



Climate Change Bureau Clean Transportation Fuel Program

NM-GREET1.0 Model Release Guidance

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Revision History Table

Revision #	Revision Date	Revised By	Reason for Revision
Original	07/01/2026	NMED Staff (The New Mexico Environment Department acknowledges technical support from Eastern Research Group, Inc. (ERG) in preparing draft documentation and supporting technical materials for NM-GREET1.0. NMED retains responsibility for the final content, interpretation, and use of this document under 20.2.92 NMAC.)	Initial publication of the NM-GREET1.0 Model Release Documentation for the Clean Transportation Fuel Program.

List of Abbreviations

Acronym	Definition
AD	anaerobic digester
AEZ-EF	Agro-Ecological Zone Emission Factor
API	American Petroleum Institute
AR5	Fifth Assessment Report (of the Intergovernmental Panel on Climate Change)
AW	animal waste (i.e., manure)
B100	Neat biodiesel
bbl	barrel
B0	fossil clear diesel (i.e., 0% biodiesel)
BD	biodiesel
CARB	California Air Resources Board
CA-GREET	California-modified GREET model
CCLUB	Carbon Calculator for Land Use and Land Management Change from Biofuels Production
C.H ₂	compressed gaseous hydrogen
CI	carbon intensity
CIDI	compression-ignition direct-injection
CLCA	consequential lifecycle assessment
CNG	compressed natural gas
CO	carbon monoxide
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
CTFP	Clean Transportation Fuel Program
DOE	Department of Energy
EPA	U.S. Environmental Protection Agency
FCEV	fuel cell electric vehicle
GHG	greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
GTAP	Global Trade Analysis Project
GTAP-BIO	Global Trade Analysis Project - Biofuels
GWP	global warming potential
H ₂	hydrogen
ICEV	internal combustion engine vehicle
ILUC	indirect land use change
IPCC	Intergovernmental Panel on Climate Change
LCA	lifecycle assessment
LF	landfill
LFG	landfill gas
L.H ₂	liquefied hydrogen
LHV	lower-heating-value
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MJ	megajoule
mmBtu	million British thermal units
NG	natural gas
NMED	New Mexico Environment Department

NM-GREET	New Mexico-parameterized GREET lifecycle model
OPGEE	Oil Production Greenhouse gas Emissions Estimator
PADD	Petroleum Administration for Defense Districts
PEM	proton exchange membrane
R100	Neat renewable diesel
RD	renewable diesel
RFS	Renewable Fuel Standard
RN	renewable naphtha
RNG	renewable natural gas or biomethane
scf	standard cubic foot
SMR	steam methane reforming
U.S. EIA	U.S. Energy Information Administration
VOC	volatile organic compound
WTW	well-to-wheel
WTRG	well-to-refinery-gate

Overview

New Mexico’s Clean Transportation Fuel Program (CTFP)—much like low-carbon fuel programs in other states—relies on well-to-wheel (WTW) lifecycle assessment (LCA) modeling of transportation fuels to calculate their lifecycle carbon intensities (CI). A fuel’s CI is reported in grams of carbon dioxide equivalent (CO₂e) per megajoule (MJ) of fuel energy. Greenhouse gas (GHG) species emitted during each stage of the fuel lifecycle are converted to CO₂e using Intergovernmental Panel on Climate Change Fifth Assessment Report 100-year global warming potential (GWP) factors (IPCC AR5 GWP100¹), summed, and divided by the MJ of fuel energy at the applicable NM-GREET flow: liquid or gaseous fuel at the pump, or electricity at the charging station.² A fuel’s energy content is defined in two ways: as the lower-heating-value (LHV) heat of combustion for liquid and gaseous fuel and as the delivered quantity of energy at a charging station or other applicable EV charging point for electricity. A fuel’s CI is thereby quantified in the composite units of grams CO₂e per megajoule (g CO₂e/MJ).

To calculate WTW fuel-pathway CI values, the New Mexico Environment Department’s (NMED) Climate Change Bureau (CCB) developed a custom version of the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model, published by the Systems Assessment Center of the U.S. Department of Energy’s Argonne National Laboratory (ANL).³ This custom version—NM-GREET1.0 (i.e., the NM-GREET_v1.0.xlsm workbook)—incorporates state-specific data and modeling, and was adapted from the latest available release of R&D GREET as of fall 2024 when the development cycle began: R&D GREET 2023 Rev1.⁴ The “R&D” version of GREET is the main development version from which other

¹ IPCC AR5 GWP100 factors are global warming potential (GWP) values for a 100-year time horizon, taken from the Intergovernmental Panel on Climate Change’s Fifth Assessment Report.

² Gunnar Myhre et al., “Anthropogenic and Natural Radiative Forcing,” in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. Thomas F. Stocker et al. (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2013), https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf.

³ U.S. Department of Energy, “GREET,” accessed May 20, 2025, <https://www.energy.gov/eere/greet>.

⁴ Michael Wang et al., “Development of R&D GREET 2023 Rev1 to Estimate Greenhouse Gas Emissions of Sustainable Aviation Fuels for 40B Provision of the Inflation Reduction Act” (Argonne National Laboratory, April 1, 2024), <https://doi.org/10.2172/2348933>.

federal and state regulatory versions, like 45VH2-GREET and the California-modified GREET model (CA-GREET), are typically adapted.

The NM-GREET fuel pathways were crafted to represent the average properties and supply chains of transportation fuels produced in New Mexico, imported into New Mexico, or dispensed for use in New Mexico, as applicable, and to support the statewide carbon intensity values and temporary fuel pathway carbon intensities identified in the CTFP rule and NM-GREET1.0 workbook. A fuel pathway in GREET is defined by a network of material and energy commodities exchanged by unit processes—i.e., extractive operations, processing facilities, transportation modes, storage structures, dispensing stations, highway and nonroad vehicle use—and specific technologies therein, all terminating in the production of one unit of an energy commodity of interest. NM-GREET's fuel pathways, as detailed in this report, were included in the applicable CTFP rule tables, including Table 4 in Subsection D of 20.2.92.701 NMAC and Table 5 in Subsection E of 20.2.92.701 NMAC, as applicable. Table 1 summarizes the identities and CI values of these conventional and alternative fuel pathways available in NM-GREET:

Table 1. Carbon intensities of CTFP pathways shown as Total and Adjusted Total CI values, in gCO₂e/MJ

Pathway ID	Alias	Fuel	CI	
			Total	Adj. Total
NMGAS001	Gasoline, Clear	Gasoline	96.7	96.7
NMETOH001	Corn Ethanol	Ethanol	68.9	75.0
NMETOH002	Sorghum Ethanol	Ethanol	60.2	65.0
NMULSD001	Diesel, Clear	Diesel	95.0	95.0
NMBD001	B100 Virgin Plant Oil	Diesel	56.6	60.0
NMRD001	R100 Virgin Plant Oil	Diesel	59.0	65.0
NMRN001	Naphtha Virgin Plant Oil	Naphtha	59.0	65.0
NMBD002	B100 Waste Oil	Diesel	19.9	25.0
NMRD002	R100 Waste Oil	Diesel	18.3	20.0
NMRN002	Naphtha Waste Oil	Naphtha	18.3	20.0
NMLPG001	LPG	Liquefied Petroleum Gas	78.4	78.4
NMCNG001	CNG Fossil	Compressed Natural Gas	74.3	74.3
NMRCNG001	CNG AW	Compressed Natural Gas	62.7	70.0
NMRCNG002	CNG AW	Compressed Natural Gas	-27.4	-25.0
NMRCNG003	CNG LF	Compressed Natural Gas	21.4	25.0
NMLNG001	LNG Fossil	Liquefied Natural Gas	87.1	87.1
NMRLNG001	LNG AW	Liquefied Natural Gas	72.1	80.0
NMRLNG002	LNG AW	Liquefied Natural Gas	-18.5	-15.0
NMRLNG003	LNG LF	Liquefied Natural Gas	31.0	35.0
NMELEC001	Elec. Net-Zero	Electricity	0.0	0.0
NMHYG001	C.H2 Fossil	Compressed Hydrogen	94.4	100.0
NMHYG002	C.H2 AW	Compressed Hydrogen	88.3	95.0
NMHYG003	C.H2 AW	Compressed Hydrogen	-1.8	0.0
NMHYG004	C.H2 LF	Compressed Hydrogen	46.1	50.0
NMHYG005	C.H2 Avg-Grid	Compressed Hydrogen	217.8	230.0
NMHYG006	C.H2 Net-Zero	Compressed Hydrogen	14.3	20.0
NMHYL001	L.H2 Fossil	Liquid Hydrogen	135.7	145.0
NMHYL002	L.H2 AW	Liquid Hydrogen	127.0	135.0

NMHYL003	L.H2 AW	Liquid Hydrogen	37.0	40.0
NMHYL004	L.H2 LF	Liquid Hydrogen	89.8	95.0
NMHYL005	L.H2 Avg-Grid	Liquid Hydrogen	266.7	285.0
NMHYL006	L.H2 Net-Zero	Liquid Hydrogen	46.9	50.0

Several key assumptions differentiate NM-GREET’s fuel pathway modeling from the R&D GREET 2023 Rev1 source workbook. These assumptions include CARB/GTAP-based (California Air Resources Board/Global Trade Analysis Project) indirect land use change (ILUC) factors reflected in NM-GREET1.0, well-to-refinery emissions aligned with OPGEE v2.0c (Oil Production Greenhouse Gas Emissions Estimator) estimates for PADD 3 (Petroleum Administration for Defense District 3), and 45VH2-GREET-based counterfactual avoided-emissions source material for applicable manure-derived biomethane pathways.

In short, this report offers detailed descriptions of how the NM-GREET1.0 model was derived from R&D GREET, fuel pathways were modeled to best reflect the expected characteristics, supply chains, and resulting CIs of an average fuel sold in the state of New Mexico, and how LCA modeling external to R&D GREET was integrated to support these efforts.

Modeling Approach

This report serves as the technical documentation for the data sources and methods by which NM-GREET1.0 was adapted from the R&D GREET 2023 Rev1 Excel workbook. NM-GREET1.0 was adapted from R&D GREET 2023 Rev1 and incorporates New Mexico-specific parameters and source data documented in this report and in the NM-GREET workbook. Because GREET generally reflects U.S. conditions, values for key GREET and external-model parameters were chosen and implemented to best reflect the typical lifecycle carbon intensity values and associated upstream supply-chain activities for transportation fuels produced in New Mexico, imported into New Mexico, or dispensed for use in New Mexico, as applicable under the CTFP rule.

This chapter summarizes both global parameter settings (i.e., those that affect all pathways) and common design patterns used to develop stagewise GHG emissions across pathways. Taken together, these summaries, the external data sources detailed later in Section 3.2.3, and the pathway-specific parameters discussed in their respective sections collectively serve as a technical record of the NM-specific parameterization and calculation structure used to produce NM-GREET1.0 outputs from the appropriate R&D GREET 2023 Rev1 workbook. The documentation identifies the principal source data, parameter changes, and pathway-specific assumptions used in NM-GREET1.0 to support review of the model outputs and future department evaluation of statewide carbon intensities under 20.2.92 NMAC.

