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TIPPING THE SCALES

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EXECUTIVE SUMMARY

The state of California has instituted numerous laws and regulations to control emissions of greenhouse gases. One of these is known as the Low Carbon Fuel Standard (LCFS), which is meant to reduce the emissions associated with the state's fuel supply.

Compliance under the LCFS is calculated using a carbon intensity (CI) score of oil that is refined in California. This CI score is in turn based on Stanford University's Oil Production Greenhouse Gas Emissions Estimator (OPGEE). But the OPGEE is seriously flawed as currently applied to the CI score. The estimator implies that oil produced in California, subject to all the state's greenhouse gas regulations, has a CI higher than even imports from thousands of miles away. At face value, that seems improbable, and closer inspection of the OPGEE shows that this incongruity is the result of several modeling limitations or errors.

In this analysis, Catalyst Environmental Solutions Corporation (Catalyst) and Yorke Engineering present a critical review of the Stanford University OPGEE. OPGEE was developed to estimate greenhouse gas (GHG) emissions from the production, processing, and transport of crude oil. Version 1 was released in 2012 and was updated to Version 2 in 2018[1]. CI is used by the California Air Resources Board (CARB) LCFS program for determining how many deficits or credits are generated from transportation fuel combustion. The CI values from OPGEE are also cited by advocacy pieces that oppose domestic production as well as media stories and government reports.

The existing model incorrectly accounts for the carbon intensity of oil

As demonstrated by this analysis, the OPGEE model greatly undercounts the CI of foreign imports and overstates the carbon intensity of crude produced in-state. The analysis outlines that OPGEE produces these inaccuracies for the following reasons:

1. OPGEE ignores actual and verified data CARB possesses on the carbon intensity of California crude.
2. OPGEE underrepresents emissions from foreign oil fields such as those in Ecuador and Saudi Arabia, California's two largest sources of foreign crude.
3. OPGEE greatly underestimates emissions from marine tanker traffic that brings foreign crude to California.

[1] El-Houjeiri, H.M., Masnadi, M., Vafi, K., Duffy, J., and Brandt, A. (2018), Oil Production Greenhouse Gas Emissions Estimator OPGEE v2.0c User Guide & Technical Documentation. June 2018.

4. OPGEE ignores California's numerous and expanding greenhouse gas emission reduction programs and the fact that California barrels are the only barrels must be compliant with the state's cap and trade program. Imports are completely exempt.

Each of these factors individually disadvantage in-state production in favor of foreign imports. Combined, these errors create a greatly skewed picture of the CI of California production. This means that compliance with the LCFS is actually easier if imported crude oil is used in preference to domestic, in-state production. These errors are not just an import dependence problem, they undermine the intended effect of the LCFS. Imported oil from Ecuador (24% of imports), Saudi Arabia (23%), or Iraq (20%) would all be preferred even though an accurate CI calculation would show a much higher value than currently used for the LCFS. So the LCFS ultimately results in greater GHG emissions because of the above calculation deficiencies.

Taken together, the way the OPGEE model is used for the LCFS significantly misrepresents California emissions with respect to low confidence estimates generated for imported foreign crudes. The numbers are striking:

1. Using CARB-required verified GHG emissions data could cut California crudes CI in half;
2. Stopping the assumption that oil produced in Ecuador and Saudi Arabia has lower CI than California simply because there is little to no supporting data available could have a substantial shift in the relative CI of foreign versus California crude oil;
3. Fixing incorrect default transportation values could cut California's CI relative to Ecuador and Saudi Arabia by another factor of 2;
4. Applying GHG reduction successes in California oil fields to their CI would have a substantial and ongoing reduction in the CI of California crude oil.

The model failures undermine the purpose of the Low Carbon Fuel Standard

The deficiencies highlighted by this analysis are not just an inconvenient matter for the California oil industry, they should be a major concern for state policymakers both at CARB and in the state legislature. By preferring potentially higher CI foreign sources of oil, the OPGEE model directly undermines the LCFS, resulting in higher GHG emissions than necessary from the California fuel market.

Correcting the errors identified by this analysis would ultimately reduce the GHG emissions of the California fuel supply. The correction is as simple as fixing the model inputs, no new spending or regulation is even required. If the goal is GHG reductions, then fixing the OPGEE model should be an immediate priority.

SECTION 01

INTRODUCTION

Catalyst Environmental Solutions Corporation (Catalyst) and Yorke Engineering have critically reviewed the Stanford University Oil Production Greenhouse Gas Emissions Estimator (OPGEE) and have prepared this Technical Memorandum to summarize our findings and provide recommendations for improvement. OPGEE was developed to serve as an engineering-based life cycle assessment tool for measuring of greenhouse gas (GHG) emissions from production, processing, and transport of crude oil. Version 1 was released in 2012 and was updated to Version 2 in 2018[1]. The life cycle assessment is the basis for estimating the carbon intensity (CI) of oil refined in California. CI is a measure of greenhouse gas emission potential from particular sources; in the context of the California Air Resources Board (CARB) Low Carbon Fuel Standard (LCFS) program, CI is used for determining how many deficits or credits are generated from transportation fuel combustion. The CI values from OPGEE are also cited by advocacy pieces, such as *Killer Crude: How California Produces Some of the Dirtiest, Most Dangerous Oil in the World*[2].

