Federal Advisory Committee Act
Clean Air Act Advisory Committee

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

March 7, 2018
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: March 7, 2018 (1 pm to 3 pm)

Topic
Welcome from the Chairs
Member Roll Call
General Announcements
Presentations: • Ethanol's Emissions Effects in MOVES2014 • Growth Energy Ethanol and Aromatics Testing Program • Implications of Emerging Trends and Needs for MOVES
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 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 at her e-mail address: Roberts.sarah@epa.gov.

Dr. Barth noted that several MOVES Work Group members have requested to have presentations not just from the EPA during the MOVES Work Group meetings, but also from other Work Group members on topics directly related to the MOVES model. He noted that today there are three presentations from MOVES Work Group members that will be approximately 25-30 minutes long with 5-10 minutes allotted for questions/answers. He noted that there are other presentations from Work Group members in the queue for the next Work Group meeting, and he encouraged others who are interested in presenting to contact him or Ms. Beardsley.

MOVES Minor Update: MOVES2014b

Ms. Beardsley announced that the EPA is planning a minor model update, which will be called MOVES2014b. She noted that this is a minor update that will improve the nonroad capabilities of MOVES, and this update will not impact plans for the larger update that is occurring. The specific updates include new nonroad engine population growth factors, removal of a bug from the nonroad fuel supply, and updated emissions for Tier 4 nonroad engines. This update will not be considered a new model for state implementation plan (SIP) and transportation conformity purposes, and it will not impact inventories of onroad criteria pollutants. The target date for releasing MOVES2014b is summer 2018.

Presentation: Ethanol's Emissions Effects in MOVES2014 – Steven VanderGriend, Urban Air Initiative (UAI)

Mr. Steven VanderGriend began by introducing the Urban Air Initiative (UAI), which he stated is a non-profit organization dedicated to improving air quality and protecting public health by reducing vehicle emissions. He stated that the UAI wants the EPA to correct MOVES2014a to more accurately estimate the emission effects of ethanol. Mr. VanderGriend stated that there are three reasons for the model's inaccurate emissions estimates, which include:1) tailpipe fuel effects are based on a study that used match-blended test fuels not representative of market fuels and that ignored confounding variables, 2) the model's fuel adjustment for ethanol's effect on permeation emissions does not account for aromatics and other hydrocarbon in test fuels, and 3) the model's default fuel parameter inputs do not reflect real-world market fuels. Mr. VanderGriend noted that the model's tailpipe fuel effects for light-duty vehicles are based on the EPAct study. He stated that this study had design defects, in that it did not control for confounding variables, the test fuels did not span the ranges of in-use fuel properties, and the design efficiency fell below the acceptable range. He further stated that the use of data from this study in MOVES results in inaccurately high emissions from ethanol fuel blends. Mr. VanderGriend noted that MOVES2014 includes a fuel adjustment factor for ethanol's permeation emissions, which predicts that the addition of ethanol to gasoline more than doubles permeation emissions in today's vehicles. He stated that this factor is based on studies by the Coordinating Research Council (CRC) that have design flaws, including the assumption of artificially high fuel aromatic content and the neglect of confounding variables, such as aromatic and paraffin speciation. Mr. VanderGriend also stated that the MOVES2014 default fuel parameters do not correspond to real-world market fuel, which tends to have a higher T50 and a

lower T90 than conventional gasoline, while the model defaults reverse this relationship. He suggested that in the short-term, the EPA could lock the MOVES2014 ethanol fuel effects at 10% ethanol to prevent inaccurate comparisons between fuels with different ethanol content. He also suggested that the default fuel parameters could be replaced with real-world market fuel properties. He suggested for the long-term that the EPA develop a new model based on data that includes gasoline direct injection (GDI)/Tier 3 vehicles and realistic test fuels. He also suggested that this new model be reviewed by the Science Advisory Board and be promulgated through the notice and comment process.

Discussion

Dr. Barth inquired, regarding the EPAct and CRC studies that Mr. VanderGriend discussed, whether enough data are available to adjust MOVES to reduce the inaccuracies the use of the study data introduces or whether additional data would be needed. Mr. VanderGriend responded that it depends on how higher ethanol content blends are to be addressed. He stated that there is plenty of data on splash blending, and he recommended that splash blending fuel data be used rather than match-blending data. He suggested that the existing data be reviewed before determining whether the data is sufficient or whether more would be needed.

