modified to

account for the heavy-duty greenhouse gas rules. The preliminary results of the analysis show increases in heavy-duty emissions for NO_x, CO₂, SO₂ and PM_{2.5} of 1% - 2% and a decrease in CO of a little over 1% at the national scale for 2010. The EPA is currently evaluating further changes to the source masses for buses and for Class 8 refuse trucks. The EPA is requesting feedback on whether the data sources and analysis approaches used are appropriate and reasonable and also whether there are better data or techniques for estimating national bus source masses than what has been used to date.

Discussion

Mr. Jeremy Heiken commented that Class 8 trucks dominate the NO_x inventory, but the data presented here do not seem to be consistent with this. Mr. Bizer-Cox responded that data shown for short-haul trucks do not reflect this, which may be due to the small amount of data available for these trucks. He noted that most Class 8 trucks are combination trucks.

Mr. Heiken noted that weight restrictions are not nationally uniform and asked whether there were any plans to allow modelers to insert vehicle weights that are appropriate for specific geographic areas. Mr. Bizer-Cox replied that this is an interesting question, and the EPA will consider that for future model updates.

Presentation: Coordinating Research Council 2017 and 2018 MOVES Related Projects – Susan Collet and Scott Mason

Ms. Susan Collet and Mr. Scott Mason began by introducing the scope and objectives of the Coordinating Research Council (CRC), which are to serve as a focal point for cooperative research between the mobility and energy industries and to provide a forum for stakeholders to participate in the research. The CRC also makes technical information available to industry, government and the public to achieve clean air and other goals. There are several committees within the CRC organization, including the Atmospheric Impacts Committee (AIC) and the Emissions & Real World Committee. The aim of the Emissions & Real World Committee is to define interactions between automotive hardware and fuel effects on emissions and to measure the contribution of vehicle emissions to the pollutant inventory. The goal of the AIC is to improve the science used for regulations and to improve the ability to predict the effect of emissions on air quality. To meet this goal, the AIC aims to improve inventories, air chemistry, and air quality models as well as to predict the importance of emerging data. Ms. Collet showed a list of current projects of the AIC and the Emissions & Real World Committees, as well as those planned for 2018. Mr. Mason highlighted and discussed several projects that he believed would interest the MOVES Review Work Group.

Discussion

Mr. Tom Darlington asked what contractor is performing the analysis for ethanol N₂O emissions. Mr. Mason replied that he was not sure, and Mr. Darlington responded that he would check on this himself.

Presentation: Recommended Updates to MY 2010+ Heavy-Duty Vehicles – Fixed Mass Factor and Diesel Particulate Matter Rates – Gurdas Sandhu and Darrell Sonntag

Dr. Sandhu provided context by stating that the MOVES Review Work Group recommended in December 2016 that the criteria pollutant emission rates for HD MY2010+ be updated and these recommendations were based on analysis with the MOVES2014 fixed mass factor (f_{scale}) values and did not include particulate matter (PM). The EPA plans to update the HD MY2010+ fixed mass factor (f_{scale}) values and PM rates based on the Heavy-Duty In-Use Testing (HDIUT) data set.

In MOVES, Scaled Tractive Power (STP) is an estimate of the tractive power exerted by a vehicle, and this value is scaled, or normalized, by f_{scale} . Currently in MOVES, gap-filling is required in high power operating modes, and the goal of the update is to choose new f_{scale} values that minimize or eliminate the need for gap filling. The current value for RegClass 41-48 is 17.1, and lower values for these classes were investigated. The effect of lowering the f_{scale} value is that increasingly more activity is assigned to higher power operating modes within a speed bin; however, changes to the f_{scale} value do not affect operating modes based only on acceleration, speed, or single bin STP. The effects on emissions are a spread in emissions over more operating modes, with the highest emissions typically present in the highest operating mode bins. The EPA's plan is to update MOVES with the appropriate f_{scale} value for each regulatory class for MY2010+ and not to update the values for pre-MY2010 at this time.

