April 25, 2015

Carnegie Mellon University
Department of Civil and Environmental
Engineering
5000 Forbes Avenue
Pittsburgh, PA 15213

Gerald W. Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
State Water Resources Control Board
1001 I Street
Sacramento, CA   95814

Dear Dr. Bowes:

Attached please find my scientific peer review of the materials requested in support of the CA LCFS re-adoption activities.

External to my scientific review, I wanted to note a few small things that might be useful for the staff in terms of making these documents ready for public dissemination.

* Make it clear that LCFS defines the CI units of gCO2e/MJ (p. 2 of CA-GREET Report)
* Figure 1 is not 'generalized' – one of the arrows refers to biofuel use
* In the middle of page 8, the VOC and CO factor determination description is hard to follow. I figured out the ratio for CO, and still it could be written more clearly (e.g., describe where the 0.85 and 0.43 values come from – and what specific reference VOC was used to generate the assumed value for 0.85?)
* There was no text description of Tier 2 Method 1 in the Summary Report

Thank you again for asking me to participate in this very worthwhile effort.

Sincerely,

H. Scott Matthews
Professor

Peer Reviewer Report
H. Scott Matthews, Carnegie Mellon University

Methodology in Calculating Fuel Carbon Intensities and Use of Greenhouse Gas Emissions Models

April 25, 2015

I was asked by the State of California to review the staff reports and additional materials associated with the work produced in support of the California Low Carbon Fuel Standard (LCFS). It was an honor to be asked to look at this work, as the work done by this evolving team over time has been one of the most impressive scholarly efforts I have seen in my career. This team continues to do excellent work. Likewise, the goal and implementation of the LCFS has been one that has been successful in 'raising the bar' in terms of the expectations of performance in the transportation energy industry, and also in terms of nudging the federal government to adopt similar programs.

The specific statement of task I was given involved various aspects:

My scientific peer review responsibility was "to determine whether the scientific basis or portion of the proposed rule is based upon sound scientific knowledge, methods, and practices." Likewise, the focus is on the methods used to develop the carbon intensity (CI) values, as opposed to the LCFS program in general.

In addition, I was asked to assess the "Big picture" to ensure whether there are scientific issues not described or dealt with in the work.

Finally, I was asked to assess whether, overall, all of the work was based on sound science?

Note that via interactions with the organizers of the peer review, I was asked to focus on the GREET and OPGEE aspects of the work. I thus focused my review into those two components including review of the staff reports as well as the underlying electronic spreadsheets and references. [Note that while I am familiar with the kinds of models used in the GTAP and AEZ component, my review of that part was more cursory, consisting only of a review of the staff reports and a skim of the additional materials provided electronically. However I did not present scientific assessments of that component.]

Finally, I was asked to review the conclusions given by the staff, namely that the CA-GREET and OPGEE models used to calculate carbon intensity values (and GTAP for ILUC) are reasonable and that the models were applied appropriately under the LCFS.

Below I provide detailed review comments separated by the materials associated with the various subcomponents provided.

Three printed staff reports related to CA-GREET, OPGEE, and GTAP models, which are used to estimate the various carbon intensities.

Aside from small issues in terms of the details presented in these summaries, I found no issues of concern related to the high-level goals or methods used in these three domains.

Staff Reports and Plain English Summaries

I note that one thing not provided explicitly in any of the Staff Reports but which would have been useful was a succinct summary (box model diagram) of the three carbon intensity model components, as well as a short summary of the more specific quantitative aspects of the LCFS (10% goal by 2020). For the latter issue, this detail was available in the various links and support provided (e.g., the ISOR).

The plain English summaries did not seem to be very different than the text in the detailed staff reports. I saw no issues in those summaries for that audience but assume that those documents have been written in conjunction with technical writing experts.

