Peer-Review Comments and EPA Responses: MOVES2014b Default Fuel Supply Report

December 2020

Peer review is an important element in ensuring the quality and integrity of the MOVES model. Peer review for the MOVES Default Fuel Supply Report was carried out under procedures described in the EPA Peer Review Handbook.[1] A contractor managed the peer review process, selecting qualified independent experts and arranging for letter reviews.

This document summarizes the comments received from the peer reviewers, and EPA's responses. Reviewer comments on minor formatting issues and typos are not included here. Note that references to specific text, figures, tables, or appendices made by the peer reviewers refer to the August 2017 draft of the report and may no longer be consistent with the final public version. Also, some of the peer review comments were addressed immediately in the MOVES2014b documentation, while others were held until we could make updates in the next major model release (MOVES3[2]). We have tried to make this clear in the responses here.

The peer-reviewed report, charge questions to the peer-reviewers, as-received peer-review comments, and other associated peer-review materials are located on EPA's science inventory webpage.[3]

Section 1: Charge Questions with Peer Reviewer Comments and EPA Responses

Question 1: Does the presentation describe data sources sufficiently to allow the reader to form a general view of the quantity, quality, and representativeness of data used in the analysis? Please note that some or all of the data used as part of these analyses are considered Confidential Business Information, and cannot be provided for review directly. The data itself have already received review, and are not the focus of this peer review. Are you able to recommend alternate data sources that might better allow the model to estimate national or regional default values?

Lindhjem comment: The presentation does describe the data sources sufficiently to form a general view of the quantity, quality, and representativeness of the data, and appropriateness of using the data. As far as I am aware, this would be the best data to use and cannot recommend alternative data sources.

No EPA response required.

Question 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 while developing the model inputs? Are examples selected for tables and figures well-chosen and effective in improving the reader's understanding of approaches and methods?

Lindhjem comment: The analytic methods description and tables and figures are sufficient to understand how the model inputs were developed in general. Additional figures and results could be presented to better describe the process through the summary results.

See EPA response in Detailed Comments section below.

Question 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 for alternate approaches, please distinguish between instances involving reasonable disagreement in adoption of methods as opposed to instances where you conclude that current methods involve specific technical errors.

Lindhjem comment: The methods and procedures appear to be technically appropriate as described.

No EPA response required.

Question 4: 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 are appropriate and reasonable? If not, and you are able to do so, please suggest alternative assumptions that might lead to more reasonable or accurate model inputs.

Lindhjem comment: There are specific instances where EPA has made assumptions and estimates that require further explanation and consideration.

See EPA response in Detailed Comments section below.

Question 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 fuel distribution, fuel blending, and historical and projected trends in mobile source fuel properties? Are the resulting model inputs empirically consistent with the body of data and literature with which you are familiar?

Lindhjem comment: The resulting model inputs appear appropriate based on the presented nationwide averages. EPA presumably has reviewed the regional variability to identify and understand outlier inputs though that review was not described in this report.

EPA response:

Outlier analysis was performed on the batch data. However, fuel batches are generally mixed together in pipelines and tanks along the distribution system. Therefore, batches of

fuel with unusually high or low values for aromatics or T50, for example, wouldn't necessarily be expected to reach a particular fuel station or subset of vehicles.

Section 2: Detailed Comments and Responses

Lindhjem comments:

Figure 1 is useful to understand the depth and range of the data available. It would be useful to show similar figures for other fuel parameters. For example, aromatics and olefins have a significant effect on toxics emissions, so it would be useful to understand the range in those estimates as well.

Also, cloud plots such as Figure 1 underrepresent the bulk of the data because most points lie on top of one another. If the report shows the uncertainty intervals (e.g. +/- 95% confidence level) of the final parameters averages provided in the Appendix, it would likely demonstrate a high level of confidence in the final averages calculated because the sample size is large.

The report stated, "In addition, due to the prevalence of downstream blending with multiple fuel deliveries, it would be unlikely that variations of this magnitude would be seen at a retail outlet (as multiple batches would tend to move the overall fuel qualities to the average)." This is likely true, and to this statement the report could add blending within the tanks at retail outlets and within vehicle or equipment tanks to strengthen the argument.

