
# Task 4: Final Report: Peer Review of

## Heavy Duty Vehicle Report

# in Support of MOVES2013

February 25, 2014

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# 1. Introduction

The MOtor Vehicle Emission Simulator (MOVES) was developed as part of OTAQ's comprehensive approach to address the impacts of light- and heavy-duty vehicles on air quality and public health. MOVES is OTAQ's current emission modeling system, capable of estimating emissions for a broad range of pollutants from on-road cars, trucks & motorcycles at multiple analysis scales, including the impact on air quality of light duty vehicle (LDV) fleet evaporative emissions. Future versions of MOVES will add various enhancements to this model, including the ability to simulate emissions from non-highway mobile sources.

As part of the development of the next release version, MOVES2013, EPA is preparing five reports/analyses documenting the results of various inquiries into the nature of fuels, vehicle exhaust and evaporative emissions on air quality. These reports detail how EPA intends to update MOVES' ability to model policy outcomes from proposed changes in the understanding of the US vehicle fleet and to help mitigate any adverse air quality impacts associated with future motor vehicle fuels.

This document reports the findings of an external peer review of one report:

- The Heavy Duty Vehicle Report.

This peer review was conducted from July 2013 to September 2013 according to *EPA's Peer Review Handbook, Third Edition*. These guidelines specify that all highly significant scientific and technical work products shall undergo independent peer review per specific agency protocols to assure the use of the highest quality science in its predictive assessments and assure stakeholders that each analysis/study has been conducted in a rigorous, appropriate, and defensible way.

This document contains the conclusions of each peer reviewer on each document included in the review, by charge question. Supporting documentation collected from the reviewers, including their curriculum vitae (CV) and conflict of interest (COI) statements, is also provided in Appendix A and Appendix B. The Task 3: Peer Review Process Report describes the process to select reviewers and administer the peer review. At the conclusion of the review, ICF collected all peer review comments and cover letters in order to provide them to EPA, unedited. The following materials are included in this Task 4 Technical Report.

1. Reviewer Responses to Charge Questions (Section 4)
2. Reviewer Supporting Documentation (Appendix A and Appendix B):
    a. Reviewer Delivery Email (i.e., Cover Letter)
    b. Reviewer CV
    c. Reviewer COI Statement

# 2. Peer Review Process

Full documentation of the process to select reviewers and administer the peer review is included in the Task 3: Peer Review Process Report. This section summarizes the process that resulted in the selection of Dr. Mohamadreza Farzaneh and Dr. Janet Yanowitz as reviewers for the Heavy Duty Vehicle Report.

## 2.1. Reviewer Selection

ICF identified a pool of independent subject matter experts to conduct this review. Initial contact to each reviewer confirmed the potential reviewer's expertise in the field, their ability to perform the work during the period of performance, any association with whom they have worked that might preclude them from being an independent and objective reviewer, their hourly billing rate, and to confirm their contact information. A curriculum vitae or resume for each peer review candidate that expressed interest and availability was also collected. This list was submitted to EPA for approval and revisions, as necessary. Multiple iterations were made to the list of selected reviewers before a set of available, conflict free reviewers for the Heavy Duty Report were agreed upon. The final pool of potential candidates was contacted via e-mail and phone. Additionally, a final peer review selection memo was delivered to EPA.

## 2.2. Administration and Completion of the Peer Reviews

Following acceptance of reviewers by EPA and by reviewers to participate, the review was administered according to the below process:

- A charge for each report was drafted with instructions to provide clear and detailed comments that distinguish between recommendations for improvements and, if appropriate, what conclusions could be drawn from the report and/or subsequent model predictions
- Electronic distribution of the review material, including the report charges,
- For each report, a teleconference was arranged between the selected peer reviewers, the EPA WAM, EPA-identified relevant project-related staff, and ICF staff. The purpose of these calls was to clarify any questions the reviewers had regarding the review material. EPA's purpose on the call was to provide technical and/or background support on the particular report or analysis under review, as needed,
- Any technical reviewer questions were facilitated through ICF to EPA, and
- A deadline for submission of materials.