The EPA is also planning to update the diesel PM emission rates for MY2010+ HD vehicles using MY 2010-2013 vehicles in the HDIUT dataset and the new f_{scale} values. The vehicles in these model years are generally equipped with both SCR and DPF controls, whereas some previous model years generally have DPFs but not SCR. Comparing the HDIUT PM emission rates to the MOVES2014 rates shows that the HDIUT rates are, on average, 90% below the MOVES2014 rates. For instance, the fleet average $PM_{2.5}$ rates for MY 2010 long-haul combination diesel trucks is 33.5 mg/mile in MOVES2014 using default national activity, whereas the recommended HDIUT-based rates for the same trucks are approximately 3.4 mg/mile. The HDIUT-based rate is within the range of PM emission rates reported in the literature for similar vehicles (i.e., 1.6 to 6.2 mg/mile).

The next steps planned are to complete the analysis for the different HD classes using the new f_{scale} values, conduct further comparisons with literature, continue to evaluate the effect of DPF regeneration on PM emission rates, and continue to evaluate methods to include these effects in MOVES. Further information will be presented to the Work Group only if the rates or methods discussed today need to change significantly.

Discussion

Ms. Julie McDill commented that some control devices, like SCR and DPF controls, do not work when trucks idle for long periods (more than 15-20 minutes) and she asked if the EPA has plans to address this in the model. Dr. Sandhu replied that cooling of SCR affects NO_x emissions when there is significant idling, and, based on a different analysis, EPA presented recommendations about extended idling rates at the December 2016 Work Group meeting. Regarding the current analysis, he stated that there was not enough data to account for extended idling effects but it

includes effects of regular work-day idling, and that work is still underway to more fully address idling emissions. He also stated that DPF control (and subsequently PM emissions) is not affected by idling. Ms. Beardsley added that running tailpipe NO_x emissions from MY2010+ heavy-duty vehicles were covered in the December 2016 Work Group meeting.

Dr. Chris Frey asked for clarification as to whether the mass factors would be changing across classes. Dr. Sandhu responded that the EPA is trying to develop good f_{scale} values that are representative of the operating mode activity experienced. He noted that source mass is not being used to guide the f_{scale} values.

Dr. Frey asserted that when talking about Scaled Tractive Power (STP), you cannot compare one source type to another. Dr. Frey stated that using differing mass factors pre-2010 and post-2010 is confusing. He suggested that the EPA be consistent in the use of f_{scale} to arrive at operating mode distributions. Dr. Sandhu noted that as long as there is consistency in using the same f_{scale} value to arrive at operating mode based activity and emissions, the cycle average emissions will be the same. While the pre-and post-MY2010 will have different f_{scale} values, the drive cycles for both will use consistent data.

Mr. Jeremy Heiken commented that there is a well-known NO_x-PM emissions tradeoff, and he suggested that the EPA review certification data to determine if and what adjustments might be required when using PM emission rates from MY2010+ vehicles for pre-MY2010 vehicles. Dr. Sandhu remarked that the emission rates would be different, and that engine-out may be different than tailpipe-out emissions. He also requested that the Work Group suggest sources of data for the frequency of DPF regeneration events.

Wrap-Up

In closing, Ms. Beardsley thanked the meeting participants and informed them that the tentative date for the next meeting is March 7, 2018. Ms. Beardsley also reminded attendees that additional comments are to be sent to Dr. Sarah Roberts at Roberts.sarah@epa.gov by January 17, 2018. She noted that several MOVES technical reports will soon be posted, and she will send the Work Group members a link to the reports when they are posted.

Ms. Beardsley invited Work Group members to give presentations at the next meeting. She stated that, anyone who would like to present, should send her and Dr. Barth a draft title and abstract along with a description of the relevancy of the topic to the MOVES Work Group.