During our review of the inputs and methods used by the life cycle assessment tool, reviewing several other sources and comparing the output of the tool against published LCFS values, we identified four significant flaws in the tool that undermine its use in decision-making. To improve the tool and resolve these flaws, we developed a set of recommendations that can improve OPGEE and LCFS policy deployment, including improvement of OPGEE accuracy, representativeness, ability to update the model with current operator data reported to CARB, and periodic recalibration of defaults.

California has a steady demand for oil, and healthy in-state oil production capacity[3]. Publications such as *Killer Crude* use OPGEE results to argue that in-state production should be phased out regardless of whether in-state demand is reduced or not. However, as described in this Technical Memorandum, the OPGEE model overestimates the CI of California crude oil, and underestimates the CI of foreign crudes, most notably those from Saudi Arabia and Ecuador, the two largest suppliers of oil to California. Each of the identified flaws is summarized below with a full technical basis for each issue and the associated recommendation for resolution following.

Issue 1: OPGEE does not use current emissions data verified and reported to CARB by oil and gas producers. These data are required by mandatory GHG emissions reporting requiring third-party verification, but OPGEE does not provide options for entry of these verified values. Instead, the OPGEE model relies on older OPGEE input data that does not reflect currently available CARB emissions data reported by oil and gas operators. By continuing to use the older data, OPGEE has in many cases overestimated the CI of California oil and gas up to a factor of 2 from actual CI levels.

Issue 2: OPGEE underrepresents greenhouse gas emissions from foreign oil fields such as those in Saudi Arabia and Ecuador. Data entry and built-in constants rely heavily on public datasets, yet these datasets have lower confidence than data California operators are required to report and submit to CARB. In particular, the public data retrieved from the major countries (Saudi Arabia and Ecuador) supplying crude oil to California do not include the same level of details as the California datasets, specifically with respect to flaring which is virtually unreported for both Ecuador and Saudi Arabia. Moreover, most datasets related to foreign oil sources that satisfy OPGEE entries are not publicly disclosed information due to proprietary reasons, which calls into question how well OPGEE accurately calculates the CIs reported for oil fields in the LCFS regulation. Because of this lack of data, OPGEE defaults are used which have the problems identified above. The compounding of these errors leads to spurious results that hinder fact-based decision-making (for example, significantly undercounting the CI of crude oil delivered to California from Saudi Arabia[4] and Ecuador[5]). Nor does OPGEE take into account production and land use practices in foreign countries such as forest removal or other activities.

OPGEE has in many cases overestimated the CI of California oil and gas up to a factor of 2 from actual CI levels.

Issue 3: The *63 OPGEE* default values have the potential to underrepresent the greenhouse gas emissions from marine tanker ships. OPGEE includes default parameters where data are unavailable and default settings for process sensitivity when considering applicable characteristics. For instance, the model uses default values for marine tankering distance to California, when the data is available for which to enter actual values. Much of the imported oil to California comes from Saudi Arabia and the default tanker transport distance in OPGEE (5,082 miles) is **half** the actual transport distance from Saudi Arabia (more than 10,000 miles). In addition, OPGEE does not appear to account for the return trip of the tanker, or for emissions while the tanker is idling near the port[6], or for indirect emissions from other non-oil cargo ships that have increased idling emissions. The continued use of default parameters increases uncertainty in the results output from this complex model, and in the case of marine tankering produces highly misleading results for oil used in California.

Issue 4: OPGEE does not account for greenhouse gas reduction measures required in California oil fields, such as the requirement for offsets set forth in the AB-32 cap and trade system, and efforts by producers to use novel approaches such as meeting field energy needs through solar power. California producers also abide by strict local air district rules and a statewide Methane Rule, all of which have significant GHG mitigation effects. These are California initiatives that foreign suppliers are not participating in and which should be considered when calculating the CI of California oil fields.

Taken together, these issues result in the OPGEE model significantly misrepresenting California emissions with respect to low confidence estimates generated for imported foreign crudes. The numbers are striking: Issue 1 (use CARB-required verified GHG emissions data) could cut California crudes CI in half; Issue 2 (stop assuming oil produced in Ecuador and Saudi Arabia has lower CI than California simply because there is little to no supporting data available) could have a substantial shift in the relative CI of foreign versus California crude oil; Issue 3 (stop using incorrect default values) could cut California's CI relative to Ecuador and Saudi Arabia by another factor of 2; and Issue 4 (apply GHG reduction successes in California oil fields to their CI) would have a substantial and ongoing reduction in the CI of California crude oil.

The following table illustrates the comparison.

Variable Category	California	Ecuador	Saudi Arabia	Notes
Production Methods	5	1	1	Saudi Arabia and Ecuador inputs rely heavily on defaults and/or unvetted sources.
Field Properties	4	2	2	Ecuador and Saudi Arabia field properties referenced to OGJ 2015 Production Survey, a closed-source, self-reported reference.
Fluid Properties	3	2	2	Common default for gas composition across all fields; less applicability to foreign oil fields.
Production Practices	4	1	1	Ecuador and Saudi Arabia fraction of reinjection assumption remained not justified by CARB and a heavy reliance on defaults.
Processing Practices	3	1	1	User-defining flaring-to-oil ratio entered without justification or reference for CA. Heavy default reliance for Saudi Arabia and Ecuador.
Land Use Impacts	5	5	5	Reasonable assumptions based on geographic locations.
Crude Oil Transport	3	4	3	No reference justifying user inputs for CA and Saudi Arabia pipeline transportation distances.
Small Sources Emissions	1	1	1	Common default used for all fields.
Overall Rating	4	2	2	Qualitative Average of All Category Ratings

The technical basis for each issue and recommendations are described in the next sections.