Both of the selected reviewers for the Heavy Duty Vehicle Report met the submission deadline. Their full set of review comments, along with their cover letters, CVs, and Conflict of Interest statements, were gathered and provided to EPA unedited.

Additionally, a technical report documenting the peer review process for each report was assembled to conclude each review. Finally, all contracting and payment issues with each reviewer were managed by ICF to ensure prompt payment of each reviewer for their services.

## 2.3. Difficulties Encountered

No notable difficulties were encountered in review of the Heavy Duty Vehicle Report.

## 2.4. Supporting Documentation

Supporting documentation collected from the reviewers and outreach material to Dr. Farzaneh and Dr. Yanowitz is captured in Appendices A and B. This includes the reviewers' cover letters, conflict of interest statements, and CVs.

# 3. Charge Questions and Scope of the Peer Review

The peer reviewers were asked to review the MOVES 2013 Heavy Duty Vehicle Report. Responses were requested to five general questions and one catch-all question. Similar general questions were asked for each peer review conducted as a part of this work assignment. Two report-specific charge questions were also included. These are repeated below.

## 3.1. General Charge Questions

The general charge questions were as follows:

1. Does the presentation give a description of selected data sources sufficient to allow the reader to form a general view of the quantity, quality and representativeness of data used in the development of emission rates? Are you able to recommend alternate data sources might better allow the model to estimate national or regional default values?
2. Is the description of analytic methods and procedures clear and detailed enough to allow the reader to develop an adequate understanding of the steps taken and assumptions made by EPA to develop the model inputs? Are examples selected for tables and figures well chosen and designed to assist the reader in understanding approaches and methods?
3. Are the methods and procedures employed technically appropriate and reasonable, with respect to the relevant disciplines, including physics, chemistry, engineering, mathematics and statistics? Are you able to suggest or recommend alternate approaches that might better achieve the goal of developing accurate and representative model inputs? In making recommendations please distinguish between cases involving reasonable disagreement in adoption of methods as opposed to cases where you conclude that current methods involve specific technical errors.
4. In areas where EPA has concluded that applicable data is meager or unavailable, and consequently has made assumptions to frame approaches and arrive at solutions, do you agree that the assumptions made are appropriate and reasonable? If not, and you are so able, please suggest alternative sets of assumptions that might lead to more reasonable or accurate model inputs while allowing a reasonable margin of environmental protection.
5. Are the resulting model inputs appropriate, and to the best of your knowledge and experience, reasonably consistent with physical and chemical processes involved in exhaust emissions formation and control? Are the resulting model inputs empirically consistent with the body of data and literature that has come to your attention?

The catch-all charge question was as follows:

1. Please provide any additional thoughts or review of the material you feel important to note that is not captured by the preceding questions.

## 3.2. Report-Specific Charge Question Questions

The two charge questions specific to the review of the Heavy Duty Vehicle Report were as follows.

1. Is the methodology for creating new MOVES2014 running and start exhaust emission rates for compressed natural gas transit buses sufficiently explained? Can you follow the procedure that was used to calculate ratios from the MOVES2010b rates to the MOVES2014 rates and how those ratios were applied? Do you have any suggestions for improving this methodology for CNG emission development or the documentation itself?
2. Does this EPA analysis of CNG buses accurately reflect the changes in control technology and emission standards? If not, how would you recommend to make the CNG emission rates more reflective of bus emission reduction trends over the past two decades?

## 3.3. Conclusion of the Peer Review

The compiled set of unedited review comments for each charge question are provided in Section 4. Each reviewer's delivery emails (i.e., cover letters), CVs, and COI statements were also gathered and are provided in Appendix A and Appendix B for each reviewer in PDF format or in the referenced attachments. This Task 4 Technical Report concludes the review.

# 4. Reviewers' Responses to Charge Questions

## 4.1. Heavy Duty Vehicle Report

This section provides a verbatim list of peer reviewer comments submitted in response to the charge questions for the Heavy Duty Vehicle Report.