From R&D GREET 2023 Rev1,⁵ the modifications NMED made to construct NM-GREET fall into two categories: adding new tabs and modifying parameter values and calculation logic (i.e., altering the contents of cells on R&D GREET 2023 Rev1’s release-default value). NMED stored the details of each parameter on a new tab named *Parameters_NM*. Two more new tabs are present in NM-GREET—*Results_NM* and *CI_Table*—on which formulas to quantify the stagewise emissions of GHG species by pathway are developed and subsequently aggregated into WTW CI totals. For each of the fuel pathways listed in the applicable CTFP rule tables, including Table 4 in Subsection D of 20.2.92.701 NMAC and Table 5 in Subsection E of 20.2.92.701 NMAC, as applicable, any external model and/or data source used to parameterize NM-GREET and calculate or support its carbon intensity value has been referenced accordingly.

⁵ Argonne National Laboratory, “GREET1 2023r1,” April 30, 2024, <https://greet.anl.gov/files/greet-2023rev1>.

1. Parameters

GREET is a parametric LCA model, in which the magnitudes of material and energy flows within and between unit processes are defined by formulas and input parameters rather than static scalar estimates. For each parameter, GREET contains a release-default value—typically chosen to best reflect a U.S.-national-average representation of said parameter. In composing statewide-average estimates of the typical carbon intensity values and upstream supply-chain activities of transportation fuels produced in New Mexico, imported into New Mexico, or dispensed for use in New Mexico, as applicable under 20.2.92 NMAC, New Mexico-specific parameters were included when possible; the national-average default selections were used when New Mexico-specific parameters were unavailable.

In NM-GREET, parameter alterations can be broken down into three categories based on which pathways' CI values they affect. A parameter affects either (1) every pathway, (2) a subset of pathways with some shared attributes (e.g., any fuel derived from animal waste [AW] biomethane), or (3) just a single pathway. A parameter is defined here as “significantly affecting” a pathway if changing it from the corresponding R&D GREET 2023 Rev1 value to the NM-GREET value causes the CI of that pathway to increase or decrease by at least +0.1 g CO₂e/MJ. To delineate which NM-GREET parameter alterations affect which pathways and how, the full table of parameter alterations on the Parameters_NM tab is reorganized into many separate tables within this report.

These separate parameters tables are embedded at different hierarchical levels of this chapter's sections to reflect which pathway or group thereof is significantly affected by a given parameter. If a parameter significantly affects only a single pathway, it is described in a parameter table within that pathway's subsection. If a parameter significantly affects multiple pathways, it is described in a table within a parent section containing each of those pathways. If a parameter significantly affects every pathway (i.e., is a “global” parameter), it is listed below in Table 3 or detailed in a subsection of Section 3.2.3. Putting these rules together, a single-pathway section without a parameter table is therefore only significantly affected by global parameters and those listed in tables of its parent section(s), if present.

Table 2. NM-GREET parameters affecting all pathways

Parameter	Value		GREET Label	Description
	Default	NM		
Year	2022	2022	Target Year for Simulation	Unmodified from R&D GREET 2023 Rev1
GWP_of_GHG_Ref	AR6/GWP	AR5/GWP	AR Edition/Type	Global warming potential of GHGs (g CO ₂ e)

All of this report's parameter tables, like the one above, share formatting and field conventions with NM-GREET's *Parameters_NM* table. The “Parameter” column contains the address—and thereby also the identity—of a parameter, given as either a <sheet>!<A1-cell> style reference or a named range identifier (e.g., the “Year” named range sets the GREET model year). The “Default” and “NM” value columns contain the release-default and altered, New Mexico-specific parameter values. The “GREET Label” column provides context for how GREET defines the parameter. Lastly, the “Description” column adds context and/or justification for how the “NM” value was chosen.

Note that in addition to the NM-GREET_v1.0.xlsm workbook, NMED derived a “baseline” version (the NM-GREET_v1.0_baseline.xlsm workbook) with one difference: the “Year” parameter is set to 2018 instead of 2022. This difference affects GREET's collections of time-series parameter estimates (i.e., on tabs named with the _TS suffix), formatted as arrays of both historical and projected values across

1990–2050. Crucially, GREET’s “Year” (i.e., “Target Year for Simulation”) model-year parameter indexes the selection of each and every one of its time-series parameters, making it by far the most influential parameter choice in the entire model. At the request of NMED’s Climate Change Bureau, NMED kept the “Year” parameter of NM-GREET1.0 set to GREET1 2023 -rev1’s release-default value of 2022, representing the most current non-projected data in the model. Note that the majority of tables on GREET’s *_TS tabs contain only base-five-year indices, such that setting “Year” to 2022 causes GREET to round down to the nearest base-five year—2020—when values are chosen from those tables.

IPCC AR5 GWP100 values were chosen via the “GWP_of_GHG_Ref” parameter to convert emitted greenhouse gas species to CO₂e masses and to account for GREET-calculated CO₂e emissions from oxidation of carbon in carbon monoxide (CO) and volatile organic compound (VOC) emissions. By default, GREET assumes CO and VOCs will oxidize into carbon dioxide (CO₂) in the atmosphere, which is why it incorporates the “CO₂ (w/ C in VOC & CO)” indicator rather than solely “CO₂” into its calculation of total GHG emissions. For both CO and VOCs, GREET multiplies the emitted mass of each species by its carbon mass fraction (i.e., g carbon/g species, labeled as “Carbon ratio of [species]”), then divides by the mass of carbon in CO₂ in order to derive the corresponding CO₂e mass associated with oxidation of that species’ carbon to CO₂.

$$CO_2e\ conversion\ factor_{species} = \left[\frac{g\ CO_2e}{g\ species} \right] = m_{C,species} \left[\frac{g\ C}{g\ species} \right] / m_{C,CO_2} \left[\frac{g\ C}{g\ CO_2} \right] \tag{Equation 1}$$

GREET repeatedly performs this same calculation within each “CO₂ (w/ C in VOC & CO)” result cell, but NMED avoids this redundancy on the *Results_NM* tab by pre-calculating the resulting GWP factors for both VOCs—which GREET uniformly approximates as being 85 percent carbon by mass—and CO. The resulting, composite set of IPCC-sourced and GREET-specific GWP factors is presented in Table 3.

Table 3. GWP100 factors used in NM-GREET1.0

GWP100 Factors (g CO ₂ e/g species)	
CO ₂	1
CH ₄	30
N ₂ O	265
VOCs	3.12
CO	1.57

Finally, while GREET is predominantly an attributional LCA (ALCA) model, it also includes consequential LCA (CLCA) elements, as outlined in the recent National Academies report on LCA and low carbon fuel standard programs.⁶ Some CLCA elements can be controlled via GREET’s parameters, such as whether co-products are accounted for via system expansion (i.e., assigning an avoided burden based on displacement of another product or process). Other CLCA elements, namely counterfactual scenario emissions adjustments—are not yet controllable via parameters, instead requiring GREET users to rewrite formulas if they wish to exclude or disaggregate the effect of those elements.

⁶ National Academies of Sciences, Engineering, and Medicine, *Current Methods for Life-Cycle Analyses of Low-Carbon Transportation Fuels in the United States* (Washington, DC: The National Academies Press, 2022), <https://doi.org/10.17226/26402>.

In tailoring R&D GREET into NM-GREET, NMED avoided system expansion wherever possible and generally used market-value allocation where documented in the NM-GREET Parameters_NM tab. Instead, market-based allocation—wherein the burdens of a process are distributed across its co-products according to their relative economic value—is given preference where documented in the NM-GREET Parameters_NM tab.⁷ Additionally, GREET’s instances of mass-based allocation often do not account for significant differences in the composition (e.g., protein content) and utility of co-products, and its energy-based allocation does not consider the energy commodities’ entropic states (i.e., heat is far less useful than electricity) or their logistical constraints (e.g., transporting and storing electricity poses different challenges than a liquid fuel does).

2. Results

The *Results_NM* tab contains the definitions of NM-GREET pathways and stages of activity therein, including metadata mappings between R&D GREET 2023 Rev1 (i.e., tab, section heading, and stage heading) and the New Mexico pathway (i.e., ID, name, stage, stage category) as well as formulas to estimate the emitted quantities of GHG and GREET-accounted CO and VOC emissions within each pathway-stage. In each column of *Results_NM*, the set of “Source,” “GREET Tab,” “GREET Section,” and “GREET Stage” fields together serve as a pointer to the location—within or external to R&D GREET 2023 Rev1—on which the subsequent GHG-emissions formulas primarily rely. For example, column D of *Results_NM* estimates the GHG emissions from on-road combustion of clear gasoline. NMED developed these formulas by combining elements from the per-distance and per-energy “Vehicle Operation” formulas of the Results tab. However, since both the *Results_NM* column D and *Results* vehicle operation formulas both primarily rely on values from the *Vehicles* tab, the “GREET Tab” field points to *Vehicles* rather than *Results*.

To define the scope of fuel pathways, NMED adhered to GREET’s nomenclature and definitions of lifecycle stages: “Feedstock” production, “Fuel” processing, and “On-Road” vehicle emissions. These three core stages are used as common stage categories for many pathways in NM-GREET and this report, but the specific supply-chain activities within each stage vary by pathway. Furthermore, pathways with agricultural crop feedstocks also include a separate “ILUC” stage for indirect land use change, as detailed below in Section 3.2.3. For all biogenic-feedstock fuel pathways, NMED disaggregates and lists “Biogenic CO₂ Uptake” as a separate stage in this report, but on the *Results_NM* tab these emissions are incorporated into the On-Road stage. Finally, once the stagewise CIs defined on *Results_NM* are calculated, those results are aggregated on the *CI_Table* tab into well-to-pump and pump-to-wheel subtotals and finally a WTW total CI for each pathway. The well-to-pump subtotal is defined as the sum of the applicable upstream stagewise CI values calculated for each pathway in *Results_NM*; pump-to-wheel is calculated in *CI_Table* from the applicable vehicle-use or end-use stage values for each pathway.

Two key patterns are reused across formulas developed on *Results_NM*:

- **Using loss factors to normalize GHG emissions to the energy content of fuel delivered to a vehicle.** As on R&D GREET 2023 Rev1’s Results tab, emissions and CO₂e-conversion formulas on *Results_NM* incorporate stagewise loss factors—themselves often calculated as composites of loss factors for specific activities within a stage. Scaling emissions by these factors ensures that results can be added across stages. For example, absent this scaling, emissions from fossil clear

⁷ National Academies of Sciences, Engineering, and Medicine, *Current Methods for Life-Cycle Analyses of Low-Carbon Transportation Fuels in the United States* (Washington, DC: The National Academies Press, 2022), <https://doi.org/10.17226/26402>.

gasoline's Feedstock stage would have units of g CO₂e/MJ of crude oil at refinery rather than MJ of gasoline at pump and thus could not be aggregated into a WTW CI.

- **Accounting for biogenic CO₂ uptake and re-emission via the -1/+1 method.** For biogenic CO₂ emissions, NMED followed the GREET convention of applying the -1/+1 method, given that all of NM-GREET's biofuel pathway feedstock crops have short growth cycles (i.e., no woody biomass feedstocks are modeled). This method represents CO₂ sequestration during plant growth as a negative emission, followed by positive emissions wherever the biogenic carbon atoms are re-released to the atmosphere as CO₂—primarily upon fuel combustion. However, the sequestered and re-released CO₂ quantities are not always identical: the -1/+1 method also considers the different impacts of biogenic carbon embedded in non-CO₂ emissions such as CH₄. Emissions of biogenic CH₄ are treated identically to fossil CH₄ in GREET.