ISSUE 1:

OPGEE does not use current emissions data verified and reported to CARB by oil and gas producers. These data are required by mandatory GHG emissions reporting requiring third-party verification, but OPGEE does not provide options for entry of these verified values. Instead, the OPGEE model relies on older OPGEE input data that does not reflect currently available CARB emissions data reported by oil and gas operators. By continuing to use the older data, OPGEE almost doubles the CI of California oil and gas, from actual CI levels.

TABLE 1: SAMPLE OF ESTIMATES COMPARED

CI Projected with OPGEE (g CO_2e/MJ)	CI based on Reported GHG Emissions (g CO_2e/MJ)	Overestimated CI by OPGEE (%)
31.20	17.66	177%
28.73	17.71	162%
25.99	19.46	134%

We compared OPGEE projections of CI values with the same calculation using current verified GHG emissions data reported by San Joaquin Valley oil and gas producers to CARB. This comparison shows that OPGEE overestimates CI projections by almost double. Table 1 summarizes field CI estimates calculated using OPGEE when compared with estimates derived from reported GHG emissions data for the respective field.

These overestimates of California oil and gas CI projections have ripple effects in secondary publications such as that by the Center for Biological Diversity[7] which concluded that California crudes have CIs averaging more than 1.5 times higher than other crudes sourced outside of California. Had OPGEE used correct emissions estimates based on currently reported and verified CARB data, the Center for Biological Diversity review may have come to the opposite conclusion that California crudes could potentially have lower CI than other crudes sourced outside of California. Furthermore, as discussed below in Issue 3, California produced oil and gas could have a lower comparative CI with foreign sources of crude oil supplying the state since OPGEE may underestimate marine tanker ship emissions from Saudi Arabia by more than a factor of two if the default distance was used in the CI calculations for Saudi Arabia. Taken together the Center for Biological Diversity's use of the CI could potentially overstate the California CI more than a factor of three, if default marine distances were used in OPGEE and inaccurate defaults were used for California oil and gas production.

Despite emissions data being reported for oil and gas production at the field level, CARB did not use the submitted data when developing LCFS published results. We have confirmed that OPGEE does not accept user entry for the information reported. Therefore, the inputs used to calculate for LCFS are field- and processrelated data rather than consumption data reported by oil and gas producers. OPGEE only allows for projecting emissions through process characteristics rather than using measured and monitored emissions data, and it is unable to use more rigorously collected data as alternative parameters to calculate more accurate CIs.

California oil fields are required to report GHG emissions to CARB under the Greenhouse Gas Mandatory Reporting Regulation. This regulation requires both reporting and 3rd party verification of those emissions. However, in the 2018 final statement of reasons, when a commenter specifically asked why CARB did not consider using verified GHG emissions data as part of the Life Cycle Analysis to calculate carbon intensity, CARB stated that reported GHG emissions do not account for the upstream GHG emissions such as land use and transportation, without giving any consideration of using verified GHG emissions for the part of the Life Cycle Analysis associated with the production emissions verified at the facility. In essence, CARB has acknowledged the shortfalls of the LCFS Life Cycle Analysis with respect to the lack of publicly available data for foreign crudes, yet the board insists on continuing to use OPGEE to estimate carbon intensities and dismissing the option to integrate verified GHG emissions data to its analysis.

Recommendation: We recommend that the tool be revised to incorporate the option to calculate CI using current and known emissions data, making OPGEE more accurate in its CI calculations by CARB.

ISSUE 2:

OPGEE data entry and built-in constants rely heavily on public datasets, yet these datasets have lower confidence than CARB required data in California, particularly for the major countries supplying crude oil to California: Saudi Arabia and Ecuador. Moreover, the majority of datasets that satisfy OPGEE entries are not publicly disclosed information due to proprietary reasons, reducing how well OPGEE represents different oil fields and impacting the potential accuracy of the calculated CIs reported for oil fields in the LCFS regulation. The compounding of these errors leads to spurious results that hinder good decision making (for example, significantly undercounting the CI of crude oil delivered to California from Saudi Arabia and Ecuador).

In addition to U.S. field CI averages, CARB LCFS also reports CI projections for international fields, including countries such as Saudi Arabia and Ecuador. In order to provide these values for OPGEE, CARB must rely on data reported from foreign agencies, but this further diminishes confidence in international comparisons due to different reporting standards, as well as a lack of data availability from oil and gas producers. Specifically, one of the significant constraints on data availability and quality is that most foreign oil production supplied to California is produced by national petroleum companies with a history of not sharing operational data. Moreover, public datasets were also utilized in the development of OPGEE, implying there are also potential internal data concerns for the model itself. For example, flaring emissions data are often unavailable due to significant gaps in publicly available information. To fill this specific gap, the developers from Stanford acquired satellite monitor data, which can make it difficult to obtain accurate regional data due to its limitations, including inability to operate effectively for overcast or precipitating areas[8]. Overall, the absence of publicly available oil and gas production data of sufficient quality adds more uncertainties rooted in these issues.[9]

Upon introduction of OPGEE version 3.0a, the developer team at Stanford expressed their intent to expand the data set, integrating over 1,000 data points tied to measured leaks across the U.S. into the OPGEE VFF emission factors[10]. While the intention to expand the data set is critical, there is still much to be done when attempting to apply the same standards to foreign oil producers.