### 4.1.1. Adequacy of Selected Data Sources

*Does the presentation give a description of selected data sources sufficient to allow the reader to form a general view of the quantity, quality and representativeness of data used in the development of emission rates? Are you able to recommend alternate data sources might better allow the model to estimate national or regional default values?*

#### 4.1.1.1. Dr. Mohamadreza Farzaneh

In general, the authors adequately described the data sources, data gaps and limitations, and assumptions and methodologies they used to address these limitations. The list below shows a few instances that they can improve the presentation by providing more details on their assumptions:

- Page 14, last line – A temperature threshold of 300C is assumed for PM regeneration. No reference is provided to support this assumption.
- Page 15, line 2 – it is assumed that 10% of VMT for PM regeneration frequency. No reference listed for to the data used for this assumption.
- Page 37, section 2.1.2.3.2 – the values "0.46" and "0.60" are taken from MOBILE6.2; is there any data to confirm they are still valid?
- Page 37. Section 2.1.2.3.2 – Where the coefficient values "0.40, 0.70, and .50" coming from?
- Page 104 - NO2/NOx fractions are based on a single 2003 study (three CNG transit buses and the same engine make/model). A 12.7% seems to be too low (based on a limited data for CNG refuse trucks collected by TTI). Although, I should admit that this fraction for CNG engines is sensitive to the drive cycle and can vary significantly for different vehicle types. Further data is definitely needed and TTI will be happy to share the mentioned CNG refuse trucks data with EPA.

TTI's Air Quality Program has performed quite a few studies using mostly PEMS equipment that could enhance the database used for this analysis. We will be happy to share any information gathered during these studies. Specifically, TTI collected second by second data from class 8b HHDVs driving at speeds as high as 85 mph which can be used to improve the rates for the high power/high speed bins.

*Expanding MOBILE6 Rates to Accommodate High Speeds*

Sponsor: Houston Advanced Research Center and Center for International Intelligent Transportation Research

Budget: $150,000

Description: PEMS testing of 3 long haul HHD trucks under different acceleration and speed conditions including speeds up to 85mph.

Location: Study performed at TTI's High Speed Test Track in Pecos, Texas

#### 4.1.1.2. Dr. Janet Yanowitz

p. 7 – "From each data set, we used only tests we determined to be valid." Specify what proportion of each data set was discarded for time alignment and other issues.

p. 19, Figure 1 - it would be useful to include the number of data points available for each operating mode, as perhaps that explains why the error bars are so large for certain operating modes. If not, perhaps the authors could suggest another reason for the large error bars (does your hole-filling technique result in these large error bars? Why?).

### 4.1.2. Clarity of Analytical Methods and Procedures

*Is the description of analytic methods and procedures clear and detailed enough to allow the reader to develop an adequate understanding of the steps taken and assumptions made by EPA to develop the model inputs? Are examples selected for tables and figures well chosen and designed to assist the reader in understanding approaches and methods?*

#### 4.1.2.1. Dr. Mohamadreza Farzaneh

The descriptions are clear and I was able to develop an adequate understanding of the steps taken and assumptions made. The following are a few questions I had on the procedures:

- Page 36, eq. 14 – Is there any study on the validity of this normalization approach? The main concern is that in the current form, it assumes that all the changes are essentially linear; which might not be necessarily true. An empirical comparison will show how this assumption is representative of the actual behavior of the data.
- Page 37, first paragraph under 2.1.2.2.3, line 4 – what is the criteria/definition for "sufficient"?
- The examples for tables and figures provide adequate information are on the methodologies used. The presentation of figures and tables can be improved as follows:
- Some of the tables and figures that use colors are not easy to follow in black and white print. For example, in figures 47 to 52, the same symbol is used for 0-3 and 4-5 age groups while their colors are not different in BW print. The same is true for figure 42. In general, when using colors in tables and charts, they should be selected in a way so they could be differentiated in BW print.
- I suggest including the pollutant name on all graphs dealing with the rates; e.g. figures 47-58.
- Tables 51 to 55. Table captions need to mention what pollutant they cover.