A full list of participants is provided as an attachment to this summary. 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

December 2017 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	Environmental Protection Agency	EPA; Work Group Co-Chair
Susan Collet	Toyota	Coordinating Research Council (CRC)
David D'Onofrio	Atlanta Regional Commission	Association of Metropolitan Planning Organizations (AMPO)
Tim French	Engine Manufacturers Association (EMA)	Engine Manufacturers Association (EMA)
Christopher Frey	North Carolina State University	North Carolina State University
Gil Grodzinsky	Georgia Department of Natural Resources	Association of Air Pollution Control Agencies (AAPCA)
Cecilia Ho	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Britt Holmen	University of Vermont	University of Vermont
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)
David Lax	American Petroleum Institute (API)	American Petroleum Institute (API)
Lubna Shoaib	East-West Gateway Council of Governments	Association of Metropolitan Planning Organizations (AMPO)
Matt Solomon	Northeast States for Coordinated Air Use Management (NESCAUM)	Northeast States for Coordinated Air Use Management (NESCAUM)
Matthew Thornton	National Renewable Energy Laboratory (NREL)	NREL
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)
Chris Wolfe	Environmental Defense Fund (EDF)	Environmental Defense Fund (EDF)
Wei Zhang	Idaho Department of Environmental Quality	National Association of Clean Air Agencies (NACAA)

Non-Work Group Attendees

Name	Home Organization	Representing Organization
Daniel Bizer-Cox	Environmental Protection Agency	Environmental Protection Agency
Kevin Black	FHWA	FHWA
Marty Boardman	Texas A&M Transportation Institute (TTI)	TTI
Andy Bollman	North Carolina Department of Environmental Quality	North Carolina Department of Environmental Quality
Chris Bovee	Wisconsin Department of Natural Resources	Wisconsin Department of Natural Resources
Christopher Boyd	Shelby County Health Department	Shelby County Health Department
Denise Cormier	Maine Department of Environmental Protection	Maine Department of Environmental Protection
Louis Corsino	Connecticut Department of Energy and Environmental Protection	Connecticut Department of Energy and Environmental Protection
Angela Cullen	Environmental Protection Agency	Environmental Protection Agency
Tom Darlington	Air Improvement Resource, Inc.	Air Improvement Resource, Inc.
Gary Dolce	Environmental Protection Agency	Environmental Protection Agency
Jaehoon Han	Environmental Protection Agency	Environmental Protection Agency
Jeremy Heiken	Oak Leaf Environmental, Inc.	Oak Leaf Environmental, Inc.
David Kall	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Yusef Khan	Cummins	Cummins
Jim Koroniades	New Jersey Department of Environmental Protection	New Jersey Department of Environmental Protection
Dorian Kvale	Minnesota Pollution Control Agency	Minnesota Pollution Control Agency
Sonya Lewis-Cheatham	Virginia Department of Environmental Quality	Virginia Department of Environmental Quality
Scott Mason	Phillips 66	Coordinating Research Council
Erin McCurry	Environmental Protection Agency	Environmental Protection Agency
Julie McDill	Mid-Atlantic Regional Air Management Association	Mid-Atlantic Regional Air Management Association
Jeff Merrell	Vermont Department of Environmental Conservation	Vermont Department of Environmental Conservation
Rachel Muncrief	ICCT	ICCT
Joanne O'Loughlin	SC&A, Inc.	EPA Contractor
Sally Otterson	Washington Department of Ecology	Washington Department of Ecology
Todd Pasley	North Carolina Department of Environmental Quality	North Carolina Department of Environmental Quality
Steven Potter	Connecticut Department of Energy and Environmental Protection	Connecticut Department of Energy and Environmental Protection
Sarah Roberts	Environmental Protection Agency	Environmental Protection Agency
Gurdas Sandhu	Environmental Protection Agency	Environmental Protection Agency
Yue Shan	Michael Baker International	Michael Baker International

Jolyon Shelton	Delaware Dept. of Natural Resources and Environmental Control	National Association of Clean Air Agencies (NACAA)
Darrell Sonntag	Environmental Protection Agency	Environmental Protection Agency
Matt Spears	EMA	EMA
Lesley Stobert	SC&A, Inc.	EPA Contractor
Hideharu Takemoto	Honda	Honda
Arvind Thiruvengadam	West Virginia University	West Virginia University
Marcus Tutt	New Jersey Department of Environmental Protection	New Jersey Department of Environmental Protection
Madhu Venugopal	TTI	TTI