Component 1 - CA-GREET

I found the CA-GREET related Staff Report report to be well organized and written. I note the following issues:

A small issue of concern, where the impact is hard to assess from the material provided, is the use of EPA AP-42 emissions factors. The reference date for the CD-ROM is 2005, but the underlying emissions factors for many processes in that document are much older than that. However there was not enough detail or method listed to give a sense of where those emissions factors were used, for what processes, etc. I trust that staff can develop more robust text that would help to clarify where they were used and any potential scientific impact from them. As a specific example recently noted by EPA (and a change forced by legal action), many of these values are quite old. I was unable to find the specific reference value in GREET/CA-GREET for these parameters but hopefully such changes could be made quickly – or at least added to a holding pile without holding up the re-adoption of LCFS. My first impression is that the net effect on a CO2e basis would be neutral between increasing VOC and decreasing CO emissions factors. (See http://www.epa.gov/ttn/chief/consentdecree/index_consent_decree.html)

Likewise, a similar concern is related to the version of the EPA MOVES model used. The ANL GREET reference (#13 in staff report) says that MOVES2010b was used (an update to previously using MOBILE6), however, MOVES2014 is available. Are there relevant differences? What is the anticipated update cycle?

The method uses the IPCC 100-year GWP factors, which I agree are the most relevant values to use. However the report and method should explicitly note that it uses these (rather than the 20 or 500 year values), and why. Too often in the past few years there have been attempts to abuse the GWP method to present results favorable to a particular fuel by cherry-picking higher GWP values that are associated with shorter time horizons.

The CA-GREET results shown on pages 14-15 (Tables 1 and 2) are presented as 'CI lookup tables'. As presented, it was not clear what these were. However from reading the ISOR my understanding is that these are default values determined ex ante by staff for a generic production of a Tier 2 fuel used for Method 1 (as a default value that would apply for a particular supplier unless they wanted to show a lower value from other use of the methods like 2A or 2B). My lack of understanding has no effect on the scientific merit of the work.

Although we were only directly provided the underlying GREET 2013 and 2014 Excel models, I was able to find information online related to the CA-GREET project, including downloadable versions of the Tier 1 and Tier 2 CA-GREET Excel spreadsheets. I see no scientific issues with respect to how the CA-specific functionality was added to the base GREET model (which was also presented in the documentation and reports provided).

The results (e.g., CI Lookup Tables) were presented as single values, as opposed to ranges or distributions. I understand that regulatory design is complex, and that providing planning certainty for companies is important, but in the end given the (un-shown) uncertainties it is possible that the actual reduction in greenhouse gas emissions is lower or higher than anticipated. The reports and tools do little to capture this. My scientific concern and how it relates to my focus on the CIs is that, as stated in the ISOR, the new LCFS will require Method 2A pathways to have 5.5 % (or 1 gCO2e/MJ – also about 5%) lower CIs. The uncertainties of the reference flows and the potentially modeled 2A pathways may have uncertainty greater than 5%, which has not been well established in the report. It is also not clear where this "5% threshold" came from. However, I do not view this as an issue with respect to the scientific credibility of the method, just in portraying the magnitude of overall potential benefits of the program and maintaining stakeholder confidence.

Notes on my review of additional resources listed in documents from Attachment 1 of Bowes' March 25 letter:

- I reviewed the staff's ISOR for the LCFS re-adoption (the Staff Reports provided to us are essentially excerpts of this document). This helped to fill in some of the gaps (identified above) with respect to how the pieces fit together.
- I am familiar with the GREET model since my own research group has used it for various projects in the past. As a result, I did not re-review individual sheets or cells of the spreadsheet model, as I know that this model has been developed with significant research and effort over the past decade.

- The study is based on the ISO LCA Standards. While I was unable to do a full review of every aspect in the comprehensive work, the work done in this study seems to conform to the LCA Standard.

Summary review of CA-GREET component of peer review:

The issues listed above are fairly cosmetic in nature. Thus, with respect to the three aspects I was asked to review:

(1) I agree with the staff's conclusion that "the assumptions and inputs used in CA-GREET 2.0 to calculate direct life cycle CIs are reasonable and the model was applied appropriately under the LCFS." The methods they have followed, including the use of literature sources and references, are consistent with what I would expect to use.