#### 4.1.2.2. Dr. Janet Yanowitz

Add a list of acronyms, with their meanings spelled out.

p. 1 – first paragraph, "exhaust rate inputs" is a confusing way to refer to "emission factors" based on various inputs such as model year, engine type, etc. Emission factors were also developed for organic species (including formaldehyde and acetaldehyde) and PM components.

p.15 – Table 10 is a very useful table, but it could be made better by ensuring that each box representing an estimate detailed the base case upon which the estimate was made and the whether it was done by proportioning by emissions standards or certification data (e.g. "proportioned to 1990 LHD by certification levels", or "proportioned to 1991-1997 HHD by emissions standards" instead of just "proportioned to certification levels" or "proportioned to HHD").

p. 19 through p. 31, Figures 1-3, 6-17 - It would be beneficial to show which graph points were developed from "hole-filling" estimation techniques for individual mode and which reflect actual data, so that the reader could better judge how well the estimation techniques work. This could be accomplished by showing all the estimated data using a different symbol than the measured data. How were the error bars for operating modes in which there was no data calculated?

p. 112, Table 54 – If I understand the text correctly, the emission factors for CNG and gasoline (1969 and later) are the same. If so the title of the table and the top of the second column should state that Table 54 applies also to CNG. If not please explain how the CNG criteria emissions from the crankcase are estimated

### 4.1.3. Appropriateness of Technical Approach

*Are the methods and procedures employed technically appropriate and reasonable, with respect to the relevant disciplines, including physics, chemistry, engineering, mathematics and statistics? Are you able to suggest or recommend alternate approaches that might better achieve the goal of developing accurate and representative model inputs? In making recommendations please distinguish between cases involving reasonable disagreement in adoption of methods as opposed to cases where you conclude that current methods involve specific technical errors.*

#### 4.1.3.1. Dr. Mohamadreza Farzaneh

Yes, I found the methodologies sound and reasonable given the data available. Below are a few questions and comments on the analyses.

- Page 8, first paragraph – it is implied that using ECU data will be more accurate than using speed and acceleration. Is this a fact supported by data (any references)? The methodology based on the ECU data uses a few simplifying assumptions that can introduce significant uncertainty into the process. A quantitative comparison would validate the implied assumption for this section.

- Figures 9 through 11- opMode 33 seems to have a high discrepancy between MOVES and data. Is there any explanation for this trend.

#### 4.1.3.2. Dr. Janet Yanowitz

p. 12 Eq. 4 - rather than k=1 underneath the leftmost sigma it should be j=1

p. 12 Eq. 5 - $s^2_{veh}$ should be $s^2_j$, n should be nj in description $s^2_{veh}$ should be $s^2_j$ = the variance in data for vehicle j

p. 13 Eqs. 7 and 8 and in text above –all subscripts pol should be p to be consistent with Equations 4 and 6

### 4.1.4. Appropriateness of Assumptions

*In areas where EPA has concluded that applicable data is meager or unavailable, and consequently has made assumptions to frame approaches and arrive at solutions, do you agree that the assumptions made are appropriate and reasonable? If not, and you are so able, please suggest alternative sets of assumptions that might lead to more reasonable or accurate model inputs while allowing a reasonable margin of environmental protection.*

#### 4.1.4.1. Dr. Mohamadreza Farzaneh

Overall, I found the assumptions reasonable and valid; however, some of the assumptions lack any supporting information/reference. Citing an appropriate reference would increase the validity of these assumptions.