The report stated, "By including this (AAM) downstream sample data as part of the validation process, we have increased our confidence that our final result is appropriately representing retail location samples for a given fuel region." Please at least outline the approach of how the AAM data was used to validate the batch refinery data. It would help to show examples of this validation to give the reader confidence in the final estimates.

EPA response:

In the MOVES3 document, Figure 1 was replaced by a figure from and reference to the EPA Gasoline Fuel Trends report (EPA-420-R-17-005, October 2017). This information is intended to illustrate the batch-to-batch variation in properties from a given refinery. The referenced report provides much more detail, including plots of many fuel parameters in a variety of formats, including statistical intervals.

Regarding adding more detail about downstream blending reducing batch-to-batch variation in the retail market, this language was part of Section 3 in the MOVES2014 Fuel Supply report, the context of which was justifying the new approach of building the fuel supply from batch data instead of the patchwork of survey points used in the 2010 model. While these are true statements, this discussion was greatly reduced in the MOVES3 report since the approach was no longer new and there were other areas of increased focus.

Regarding validation of the batch data fuel supply against retail survey datapoints, this was a qualitative comparison as depicted in the Fuel Trends reports, as cited at the bottom of Section 4 in the MOVES3 document. As explained in the MOVES3 report, where retail survey results and batch data differ, the batch data is preferable for MOVES purposes.

Lindhjem comments:

As an addendum to Table 1, the fuel regions could be better detailed. The whole state and individual counties or cities (when not included in a county list) could be cross referenced to the fuel regions by fuelRegionID. For example the appendix could include a lookup table as might appear in the MOVES database. This would provide the MOVES user with context in case fuel regions change or consider changing (e.g. expanding or contracting RFG regions). Also, Table 2 showed 23 fuelRegionIDs but the text below the table read, "In total, MOVES201X has 24 fuel regions."

EPA response:

The 24 regions was a typo; the MOVES3 fuel supply revised the number of regions and correctly describes them in the text. It also presents a new table showing changes in regional volatility controls over time, and an appendix with year-by-year maps of the continental US with color-coded fuel regions at the county level. Region assignments for all counties and years can be obtained by opening the MOVES regionCounty table and searching for specific counties.

Lindhjem comments:

The report read, "After reviewing the results of these categories, EPA determined that there was not adequate data (<100 batches for some regions) for the shoulder seasons to remain as separate categories, and, therefore, these data were re-aggregated into the summer and winter seasons…The two aggregation seasons used for this dataset are summer (May, June, July, and August) and winter (January, February, March, April, September, October, November, and December)."

The report should describe how shoulder season RVP levels could be estimated and incorporated into MOVES. For example, according the report, wintertime RVP levels are assumed for April, September, and October for all regions when, for example, the Houston and Atlanta regions have shown ozone exceedances in those months in recent years. The report could point the MOVES user specifically on how to vary the RVP levels for shoulder seasons in southern counties such that MOVES would not assume wintertime RVP levels in April or September.

EPA response:

The MOVES2014b default fuel supply was updated to include shoulder fuels for all regions. For these the RVP and distillation parameters reflect values in between summer

and winter, as expected. Other fuel parameters, such as aromatics and sulfur, mirror winter properties for years 2013 and earlier, and take on intermediate values in 2014 and later. More discussion of the determination of fuel properties is available in Sections 5 and 6 the MOVES3 document.

In addition, the MOVES training and technical guidance provide information on how to use the Fuel Wizard to model fuels that are not in the MOVES default database.

Lindhjem comments:

The report does not describe regional and seasonal differences in diesel fuel. One understandable reason is that MOVES has not adjusted and will not adjust emissions by diesel fuel component.

There are cases where spatial and seasonal differences occur. For example, California (entire state) and Texas (110 central and eastern counties) have diesel fuel regulations and claim emissions reductions for the state fuel when compared with national average diesel. Texas and bordering states experience spillover, at least in traffic to or from Texas, which affects the estimated emission reduction. Northern states typically have seasonal variations in diesel fuel when lighter diesel is used during winter.