Looking at the larger field perspective, whole fields have gaps in publicly available datasets, such as Saudi Arabia and Ecuador, leaving wide gaps in regional data that could be built into the model.[11] Since proprietary data necessary for OPGEE to process are mostly unavailable for public access, international CI values may be underestimated for foreign entities. Figure 1 illustrates the uncertainty associated with the results derived with current defaults against public datasets, concluding that OPGEE CI estimates with higher dependance on default settings are more likely to generate low values near the 25th percentile due to the lack of accessibility to high-quality data.[12]

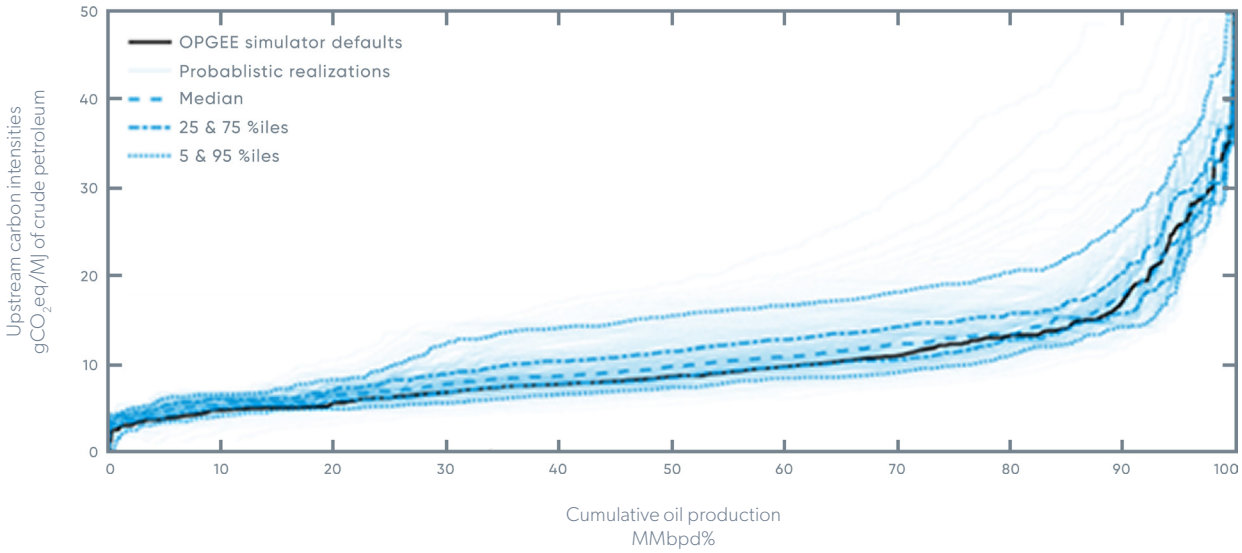
Lower dispersion occurring around the 5th percentile is attributed to more readily available, high quality data from fields such as California, highlighting the significance of accurate, comprehensive data availability on CI estimates for OPGEE.

CARB Agrees Lack of Data for CI Estimates of Foreign Oil is a Significant Problem in their Methods

CARB has conducted reviews of the utility of the OPGEE model for application to the Low Carbon Fuel Standard (LCFS) and posted their statement of reasons and responses to comments in 2011, 2014, and 2018. When OPGEE version 1.0 was implemented in the 2011 revisions, CARB does not appear to have compared the utility of OPGEE to other methods used to calculate carbon intensity. The method appears to have been accepted without comparative analysis. Even in the 2011 final statement of reasons CARB staff acknowledge: "We agree that the lack of accurate data on crude production parameters for many imported crudes is a problem." Based on the review of the most recent data inputs used by CARB for OPGEE, it is apparent the lack of accurate data still exists to this day, 10 years later.

With several subsequent reviews of OPGEE for the LCFS standard and updates to OPGEE model and improvements to the tool, there are still admitted concerns related to a lack of accurate source data for imported oil. This raises serious concerns about the accuracy of the data, especially considering that the inputs for OPGEE use demonstrably misleading assumptions, such as that methane capture efficiency for fuels in Saudi Arabia and Ecuador are similar to the methane capture for processes in California, when that assumption is unlikely to be true, since methane control regulations in those nations are nearly non-existent while Europe, America and especially California have much stronger regulations and enforcement of the regulations, requiring the monitoring and control of methane leakage from oil fields and pipelines.

FIGURE 1: UNCERTAINTY OF OPGEE DEFAULT CALCULATIONS



SOURCE: Masnadi et al., 2018

In 2009 CARB deployed the 2007 OGI Survey to California oil and gas producers to obtain data that would allow them to more accurately calculate emission reductions of potential control measures to meet the GHG emission reduction requirements set forth by Assembly Bill 32 (AB 32), the California Global Warming Solutions Act (Detwiler, 2013). As part of the Life Cycle analysis for oil and gas fields, OPGEE incorporated data from the 2007 OGI Survey to estimate carbon intensities associated with the venting, flaring, and fugitive (VFF) emissions of methane from crude oil extraction, processing, and storage. And, as noted in Issue 1, there is higher quality data available for California fields that is not used in OPGEE or by CARB.

California continues to enforce the application of leading air pollution control technologies and standards that are not practiced as extensively in other parts of the world.