#### 4.1.4.2. Dr. Janet Yanowitz

p. 7- "Updating MOVES emission rates …was considered when….MOVES 2010 rates …were not based on actual data….and the comparisons between MOVES 2010 and independent data show a clear indication of disagreement" . I would suggest that you develop criteria for what is a "clear indication of disagreement" such that it can be consistently applied for all comparisons between existing rates and new data. This reviewer recommends that you replace older values not based on actual data, whenever actual data becomes available, rather than set some arbitrary level of acceptable disagreement. Actual data should take precedence over estimated values in virtually all circumstances except when there is reason to believe the actual data is not representative.

p. 13 – please clarify why you use MY 2003-2006 data to estimate the rates for model year 2010 instead of the 2007-2009 data.

p. 14 – paragraph beginning "For certain model years…" clarify why you used a ratio of emission standards for missing regulatory classes instead of a ratio of certification data. Generally it appears that you used certification data to predict missing values (for example for all the 1990 and earlier data), as

opposed to emission standards. To this reviewer this appears to be the better approach as it is based on actual emissions measurements as opposed to standards which are frequently exceeded by a significant safety factor. For the years 2007-2009 you have data to test which approach works best, certification data or emissions standards for different regulatory classes – consider running a test, although in the absence of further information you should use a ratio of certification data in place of a ratio of emissions standards where possible.

## 4.1.5. Consistency with Existing Body of Data and Literature

*Are the resulting model inputs appropriate, and to the best of your knowledge and experience, reasonably consistent with physical and chemical processes involved in exhaust emissions formation and control? Are the resulting model inputs empirically consistent with the body of data and literature that has come to your attention?*

### 4.1.5.1. Dr. Mohamadreza Farzaneh

Yes, the model inputs are appropriate are consistent with physical and chemical processes involved in exhaust emissions formation and control. The rates can benefit significantly from more data collection and assembly.

I found the resulting inputs empirically consistent with the body of data and literature that I have worked with. In my response to Question 1, I listed a study by TTI that produced emissions testing data of heavy duty vehicles at high speeds which could be of use to expand the existing database. The following are a few examples of areas where additional data will greatly enhance the emission rates developed for heavy duty vehicles:

- NOx emissions increase due to disabling SCR after the end of warranty period
- More data on crankcase emissions for 2007+ to better characterize the effect of aging
- Emissions of 2010+ heavy duty diesel vehicles
- I suggest using "×" symbol instead on "*" in equations on page 37.

### 4.1.5.2. Dr. Janet Yanowitz

Yes.

## 4.1.6. CNG Transit Bus Running and Start Exhaust Emission Rate Methodology

*Is the methodology for creating new MOVES2014 running and start exhaust emission rates for compressed natural gas transit buses sufficiently explained? Can you follow the procedure that was used to calculate ratios from the MOVES2010b rates to the MOVES2014 rates and how those ratios were applied? Do you have any suggestions for improving this methodology for CNG emission development or the documentation itself?*

#### 4.1.6.1. Dr. Mohamadreza Farzaneh

Yes, the methodology and data were adequately explained and I was able to follow the procedures.

#### 4.1.6.2. Dr. Janet Yanowitz

All references to MOVES2013 should be replaced with MOVES2014.

p. 85 - Figure 42 does not show what is discussed in the text referencing this table. A table which showed the number of natural gas buses relative to the total number of buses would have been useful.

p. 88 - Equation 28 use consistent subscript – either p or pol for pollutant

p. 90 - text says that in some cases the same vehicle may have been driven over more than one driving cycle, although the table says that each study included only one driving cycle; it is possible that one of the NREL vehicles was used in one of the other tests but that seemed unlikely.

p. 101, Table 42 - This table could use some clarification – for example the title and the caption should indicate that the table also includes calculated data not just measured and certification data, and the caption could explain that the last line is the calculated values. The caption could also include a brief description of how the calculation was made, i.e. Equation 29. It is unclear what the footnote refers to – I would think it would be better placed under the column for THC on the two certification lines with an explanation. A footnote to explain where the red value for CO comes from would also be useful.

p. 102 and p. 99 seem to conflict– On p. 102 compare the sentence which begins: "We replaced it with a value equal…." To what is written at the bottom of p. 99 " We did, however, throw out the CO rate (0.14 g/mi) for these WMATA vehicle**s**……" p.. 99 appears to say that the anomalous CO data point was discarded, and that there was more than one vehicle involved in the calculation of the anomalous CO data point, where p. 102 refers to only a single vehicle with an anomalous CO rate, and appears to say (it is not really clear) that the new value somehow includes the certification level.