Finally, to ensure that the CI values of temporary pathways (Table 5 in Subsection E of 20.2.92.701 NMAC) represent conservative estimates, NM-GREET1.0 applies the adjustment routine described below to calculate the Adjusted Total values used for temporary pathway carbon intensities. For each unique category of temporary fuel pathways (e.g., compressed biomethane from landfills), find the maximum CI value among applicable alternative fuel pathway applications calculated using the Tier 1 calculator or Tier 2 calculator for that pathway. With this maximum CI as an input, multiply it by 105% and round up to the nearest base-5 integer to yield that pathway category's temporary CI. This routine can be more succinctly represented via the following formula:

$$y = \text{ceiling} \left(\frac{x * 1.05}{5} \right) * 5, \text{ where } y = CI_{\text{temporary}} \text{ and } x = CI_{\text{max}} \quad \text{Equation 2}$$

Since alternative fuel pathway applications calculated using the Tier 1 calculator or Tier 2 calculator were not available for establishing pathway-maximum carbon intensity values at the time NM-GREET1.0 was developed, NMED instead used NM-GREET to estimate "Total" pathway CIs as the inputs (x) to this formula. The "Adjusted Total" outputs (y) are then the resulting CI values reflected in Table 5 in Subsection E of 20.2.92.701 NMAC.

Key Assumptions

Results from select external models are incorporated into NM-GREET to best represent transportation fuels produced in New Mexico, imported into New Mexico, or dispensed for use in New Mexico, as well as to mitigate limitations in R&D GREET's model scope and data resolution. These results fall into three categories: indirect land-use change, crude oil supplied to PADD 3, and national-average livestock manure methane emissions.

3. Indirect Land-Use Change

In order to estimate the average estimated shift in fuel lifecycle CI resulting from GHG emissions and biogenic carbon related to land-use changes that occur in response to increased demand for crop-based transportation fuels in NM-GREET, NMED adopts and reuses the ILUC factors developed by CARB and reflected in NM-GREET as CARB/GTAP-based ILUC factors.⁸

⁸ California Air Resources Board, "Detailed Analysis for Indirect Land Use Change," 2015, ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/iluc_assessment/iluc_analysis.pdf.

Table 4. ILUC factors used in NM-GREET1.0

Fuel Pathway	ILUC Value (g CO₂e/MJ)
Corn ethanol	19.8
Sorghum ethanol	19.4
Sugarcane ethanol	11.8
Soybean biodiesel or renewable diesel	29.1
Canola biodiesel or renewable diesel	14.5
Palm biodiesel or renewable diesel	71.4

Given the complexity of ILUC modeling, the absence of scientific consensus on model structure and parameterization, and the still-sizable uncertainty ranges surrounding ILUC factors calculated by an array of prominent models, NMED opted to reuse CARB's 2015 ILUC analysis and resulting factors. Performing novel ILUC analysis requires significant time and effort to achieve accuracy, and even then, the resulting ILUC factors arrive with substantial quantitative uncertainty. NMED opted to adopt ILUC factors from CARB's ILUC analysis as reflected in NM-GREET1.0 source documentation rather than compose a new NM-specific ILUC analysis (or meta-analysis, comparing multiple models) and resulting factors. NMED recognizes that CARB's ILUC factors are not the most recently published, but nonetheless chose to use them for the following reasons:

- CARB's ILUC assessment was conducted by a regulatory body with (1) extensive expert review and (2) robust stakeholder input via a transparent, rigorous engagement process.
- The International Council on Clean Transportation recommended reusing CARB's ILUC values in their peer review of the Washington Clean Fuel Standard program's carbon intensity modeling.⁹
- Whereas GREET's Carbon Calculator for Land Use and Land Management Change from Biofuels Production (CCLUB)-based ILUC factors are lower than those from CARB and thereby suggest that CARB's factors may overestimate the impact of ILUC, a pair of recent ILUC model-review and -validation studies—EPA's 2023 Model Comparison Exercise¹⁰ and Lark et al. (2022)¹¹ — suggest that CARB's factors may instead be underestimated.

Thus, despite its age, CARB's assessment was selected as the ILUC source basis for NM-GREET1.0 based on the considerations documented above and the CARB/GTAP factors reflected in the workbook.

Furthermore, there is no single harmonized ILUC model, and each ensemble of available models and underlying data has their respective strengths and weaknesses. Regulatory ILUC analyses, including CARB's ILUC analysis and EPA's Renewable Fuel Standard lifecycle modeling, generally use linked economic and biophysical modeling components to estimate land-use change and associated emissions: (1) a macroeconomic model which estimates the quantity of land-use change induced by a shift in demand for crop-based biofuels and their feedstocks, and (2) a biophysical land-use-change and land-

⁹ International Council on Clean Transportation (ICCT), "Washington Clean Fuels Standard—Carbon Intensity Model Peer Review," April 6, 2022, <https://ecology.wa.gov/getattachment/3ff97fb5-9ba4-4507-8741-4be625e4e690/CIModelPeerReview20220406.pdf>.

¹⁰ U.S. Environmental Protection Agency, "Model Comparison Exercise Technical Document," 2023, <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1017P9B.txt>.

¹¹ Tyler J. Lark et al., "Environmental Outcomes of the US Renewable Fuel Standard," *Proceedings of the National Academy of Sciences* 119, no. 9 (March 2022): e2101084119, <https://doi.org/10.1073/pnas.2101084119>.

management-change GHG emissions model, which produces the emissions factors by which the first model's results are multiplied to yield ILUC factors.

To date, EPA's 2023 Model Comparison Exercise (MCE) Technical Document summarizes differences among ILUC modeling frameworks and explains how those differences affect biofuel GHG estimates.¹² The MCE highlights that uncertainty in ILUC factors is a result of both structural uncertainty originating in the selection of the aforementioned economic and biophysical models, as well as numeric uncertainty attached to each of said models' parameters. The economic portion of models (i.e., how markets respond to the demand for bio-based fuels) was structured differently across the models examined, which affected the sensitivity of ILUC results to model parameterization and assumptions about land-use responses to additional biofuel demand. For example, the MCE highlights limitation identified for GTAP-BIO (biofuels): it lacks robust modeling of commodity substitutability and competition in the global vegetable oil market. Whenever soybean oil is diverted to produce fuel, other vegetable oils may replace it to varying degrees; this substitution is a key driver of ILUC and its resulting GHG emissions. Unlike other models in the MCE—whose results included significant replacement of the soybean oil diverted from the international food market with palm, canola, and other crop oils—GTAP's results project an overall reduction in oil crops consumed as food, with little replacement. This discrepancy indicates that CARB's 2015 oil-crop ILUC factors may be sensitive to GTAP-BIO's treatment of vegetable-oil substitution and should be interpreted with that modeling limitation in mind.

Lark et al. (2022) evaluated environmental outcomes of the U.S. Renewable Fuel Standard (RFS) using econometric analyses, land-use observations, and biophysical modeling, and reported that corn ethanol produced under the RFS had a carbon intensity no less than gasoline and likely at least 24% higher, even without considering likely international land-use effects.¹³ Lark et al. attribute this additional ethanol as demand induced by the 2007 RFS expansion. To this additional fuel volume, the authors attribute and calculate a domestic ILUC factor of 29.7 g CO₂e / MJ—a result which far exceeds EPA's original regulatory impact assessment projection of -3.8 g / MJ for domestic ILUC emissions by 2022. Furthermore, the authors use this corrected ILUC factor to calculate a revised CI for corn ethanol of 115.7 g/MJ (as produced in 2022, or higher in preceding years) 24% higher than the program's corresponding baseline gasoline CI of 91.3 g/MJ. These findings illustrate the potential risk of underestimating land-use-change emissions and support periodic validation of ILUC factors using historical data where appropriate.

On the other hand, R&D GREET's default ILUC factors calculated via its CCLUB module are significantly lower than those from CARB's 2015 analysis across pathways. In 2024, Taheripour et al. published a comparative analysis of land-use-change emissions factors using GTAP-BIO land-use-change estimates and two emissions-factor models, CCLUB and Agro-Ecological Zone Emission Factor (AEZ-EF¹⁴). Unlike EPA's MCE, Taheripour et al. used only one macroeconomic model, GTAP-BIO, and instead focused their comparison on two different land-use-change emissions models, CCLUB and AEZ-EF, the latter of which was used to calculate CARB's 2015 ILUC factors. For an array of crop-based jet fuel production pathways and corresponding additional-demand scenarios, the authors found AEZ-EF's ILUC factors to be more extreme than those from CCLUB. Taheripour et al. reported substantial differences between AEZ-EF and CCLUB results. For example, for corn ethanol-to-jet fuel over a 25-year amortization period, AEZ-EF produced an ILUC value of 24.9 gCO₂e/MJ, while CCLUB produced 15.96 gCO₂e/MJ, a

¹² U.S. Environmental Protection Agency, "Model Comparison Exercise Technical Document," 2023, <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1017P9B.txt>.

¹³ Tyler J. Lark et al., "Environmental Outcomes of the US Renewable Fuel Standard," *Proceedings of the National Academy of Sciences* 119, no. 9 (March 2022): e2101084119, <https://doi.org/10.1073/pnas.2101084119>.

¹⁴ Farzad Taheripour et al., "Biofuels Induced Land Use Change Emissions: The Role of Implemented Land Use Emission Factors," *Sustainability* 16, no. 7 (January 2024): 2729, <https://doi.org/10.3390/su16072729>.

60% difference for the same land-use-change estimate. The authors conclude by noting the difficulty in pinpointing root causes of these differences—due to variation in underlying data, model assumptions, and system boundaries—and emphasize the importance of model validation, particularly by way of remote-sensing technologies.

In summary, the ILUC model-comparison and validation studies indicate how scientists in this field continue to grapple with many of the same open questions, disagreements, and quantitative uncertainty which have persisted since CARB's 2015 analysis. Given the large range of uncertainty surrounding these estimates, NMED uses CARB/GTAP-based ILUC factors in NM-GREET1.0 and reflects applicable ILUC values in the CTFP rule where required for CI calculations.

4. *OPGEE Crude Slate Modeling*

NMED modified NM-GREET to substitute R&D GREET 2023 Rev1's default modeling of crude oil's well-to-refinery-gate (WTRG) CI with an estimate derived from the OPGEE v2.0c model, U.S. Energy Information Administration (U.S. EIA) data, and the work of Masnadi et al. (2018).¹⁵ Unlike R&D GREET, OPGEE allows users to model GHG emissions from the extraction, processing, and transportation of crude oil by defined-origin mixtures as consumed within a certain PADD region.¹⁶ This improved resolution allowed NMED to model the mixture of crude oil produced domestically within and imported internationally into PADD 3, the Gulf Coast Petroleum Administration for Defense District, which includes New Mexico, so as to best characterize the supply chains of petroleum-derived fuels produced in New Mexico, imported into New Mexico, or dispensed for use in New Mexico, as applicable.

In 2018 Masnadi et al. published carbon intensity estimates for 98% of global crude production for the 2015 production year, which were modeled with field-specific data.¹⁷ NMED combined data and results from the supplementary material of Masnadi et al.'s work with OPGEE v2.0c and domestic crude oil production and foreign import data from U.S. EIA,¹⁸ as detailed in Appendix A: Crude Oil Production Modeling. The resulting weighted-average PADD 3 CI values are calculated as 11.83 g CO₂e/MJ refinery input for 2018 and 11.46 g CO₂e/MJ for 2022. Integrating these WTRG CIs into NM-GREET's *Petroleum* tab in both the v1.0 and baseline versions of NM-GREET causes a ~4–5 g CO₂e/MJ increase in the pathway CI values of crude-oil-derived transportation fuels (i.e., gasoline, diesel, and liquefied petroleum gas) and only modest ≤0.2 g CO₂e/MJ increases in other pathways.¹⁹

In order to ensure that all fuel pathways incorporate this Feedstock-stage CI into the petroleum-derived fuels they consume as process and/or transportation fuels within their supply chains, NMED increased

¹⁵ Hassan M. El-Houjeiri et al., "Oil Production Greenhouse Gas Emissions Estimator OPGEE v2.0 User Guide & Technical Documentation," 2017, https://pangea.stanford.edu/departments/ere/dropbox/EAO/OPGEE/OPGEE_documentation_v2.0.pdf; Mohammad S. Masnadi et al., "Global Carbon Intensity of Crude Oil Production," *Science* 361, no. 6405 (August 31, 2018): 851–53, <https://doi.org/10.1126/science.aar6859>.