Mr. Jeremy Heiken asked whether CRC reports E101 and E116 had been considered, noting that methodologies for estimating emissions from higher ethanol blends were examined in those studies. He said that in the E101 study, MOVES was examined for E10 and E15, and it was found that MOVES was rather insensitive to the increase from E10 to E15. He also commented that MOVES does use real-world data. Mr. VanderGriend responded that MOVES depends on default values for distillation. He also remarked that in MOVES, raising the Reid Vapor Pressure (RVP) results in a lower T50, and these MOVES T50 defaults are opposite to what really occurs.

Mr. Gil Grodzinsky asked about the RVP-ethanol relationship and about how vehicle age may affect this relationship. Mr. VanderGriend replied that for newer vehicles with direct injection, there is strong particulate matter (PM) reduction seen with ethanol blends when real-world data is used.

Mr. Grodzinsky asked if Mr. VanderGriend was concerned about MOVES emissions estimates for E10 or whether he was only concerned about fuel blends higher than E10. Mr. VanderGriend replied that he was most concerned with higher ethanol blends, but the way T50 is treated in MOVES is still a problem for E10. He stated that the questions are how should T50 be addressed now in MOVES for E10 and then also going forward how it should be addressed for higher ethanol blends.

Presentation: Growth Energy Ethanol and Aromatics Testing Program – Tom Darlington, Air Improvement Resource (AIR), Inc.

Mr. Tom Darlington stated that there is concern with the EPAct test fuels and results for ethanol, noting that the study focused on port fuel injection (PFI) vehicles, while gasoline direct injection (GDI) is becoming the predominant technology used. This concern provided motivation for a study conducted by the University of California, Riverside, in which 5 GDI vehicles were tested

with 8 fuels, ranging from 0-20% ethanol, 20-30% aromatics and 2 splash blends. The purpose of this study was to determine the impact of aromatics and ethanol on emissions. The results of the study showed that higher levels of ethanol in the fuel reduced energy consumption in GDI vehicles and that emissions for GDI vehicles are quite different from the EPAct results for PFI vehicles.

Discussion

During the presentation, a comment was made by Rafal Sobotowski (EPA) on Slide 15 (which shows the PM composite emissions versus ethanol content for all fuels) that bias may be introduced by showing all fuels together and that the data for the different fuels should be examined separately. Mr. Darlington acknowledged the comment.

Dr. Chris Frey inquired why higher levels of ethanol reduce per mile energy consumption in GDI vehicles. Mr. Darlington responded that the auto industry was not surprised and believed that energy consumption may even be better than the data represents. He stated that one of the reasons may be that there have been improvements in advanced timing under load, resulting in gained efficiency.

Mr. Jeremy Heiken asked whether the Btu heating value is higher or lower at higher ethanol fuel content and Mr. Darlington responded that the Btu heating value is lower at higher ethanol content. Mr. Heiken also asked whether GDI vehicles show higher levels of ethanol effects due to the way in which starts and running conditions were considered. Mr. Darlington agreed that differences in how starts and running conditions were considered between this GDI study and previous studies with earlier Tier 1 vehicles could be a factor in the differences observed.

Mr. James Warila asked about the rationale for the fuels chosen in the study. Mr. Darlington stated that many fuels could have been included in the study, but it was decided that E10 is generally representative of the baseline. He explained that using higher octane fuels or higher ethanol blends was considered, but, ultimately, splash blends of E15 and E20 were chosen.

Presentation: Implications of Emerging Trends and Needs for MOVES, Chris Frey, North Carolina State University

Dr. Chris Frey began by showing trends in light duty vehicle emissions, fuels and technology. He showed graphs of declining trends in CO_2 and NO_x emissions rates from light duty gasoline vehicles since 1975 and 1990, respectively. He also showed a slight decline in passenger car and truck emissions of $PM_{2.5}$ since 1990, but he also showed that this trend is expected to reverse itself in the future as activity increases. Looking forward, he presented a graph showing an expected slight decrease in gasoline use with slight increases in diesel, E85, CNG/LNG, electricity, propane, and hydrogen fuels. Dr. Frey also presented data showing that since 2007 there has also been a rapid increase in the use of GDI technology with a corresponding decrease in port fuel injection (PFI) technology. He noted that there has been much focus on PM from GDI, as these emissions are generally higher from GDI over PFI by more than an order of magnitude, and controls, such as particulate filters for GDI engines, are being considered. He noted that there are a significant number of flex fuel vehicles (FFVs) in the market today, and