p. 102 – typo – developing for developed

p. 102 Table 43- This table can provide a useful summary, with a little additional explanation in the caption and explanatory subtitles.

p. 104 and p. 107 – it is not at all clear how you propose changing the CH4/THC ratio with age of bus. If you are changing the ratio with age, please provide those values. You say (p. 104) that the CH4/THC ratio changes with deterioration of the after-treatment equipment, but then later state that you keep the CH4/THC ratio constant at all ages ("we assume that the change in the THC emission rate is proportional to the changes in the methane emission rate, and keep this ratio constant at all ages." Then on p. 107 you say something different again: deterioration assumptions used in the MOVES 2010b rates are incorporated into the new model

p. 104 - It is not clear why keeping "the THC emission rate …proportional to the changes in the methane emission rate…. is consistent with a decrease in combustion efficiency." Please explain.

p. 104 Table 44 – this table is not a comparison of different ratios as stated in the title, as no information is given for the MOVES 2010B CNG bus rates. The values for 2002-2006 and 2007-1012 should actually be exactly the same as that is how the ratio for 2007-2012 was derived (see p. 101) - seems like you are including too many significant digits.

p. 104 - The sentence which begins "Studies have shown…." refers to three categories of buses: "uncontrolled CNG buses, CNG buses with oxidation catalysts and CNG buses." Looks like a typo or it needs a better explanation.

p. 104 - "Formaldehyde has … a large impact on the NMOG/NMHC ratio because formaldehyde has a small response to the THC-FID measurements." This is not clear - please explain further or revise

p. 104 - last partial paragraph references tests made by Ayala et al. on an *engine* and then speciated measurements made on a *vehicle*. If this is not a typo, please clarify where data for the vehicle test came from.

p. 106 – Please explain how you calculated MOVES2010b emission rates for diesel transit buses by model year if the rates are applied by engine family. Did you do sales weighting of the various engine families?

## 4.1.7. Changes in Control Technology and Emission Standards for CNG Buses

*Does this EPA analysis of CNG buses accurately reflect the changes in control technology and emission standards? If not, how would you recommend to make the CNG emission rates more reflective of bus emission reduction trends over the past two decades?*

### 4.1.7.1. Dr. Mohamadreza Farzaneh

To the best of my knowledge and based on the available data used for this purpose by the EPA, the described methodology accurately reflects the changes in the control strategies and emissions standards.

### 4.1.7.2. Dr. Janet Yanowitz

The inclusion of emission factors out to four or more significant digits give the appearance of far more certainty in these emissions factors than is reasonable based on the available data.

Given the limited data which was available to the authors of this report, the approach used was defensible, and will show, as is warranted, reduced emissions from more modern CNG buses. It is an improvement on the emission factors used in MOVES2010b. However, as the authors themselves point out a number of papers discuss newer CNG vehicles. It is hard to believe that studies from 2007 (cited on p. 99) or 2011 (see first paper cited below) cannot be included in the 2014 version of the MOVES model, because they were not available in time. Although a review of additional data available was beyond the scope of this reviewer's charge, the authors of the MOVES2014 should consider additional data available in the following documents, even if they are only able to do so briefly to roughly evaluate the accuracy of their proposed model:

Gautam, M., Thiruvengadam, A., Carder, D., Besch, M., Shade, B., Thompson, G. & Clark, N. Testing of volatile and nonvolatile emissions from advanced technology natural gas vehicles. West Virginia University. 2011; available at http://www.arb.ca.gov/research/apr/past/07-340.pdf

Seungju Yoon, John Collins, Arvind Thiruvengadam, Mridul Gautam, Jorn Herner, Alberto Ayala. Criteria pollutant and greenhouse gas emissions from CNG transit buses equipped with three-way catalysts compared to lean-burn engines and oxidation catalyst technologies Journal of the Air & Waste Management Association Vol. 63, Iss. 8, 201. The inclusion of emission factors out to four or more significant digits give the appearance of far more certainty in these emissions factors than is reasonable based on the available data.