¹⁶ U.S. Energy Information Administration, "Petroleum Administration for Defense Districts," February 7, 2012, <https://www.eia.gov/todayinenergy/detail.php?id=4890>.

¹⁷ Mohammad S. Masnadi et al., "Global Carbon Intensity of Crude Oil Production," *Science* 361, no. 6405 (August 31, 2018): 851–53, <https://doi.org/10.1126/science.aar6859>.

¹⁸ U.S. Energy Information Administration, "Crude Oil Production, Annual," 2025, https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbb1_a.htm; U.S. Energy Information Administration, "PAD District Imports by Country of Origin: Gulf Coast (PADD3), Crude Oil, Annual," 2025, https://www.eia.gov/dnav/pet/pet_move_impcp_a2_r30_epc0_IP0_mbb1_a.htm.

¹⁹ Petroleum fuels are consumed within the supply chains of all liquid fuel pathways, but marginal increases in the CI of petroleum has only a limited impact on the CI values of these other pathways.

the well-to-refinery-gate CO₂ emissions value of unrefined crude oil on the *Petroleum* tab such that it matched the above pair of PADD 3 -specific 2018 and 2022 estimates. Using the 2022 adjustment to illustrate this change, NMED made up the difference between R&D GREET's release-default WTRG CI of 7,911 g CO₂e per million British thermal units (mmBtu) and the calculated 2022 PADD 3 value of 12,091 g CO₂e/mmBtu (i.e., converted from 11.46 g CO₂e /MJ) by increasing the well-to-refinery-gate CO₂ emissions for unrefined crude oil (in cell *Petroleum!B279*) by the difference between the CI values. Therefore, NMED added 4,180 g CO₂e /mmBtu (i.e., 12,091 minus 7,911) of CO₂ emissions to the WTRG CI of unrefined crude oil, which has a release-default value of 5,129 g CO₂e /mmBtu. Prioritizing the transparency and traceability of these calculations, NMED inserted a condensed version of these calculations as the following formula into the *Petroleum*-tab WTRG CO₂ emissions cell, where "MJ2mmBtu" references R&D GREET 2023 Rev1's named range for converting MJ to mmBtu:

$$\begin{aligned} \text{WTRG CO}_2 \text{ emissions in Petroleum!B279, g CO}_2\text{e/mmBtu} \\ = (11.46/\text{MJ2mmBtu} - 7,911.2) + 5,128.8 \end{aligned} \quad \text{Equation 3}$$

5. *Manure Biomethane Counterfactual Emissions*

Avoided methane emissions adjustments are constructed from pairs of counterfactual scenarios: a "baseline" or status quo scenario (which is avoided) and an "alternative" intervention (which may be enacted via public policy, private investment, and/or additional decision points). When considering the diversion of animal manure from some existing manure management practice to an anaerobic digester (AD) system that produces biomethane for use as transportation fuel produced in New Mexico, imported into New Mexico, or dispensed for use in New Mexico, as applicable, the baseline scenario is defined as the national-average array of manure management practices, and the alternative scenario as a weighted average of the array of available, deployed AD technologies. Under 20.2.92.202(E), avoided methane emissions may be included in certified CI values only when the regulated party demonstrates the applicable requirements and receives department approval.

However, the structure of R&D GREET only allows users to access a single AD technology at a time, and working around this limitation would thereby require extensive re-writes of the formulas from the RNG (renewable natural gas) and Waste tabs. Instead, NM-GREET uses source material from the Department of Energy's (DOE) 45VH2-GREET-related generic counterfactual analysis for avoided GHG emissions for manure-derived biomethane, which provides a generic average manure counterfactual emissions value for manure-derived biogas and renewable natural gas.²⁰ This recent analysis used production-weighted-national-average statistics and modeling of both (1) manure generation by all major livestock types in U.S. animal agriculture, and (2) emissions from U.S.-average manure management practices as the baseline scenario. Then, the total net difference in GHG emissions between that baseline and the alternative—diversion into a mixture of the three most prevalent AD technologies (covered lagoon, mixed plug flow, and complete mix)—is calculated. Together, these elements produced a "generic" avoided methane emissions potential per unit energy of biomethane yield, agnostic of the specific manure source, management practice, or digester system. These generic avoided emissions factor allows NM-GREET to apply the resulting adjustment across applicable manure-derived biomethane temporary pathway CI calculations, subject to the requirements of 20.2.92 NMAC.

²⁰ U.S. Department of Energy, "A Generic Counterfactual Greenhouse Gas Emission Factor for Life-Cycle Assessment of Manure-Derived Biogas and Renewable Natural Gas," January 2025, https://www.energy.gov/sites/default/files/2025-01/generic-counterfactual-greenhouse-gas-emission-factor-for-life-cycle-assessment-of-manure-derived-biogas-and-renewable-natural-gas_010225.pdf.

Reproducing the calculations outlined in the DOE generic counterfactual report's "Estimated Emissions Per Unit Biomethane" section yields an avoided emission factor of -90.3 g CO₂e/MJ CH₄ when expressed as an avoided-emissions adjustment in biomethane, which is lower in magnitude than the R&D GREET 2023 Rev1 default factor of 110.3 g CO₂e/MJ. In the following formulas, "manure" denotes manure mass as excreted including moisture, CO₂e values are calculated via AR5 GWP100 factors, and the LHV of CH₄ is obtained from GREET (i.e., at conditions of 32°F and 1 atmosphere):

$$\frac{81,696,000 \frac{MT CO_2e}{year}}{1,460,542,191 \frac{MT manure}{year}} * \frac{1 MT manure}{10^3 kg manure} * \frac{10^6 g CO_2e}{1 MT CO_2e} = 55.9 \frac{g CO_2e}{kg manure}$$

$$55.9 \frac{g CO_2e}{kg manure} * \frac{1 kg manure}{0.61 scf CH_4 in biogas} = 91.7 \frac{g CO_2e}{scf CH_4 in biogas}$$

$$91.7 \frac{g CO_2e}{scf CH_4 in biogas} * \frac{1 scf CH_4 in biogas}{962.2 Btu (LHV, CH_4)} * \frac{1000 Btu}{1.055056 MJ} = 90.3 \frac{g CO_2e}{MJ CH_4 in biogas}$$

Since these emissions are considered avoided, a negative sign is prepended to the emission factor. Note that, while the per-MJ value of -90.3 equals the "-90 g CO₂e/MJ" value after rounding on page 11 of the 45VH2 generic counterfactual report, the -91.7 g CO₂e/standard cubic foot (scf) CH₄ in biogas value differs from the "-90 g CO₂e/scf biomethane in biogas" on page 10. Based on the calculations above and subsequent differences in per scf and per MJ emission factors in the report, the 90.3 per MJ value is correct, whereas the per scf value should be 91.7.

In addition to this counterfactual avoided emission factor, NM-GREET also integrates the 45VH2 report's estimated emissions intensities for both average digester (i.e., across a "manure-weighted average of the three primary digester technologies"—covered lagoon, mixed plug flow, and complete mix) and biogas upgrader operations. The former emits 39 g CO₂e/MJ by way of its consumption of grid electricity and natural gas (NG), and the latter emits 19.4 g CO₂e/MJ via fugitive biogas plus upstream emissions of consumed grid electricity. For each pathway that includes AW biomethane as a fuel or feedstock, NMED uses the sum of these values, 58.4 g CO₂e/MJ, as an NM-GREET1.0 modeling input to represent biogas production activities within the Fuel-processing stage.

Gasoline Pathways

1. *Fossil Clear Gasoline (E0)*

The Fossil Clear Gasoline (E0) pathway approximates a weighted average of crude-oil-derived gasoline supplied to New Mexico, as delivered in "clear" state before any potential blending with other fuels, such as ethanol. As detailed in the [OPGEE Well-to-Refinery Crude Oil Modeling](#) section of this report, the Feedstock stage is composed of PADD 3 -weighted average crude oil extraction activities, followed by transport to a refinery. The Fuel processing stage includes the refining of crude oil into gasoline followed by transportation and distribution to refueling stations. Finally, the On-Road stage models gasoline combustion within a light-duty, passenger internal combustion engine vehicle (ICEV).

The parameter listed in Table 5 is altered from the corresponding R&D GREET 2023 Rev1 value to ensure that this model pathway is representative of clear gasoline represented by the NMGAS001 pathway in NM-GREET1.0. NMED decreased the value of "Petro_FRFG_EtOH" from 10 to 0 percent in

order to model tailpipe emissions from combusting clear gasoline (E0) on the *Vehicles* tab rather than E10.

Table 5. Parameters relevant to the Fossil Clear Gasoline (E0) pathway

Parameter	Value		GREET Label	Description
	Default	NM		
Petro_FRFG_EtOH	10.0%	0.0%	Ethanol blending level (by volume)	Set to 0% so <i>Results_NM</i> formulas can reuse calculations from <i>Vehicles</i> tab for clear gasoline

Table 6 below, summarizes the cumulative CI and the CI values by stage. Formulas defining this pathway’s stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1’s *Petroleum* sheet Section 5.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 6. Summary of the Fossil Clear Gasoline (E0)’s stagewise CI values

Stage	Total CI* (g CO2e/MJ)
Feedstock	9.9
Fuel	13.7
On-Road	73.1
Total	96.7

* Values may not sum exactly to the pre-adjusted total due to rounding

2. *Corn Ethanol (E100)*

The Corn Ethanol (E100) pathway estimates the typical WTW CI value of corn-derived denatured fuel ethanol based on the North American average pathway represented in NM-GREET1.0, as delivered before any potential blending with other fuels. The Feedstock lifecycle stage is composed of corn farming and transport to an ethanol production plant. The Fuel processing stage includes an industry-weighted average of ethanol production plant types—using dry and wet milling, with and without the extraction of a corn oil co-product—followed by transportation and distribution to refueling stations. The On-Road stage models fuel combustion within a light-duty passenger ICEV. Finally, the ILUC and Biogenic CO₂ Uptake stages are incorporated to account for the effects of feedstock crop growth.

