

**Review of  
“Update of Speciation & Toxic Emissions, and Particulate Matter Emissions from  
LDVs”**

**By  
Georgios Karavalakis, Ph.D.**

**University of California, Riverside  
Center for Environmental Research and Technology &  
Department of Chemical and Environmental Engineering**

In the following review, I have attempted to address the specific points/concerns identified by EPA. The review addresses the charge questions and is categorized by document submitted separately to the reviewer.

**1. Review for: 'Speciation of Total Organic Gas and Particulate Matter Emissions from Onroad Vehicles in MOVES201X'**

Charge Question 1:

The document is well written, well structured, and contains comprehensive information. It certainly represents a significant improvement over the previous MOVES versions. I am particularly satisfied that in MOVES201X the ratios of CH<sub>4</sub>/THC, NMOG/NMHC, and VOC/NMHC were calculated based on profiles from the SPECIATE database. On the other hand, I was particularly concerned about how representative and realistic MOVES201X might be since all these information derived essentially from one (1) testing campaign (EPA Act program). This could be a major critique for the MOVES201X model in terms of the representativeness of the data used. Essentially, the estimations for the national and/or regional values of the model came from older technology Tier 2 LDVs equipped with port fuel injection (PFI) engines. The model fails to capture the emissions from newer technology LDVs equipped with gasoline direct injection (GDI) engines. This is major concern about the representability of MOVES201X, since GDI vehicles are dynamically penetrating the US market, with a prognosticated market share of up to 97% by 2025.

For the CNG vehicles, the analysis is focusing only on transit buses. The model fails to capture vehicles of different vocations, such as trucks and waste haulers.

It is not clear to this reviewer as to whether the ACES Phase 1 profile is used for all current diesel sources, including LDVs. If this is the case, perhaps EPA should reconsider and include studies conducted on diesel light-duty passenger cars and trucks, such as the CRC AVFL-17b program.

Charge Question 2:

The description of the methods is well written and adequate. The reader has enough details to understand the steps taken and details behind them made by EPA. I find the examples for tables and figures adequate.

Charge Question 3:

The methods and procedures are technically appropriate and well described. I have reviewed the mathematical formulations and statistics and appear to be sound.

Charge Question 4:

With few exceptions, the assumptions made by EPA are appropriate and reasonable. MOVES201X has limitations that need to be addressed. For example, the results of ACES Phase 1 program cannot be used to represent light-duty diesel passenger cars and trucks. For more accurate model inputs, MOVES201X should utilize data from studies employed diesel LDVs.

Charge Question 5:

EPA has made significant progress with MOVES201X. It appears that the resulting model inputs are mostly consistent with the body of data and literature that the model accounted for. However, the lack of newer engine/vehicle technologies and their emissions makes me to question the representativeness of MOVES201X.

It should be noted that the model did a good job in incorporating three air quality chemical mechanisms. This strengthens the current model and makes it more useful among the air quality community. My understanding is that the current model has a larger interaction with SMOKE.

## ***2. Review for: 'Air Toxic Emissions from Onroad Vehicles in MOVES201X'***

Charge Question 1:

This section is well written and adequately organized. EPA did a good job in categorizing the data of toxic fractions for pre-2007 diesel engines and for newer engines.

For partitioning factors for diesel PAH emissions, I do see some limitations of MOVES201X, since the bulk of data came from a limited number of engines and of older technology.

At the beginning of section 3.2.2, there is statement about the change in PAH composition with diesel HDVs manufactured in 2007 and later. Could you please elaborate as to how PAH composition changes with newer engines?

Why didn't the toxic fractions differentiated by emission process?

Charge Question 2:

Overall, the methods and procedures were well described and defined.

Was the measurement uncertainty for the gaseous air toxics taken into account? If the measurement uncertainty for some toxics is considerably great, how is the model affected? What is the accuracy of the model?