EPA response:

At this time MOVES does not have emission adjustments for diesel fuel properties other than biodiesel in 2007 and older engines, and sulfur in all engines. Therefore, seasonal and regional variations in properties such as density, cetane, or aromatics have no effect on emissions in MOVES and are not tracked in the MOVES fuel supply. These effects may be considered for a future version of MOVES.

Lindhjem comments:

Table 13 in the report stated that marine diesel exceeds 15 ppm levels for all future years despite the regulation limiting the fuel sulfur level. However, the MOVES2014a model did not provide an emission estimation method for marine vessels or locomotives, so perhaps this table is unnecessary unless the next version of MOVES estimates marine vessels emissions.

The marine fuel sulfur limits are the same as the locomotive fuel. "Specifically, the sulfur standards finalized under today's program apply to all the diesel fuel that is used in nonroad, locomotive, and marine diesel applications—fuel not already covered by the previous standards for highway diesel fuel. This includes all fuel used in nonroad, locomotive, and marine diesel engines, except for fuels heavier than a No. 2 distillate used in Category 2 and 3 marine engines and any fuel that is exempted for national security or other reasons."[4]

If the marine fuel sulfur estimate assumed spillover from the deep draft Ocean-Going Vessels using Category 3 engines (or Category 2 engines in those types of vessels) is affecting the general marine diesel market, one might expect counties close to ports to have different fuel than

those far from deep draft vessel ports. In addition, the fuel sulfur spillover effect may have changed since the Emission Control Area declaration for U.S. and Canada and worldwide IMO regulations reducing fuel sulfur for bunker fuels have begun to be implemented. The Category 1 and 2 engines used in tow boats, ferries, and other smaller craft should not be exempted from the regulation.

Reference to the 2004 Regulatory Impact Analysis[5] does not detail how the average marine fuel estimate shown in Table 13 was determined. Table 13 provided the same estimate as EPA (2009)[6] EPA-420-B-09-018, but this EPA document provides no description of how these sulfur levels were determined.

Marine engines are being offered with diesel particulate filters that are sensitive the fuel sulfur level. If the marine diesel sulfur level is high, EPA should address what types of vessel would use higher than regulated sulfur fuels.

EPA response:

As the reviewer noted, MOVES does not model locomotives or commercial marine vessels. The "marine diesel" cited here is for use in "recreational marine" vessels (also called "pleasure craft."), which we clarified in the MOVES3 fuel supply report. These sulfur levels were corrected in MOVES2014b. We've also added text that explains that these levels represent a walk-down in sulfur to meet regulatory requirements based on what was known about refining, consumption, and credit trading patterns.

Lindhjem comments:

The report reviewed is similar in scope and detail to the previous technical documentation for the MOVES2014 model. It describes the changes in approach and estimates at the same level of detail. Overall, the methods, procedures appear to be reasonable.

EPA response:

No response required.

Hoekman comments on Section 1 Introduction:

To provide greater context for the reader, it should be mentioned that the fuel quality database tables used in MOVES pertain to gasoline, diesel, and natural gas fuels that are used in both on-road and non-road applications. However, the Fuel Wizard only applies to gasoline fuels, and only addresses changes in three properties: ethanol content, sulfur content, and RVP. In addition, perhaps a brief statement should be provided to explain why the projection of E15 usage beyond the year 2015 has been removed.

EPA response:

Clarification has been added to the introduction to clarify that the Fuel Wizard is only used to estimate gasoline fuel properties. Additional detail has been provided in Section 9 on the scope of the Fuel Wizard

Given the low sales volumes of E15 and the difficulty in determining E15 sale locations, E15 market share projections have been removed from the default fuel supply for all calendar years. However, splash-blend formulations are provided for users to adopt if desired. More detail on these updates is available in the Fuel Wizard section of the revised report.