Certain parameters listed in Table 7 are altered from the corresponding R&D GREET 2023 Rev1 values to ensure that this model pathway is representative of the Corn Ethanol (E100) pathway represented by NMETOH001 in NM-GREET1.0. NMED increased the value of “Vehicles_EtOHDediVehi_EtOHShare” from 85 percent to 100 percent in order to model tailpipe emissions from combusting E100 on the *Vehicles* tab rather than E85. Since CARB ILUC factors are applied, GREET’s internal estimation of ILUC is disabled via the “EtOH_CornEtOH_LandChange_Option” parameter. Finally, as described in the Parameters section, market-based allocation is given preference over other available modes; for this reason, NMED altered the three enumerated allocation-selector parameters from their default values to the NM values shown in Table 7 to apply market-based allocation where documented in *Parameters_NM*

Table 7. Parameters relevant to the Corn Ethanol (E100) pathway

Parameter	Value		GREET Label	Description
	Default	NM		
Vehicles_ EtOHDediVehi_ EtOHShare	85.0%	100.0%	Ethanol in dedicated vehicle fuel	Set to 100% so <i>Results_NM</i> formulas can reuse calculations from <i>Vehicles</i> tab for fuel ethanol
EtOH_CornEtOH_ LandChange_ Option	2	0	Inclusion of GHG Emissions from Land Use Change; Corn	Remove GREET's ILUC value for corn ethanol; use CARB value instead
Ethanol_Farming_ Corn_Allocation	1	4	Allocation of corn farming energy between corn grain and stover	Preference market allocation
EtOH_CornEtOH_ CoProductMethod	1	3	Allocation of Corn ethanol w/o corn oil extraction	
EtOH_CornEtOH_C oProductMethod_w_ CornOilExtraction (Inputs!F503)	6	3	Allocation of Corn ethanol w/ corn oil extraction	

The pathway's total WTW CI and those of its stages are provided below in Table 8. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *EtOH* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 8. Summary of Corn Ethanol (E100)'s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-68.9
Feedstock	23.1
Fuel	23.4
On-Road	71.4
ILUC	19.8
Total	68.9
Adjusted Total	75.0

* Values may not sum exactly to the pre-adjusted total due to rounding

3. Sorghum Ethanol (E100)

The Sorghum Ethanol (E100) pathway estimates the typical WTW CI value of sorghum-derived denatured fuel ethanol based on the North American average pathway represented in NM-GREET1.0, as delivered before any potential blending with other fuels. The Feedstock lifecycle stage is composed of grain sorghum farming and transport to an ethanol production plant. The Fuel processing stage includes ethanol production followed by transportation and distribution to refueling stations. The On-Road stage models fuel combustion within a light-duty passenger ICEV. Finally, the ILUC and Biogenic CO₂ Uptake stages are incorporated to account for the effects of feedstock crop growth.

The parameter listed in Table 9 is altered from the corresponding R&D GREET 2023 Rev1 value to ensure that this model pathway is representative of the Sorghum Ethanol (E100) pathway represented by NMETOH002 in NM-GREET1.0. NMED increased the value of “Vehicles_EtOHDediVehi_EtOHShare” from 85 to 100 percent to model tailpipe emissions from combusting E100 on the *Vehicles* tab rather than E85. Since R&D GREET 2023 Rev1’s internal estimation of ILUC for sorghum is disabled by default, no parameter alteration was necessary to avoid double-counting emissions when applying CARB’s ILUC factor. Finally, as described in the Parameters section, market-based allocation is given preference over other available modes; for this reason, NMED altered the sorghum-ethanol-plant allocation selector from its default value of “1: Displacement method” to “3: Market value-based allocation,” consistent with the Parameters_NM note “Preference market allocation.”

Table 9. Parameters relevant to the Sorghum Ethanol (E100) pathway

Parameter	Value		GREET Label	Description
	Default	NM		
Vehicles_EtOHDediVehi_EtOHShare	85.0%	100.0%	Ethanol in dedicated vehicle fuel	Set to 100% so <i>Results_NM</i> formulas can reuse calculations from <i>Vehicles</i> tab for fuel ethanol
EtOH!C270	1	3	Co-products handling methods of sorghum ethanol plant	Preference market allocation

The pathway’s total WTW CI and those of its stages are provided below in Table 10. Formulas defining this pathway’s stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1’s *EtOH* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 10. Summary of Sorghum Ethanol (E100)’s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-68.9
Feedstock	23.7
Fuel	19.4
On-Road	71.4
ILUC	14.5
Total	60.2
Adjusted Total	65.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Diesel Pathways

1. Fossil Clear Diesel (B0)

The Fossil Clear Diesel (B0) pathway approximates a weighted average of crude-oil-derived diesel supplied to New Mexico, as delivered in “clear” state before any potential blending with other non-fossil-diesel fuels. As detailed in the OPGEE Crude Slate Modeling section, the Feedstock stage is

composed of PADD 3 -weighted average crude oil extraction activities, followed by transport to a refinery. The Fuel processing stage includes the refining of crude oil into diesel followed by transportation and distribution to refueling stations. Finally, the On-Road stage models diesel combustion within a light-duty passenger vehicle with a compression-ignition direct-injection (CIDI) engine.

The pathway's total WTW CI and those of its stages are provided below in Table 11. Formulas defining this pathway's stagewise emissions on Results_NM primarily refer to and derive from R&D GREET 2023 Rev1's Petroleum sheet Section 5.1, Vehicles sheet Section 3, and Results tab Section 2.

Table 11. Summary of Fossil Clear Diesel (B0)'s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	11.5
Fuel	7.9
On-Road	75.6
Total	95.0

* Values may not sum exactly to the pre-adjusted total due to rounding

2. Biodiesel (B100)

The neat biodiesel (B100) pathways approximate categorical averages of biodiesel (BD) fuel categories represented in NM-GREET1.0, including virgin plant oil and animal fat or waste oil feedstock categories, as delivered in their pure state before any potential blending with fossil diesel fuels. For both B100 temporary pathways, Table 12 lists the parameter alterations NMED made from the corresponding R&D GREET 2023 Rev1 values to disaggregate overlapping R&D GREET 2023 Rev1 source-model formulas, as described in the Results_NM methodology section, and to represent the B100 biodiesel pathways listed in NM-GREET1.0.

Table 12. Parameters relevant to all Biodiesel (B100) pathways

Parameter	Value		GREET Label	Description
	Default	NM		
Vehicles_BDCIDI_BDShare	20%	100%	Biodiesel in CIDI fuel	Causes <i>Vehicles</i> -tab results to reflect pure biodiesel (BD), on which <i>Results_NM</i> formulas depend

Virgin Non-Palm Plant Oil

The Virgin Non-Palm Plant Oil pathway estimates the typical WTW CI of neat biodiesel (B100) derived from non-palm virgin plant oil, based on the North American average pathway represented by NMBD001 in NM-GREET1.0, as delivered before any potential blending with other diesel fuels. The Feedstock lifecycle stage is composed of soy farming and transport to a fuel production facility. The Fuel processing stage includes soy oil extraction, transesterification, and transportation plus distribution to refueling stations. The On-Road stage models B100 combustion within a light-duty passenger CIDI vehicle. Finally, ILUC and Biogenic CO₂ Uptake stages are incorporated to account for the effects of feedstock crop growth.

Certain parameters listed in Table 13 are altered from the corresponding R&D GREET 2023 Rev1 values to ensure that this model pathway is representative of the Virgin Non-Palm Plant Oil Biodiesel (B100) pathway represented by NMBD001 in NM-GREET1.0. Since CARB ILUC factors are applied, R&D GREET 2023 Rev1's internal estimation of ILUC is disabled via the "Soybean_LUC_Selector" parameter. Also, as described in Section 3.2.1, market-based allocation is given preference over other available modes. For this reason, NMED altered the enumerated "BD_SoybeanOilExtraction_Allocation" selector from "4 - Mass-Based Allocation" to "3 - Market-Based Allocation."

Table 13. Parameters relevant to the Virgin Non-Palm Plant Oil Biodiesel (B100) pathway

Parameter	Value		GREET Label	Description
	Default	NM		
Soybean_LUC_Selector	2	0	Inclusion of GHG Emissions from Induced Land Use Change	Exclude GREET estimate; replace with CARB estimate on <i>Results_NM</i>
BD_SoybeanOilExtraction_Allocation	4	3	Process level allocation for all biooil-based fuels: Oil Extraction Process for Soybean	Preference market allocation

The pathway's total WTW CI and those of its stages are provided below in Table 14. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's BioOil sheet Section 4.1, Vehicles sheet Section 3, and Results tab Section 2.

Table 14. Summary of Virgin Non-Palm Plant Oil Biodiesel (B100)'s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO₂ Uptake	-71.2
Feedstock	13.2
Fuel	9.7
On-Road	75.9
ILUC	29.1
Total	56.6
Adjusted Total	60.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Waste Animal Fat or Cooking Oil

The Waste Animal Fat or Cooking Oil pathway estimates the typical WTW CI value of neat biodiesel (B100) derived from animal fat or waste oil feedstock, based on the North American average pathway represented by NMBD002 in NM-GREET1.0, as delivered before any potential blending with other diesel fuels. The estimated WTW CI values for animal-fat-derived and used-cooking-oil-derived biodiesel are represented in NM-GREET1.0 by the composite animal fat or waste oil feedstock category to represent this composite category of temporary pathways. The Feedstock lifecycle stage is devoid of activity and emissions, since GREET treats waste animal fat as being obtained burden-free at the point of disposal. The Fuel processing stage includes rendering fat to tallow, tallow transport to a fuel production facility, transesterification of tallow to BD, and transportation plus distribution to refueling stations. The On-Road stage models B100 combustion within a light-duty passenger CIDI vehicle.

Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of carbon embedded in the final fuel product.

The pathway’s total WTW CI and those of its stages are provided below in *Table 15*. Formulas defining this pathway’s stagewise emissions on Results_NM primarily refer to and derive from R&D GREET 2023 Rev1’s BioOil sheet Section 4.1, Vehicles sheet Section 3, and Results tab Section 2.

Table 15. Summary of Waste Animal Fat or Cooking Oil Biodiesel (B100)’s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-71.4
Feedstock	0.0
Fuel	15.2
On-Road	76.1
Total	19.9
Adjusted Total	25.0

* Values may not sum exactly to the pre-adjusted total due to rounding

3. Renewable Diesel (R100) and Naphtha

The production of renewable diesel (RD) at biorefineries typically also yields renewable naphtha (RN) as a co-product represented in NM-GREET1.0 for the corresponding R100 and RN pathways. In allocating the cumulative GHG emissions from feedstock origin to exiting the biorefinery across these co-products, R&D GREET 2023 Rev1 relies on the fuels’ LHV energy contents, such that each Joule of each fuel is attributed the same proportion of the total emissions. This energy-based allocation plus the near-total negation of combustion emissions by initial biogenic CO₂ uptake mean that the R100 Virgin Plant Oil and Naphtha Virgin Plant Oil pathways represented in NM-GREET1.0 have equivalent Total and Adjusted Total CI values—an assumption NMED uses to extend the following RD temporary pathway CIs as applying to their RN co-product as well.

Virgin Non-Palm Plant Oil

The Virgin Non-Palm Plant Oil Renewable Diesel (R100) pathway estimates the typical WTW CI value of neat renewable diesel (R100) derived from non-palm virgin plant oil, based on the North American average pathway represented by NMRD001 in NM-GREET1.0, as delivered before any potential blending with other fuels. The Feedstock lifecycle stage is composed of soy farming and transport to a fuel production facility. The Fuel processing stage includes soy oil extraction, RD and naphtha production, and transportation plus distribution to refueling stations. The On-Road stage models R100 combustion within a light-duty passenger CIDI vehicle. Finally, ILUC and Biogenic CO₂ Uptake stages are incorporated to account for the effects of feedstock crop growth.

Certain parameters listed in *Table 16* are altered from the corresponding R&D GREET 2023 Rev1 values to ensure that this model pathway is representative of the Virgin Non-Palm Plant Oil Renewable Diesel (R100) and Naphtha pathways represented by NMRD001 and NMRN001 in NM-GREET1.0. Since CARB ILUC factors are applied, R&D GREET 2023 Rev1’s internal estimation of ILUC is disabled via the “Soybean_LUC_Selector” parameter. Also, as described in Section 3.2.1, market-based allocation is used where documented in NM-GREET1.0. For this reason, NMED altered the enumerated “BD_SoybeanOilExtraction_Allocation” selector from “4 - Mass-Based Allocation” to “3 - Market-Based Allocation.”