non-FFV light duty gasoline vehicles can adapt to higher ethanol blends also. He presented data showing that alternative technology vehicles represent about 3.5% of the market share, and this percentage is projected to dramatically increase in the future. In further slides, Dr. Frey presented data showing that hybrid electric vehicles produce less CO_2. NO_x, CO and hydrocarbon emissions than conventional vehicles. In field testing of one hybrid electric vehicle, it was shown that emissions of CO, NO_x, SO_x and PM are higher when in charge depleting mode than when in charge sustaining mode. Dr. Frey noted that the amount of CO_2 emissions attributed to electric vehicles is dependent on the source of electricity, with higher amounts seen where coal-based power generation is prevalent. Dr. Frey presented data showing emissions in different operating modes, noting that within a speed range, higher modes represent greater engine power demand and have higher emissions.

Considering the trends presented, Dr. Frey suggested several areas in which updates or changes to MOVES should be considered. He stated with the growing number of available real-world cycles, MOVES should move away from default cycles to distributions of cycles. He also noted that while fuel use and emissions are sensitive to vehicle load, this is not a variable in MOVES. Dr. Frey stated that HEVs can likely be modeled with existing operating modes, but the fraction of time the engine is off should be accounted for. Mr. Frey stated that grid-based emissions for PEVs and PHEVs should be considered in the MOVES model. He noted several other needs that MOVES should consider, including accounting for secondary organic aerosol precursors, the role of lubricating oil in particle emissions, ultrafine particle characteristics, improved brake and tire wear estimates and updated air conditioning adjustments.

Discussion

Julie McDill inquired whether upstream emissions to manufacture gasoline were included in Slides 24 and 32 (slides showing energy use and emission rates). She specifically asked whether emissions from oil and gas wells, refineries, pipelines, storage, and gasoline stations are included. She also noted that exposure and the proximity of emissions sources to the population is important. Dr. Frey responded that he believed the upstream emissions are included in the information presented on those slides. He also noted that while near-roadway emission exposure is important to consider, the total amount of emissions at other levels, such as at the regional scale, should also be considered.

Mr. Dale Wells stated that including real-world data for cycles introduces a lot of variables and may not be desirable when there is a small sample size. Mr. Frey stated that, for purposes of an inventory, he believed including real-world cycles are better. They both agreed to talk more about this off-line.

Mr. Jim Kliesch noted for Slide 21 (which shows the projected trend in global PHEV vehicles) that there is a difference between plug-in electric vehicles (PEVs) and plug-in hybrid electric vehicles (PHEVs). He indicated that he was not sure there was a distinction made between the two types for the data presented there. He also stated that the data shown for the field-tested 2013 Toyota Prius PHEV is different from most vehicles on the market today and is likely not representative of them. Mr. Frey responded that the values may be different for longer-range batteries, but the concept is the same.

Wrap-Up

In closing, Ms. Beardsley thanked the meeting participants and informed them that the next meeting will be in the summer, but a specific date has not yet been set. Ms. Beardsley also reminded attendees that additional comments are to be sent to Dr. Sarah Roberts at Roberts.sarah@epa.gov.

Ms. Beardsley invited Work Group members to provide presentation ideas for the next meetings. 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

March 2018 MOVES Review Work Group Attendees

Name	Home Organization	Representing Organization
Matt Barth	University of California, Riverside (CE-CERT)	UC Riverside (CE-CERT), Work Group Co-chair
Megan Beardsley	U.S. Environmental Protection Agency (EPA)	EPA; Work Group Co-Chair
Giedrius Ambrozaitis	Alliance of Automobile Manufacturers	Alliance of Automobile Manufacturers
Susan Collet	Toyota	Coordinating Research Council (CRC)
Tim French	Engine Manufacturers Association (EMA)	Engine Manufacturers Association (EMA)
Christopher Frey	North Carolina State University	North Carolina State University
Mike Geller	Manufacturers of Emission Controls Association (MECA)	Manufacturers of Emission Controls Association (MECA)
John German	International Council on Clean Transportation (ICCT)	International Council on Clean Transportation (ICCT)
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
Joseph 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)
Jim Kliesch	Honda	Honda
David Lax	American Petroleum Institute (API)	American Petroleum Institute (API)
Lubna Shoaib	East-West Gateway Council of Governments	Association of Metropolitan Planning Organizations (AMPO)
Matthew Thornton	National Renewable Energy Laboratory	National Renewable Energy Laboratory
Steven VanderGriend	ICM Inc.	Energy Future Coalition/Urban Air Initiative
Chris Voigt	Virginia Department of Transportation	Amer. Assoc. of State Highway and Transp. 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)