Charge Question 3:

The methods and approaches are technically sound. The assumptions followed for the hexavalent chromium estimations appear to be sound.

Charge Question 4:

For this section, the amount of data is quite comprehensive and all the assumptions made by EPA are appropriate.

Charge Question 5:

The resulting model inputs described in this document are appropriate. What might be missing from MOVES201X are the nitrated PAH emissions that can be formed de novo in the DPF/SCR system through nitration reactions. From toxicity and human exposure standpoints, some of these species (i.e., 1-nitropyrene) should be included in the model.

### **3. Review for 'Exhaust Emission Rates for Light-Duty On-road Vehicles in MOVES201X'**

Charge Question 1:

This section is well written, well organized with sufficient quantity and quality of data used in the analysis. The analysis successfully included the cold-start emissions and implemented a correction factor A for different emissions. Why EPA didn't apply this correction factor for NMHC and CH<sub>4</sub> emissions?

EPA did a good job in emphasizing mileage accumulation and odometer readings.

EPA went into great efforts to emphasize on GDI PM emissions. It is also useful that fuel type and composition were also considered in the analysis.

I am concerned that the model fails to capture PM emissions from GDI vehicles with different injection architectures (wall-guided versus spray-guided) that are generally significantly different.

Charge Question 2:

The description of analytic methods and procedures is very detailed and comprehensive. There are several examples throughout the document explaining the steps taken by EPA in the development of the model. The tables and figures are sufficient, providing detail and clear information to the reader.

For the PEMS work, EPA should comment on the PEMS limitations, including measurements variability and repeatability. EPA should have done a PEMS correlation study in the lab mimicking the real-world testing.

Charge Question 3:

I have reviewed the methods and procedures and the mathematics. They all appear to be technically sound and are described in reasonable detail.

Charge Question 4:

The assumptions made to determine GDI truck scaling factors are both reasonable and appropriate.

Charge Question 5:

I believe the resulting model inputs are appropriate and generally consistent with the body of data and published literature. Overall, the model seems to be well specified and much more comprehensive than previous versions. To the best of my knowledge, much of the design used for MOVES201X is well articulated in this draft documented, which will help the reader understand how the model was developed.

**4. Review for 'Emission Adjustments for Temperature, Humidity, Air Conditioning, and Inspection and Maintenance for On-road Vehicles in MOVES201X'**

Charge Question 1:

The analysis conducted for the PM running emissions and exhaust temperature effects is well done. I believe that EPA did well to remove the temperature effect for Tier 2 vehicle in MOVES2014 and it was also an appropriate approach removing the running temperature effect for PM emissions from MOVES201X. It appears that EPA did a thorough literature search on the available data and reached on a reasonable conclusion for the current model.

Charge Question 2:

This section is clear and concise with enough details for the reader to understand the steps taken by EPA to remove the running temperature effect for PM emissions from the current model.

Charge Question 3:

While all methods and procedures employed for this task were technically appropriate and reasonable, I would suggest to keep monitor the future published data on PM running emissions and temperature effects from GDI vehicles. I consider this more of a reality check to make sure the temperature has no effect on PM running emissions and what was observed in KCVES was indeed an artifact of the measurement.

Charge Question 4:

Based on the available data EPA used, the conclusions and assumptions derived in section are all reasonable and scientifically accurate.

Charge Question 5:

The resulting model inputs are appropriate and in-line with the literature.

**5. Review for “Update of Speciation & Toxic Emissions, and Particulate Matter Emissions from LDVs”**

I am not entirely convinced that for a non-detected value an assumption should be made to be zeroed out. I would leave this value as ‘not detected’ instead of assuming it is zero.

While it is reasonable that benzene was low or even not detected from newer trucks, I cannot see any obvious formation pathways for ethanol emissions. I would assume that ethanol could be an artifact of the measurement during sampling or more likely an artifact of the measurement during the analysis in the lab (contamination). I would therefore use my engineering judgement and exclude ethanol from the analysis from the current model.