Table 16. Parameters relevant to the Virgin Non-Palm Plant Oil Renewable Diesel (R100) and Naphtha pathways

Parameter	Value		GREET Label	Description
	Default	NM		
Soybean_LUC_Selector	2	0	Inclusion of GHG Emissions from Induced Land Use Change	Exclude GREET estimate; replace with CARB estimate on <i>Results_NM</i>
BD_Soybean OilExtraction_Allocation	4	3	Process level allocation for all biooil-based fuels: Oil Extraction Process for Soybean	Preference market allocation

The pathway's total WTW CI and those of its stages are provided below in Table 17. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's BioOil sheet Section 4.1, Vehicles sheet Section 3, and Results tab Section 2.

Table 17. Summary of Virgin Non-Palm Plant Oil Renewable Diesel (R100) and Naphtha's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-72.6
Feedstock	13.3
Fuel	15.9
On-Road	73.3
ILUC	29.1
Total	59.0
Adjusted Total	65.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Waste Animal Fat or Cooking Oil

The Waste Animal Fat or Cooking Oil Renewable Diesel (R100) and Naphtha pathways estimate the typical WTW CI values of neat renewable diesel (R100) and renewable naphtha derived from animal fat or waste oil feedstock, based on the North American average pathways represented by NMRD002 and NMRN002 in NM-GREET1.0, as delivered before any potential blending with other fossil-diesel fuels. The estimated WTW CI values for animal-fat-derived and used-cooking-oil-derived RD are represented in NM-GREET1.0 by the composite animal fat or waste oil feedstock category to represent this composite category of temporary pathways. The Feedstock lifecycle stage is devoid of activity and emissions, since R&D GREET 2023 Rev1 treats waste animal fat as being obtained burden-free at the point of disposal. The Fuel processing stage includes rendering fat to tallow, tallow transport to a fuel production facility, RD and naphtha production, and transportation plus distribution to refueling stations. The On-Road stage models R100 combustion within a light-duty passenger CIDI vehicle.

Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of carbon embedded in the final fuel product.

The pathway's total WTW CI and those of its stages are provided below in Table 18. Formulas defining this pathway's stagewise emissions on Results_NM primarily refer to and derive from R&D GREET 2023 Rev1's BioOil sheet Section 4.1, Vehicles sheet Section 3, and Results tab Section 2.

Table 18. Summary of Waste Animal Fat or Cooking Oil Renewable Diesel (R100) and Naphtha's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-72.6
Feedstock	0.0
Fuel	17.6
On-Road	73.3
Total	18.3
Adjusted Total	20.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Propane Pathways

1. *Fossil Liquefied Petroleum Gas*

The Fossil Liquefied Petroleum Gas (LPG) pathway estimates the typical WTW CI value of liquefied petroleum gas based on North American average shares of LPG from natural gas production and crude refining, as represented by NMLPG001 in NM-GREET1.0. By default, R&D GREET 2023 Rev1 defines LPG as being produced with national-average production shares of 86.6% from NG and 13.4% from crude oil. For the fraction of LPG derived from NG, the Feedstock stage is composed of NG recovery (i.e., extraction of conventional and shale gas), processing, and pipeline transmission to an LPG plant. The Fuel processing stage includes LPG production, followed by transportation and distribution to refueling stations. For the fraction of LPG derived from crude oil, the Feedstock stage is composed of a PADD 3 -weighted average of crude oil extraction activities (as detailed in the OPGEE Crude Slate Modeling section), followed by transport to a refinery. The Fuel processing stage includes the refining of crude oil into LPG, followed by transportation and distribution to refueling stations. Finally, the On-Road stage models fuel combustion within a light-duty passenger ICEV.

The pathway's total WTW CI and those of its stages are provided below in Table 19. Formulas defining this pathway's stagewise emissions on Results_NM primarily refer to and derive from R&D GREET 2023 Rev1's Petroleum sheet Section 5.1, Vehicles sheet Section 3, and Results tab Section 2.

Table 19. Summary of Fossil LPG's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	8.8
Fuel	4.8
On-Road	64.8
Total	78.4

* Values may not sum exactly to the pre-adjusted total due to rounding

Natural Gas Pathways

1. *Fossil Natural Gas*

The Fossil NG pathways in NM-GREET—including both compressed (CNG) and liquefied (LNG) natural gases—are composed of national-average mixes of shale and conventional NG produced domestically. Leaks of NG to the atmosphere are characterized by each activity within the Fuel and Feedstock stages. Since GREET does not contain parameters to differentiate fugitive emissions during NG recovery by basin, regions therein, or consumption mix in a given state, NMED instead relied on R&D GREET 2023 Rev1's national-average methane leakage and venting-rate estimates of 0.94 percent (i.e., Inputs!G136 and Inputs!H136) for both shale and conventional NG. Furthermore, the U.S. NG pipeline network is heavily interconnected, such that to compose a New-Mexico-specific supply-chain-weighted fugitive emissions rate for NG NMED would first need high-resolution data and modeling of NG supply chain activities, fugitive emissions, and inter-state distribution rates.

Fossil CNG

The Fossil CNG pathway estimates the typical WTW CI value of North American NG delivered by pipeline and compressed in New Mexico, as represented by NMCNG001 in NM-GREET1.0. The Feedstock lifecycle stage is composed of NG recovery (i.e., extraction of conventional and shale gas), processing, and pipeline transmission to refueling stations. The Fuel processing stage includes NG compression in New Mexico. Finally, the On-Road stage models fuel combustion within a light-duty passenger ICEV.

The pathway's total WTW CI and those of its stages are provided below in Table 20. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's NG sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 20. Summary of Fossil CNG's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	13.7
Fuel	3.0
On-Road	57.6
Total	74.3

* Values may not sum exactly to the pre-adjusted total due to rounding

Fossil LNG

The Fossil LNG pathway estimates the typical WTW CI value of fossil NG delivered by pipeline and liquefied in New Mexico, as represented by NMLNG001 in NM-GREET1.0. The Feedstock lifecycle

stage is composed of NG recovery (i.e., extraction of conventional and shale gas), processing, and pipeline transmission to a liquefaction plant. The Fuel processing stage includes liquefaction, truck transportation and distribution to refueling stations, and storage. Finally, the On-Road stage models fuel combustion within a light-duty passenger ICEV.

The parameter listed in Table 21 is altered from the corresponding R&D GREET 2023 Rev1 value to ensure that this model pathway is representative of the Fossil LNG pathway represented by NMLNG001 in NM-GREET1.0. An in-state liquefaction efficiency of 80 percent is chosen to match the NM-GREET1.0 parameterization for the Fossil LNG pathway.

Table 21. Parameters relevant to the Fossil LNG pathway

Parameter	Value		GREET Label	Description
	Default	NM		
NG_LNG_Liq_Eff_NANG_TS	=AL57	80%	NA NG Liquefaction Efficiency	Specified in draft rule pathway description

The pathway’s total WTW CI and those of its stages are provided below in Table 22. Formulas defining this pathway’s stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1’s *NG* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 22. Summary of Fossil LNG’s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	8.6
Fuel	20.9
On-Road	57.6
Total	87.1

** Values may not sum exactly to the pre-adjusted total due to rounding*

2. *Animal Waste Biomethane*

The Animal Waste (AW) Biomethane (a.k.a. renewable natural gas, or RNG) temporary fuel pathways listed in Table 5 in Subsection E of 20.2.92.701 NMAC—including both compressed (AW CNG) and liquefied (AW LNG) gases—in NM-GREET are composed of national-average mixes of livestock manure and anaerobic digester technologies used to convert manure into biomethane. Details on how these feedstock and AD national averages are defined can be found in the Manure Biomethane Counterfactual Emissions section.

AW CNG

The AW CNG pathway estimates the typical WTW CI value of compressed natural gas derived from biomethane from anaerobic digestion of North American livestock manure, delivered by pipeline and compressed in New Mexico, as represented by NMRCNG001 and NMRCNG002 in NM-GREET1.0. The Feedstock lifecycle stage is devoid of activity and emissions, since R&D GREET 2023 Rev1 treats AW as being obtained burden-free at the point of generation. The Fuel processing stage includes manure hauling via truck to a local AD installation, AD and biogas upgrader operation, pipeline transmission to refueling stations, and compression to CNG. The On-Road stage models fuel combustion within a light-duty passenger ICEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of carbon embedded in the final fuel product.

The pathway's total WTW CI and those of its stages are provided below in Table 23. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's RNG sheet Section 3, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 23. Summary of AW CNG's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	0.0
Fuel	61.4
On-Road	57.6
Total	62.7
Adjusted Total	70.0
Total with avoided methane emissions adjustment	-27.4
Adjusted Total with avoided methane emissions adjustment	-25.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Avoided Methane Emissions Adjustment

As outlined, avoided methane emissions may be included in certified CI values only when the regulated party demonstrates the applicable requirements under 20.2.92.202(E) NMAC and receives department approval. NM-GREET1.0 models the applicable AW CNG avoided methane emissions adjustment as - 90.0 g CO₂e/MJ.

AW LNG

The AW LNG pathway estimates the typical WTW CI value of liquefied natural gas derived from biomethane from anaerobic digestion of North American livestock manure, delivered by pipeline and liquefied in New Mexico using liquefaction with 80% efficiency, as represented by NMRLNG001 and NMRLNG002 in NM-GREET1.0. The Feedstock lifecycle stage is devoid of activity and emissions, since R&D GREET 2023 Rev1 treats AW as being obtained burden-free at the point of generation. The Fuel processing stage includes manure hauling via truck to a local AD installation, AD and biogas upgrader operation, pipeline transmission to a liquefaction plant, liquefaction, transportation and distribution to refueling stations, and storage. The On-Road stage models fuel combustion within a light-duty passenger ICEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of carbon embedded in the final fuel product.

The parameter listed in Table 24 is altered from the corresponding R&D GREET 2023 Rev1 value to ensure that this model pathway is representative of fuel commercially available in New Mexico. An in-state liquefaction efficiency of 80 percent is chosen to match the NM-GREET1.0 parameterization for the AW LNG pathways.

Table 24. Parameters relevant to the AW LNG pathway

Parameter	Value		GREET Label	Description
	Default	NM		
LFG_LNG_Liq_Eff	89%	80%	NG Small Scale Liquefaction Efficiency (powered by RNG)	Specified in draft rule pathway description

The pathway's total WTW CI and those of its stages are provided below in Table 25. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *RNG* sheet Section 3, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 25. Summary of AW LNG's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	0.0
Fuel	70.9
On-Road	57.6
Total	72.1
Adjusted Total	80.0
Total with avoided methane emissions adjustment	-18.5
Adjusted Total with avoided methane emissions adjustment	-15.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Avoided Methane Emissions Adjustment

As outlined, avoided methane emissions may be included in a certified CI only when the regulated party demonstrates the applicable requirements under 20.2.92.202(E) NMAC and receives department approval. NM-GREET1.0 models the applicable AW LNG avoided methane emissions adjustment as - 90.0 g CO₂e/MJ.

3. Landfill Biomethane

The Landfill (LF) Biomethane temporary fuel pathways listed in Table 5 in Subsection E of 20.2.92.701 NMAC—including both compressed (LF CNG) and liquefied (LF LNG) gases—in NM-GREET are composed of biomethane derived from landfill gas (LFG) as is generated by landfills containing a U.S.-average composition of non-recycled municipal solid waste.