Hoekman comments on Section 3 Background:

This section introduces the problem of how to define appropriate sets of fuel properties that accurately represent actual marketplace fuels. This is complicated by seasonal and regional variations in fuel specifications. For gasoline, this is further complicated by the fact that much (maybe most?) product batches from refineries are blendstocks for oxygenate blending (BOBs), not finished, marketplace gasoline.

In view of this, Figure 1 may give a somewhat misleading depiction of the variability of E200 in realistic fuels, as this figure appears to include BOBs as well as finished gasolines, and it appears to include both summer and winter fuels. Segregation of the fuels into conventional gasoline (CG) and reformulated gasoline (RFG) may be useful, as these categories have slightly different specifications, and may be treated separately in MOVES. Segregation by grade (Regular and Premium) may not be as useful, as these categories do not have different regulatory specifications. Nevertheless, it would be of interest to indicate what fraction of U.S. gasoline is RFG vs. CG, and what fraction is Regular vs. Premium. Presumably, the fuel properties shown in Appendix A represent volume-weighted averages of all gasoline types (i.e., Regular and Premium grades of both CG and RFG).

To get a more realistic picture of variability of fuel properties, it would be better to limit the data to only finished, marketplace gasolines for a single season (summer or winter). It would be quite instructive to show such data in graphical form similar to Figure 1 for a few gasoline properties that are regulated (e.g., RVP, sulfur content, and benzene content) and for a few properties that are not regulated (e.g., E200, olefins content, and aromatics content).

EPA response:

As mentioned above, Figure 1 was replaced in the revised document with a figure from and citation to the EPA Gasoline Fuel Trends report (EPA-420-R-17-005, October 2017). The Trends report summarizes gasoline batch data for several fuel properties over multiple years, and includes a comparison to the AAM survey data.

Given the prevalence of E10, almost all of the conventional gasoline data is for BOBs. Thus, limiting the batch data to finished marketplace fuels would result in a small dataset, leaving large geographical gaps where no surveys were conducted, and preventing quantitative assessment of fuel variation across the country that we know exists.

Under the October 2020 fuel streamlining rule, we expect to begin developing a larger database of retail fuel property information to draw upon in future model releases.[7] For the current model, we maintain the previous methodology of building the fuel supply from the large database of refinery batch data, adjusted for ethanol blending and regional transport. More detail is given in the updated fuel supply report released with MOVES3.

The updated fuel supply report does not quantify volumes or fractions of the national fuel supply that are premium grade, but the properties derived from refinery batch data include premium fuels and their properties are volume-weighed accordingly. Reformulated fuels are captured separately in MOVES with specific regionID values. Therefore, MOVES emission estimates do consider premium and reformulated fuels via their impact on values for specific properties such as the vapor pressure, aromatics content, etc.

Hoekman comments on Section 4 Regional Fuels:

This section describes the approach used by EPA to aggregate fuels and their properties into a relatively small number of geographic regions. It is curious why the numbering of the eleven base fuel regions identified in Table 1 are not sequential. To further illustrate these regions, it would be useful to show a larger sized map in Figure 3, and to include a legend to identify the correspondence between the 11 regions and the colors used in the map.

On page 9 it is stated that MOVES201X has 24 regions. Yet, Table 2 identifies only 23 regions. Why the discrepancy? Also, the RFG regions (base regions 11, 12, 13, and 14) all indicate a minimum ethanol volume of 10%. My understanding is that the original ethanol requirement for RFG no longer applies. In fact, there is virtually no difference any longer in ethanol contents of RFG and CG.

EPA response:

More detailed maps of the fuel regions have been included in the MOVES3 documentation and the number of regions has been updated. As suggested, there is very little difference in ethanol content between conventional and reformulated gasoline. The indication of minimum 10% ethanol in RFG was left in place for all years to be consistent with historical requirements. As the text now explains, this has no impact on the actual fuel properties or emission impacts. We are considering revising the RFG region IDs in a future version of MOVES.