(2) With respect to the big picture issue, I do not believe there are any significant scientific issues that have been neglected in the method descriptions.

(3) Taken as a whole, I believe that all of the work done (including conclusions and scientific assessments) is based on sound science.

Component 2 – OPGEE Model

I again found the Staff Report report to be well organized and written. I was aware of but not familiar with the details of the OPGEE model before undertaking this review – I had only read a few of Professor Brandt's published papers. Unlike the GREET-based analysis, which significantly leverages an existing DOE/ANL model (GREET), most of OPGEE has been developed in the last few years and much has been done with the goal of supporting LCFS specifically. It thus represents a tighter fit to the work needed here. It is truly an impressive and expansive effort, especially given the relatively small research team involved in it as compared to other publicly available life cycle models.

The core results (updated for OPGEE v1.1) are the Lookup Table values as well as those that create the Baseline Crude Average CIs.

I noted the following issues in the OPGEE-related staff report:

Similar to my comments above associated with CA-GREET, I am admittedly uncomfortable in seeing the lookup table CI values represented with 4 significant digits (implying accuracy to the level of 10mg CO_2e/MJ. While the underlying model is comprehensive and rigorous, my concern would be that it is easy for the lookup table / model results to be construed as more exact than they may be (since the uncertainty is not able to be presented as such in these lookup tables). Similar to the fuel pathways above, the "extra digits" may in fact be a target for producers to seek their own pathway approvals because they can show them to be lower when in fact they are mostly just rounded off values (example – 10 instead of 10.35 would be 5% lower yet still within a reasonable uncertainty bound of 10.35). This is not explicitly an issue related to the scientific method used to generate the results (as

requested in my peer review charge) but in application in the LCFS becomes an issue. Even removing one of these digits (one after the decimal point) would be an improvement. It is also potentially relevant because the Board has proposed a three-year model version update cycle, which to me suggests that nothing would officially change for 3 years).

Notes on my review of additional resources listed in documents from Attachment 1 of Bowes' March 25 letter:

- I reviewed Chapter II and Appendix H of the ISOR. This helped to fill in some of the gaps (identified above) with respect to how the pieces fit together. There were too many references in Appendix H to read all of them in this review (some of them already referenced in the published journal papers). I studied a sample of them (Oil and Gas Journal articles, California monthly oil and gas reports, etc.) and agree that they are the relevant types of studies to create parameters or methods in estimating the needed CI values for this project. I note again that the attention to detail in this model, including the identification of production parameters for many foreign countries and fields, is extraordinary.
- The study is based on the ISO LCA Standards. While I was unable to do a full review of every aspect in the comprehensive work, the overall work done in this study seems to conform to the LCA Standard. Several of the main pieces behind OPGEE have already been published in peer-reviewed journal articles.

Summary review of OPGEE component of peer review:

The issues listed above are fairly cosmetic in nature (even my concern about presenting uncertain values). Thus, with respect to the aspects I was asked to review:

(1) I agree with the staff's conclusion that "the assumptions and inputs used in OPGEE to calculate CI values for crude oil production and transport are reasonable and the model was applied appropriately under the LCFS." The methods they have followed, including the use of literature sources and references, are consistent with what I would expect to use.

(2) With respect to the big picture issue, I do not believe there are any significant scientific issues that have been neglected in the method descriptions.

(3) Taken as a whole, I believe that all of the work done (including conclusions and scientific assessments) is based on sound science.

Component 3 – GTAP/Indirect Land Use Model

While my area of expertise is connected with the first two models, I did my best to read through the third modeling area. While I was unable to comprehend the model, data, or inputs at the same level of critical insight, I found nothing associated with that work that caused me to doubt its credibility. I thus agree with the staff's conclusion, have no big picture issues, and have no doubt that the work done was based on sound science.