LF CNG

The LF CNG pathway estimates the typical WTW CI value of compressed natural gas derived from biomethane from landfill gas or wastewater treatment, delivered by pipeline and compressed in New Mexico, as represented by NMRCNG003 in NM-GREET1.0. The Feedstock lifecycle stage is devoid of activity and emissions, since R&D GREET 2023 Rev1 treats LFG as being obtained burden-free at the point of generation. The Fuel processing stage includes LFG upgrading, pipeline transmission to refueling stations, and compression to CNG. The On-Road stage models fuel combustion within a light-duty passenger ICEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of carbon embedded in the final fuel product.

The pathway's total WTW CI and those of its stages are provided below in Table 26. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *RNG* sheet Section 3, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 26. Summary of LF CNG's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	0.0
Fuel	21.1
On-Road	57.6
Total	21.4
Adjusted Total	25.0

* Values may not sum exactly to the pre-adjusted total due to rounding

LF LNG

The LF LNG pathway estimates the typical WTW CI value of liquefied natural gas derived from biomethane from landfill gas or wastewater treatment, delivered by pipeline and liquefied in New Mexico using liquefaction with 80% efficiency, as represented by NMRLNG003 in NM-GREET1.0. The Feedstock lifecycle stage is devoid of activity and emissions, since R&D GREET 2023 Rev1 treats LFG as being obtained burden-free at the point of generation. The Fuel processing stage includes LFG upgrading, pipeline transmission to a liquefaction plant, liquefaction, transportation and distribution to refueling stations, and storage. The On-Road stage models fuel combustion within a light-duty passenger ICEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of carbon embedded in the final fuel product.

The parameter listed in Table 27 is altered from the corresponding R&D GREET 2023 Rev1 value to ensure that this model pathway is representative of fuel commercially available in New Mexico. An in-state liquefaction efficiency of 80 percent is chosen to match the NM-GREET1.0 parameterization for the LF LNG pathway.

Table 27. Parameters relevant to the LF LNG pathway

Parameter	Value		GREET Label	Description
	Default	NM		
LFG_LNG_Liq_Eff	89%	80%	NG Small Scale Liquefaction Efficiency (powered by RNG)	Specified in draft rule pathway description

The pathway's total WTW CI and those of its stages are provided below in Table 28. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's RNG sheet Section 3, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 28. Summary of LF LNG's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	0.0
Fuel	29.8
On-Road	57.6
Total	31.0
Adjusted Total	35.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Hydrogen Pathways

The hydrogen pathways summarized in this section include compressed hydrogen (C.H₂) and liquid hydrogen (L.H₂) produced via steam methane reforming (SMR) of fossil natural gas, SMR of animal-waste or landfill-gas biomethane, and proton exchange membrane (PEM) electrolysis using either American average grid electricity or solar-, wind-, hydro- or geothermal-generated electricity. The applicable hydrogen pathways are represented in NM-GREET1.0 and listed in the applicable CTFP rule table. For AW-biomethane-SMR pathways, NM-GREET1.0 also models an avoided methane emissions adjustment; under 20.2.92.202(E) NMAC, avoided methane emissions may be included in certified CI values only when the regulated party demonstrates the applicable requirements and receives department approval.

Certain parameters, listed in Table 29, are altered from the corresponding R&D GREET 2023 Rev1 values to ensure that the modeled fuels are broadly representative of the hydrogen pathway categories represented in NM-GREET1.0. As described in the Parameters section, market-based allocation is used where documented in NM-GREET1.0. For this reason, NMED altered the two enumerated allocation-selector parameters from their default values of “1 -- Displacement method” to “3 -- Market value-based allocation”. Furthermore, NMED updated the price of process-heat steam generated via fossil NG from its default value of \$0 per Btu (as embedded in “MeOH_FTD!L59”) to \$1.02E-05 per Btu, derived from rounded 2024 U.S. average commercial natural gas price of approximately \$10 per thousand scf, based on U.S. EIA data.²¹

Table 29. Parameters relevant to all Hydrogen pathways

Parameter	Value		GREET Label	Description
	Default	NM		
Inputs! F267	1	3	Central Plant G.H2; NG/RNG; 6.8) Selection of Method for Estimating Credits of Co-Products for NG Based Fuel Pathways (Co-products are defined in Section 6.7)	Preference market allocation, as detailed in the <u>Parameters</u> section
Inputs! F269	1	3	Central Plant L.H2; NG/RNG; 6.8) Selection of Method for Estimating Credits of Co-Products for NG Based Fuel Pathways (Co-products are defined in Section 6.7)	
Hydrogen! K37	0	1.02E-05	\$/Btu, Steam, Market value-based allocation	Use rounded 2024 U.S. average commercial NG price ²² and R&D GREET 2023 Rev1 NG LHV to calculate the NM steam price as $10/(\text{NG_LHV} \times 10^3)$; default value is from MeOH_FTD!L59

²¹ U.S. Energy Information Administration, “Natural Gas Prices,” accessed June 19, 2025, https://www.eia.gov/dnav/ng/NG_PRI_SUM_A_EPG0_PCS_DMCF_M.htm.

²² U.S. Energy Information Administration, “Natural Gas Prices,” accessed June 19, 2025, https://www.eia.gov/dnav/ng/NG_PRI_SUM_A_EPG0_PCS_DMCF_M.htm.

1. H₂ via SMR of Fossil Methane

Fossil C.H₂

The Fossil C.H₂ pathway estimates the typical WTW CI value of compressed hydrogen produced in North America via central SMR of North American NG. The Feedstock lifecycle stage is composed of the set of activities defined in the Fossil Natural Gas pathway description, followed by NG pipeline transmission to a central SMR plant. The Fuel processing stage includes H₂ production via SMR, transportation and distribution of gaseous H₂ to refueling stations, compression and precooling, and storage and dispensing with associated losses. Finally, the On-Road stage models hydrogen use in a light-duty passenger fuel cell electric vehicle (FCEV).

The pathway's total WTW CI and those of its stages are provided below in Table 30. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 30. Summary of Fossil C.H₂'s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	10.2
Fuel	84.2
On-Road	0.0
Total	94.4
Adjusted Total	100.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Fossil L.H₂

The Fossil L.H₂ pathway estimates the typical WTW CI value of liquefied hydrogen produced in North America via central SMR of North American NG. The Feedstock lifecycle stage is composed of the set of activities defined in the Fossil Natural Gas pathway description, followed by NG pipeline transmission to a central SMR plant. The Fuel processing stage includes H₂ production via SMR, liquefaction and bulk storage, transportation and distribution to refueling stations, and storage and dispensing with associated losses. Finally, the On-Road stage models hydrogen use in a light-duty passenger FCEV.

The pathway's total WTW CI and those of its stages are provided below in Table 31. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 31. Summary of Fossil L.H₂'s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	13.3
Fuel	122.4
On-Road	0.0
Total	135.7
Adjusted Total	145.0

* Values may not sum exactly to the pre-adjusted total due to rounding

2. H₂ via SMR of AW Biomethane

AW C.H₂

The AW C.H₂ pathway estimates the WTW CI value of compressed hydrogen produced via central SMR of biomethane from North American animal agriculture, with SMR process heat derived from North American natural gas. The Feedstock lifecycle stage is composed of the set of activities defined in the Animal Waste Biomethane pathway description, except that biomethane is transmitted via pipeline to a central SMR plant rather than a refueling station and is not initially compressed. The Fuel processing stage includes H₂ production via SMR with process heat derived from fossil NG (i.e., not biomethane), transportation and distribution of gaseous H₂ to refueling stations, compression and precooling, and storage and dispensing with associated losses. The On-Road stage models hydrogen use in a light-duty passenger FCEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of the biogenic carbon in the biomethane feedstock that is released as CO₂ during hydrogen production.

The pathway's total WTW CI and those of its stages are provided below in Table 32. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 32. Summary of AW C.H₂'s stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	30.7
Fuel	27.9
On-Road	0.0
Total	88.3
Adjusted Total	95.0
Total with avoided methane emissions adjustment	-1.8
Adjusted Total with avoided methane emissions adjustment	0.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Avoided Methane Emissions Adjustment

As described in the Manure Biomethane Counterfactual Emissions section, this pathway includes an avoided methane emissions adjustment of -90.0 g CO₂e/MJ for the animal-waste biomethane feedstock. Under 20.2.92.202(E) NMAC, avoided methane emissions may be included in certified CIs only when the regulated party demonstrates the applicable requirements and receives department approval.

AW L.H₂

The AW L.H₂ pathway estimates the WTW CI value of liquid hydrogen produced via central SMR of biomethane from North American animal agriculture, with SMR process heat derived from North American NG. The Feedstock lifecycle stage is composed of the set of activities defined in the Animal Waste Biomethane pathway description, except that biomethane is transmitted via pipeline to a central SMR plant rather than a refueling station and is not initially compressed. The Fuel processing stage includes H₂ production via SMR with process heat derived from fossil NG (i.e., not biomethane),

liquefaction and bulk storage, transportation and distribution to refueling stations, and storage and dispensing with associated losses. The On-Road stage models hydrogen use in a light-duty passenger FCEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of the biogenic carbon in the biomethane feedstock that is released as CO₂ during hydrogen production.

The pathway's total WTW CI and those of its stages are provided below in Table 33. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 33. Summary of AW L.H2's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	60.9
Fuel	122.4
On-Road	0.0
Total	127.0
Adjusted Total	135.0
Total with avoided methane emissions adjustment	37.0
Adjusted Total with avoided methane emissions adjustment	40.0

* Values may not sum exactly to the pre-adjusted total due to rounding

Avoided Methane Emissions Adjustment

As described in the Manure Biomethane Counterfactual Emissions section, this pathway includes an avoided methane emissions adjustment of -90.0 g CO₂e/MJ for the animal-waste biomethane feedstock. Under 20.2.92.202(E) NMAC, avoided methane emissions may be included in certified CIs only when the regulated party demonstrates the applicable requirements and receives department approval. This adjustment results in a pathway Total carbon intensity value of 37.0 g CO₂e/MJ.

3. H₂ via SMR of LF Biomethane

LF C.H₂

The LF C.H₂ pathway estimates the WTW CI value of compressed hydrogen produced via central SMR of biomethane from North American landfills or wastewater treatment, with SMR process heat derived from North American natural gas. The Feedstock lifecycle stage is composed of the set of activities defined in the Landfill Biomethane pathway description, except that biomethane is transmitted via pipeline to a central SMR plant rather than a refueling station and is not initially compressed. The Fuel processing stage includes H₂ production via SMR with process heat derived from fossil NG (i.e., not biomethane), transportation and distribution of gaseous H₂ to refueling stations, compression and precooling, and storage and dispensing with associated losses. The On-Road stage models hydrogen use in a light-duty passenger FCEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of the biogenic carbon in the biomethane feedstock that is released as CO₂ during hydrogen production.