However, the data for foreign sources, particularly the major sources to California, Saudi Arabia and Ecuador, are a data-free zone. OPGEE developers at Stanford acknowledge that the current version of the model lacks broader applicability to oil and gas production outside California. Consequently, there is an ongoing effort by the team at Stanford to address the shortfall. As of August 2021, the research and development team at Stanford introduced OPGEE version 3.0a as the future replacement for version 2.0c. In version 3.0a, Stanford has proposed the introduction of a broader methane dataset to expand the applicability of analysis. The new dataset for VFF emissions utilizes bottom-up databases and studies such as the EPA Greenhouse Gas Inventory to represent U.S.-wide emissions (Brandt, et al., 2021). This improvement helps to improve CI estimates in the other oil producing states in the US. However, even in version 3.0a there are little or no reliable emissions data with which to develop comparable CI estimates. Specifically, OPGEE will continue to struggle with the uncertainties of bottom-up inventories it uses and the lack of applicability to foreign crude oil.

Bottom-up methodologies for estimating emissions play a key role in the central functionality of OPGEE, providing the basis for estimate calculations. The bottom-up approach is often represented by greenhouse gas inventories, scaling up measurements from component-level activities to estimate overall emissions. However, it has been found that GHG inventories and bottom-up estimates tend to underestimate emissions by up to 50% when compared with top-down methods such as satellite measurements (Rutherford, et al., 2021; Shen, et al., 2021). The discrepancies found in bottom-up datasets related to methane have so far been attributed to unaccounted fugitive emissions from sources such as leaking pipelines, equipment, and liquid storage tanks (Pultarova, 2021). Consequently, integration of bottom-up methods can potentially skew the accuracy of OPGEE results. Moreover, with some of the strictest environmental policies globally and as a leading economic force, California continues to enforce the application of leading air pollution control technologies and standards that are not practiced as extensively in other parts of the world (Schmidt, 2007). Despite the lack of applicability to foreign oil production, OPGEE is still used to represent international production processes.

Equity Gap in Comparative Analysis of CI Between California and Foreign Sources of Oil

As a result, there is a clear equity gap in using OPGEE for comparative estimates of CI between California and foreign sources of oil. Every year, CARB LCFS publishes its Life Cycle Analysis, using OPGEE to calculate the approximate carbon intensities of crude oil production in California and for foreign oil producers to determine emission credits or deficits for California producers. In terms of the California analysis, CARB LCFS staff source over 30 documents from the California Department of Conservation that are used to provide inputs for California oil production fields, including field property, production practices, and assay data (Stanford, 2018). The information is generated to represent the granular or field level, allowing for a more nuanced analysis of each emitter in California, and this can be observed readily when reviewing the tabulated carbon intensities in each Life Cycle Analysis published by CARB LCFS each year. However, when reviewing sources used for input in foreign crude analyses, the same granularity and rigor cannot be found.

Along with the annual Life Cycle Analysis, CARB publishes the annual crude oil reports (MCON reports), Inputs Spreadsheet for Crude Lookup Table, tabulating every input used in calculating crude oil production carbon intensities. By accessing the MCON Inputs, Yorke has found that analysis of foreign oil production is not as extensive as the California analysis, establishing an inequitable comparison amongst oil and gas producers. In the case of producers in Ecuador and Saudi Arabia, the largest foreign oil suppliers to California, there are only a few sources used to fill in field properties (MCON, 2021). However, the lack of inputs for foreign oil producers falls in line with prior expectations due to the lack of open-source data available. Consequently, majority of the analysis for foreign oil relies on generic defaults supplied by OPGEE. Emphasized in previous work, the heavy reliance of defaults can be significant contributor to increased estimate uncertainty in the foreign oil analysis (Masnadi, et al., 2018). Furthermore, the cases of Ecuador and Saudi Arabia are further put into question when reviewing current open-source data availability and satellite imagery, as described in the following.

Satellite Imagery Indicators for Ecuador and Saudi Arabia CI Analysis

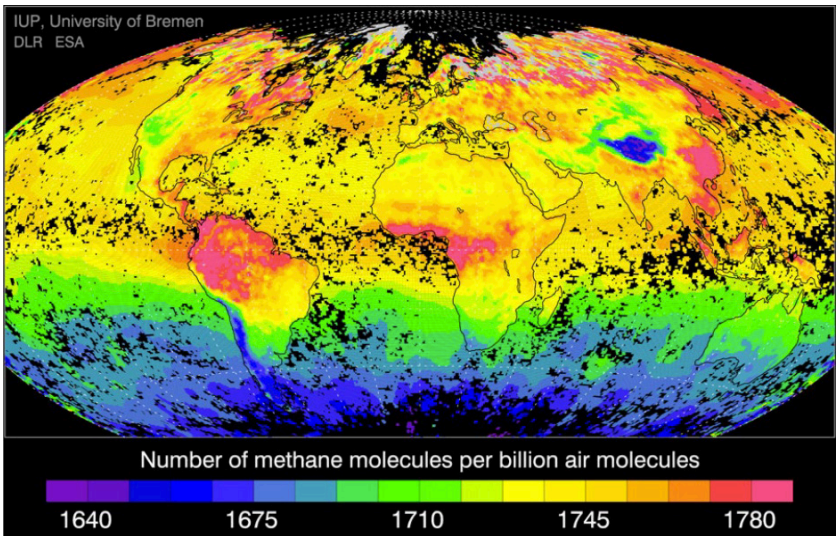
Despite the importance of Ecuador and Saudi Arabia in supplying foreign crude to California's energy sector, there is a lack of data available to use in the operation of OPGEE to generate carbon intensity estimates. The immediate lack of data for input leads to the dependency of defaults provided in OPGEE to fill in the gaps, raising uncertainty tied to the analysis of Ecuador and Saudi Arabia. When inspecting satellite imagery related to the measurement of methane, the uncertainty is perpetuated further due to high concentrations of methane found in the airspace above these countries.