Given the limited data which was available to the authors of this report, the approach used was defensible, and will show, as is warranted, reduced emissions from more modern CNG buses. It is an improvement on the emission factors used in MOVES2010b. However, as the authors themselves point out a number of papers discuss newer CNG vehicles. It is hard to believe that studies from 2007 (cited on p. 99) or 2011 (see first paper cited below) cannot be included in the 2014 version of the MOVES model, because they were not available in time. Although a review of additional data available was beyond the scope of this reviewer's charge, the authors of the MOVES2014 should consider additional data available in the following documents, even if they are only able to do so briefly to roughly evaluate the accuracy of their proposed model:

Gautam, M., Thiruvengadam, A., Carder, D., Besch, M., Shade, B., Thompson, G. & Clark, N. Testing of volatile and nonvolatile emissions from advanced technology natural gas vehicles. West Virginia University. 2011; available at http://www.arb.ca.gov/research/apr/past/07-340.pdf

Seungju Yoon, John Collins, Arvind Thiruvengadam, Mridul Gautam, Jorn Herner, Alberto Ayala. Criteria pollutant and greenhouse gas emissions from CNG transit buses equipped with three-way catalysts compared to lean-burn engines and oxidation catalyst technologies Journal of the Air & Waste Management Association Vol. 63, Iss. 8, 201.

Clark, N., Wayne, W., Khan, A., Lyons, D. "Effects of Average Driving Cycle Speed on Lean-Burn Natural Gas Bus Emissions and Fuel Economy," SAE Paper No. 2007-01-0054, 2007. Cited on p. 99 of this report.

## 4.1.8. General/Catch-All Reviewer Comments

### 4.1.8.1. Dr. Mohamadreza Farzaneh

The report is well written, and methodologies and assumptions adequately described. The authors applied creative methodologies to address the data gaps specifically for the newer vehicles. I did not notice any major flaws in the methodologies and assumptions used.

The MOVES model has come a long way since its first release. It is clear that it still requires more data to strengthen the overall emission rates as well as to address current data limitation such as newer model years.

- A recent remote sensing data by TTI showed that some of the newer trucks have high NOx levels. When the researchers checked with the owners, they mentioned that SCR causes problem and requires repairs, therefore they sometime disable the SCR unit after the warranty period.
- Section 2.1.1.3.4 – As stated above, some truck owners disable the SCR unit entirely. These are not captured under this section.
- Table 42 – since certification testing is an engine dynamometer testing, “duty cycle” would be a better term for vehicle activity than “drive cycle.”
- There are references to MOVES2013 in the text which I believe should be updated to MOVES2014; especially in section 4.
- Table 35 – The table uses “VSP bin” and “TSP bin”, my understanding is that the correct term for them is “operating mode bins”
- Section 4 - A statement on the use of these rates for LNG buses, whether it is acceptable or not, would be helpful for users.

#### 4.1.8.2. Dr. Janet Yanowitz

No further comments.

# Appendix A. Dr. Mohamadreza Farzaneh's Supporting Documentation

## A.1. Reviewer's Delivery Email (i.e., Cover Letter)

See file: *Mohamadreza Farzaneh Review.msg.pdf*

## A.2. Reviewer's CV

See file: *RezaFarzaneh_Resume_Aug2013.pdf*

## A.3. Reviewer's COI Statement

See file: *Signed_COI_Disclosure_Farzaneh(HD)_Redacted.pdf*

# Appendix B. Dr. Janet Yanowitz's Supporting Documentation

## B.1. Reviewer's Delivery Email (i.e., Cover Letter)

See file: *Janet Yanowitz Review.msg.pdf*

## B.2. Reviewer's CV

See file: *Resume Yanowitz Janet August 2013.pdf*

## B.3. Reviewer's COI Statement

See file: *Signed_COI_Disclosure_Yanowitz(HD)_Redacted.pdf*

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