The pathway's total WTW CI and those of its stages are provided below in Table 34. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 34. Summary of LF C.H2's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	18.2
Fuel	84.2
On-Road	0.0
Total	46.1
Adjusted Total	50.0

* Values may not sum exactly to the pre-adjusted total due to rounding

LF L.H2

The LF L.H₂ pathway estimates the WTW CI value of liquid hydrogen produced via central SMR of biomethane from North American landfills or wastewater treatment, with SMR process heat derived from North American natural gas. The Feedstock lifecycle stage is composed of the set of activities defined in the Landfill Biomethane pathway description, except that biomethane is transmitted via pipeline to a central SMR plant rather than a refueling station and is not initially compressed. The Fuel processing stage includes H₂ production via SMR with process heat derived from fossil NG (i.e., not biomethane), liquefaction and bulk storage, transportation and distribution to refueling stations, and storage and dispensing with associated losses. The On-Road stage models hydrogen use in a light-duty passenger FCEV. Finally, a Biogenic CO₂ Uptake stage is incorporated to account for the biosphere origin of the biogenic carbon in the biomethane feedstock that is released as CO₂ during hydrogen production.

The pathway's total WTW CI and those of its stages are provided below in Table 35. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 35. Summary of LF L.H2's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Biogenic CO ₂ Uptake	-56.3
Feedstock	23.7
Fuel	122.4
On-Road	0.0
Total	89.8
Adjusted Total	95.0

* Values may not sum exactly to the pre-adjusted total due to rounding

4. H₂ via PEM Electrolysis

C.H2 from American-Average Grid Electricity

The C.H₂ from American-Average Grid Electricity pathway estimates the WTW CI value of compressed hydrogen produced in North America via PEM electrolysis using American average grid electricity. The Feedstock lifecycle stage is composed of electricity generation using American average grid electricity, followed by transmission to an electrolyzer. The Fuel processing stage includes H₂ production via PEM electrolysis, transportation and distribution of gaseous H₂ to refueling stations, and storage and

dispensing with associated losses. Finally, the On-Road stage models hydrogen use in a light-duty passenger FCEV.

The pathway's total WTW CI and those of its stages are provided below in Table 36. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 36. Summary of C.H2 from American-Average Grid Electricity's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	203.5
Fuel	14.3
On-Road	0.0
Total	217.8
Adjusted Total	230.0

* Values may not sum exactly to the pre-adjusted total due to rounding

L.H2 from American-Average Grid Electricity

The L.H₂ from American-Average Grid Electricity pathway estimates the WTW CI value of liquid hydrogen produced in North America via PEM electrolysis using American average grid electricity. The Feedstock lifecycle stage is composed of electricity generation using American average grid electricity, followed by transmission to an electrolyzer. The Fuel processing stage includes H₂ production via PEM electrolysis, liquefaction and bulk storage, transportation and distribution to refueling stations, and storage and dispensing with associated losses. Finally, the On-Road stage models hydrogen use in a light-duty passenger FCEV.

The pathway's total WTW CI and those of its stages are provided below in Table 37. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 37. Summary of L.H2 from American-Average Grid Electricity's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	219.8
Fuel	46.9
On-Road	0.0
Total	266.7
Adjusted Total	285.0

* Values may not sum exactly to the pre-adjusted total due to rounding

C.H2 from Net-Zero Electricity

The C.H₂ from Net-Zero Electricity pathway estimates the WTW CI value of compressed hydrogen produced in North America via PEM electrolysis using solar-, wind-, hydro- or geothermal-generated electricity. The Feedstock lifecycle stage is composed of solar-, wind-, hydro or geothermal-generated electricity, followed by transmission to an electrolyzer. The Fuel processing stage includes H₂ production via PEM electrolysis, transportation and distribution of gaseous H₂ to refueling stations, and storage and dispensing with associated losses. Finally, the On-Road stage models hydrogen use in a light-duty passenger FCEV.

The pathway's total WTW CI and those of its stages are provided below in Table 38. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 38. Summary of C.H2 from Net-Zero Electricity's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	0.0
Fuel	14.3
On-Road	0.0
Total	14.3
Adjusted Total	20.0

* Values may not sum exactly to the pre-adjusted total due to rounding

L.H2 from Net-Zero Electricity

The L.H₂ from Net-Zero Electricity pathway estimates the WTW CI value of liquid hydrogen produced in North America via PEM electrolysis using solar-, wind-, hydro, or geothermal-generated electricity. The Feedstock lifecycle stage is composed of solar-, wind-, hydro, or geothermal-generated electricity, followed by transmission to an electrolyzer. The Fuel processing stage includes H₂ production via PEM electrolysis, liquefaction and bulk storage, transportation and distribution to refueling stations, and storage and dispensing with associated losses. Finally, the On-Road stage models hydrogen use in a light-duty passenger FCEV.

The pathway's total WTW CI and those of its stages are provided below in Table 39. Formulas defining this pathway's stagewise emissions on *Results_NM* primarily refer to and derive from R&D GREET 2023 Rev1's *Hydrogen* sheet Section 4.1, *Vehicles* sheet Section 3, and *Results* tab Section 2.

Table 39. Summary of L.H2 from Net-Zero Electricity's stagewise CI values

Stage	Total CI* (g CO ₂ e/MJ)
Feedstock	0.0
Fuel	46.9
On-Road	0.0
Total	46.9
Adjusted Total	50.0

* Values may not sum exactly to the pre-adjusted total due to rounding.

Appendix A: Crude Oil Production Modeling

1. Summary

Crude oil CI values were calculated with a well-to-refinery scope using OPGEE v2.0c, the work of Masnadi et al. (2018)²³, and crude oil production and foreign import data from the U.S. Energy Information Administration²⁴. Table A-1 details the weighted CI values for PADD 3 for 2018 and 2022, which are 11.83 and 11.46 g CO₂e/MJ refinery input, respectively. These CI values are for a well-to-refinery-gate boundary and are used in place of the corresponding R&D GREET 2023 Rev1 well-to-refinery-gate crude oil emissions value used in the Petroleum tab across the baseline (2018) and v1.0 default/temporary (2022) versions of NM-GREET.

Table A-1. CI values of PADD 3 crude oil supply for 2018 and 2022

Summary Result	2018 Value	2022 Value	Units
Total foreign imports	7.31E+12	4.26E+12	MJ
Total PADD 3 production	1.46E+13	1.78E+13	MJ
Import CI (weighted)	12.88	12.15	g CO ₂ e/MJ refinery input
Domestic production CI assumption (U.S. average)	11.30	11.30	g CO ₂ e/MJ refinery input
Weighted CI	11.83	11.46	g CO ₂ e/MJ refinery input

5. Methods

Country-specific crude oil CI and crude oil properties (American Petroleum Institute [API] gravity, energy density) were sourced from Masnadi et al. (2018); they represent ~98% of crude oil production for the study's 2015 scope.²³ These values are detailed in Table A-2. Crude oil production and foreign import data for PADD 3 were sourced from the U.S. EIA for 2018 and 2022; please note that only crude oil imports were considered for CI weighting (i.e. oil products such as gasoline blending components were not included).²⁴ Inter-PADD crude oil movements into PADD 3 were not included in the calculation. In 2018, total PADD 3 crude imports were 1,017,321 thousand barrels, and crude production was 2,582,134 thousand barrels. For 2022, PADD 3 total imports were 597,650 thousand barrels, and production was 3,145,563 thousand barrels.

Import volumes (in bbl) were converted to MJ of LHV by way of their average API gravity. Carbon intensities (in g CO₂e / MJ refinery input) were then weighted based on the import amount, in MJ, from each country. Across PADD 3 crude production, it was assumed that both carbon intensity and crude properties were the same as the U.S. average in Masnadi et al. (2018). Where needed, crude oil API gravity was converted to specific gravity with the following formula:

$$\text{Specific Gravity} = \frac{141.5}{\text{API Gravity} + 131.5}$$

²³ Mohammad S. Masnadi et al., "Global Carbon Intensity of Crude Oil Production," *Science* 361, no. 6405 (August 31, 2018): 851–53, <https://doi.org/10.1126/science.aar6859>.

²⁴ U.S. Energy Information Administration, "Crude Oil Production, Annual," 2025, https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbbl_a.htm.

LHV energy density, in MJ/kg crude oil, was calculated using OPGEE's "Crude Oil Chemical Composition" table, which is copied in Table A-3. Energy densities for non-integer API gravities were linearly interpolated from the nearest values available. For all calculations, the volumetric conversion factor of $1 \text{ m}^3 = 6.28981 \text{ bbl}$ was used.

Table A-2. Crude oil CI, 2018 and 2022 import volumes and API gravity by country

Country	CI (g CO ₂ e/MJ) (Masnadi, 2018)	2018 Imports (thousand bbl) (U.S. EIA, 2025)	2022 Imports (thousand bbls) (U.S. EIA, 2025)	Average Crude API Gravity (Masnadi, 2018)
Angola	7.8	6,967	949	30.33
Argentina	9.4	2,867	-	27.00
Australia	9.4	529	-	47.25
Azerbaijan	6.8	3,833	-	35.00
Barbados	9.5	50	-	33.00
Belize	9.0	198	-	33.00
Bolivia	9.2	318	-	33.00
Brazil	10.5	19,887	3,982	22.94
Canada	17.7	180,246	214,870	19.65
Chad	10.2	3,554	-	33.00
Colombia	8.8	53,880	58,435	26.58
Ecuador	9.5	12,015	-	41.56
Egypt	10.6	2,761	-	33.00
Equatorial Guinea	6.8	1,943	-	33.00
Gabon	13.1	398	-	33.00
Ghana	6.0	3	-	33.00
Guatemala	9.8	2,501	868	33.00
Iran	17.4	-	507	30.70
Iraq	14.0	144,524	19,994	29.90
Italy	6.7	438	-	33.00
Kuwait	7.1	13,377	6,716	24.20
Libya	11.2	598	-	35.05
Mexico	9.9	216,855	194,883	19.69
Niger	11.5	10,465	-	33.00
Nigeria	12.4	10,465	-	34.74
Peru	11.1	-	259	33.00
Russian Federation	9.7	718	-	33.51
Saudi Arabia	5.1	141,071	75,451	31.97
Trinidad and Tobago	14.4	2,155	9,076	33.00
United Kingdom	8.3	12,508	8,623	34.00
Venezuela	19.9	181,614	-	13.92

Table A-3. Crude Oil API gravity and energy density values from OPGEE v2.0c²⁵

API Gravity	Specific Gravity	Lower Heating Value (MJ/kg)	API Gravity	Specific Gravity	Lower Heating Value (MJ/kg)
4	1.04	39.33	25	0.90	41.47
5	1.04	39.52	26	0.90	41.54
6	1.03	39.66	27	0.89	41.61
7	1.02	39.80	28	0.89	41.68
8	1.01	39.94	29	0.88	41.75
9	1.01	40.08	30	0.88	41.82
10	1.00	40.17	31	0.87	41.87
11	0.99	40.26	32	0.87	41.94
12	0.99	40.35	33	0.86	41.98
13	0.98	40.47	34	0.85	42.05
14	0.97	40.56	35	0.85	42.12
15	0.97	40.66	36	0.84	42.17
16	0.96	40.75	37	0.84	42.21
17	0.95	40.82	38	0.83	42.28
18	0.95	40.91	39	0.83	42.33
19	0.94	41.01	40	0.83	42.40
20	0.93	41.08	41	0.82	42.45
21	0.93	41.14	42	0.82	42.52
22	0.92	41.24	43	0.81	42.56
23	0.92	41.31	44	0.81	42.61
24	0.91	41.40	45	0.80	42.66

Values from OPGEE v2.0c 'Fuel Spec' table

²⁵ Hassan M. El-Houjeiri et al., "Oil Production Greenhouse Gas Emissions Estimator OPGEE v2.0 User Guide & Technical Documentation," 2017, https://pangea.stanford.edu/departments/ere/dropbox/EAO/OPGEE/OPGEE_documentation_v2.0.pdf.

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