Making up approximately 24% and 23% of crude oil imports in California for 2020 respectively, the analysis of Ecuador and Saudi Arabia are high-profile interests for the California economy (California Energy Commission). Despite the importance of the two entities, little is known about the specific oil and gas production practices and their related emissions. This is indirectly reflected in the MCON inputs for Ecuador and Saudi Arabia fields in which only the Oil and Gas Journal Survey (OGJ) and registered properties from the U.S. Energy Information Agency (EIA) is used to fill in field properties and API gravity input fields (MCON, 2021). With the exception of the above sources and an article published by Saudi Aramco in 1973, CARB has not utilized any further sources to accurately illustrate the operations that take place in Ecuador and Saudi Arabia (Bates, 1973; MCON, 2021). Consequently, Yorke performed a data search to verify what is available for use in calculations, including searches for updated GHG Inventories, emission estimates, and satellite imagery.

At the highest level, national GHG Inventories provide the most comprehensive snapshot of where countries stand with their emissions. While the U.S. EPA and California GHG Inventories are widely available and even integrated into the functionality of OPGEE, there is much to be desired when searching for GHG Inventories for Ecuador and Saudi Arabia. The closest and most recent findings available are the first Biennial Update Report presentations published by the United Nations Framework Convention on Climate Change (UNFCCC), summarizing the GHG Inventories for Ecuador and Saudi Arabia from the years 2010 and 2012 respectively (Chiriboga, 2017; UNFCCC, 2019). Looking outside of GHG Inventories, several organizations such as the World Resources Institute (WRI) and the Potsdam Institute for Climate Impact Research (PIK) publish emission estimates to help fill the information gaps. However, the published estimates tend to have high variances. For instance, in 2018 the estimates for methane emissions from Saudi Arabia's energy sector were between 14.34 to 79.75 MT CO2e published by WRI and PIK respectively (ClimateWatchData). With such a high variability, the confidence in relying on these numbers for the purposes of OPGEE is low. While there is a lack in transparency and availability of bottom-up data, there has been an accelerating push for the advancement of satellite methane measurements in recent years, uncovering emissions that have not been accounted for previously.

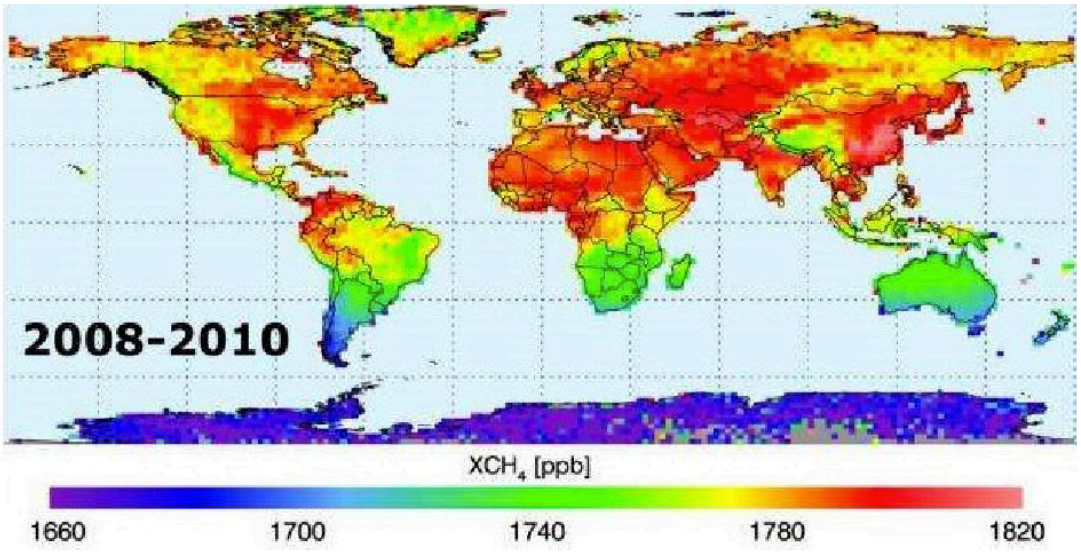
Searching through the data used for the Life Cycle Analysis and what is available on public queries, it has been made evident that Ecuador and Saudi Arabia are not completely transparent about their emissions. The concept of keeping emissions information and data under lock and key has been a common theme amongst some foreign emitters, prompting the push toward more development in satellite monitoring. Comparing satellite imagery to calculated CI estimates published by LCFS, there does not seem to be a strong agreement with the results, observing high concentrations of methane measured over Ecuadorian and Saudi Arabian air spaces as seen in Figures 2 and 3 (University of Bremen, 2013; ESA, 2016; Tropomi Sentinel-5p, 2021).