March 2018 MOVES Review Non-Work Group Attendees

Name	Home Organization	Representing Organization
Daniel Bizer-Cox	U.S. Environmental Protection Agency (EPA)	U.S. Environmental Protection Agency (EPA)
Lucas Bistodeau	Minnesota Department of Transportation	Minnesota Department of Transportation
Kevin Black	Federal Highway Administration	Federal Highway Administration
Chris Bovee	Wisconsin Department of Natural Resources	Wisconsin Department of Natural Resources
Chris Boyd	Shelby County Health Department	Shelby County Health Department
Ying-Tzu Chung	Michael Baker International	Michael Baker International
James Conde	Boyden Gray and Associates	Boyden Gray and Associates
Denise Cormier	Maine Department of Environmental Protection	Maine Department of Environmental Protection
Marc Corrigan	Tennessee Department of Environment and Conservation	Tennessee Department of Environment and Conservation
Tom Darlington	Air Improvement Resource, Inc.	Air Improvement Resource, Inc.
Matthew Davis	North Carolina Department of Environmental Quality	North Carolina Department of Environmental Quality
Alison Eyth	Environmental Protection Agency OAQPS	Environmental Protection Agency OAQPS
Adam Gustafson	Boyden Gray and Associates	Boyden Gray and Associates
Connie Hart	U.S. Environmental Protection Agency (EPA)	U.S. Environmental Protection Agency (EPA)
Jeremy Heiken	Oak Leaf Environmental, Inc.	Oak Leaf Environmental, Inc.
Joey Huang	North Carolina Department of Environmental Quality	North Carolina Department of Environmental Quality
Dennis Kahlbaum	Air Improvement Resource, Inc.	Air Improvement Resource, Inc.
David Kall	Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA)
Dorian Kvale	Minnesota Pollution Control Agency	Minnesota Pollution Control Agency
Sonya Lewis-Cheatham	Virginia Department of Environmental Quality	Virginia Department of Environmental Quality
Jeff Long	California Air Resources Board (CARB)	California Air Resources Board (CARB)
Tom Malamakal	Washington Department of Ecology	Washington Department of Ecology
Julie McDill	Mid-Atlantic Regional Air Management Association	Mid-Atlantic Regional Air Management Association
Jeff Merrell	Vermont Department of Environmental Conservation	National Association of Clean Air Agencies (NACAA)
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

March 2018 MOVES Review Non-Work Group Attendees

Name	Home Organization	Representing Organization
Sarah Roberts	U.S. Environmental Protection Agency (EPA)	U.S. Environmental Protection Agency (EPA)
Kathryn Sargeant	U.S. Environmental Protection Agency (EPA)	U.S. Environmental Protection Agency (EPA)
Jolyon Shelton	Delaware Dept. of Natural Resources and Environmental Control	National Association of Clean Air Agencies (NACAA)
James Smith	Tennessee Department of Environment and Conservation	Tennessee Department of Environment and Conservation
Matt Spears	Engine Manufacturers Association	Engine Manufacturers Association
Lesley Stobert	SC&A, Inc.	EPA Contractor
Hideharu Takemoto	Honda	Honda
Vivek Thimmavajjhala	North Central Texas Council of Governments	North Central Texas Council of Governments
Kim Trinchet	Urban Air Initiative	Urban Air Initiative
Jeff Vukovich	Environmental Protection Agency OAQPS	Environmental Protection Agency OAQPS
James Warila	U.S. Environmental Protection Agency (EPA)	U.S. Environmental Protection Agency (EPA)
Peter Wasko	Minnesota Department of Transportation	Minnesota Department of Transportation