Hoekman comments on Section 5 Fuel Properties:

This section describes the information sources used by EPA to develop base fuel properties for different regions, and explains modifications made to these properties to better represent actual marketplace fuels. Table 3 identifies the gasoline properties included in the fuel compliance database. It would be helpful to expand this table to include the units of measurement for each property. It would also be useful to indicate which of these properties are used directly within MOVES.

As pointed out on page 10, the fuel compliance data includes information on fuel batches as they leave their points of production. However, fuels (and BOBs) produced in one region are often transported and used in other regions. This cross-regional transport is facilitated by pipelines, which also serve to homogenize the composition of different batches. Some discussion of these issues should be provided, along with an explanation of the approach used by EPA to account for such transport, and the uncertainties in regional marketplace gasoline compositions that this creates.

The adjustment of BOB fuels to account for ethanol blending is mentioned on page 11, but no details are provided to explain what these adjustments are, and how they are made. Adjustments in fuel properties resulting from ethanol blending are complicated, as some properties "blend linearly" (such as sulfur, aromatics, olefins, and oxygen levels), while other properties do not (such as RVP, T50, T90, E200, and E300). Some discussion of these issues should be provided. In addition, it would be useful to show the final fuel properties resulting from these BOB adjustments. Perhaps Appendix B could be added, which would resemble the existing Appendix A, but show adjusted fuel properties rather than the properties based only on compliance batch data.

The approach by which AAM fuel sampling data are used to validate the adjustments made to compliance batch data should be explained. For example, is it required that the adjusted data match the AAM data within specified tolerance ranges for individual fuel properties? What is done if the compliance data and AAM data don't match?

> *EPA response:*
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> *See response to Lindhjem on pages 3-4 above regarding validation of batch data results with AAM surveys, and transport of batches through the distribution system acting to homogenize individual batches toward pipeline or regional means. Text was added to Section 5.1 of the MOVES3 document giving more detail on how production-level properties in different areas of the country were weighted together with other areas based on EIA's PADD-to-PADD transfer data.*

The adjustments to secondary fuel properties resulting from changes to gasoline ethanol level, RVP, and sulfur level are shown in Tables 4, 5, and 6, respectively. However, the discussion about this is quite brief (page 12) and somewhat confusing. One point of clarification would be

to include the units for each fuel property. Table 4 would then more clearly show that when going from E0 to E10 in summer gasoline, not only does RVP increase by 1.0 psi, but also aromatics are reduced by 2.02 vol.%, olefins are reduced by 0.46 vol.%, E200 is increased by 3.11 vol.% evaporated, E300 is increased by 0.39 vol.% evaporated, T50 is decreased by 6.34 °F, and T90 is reduced by 1.77 °F.

Near the bottom of page 15, it is mentioned that the "density, energy and carbon content" of fuels used in MOVES are shown in Table 10. Actually, the carbon contents are shown in Table 9. However, it would be helpful to simply combine Tables 9 and 10 into a single table. Also, the carbon content of each fuel subtype shown in Table 9 is expressed in units of g/kJ. While this is appropriate for the calculation of CO2 emission rates, it would be helpful to the reader to also express carbon contents in terms of wt.%.

While their current usage levels are very small, there are a handful of other fuels that have a marketplace presence – including renewable diesel (RD), LNG, and H2. The way in which these minor fuels are treated within MOVES should be explained.

EPA response:

Table 4-1 (previous Table 3), containing batch data fuel properties, has been revised to focus on the properties used in MOVES and providing their units of measure. Additional information is given in Section 5.1 about the adjustment of fuel production data to better reflect in-use properties, including ethanol and volatility adjustments with units of measure.

Density, energy and carbon contents have been also been added to this report in Table 8-2. This information is also present in the report: "Greenhouse Gas and Energy Consumption Rates for On-road Vehicles: Updates for MOVES3", which presents the calculations that MOVES uses to calculate carbon dioxide and fuel consumption.

Renewable diesel and LNG are not currently included in MOVES3, and this is clarified in the Introduction section of the updated report. Hydrogen is not included in the model nor discussed the report.