FIGURE 2: SATELLITE METHANE CONCENTRATIONS IN 2004



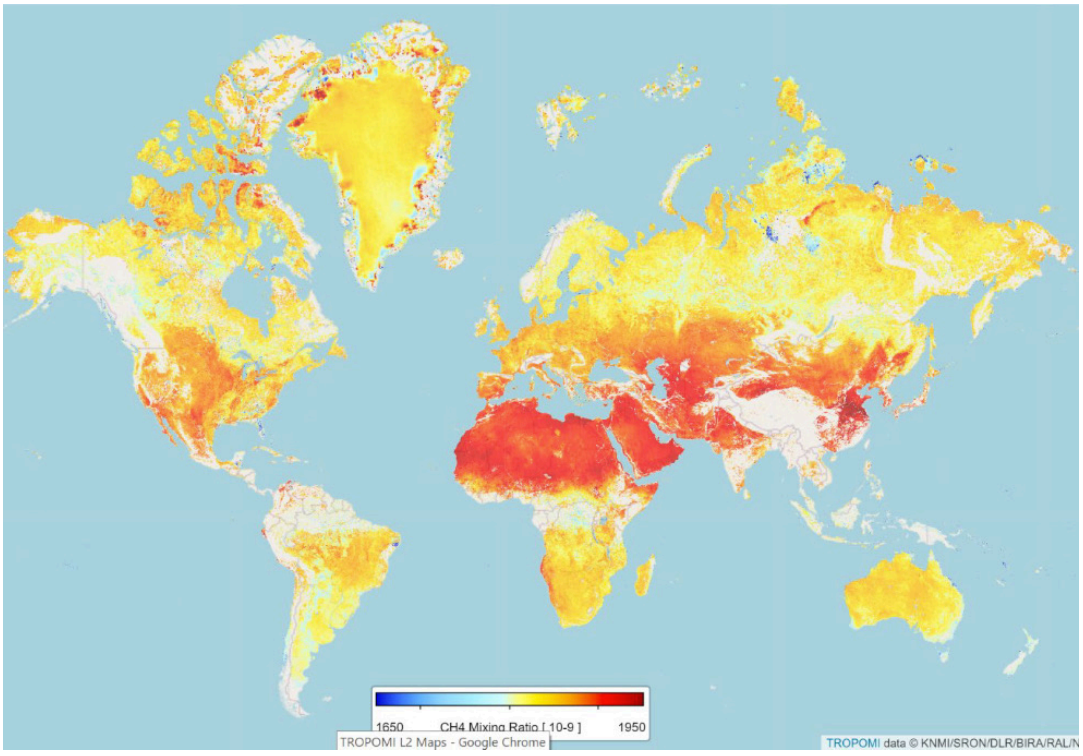
SOURCE: University of Bremen, 2013

FIGURE 3: SATELLITE METHANE CONCENTRATIONS FROM 2008 TO 2010



SOURCE: ESA, 2016

FIGURE 4: SATELLITE METHANE CONCENTRATIONS IN 2021



SOURCE: Tropomi Sentinel-5p, 2021

Despite the availability and advancement of satellite monitoring efforts to uphold international transparency of methane emissions, the deployment and application of this technology is still limited. With limited opensources, specialized software requirements, and discontinuous measurement of methane emissions, it is still difficult to use satellite measurements as a basis for the Life Cycle Analysis. However, satellites have so far been able to put into perspective the shortfalls of bottom-up estimates currently used by OPGEE to calculate emissions, putting a wedge in the confidence in the LCFS Life Cycle Analysis results.

After a thorough search and analysis of what has been used for the Life Cycle Analysis and what is publicly available, it has been made clear that there is a large gap between how California is assessed by CARB LCFS compared to Ecuador and Saudi Arabia. California's estimates are produced with a rich set of data that can be accessed from a public data search and represent individual field emissions. On the other hand, the well of available data for Ecuador and Saudi Arabia emissions are near dry with only general emissions estimates and semi-quantitative imagery available, and the inputs published by CARB reflect that lack of availability. As a result, there is a large dependence on generic defaults that have lower applicability to producers outside California and the United States as a whole, and it can be concluded that the comparison of California to foreign crude producers is inequitable.

Recommendation: While OPGEE relies on public access to datasets, these datasets fall short in availability and accuracy. We acknowledge the limits to what CARB can access and recommend that all public data available be accessed for LCFS CI calculations, as mentioned prior, while also providing disclosure of data availability. However, simply relying on default values that significantly undercount the CI of foreign produced crude oil supplied to California is misleading to decision makers. CARB should provide more data transparency for sources of information and values selected for non-California oils, and OPGEE should allow users to input accurate data as it is available.

We recommend that as part of the carbon intensity analysis of initial oilfields, an adjustment factor is applied to oil fields where high methane emissions from satellite data based on the ratio of methane from the approximate location of the oil field with respect to the baseline of methane emissions from California satellite data. This factor would help compensate for the data gaps and reliance on old, inaccurate or default data from other oil fields to more accurately calculate carbon intensities of these sources.

ISSUE 3:

OPGEE default values have the potential to underrepresent the greenhouse gas emissions from marine tanker ships. OPGEE includes default parameters where data are unavailable and default settings for process sensitivity when considering applicable characteristics. Much of the imported oil to California comes from Saudi Arabia and the default tanker transport distance in OPGEE (5,082 miles) is half the transport distance from the largest supplier (more than 10,000 miles). The continued use of default parameters increases uncertainty in the results output from this complex model, and in the case of marine tankering produces highly misleading results.

When a user does not have a value required by OPGEE, default values are used in lieu of leaving the input blank. For defaults, we found that there are three general modes by which they can hinder the accuracy of CI calculations produced by OPGEE. These include increasing dependence on default constants to fill input gaps and omission of different upstream subprocesses in calculations. If CARB uses default values in OPGEE, the uncertainty of projected CIs will increase.

For example, one of the default constants used to fill input gaps is marine tanker transport distance. Much of California's crude oil comes by tanker from Saudi Arabia.[13] The OPGEE default distance for marine tanker transport is 5,082 miles, but the actual tanker distance from Saudi Arabia to California is well over 10,000 miles. As a consequence, if default constants are used in the calculation of crude oil CI from Saudi Arabia, it underestimates the actual CI of crude from there. If we follow recommendation to reduce California oil and gas production, it would require an increase in imported oil, mostly from Saudi Arabia. Consequently, accurate tankering emissions should be added to the life cycle assessment of Saudi Arabian oil CI to more accurately understand the impact of importing more oil.

Within the model, there is a subsection detailed as "Model Coverage," and within that section is a table of emissions sources that are currently modelled through OPGEE. These emissions sources are categorized into four categories, rating the extent or rigor with which OPGEE will consider these sources in calculations. For items rated as a low contributor, they can be either excluded or included in calculations as defaults (OPGEE, 2018). This means that customizability of entries and sensitivity of treatment are entirely controlled by the model coverage settings. As a result, occurrences of default errors will more likely occur for users who fail to adjust these settings due to human error.

In development and deployment of OPGEE, its authors acknowledge that if more defaults are incorporated into calculations, a less accurate estimate of CI will be generated.[14] To that effect, all three modes of default error can be attributed to accuracy of data used in the development of OPGEE parameters, and data availability for the model developers.

Recommendation: OPGEE default values should be reviewed and updated with accurate and current information in order to improve the functionality of the model and increase the accuracy of its outputs.

ISSUE 4:

OPGEE does not account for greenhouse reduction measures required in California oil fields, such as the AB-32 cap and trade system, requirements for offsets, compliance with local and state air emission rules, and efforts by producers to use novel approaches such as meeting field energy needs through solar power. These are California initiatives that foreign suppliers to California are not required to meet.

GHG emissions from oil production in California have already been effectively accounted for by State, regional and local policy and are required to be reduced to meet our climate change goals. None of these reductions in CI are accounted for in OPGEE or used by CARB in the LCFS. Oil and gas operators must comply with California's Cap-and-Trade Program, which began on January 1, 2013. CARB also implemented methane reduction requirements in April 2017. The State is currently in the process of further assessing mechanisms to achieve California's Carbon Neutrality Goals. Taken together, these policies ensure that the GHG emissions from oil and gas production are fully accounted for in the State's overall inventory and have proven effective in meeting the State's GHG emission reduction goals to date.

The State is currently in the process of further assessing mechanisms to achieve California's Carbon Neutrality Goals.

Mandatory reporting to CARB shows that between 2013 and 2020, methane emissions from oil and gas production facilities contributed to the cumulative net decrease in GHG emissions in the State. This is largely due to CARB's adoption of a comprehensive Methane Rule as well as monitoring efforts such as SNAPS. These data indicate that operator compliance with California's regulatory framework and the economic incentives of the Cap-and-Trade Program effectively allowed California to meet its ambitious climate change goals and while also supporting consumer demand for fuel. These reductions in emissions and in CI are not factored in to OPGEE or to CARBs use of OPGEE in the LCFS proceedings.

In addition to State policy, local jurisdictions have climate change action plans that include emission reductions from the oil and gas sector. Kern County has the largest concentration of active production wells in the State[15] and has adopted requirements that permitted projects must achieve net-zero GHG emissions. Kern County developed an oil and gas permitting program and prepared a programmatic EIR to analyze the potential effects of continued oil and gas development in the County. The County's analysis determined that without mitigation there would be an overall increase in GHG emissions from oil and gas production activities within the County.[16] GHG emissions not covered by the Cap-and-Trade Program and fugitive emissions also contribute to a net increase of GHGs in the region. As part of its analysis of GHG emissions in the EIR, the County determined that it would conservatively mitigate all GHG emissions to achieve net zero emissions.[17] The EIR describes that net zero would be achieved through compliance with the State's Cap-and-Trade Program, and for those emissions not covered by the

Cap-and-Trade Program, through implementation of additional mitigation measures that are imposed as permit conditions for any new wells or well stimulations proposed in the County. The GHG emissions from oil and gas production in the County with the greatest number of wells is on its way to net zero, without a corresponding removal of allowable emissions credits in the Cap-and-Trade program. None of these accomplishments are factored in to the OPGEE model or in its use by CARB. The deficiencies highlighted by this analysis are not just an inconvenient matter for the California oil industry, they should be a major concern for state policymakers both at CARB and in the state legislature. By preferring potentially higher CI foreign sources of oil, the OPGEE model directly undermines the LCFS, resulting in higher GHG emissions than necessary from the California fuel market. This favoring of imported oil is compounded by well-known environmental impacts from imported oil, such as damage to Ecuadorian rainforest, that are also not reflected in the CI calculation.

The California oil and gas industry is also embracing innovative ways to further cut GHG emissions from their fields. CARB created the Innovative Crude Methods program to allow California producers of crude to generate GHG credits by demonstrating they have lowered the CI of their production methods. CARB encourages solar thermal steam, carbon capture and sequestration, and photovoltaic solar to offset the use of fossil fuels for self-generation of power. For the industry, the approach makes economic sense and has spurred further innovations on the road to net zero. There are direct cost savings including lower electricity and/or natural gas usage, including, lower energy costs, and avoided demand charges from the local utility. Companies also earn the value of generating secondary revenue through the creation and selling of LCFS credits.

Recommendation: OPGEE should account for the many requirements and innovations applied in California oil and gas fields to reduce the CI of their production. This is an important area of work by the industry, it is working by meeting reduction thresholds, but it is entirely ignored by OPGEE and by CARBs use of OPGEE in calculating the CI of California-produced oil.

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