Hoekman comments on Section 6 Renewable Fuels Market Share and Usage:

This section explains the methodology used to estimate the volumes and market shares of various fuels used in MOVES – both in the past and projected into the future. It would be simpler and clearer to the reader if Tables 11 and 12 were combined into a single table. In the current Table 11, why are there two different values for FFV Market Share (Sourcetype 21 and Sourcetype 31)? Also, are the FFV Market Share and Fuel Usage Fraction values shown here the national average default values? How do these values vary regionally, and how is such variability handled within MOVES?

The description of biodiesel usage rates on pages 21-22 is somewhat confusing. Is this saying that all diesel fuel from 1990 to 2013 is assumed to be B0, while all diesel fuel in 2014 and beyond is assumed to be B5?

EPA response:

Discussion of FFV market share and fuel usage fraction was simplified in the MOVES2014b report, including removal of Tables 11-12. For MOVES3, future market shares of ethanol blends are further simplified, with flat E85 use for 2010 and later for all regions.

Biodiesel blend levels have been adjusted in MOVES3 to 3.4 vol% starting in 2011, based on review of EIA Monthly Energy Review datasets. Additional formulations are available to users who wish to model other scenarios. A consistent nationwide blend level was retained in MOVES3 as we do not currently have data to produce year-by-year regional blend levels.

Hoekman comments on Section 7 Nonroad Fuel Supply:

Are the sulfur levels shown in Table 13 for nonroad diesel and marine diesel supported by fuel survey data? Also, it appears that these sulfur values represent national average levels. How much regional variation is there?

It would be useful to include nonroad diesel (fuelTypeID 23) and marine diesel (fuelTypeID 24) in Tables 9 and 10, along with the other fuel types shown in this table. Are there additional fuel types used in MOVES that are not currently listed in Tables 9 and 10?

EPA response:

Additional detail has been added to the MOVES3 report on the properties of both onroad and nonroad diesel fuels. Sulfur levels were updated after review of several years of retail survey data. This information showed average in-use sulfur around 6ppm with little variation by state or region.

Nonroad estimates fuel consumption and CO_2 rates using brake-specific fuel consumption (BSFC) values stored in the nonroad MOVES database. We have added references to the nonroad reports that contain the data and methods for calculate nonroad fuel consumption and CO_2 emission rates to the introduction of the report "Greenhouse Gas and Energy Consumption Rates for On-road Vehicles: Updates for MOVES3."

Hoekman comments on Section 8 Fuel Wizard:

For clarification, it would be helpful to include a small table that shows the adjustable fuel properties in the Fuel Wizard (ethanol, sulfur, and RVP) along with the range over which these properties can be varied within the Fuel Wizard.

EPA response:

The three adjustable properties (ethanol. RVP, sulfur) have been clarified in the text and their valid ranges stated.

References

[1] US EPA, *Peer Review Handbook, 4th Edition,* EPA-100-B-15-001, October 2015, https://www.epa.gov/sites/production/files/201603/documents/epa_peer_review_handbook_4th_edition.pdf
[2] USEPA (2020). *Fuel Supply Defaults: Regional Fuels and the Fuel Wizard in MOVES3*. EPA-420-R-20-017. Office of Transportation and Air Quality. US Environmental Protection Agency. Ann Arbor, MI. November 2020. https://www.epa.gov/moves/moves-technical-reports.
[3] USEPA (2017). *Fuel Supply Defaults for Regional Fuels and Fuel Wizard Tool in MOVES201X - Draft Report*. Draft report and peer-review documents. Record ID 328850. EPA Science Inventory. September 2017. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=328850.
[4] 40 CFR Parts 9, 69, et al. Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel; Final Rule, Tuesday, June 29, 2004.
[5] EPA 2004, "Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines," EPA420-R-04-007 May 2004.
[6] EPA 2009. "Suggested Nationwide Average Fuel Properties, EPA-420-B-09-018, April 2009.
[7] EPA, October 2020, "Final Rulemaking: Streamlining and Consolidating of Existing Gasoline and Diesel Fuel Programs." https://www.epa.gov/diesel-fuel-standards/final-rulemaking-streamlining-and-consolidating-existing-gasoline-and-diesel