LOW CARBON FUEL STANDARD
ANNUAL UPDATES TO LOOKUP TABLE PATHWAYS

2024 Carbon Intensity Values for
California Average Grid Electricity Used as a
Transportation Fuel in California
and
Electricity Supplied Under the Smart Charging or
Smart Electrolysis Provision

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I. Summary

This document proposes the annual update to carbon intensity (CI) values for Lookup Table electricity pathways under the Low Carbon Fuel Standard (LCFS).

Section 95488.5(d) of the LCFS regulation[1] directs the Executive Officer to update the CI annually for these two Lookup Table pathways using the methodology described in Section E of the Lookup Table Pathways Technical Support Documentation.[2] Upon certification, the updated pathway CI values will be available for reporting fuel transactions that occur between January 1 and December 31, 2024.

The carbon intensity values for smart charging or smart electrolysis are determined using the California Average Grid Electricity CI and the normalized marginal emission rates for that period. The carbon intensity values calculated for smart charging or smart electrolysis pathways in 2024 are shown in Tables 1 and 2 below.

Table 1. Proposed CI Values for 2024 Update to Electricity Lookup Table Pathways

Fuel Pathway Code	Fuel Pathway Description	CI (gCO_2e/MJ)
ELC000L00072024	California average grid electricity (subject to annual updates)	80.55
ELCT	Electricity supplied under the smart charging or smart electrolysis provision (subject to annual updates)	See Table 2

[1] All citations to the LCFS Regulation are found in Title 17, California Code of Regulations (CCR), sections 95480-95503

[2] CA-GREET3.0 Lookup Table Pathways Technical Support Documentation. August 13, 2018. California Air Resources Board. Accessed 12/2023. https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/ca-greet/lut-doc.pdf?_ga=2.72734547.1572616437.1642472386-237633646.1594072165

Table 2. Proposed CI Values (gCO_2e/MJ) for Smart Charging or Electrolysis in 2024

	Q1	**Q2**	**Q3**	**Q4**
12:01 AM – 1:00 AM	85.72	86.59	89.68	95.47
1:01 AM – 2:00 AM	85.68	84.70	86.53	91.41
2:01 AM – 3:00 AM	85.68	84.65	85.89	89.16
3:01 AM – 4:00 AM	85.68	84.63	85.65	88.71
4:01 AM – 5:00 AM	85.68	85.87	85.52	90.64
5:01 AM – 6:00 AM	91.36	94.66	87.65	102.34
6:01 AM – 7:00 AM	114.29	93.24	99.38	125.34
7:01 AM – 8:00 AM	112.49	29.65	95.42	123.85
8:01 AM – 9:00 AM	66.73	2.39	60.16	101.88
9:01 AM – 10:00 AM	30.52	1.73	7.39	40.79
10:01 AM – 11:00 AM	0.43	3.12	12.83	32.68
11:01 AM – 12:00 PM	0.00	49.54	21.65	8.00
12:01 PM – 1:00 PM	0.00	52.72	31.96	9.52
1:01 PM – 2:00 PM	0.00	54.68	44.83	11.87
2:01 PM – 3:00 PM	0.00	58.39	55.08	42.10
3:01 PM – 4:00 PM	29.93	63.36	104.30	77.72
4:01 PM – 5:00 PM	66.48	27.29	109.71	129.86
5:01 PM – 6:00 PM	110.60	31.80	136.01	151.32
6:01 PM – 7:00 PM	143.63	78.84	148.41	154.45
7:01 PM – 8:00 PM	138.45	153.41	155.80	150.29
8:01 PM – 9:00 PM	128.01	154.52	147.51	143.39
9:01 PM – 10:00 PM	106.65	131.10	125.97	128.46
10:01 PM – 11:00 PM	92.20	98.98	107.44	114.36
11:01 PM – 12:00 AM	86.21	88.62	95.54	99.91

These updates reflect changes in the carbon intensity of California grid electricity driven by rapidly increasing contributions from low-carbon sources in the California electricity mix (Figure 1) [3] due to mandates driven by the Renewable Portfolio Standard (RPS), requirements related to integrated resource planning (IRP)[4], the inclusion of Cap-and-Trade carbon pricing in dispatch models, and other structural or systemic changes.

[3] Total System Electric Generation, 2011-2022. California Energy Commission. Accessed 12/2023. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/california-electrical-energy-generation

[4] Integrated Resource Plan and Long-Term Procurement Plan. California Public Utilities Commission. Accessed 12/2023.https://www.cpuc.ca.gov/irp/

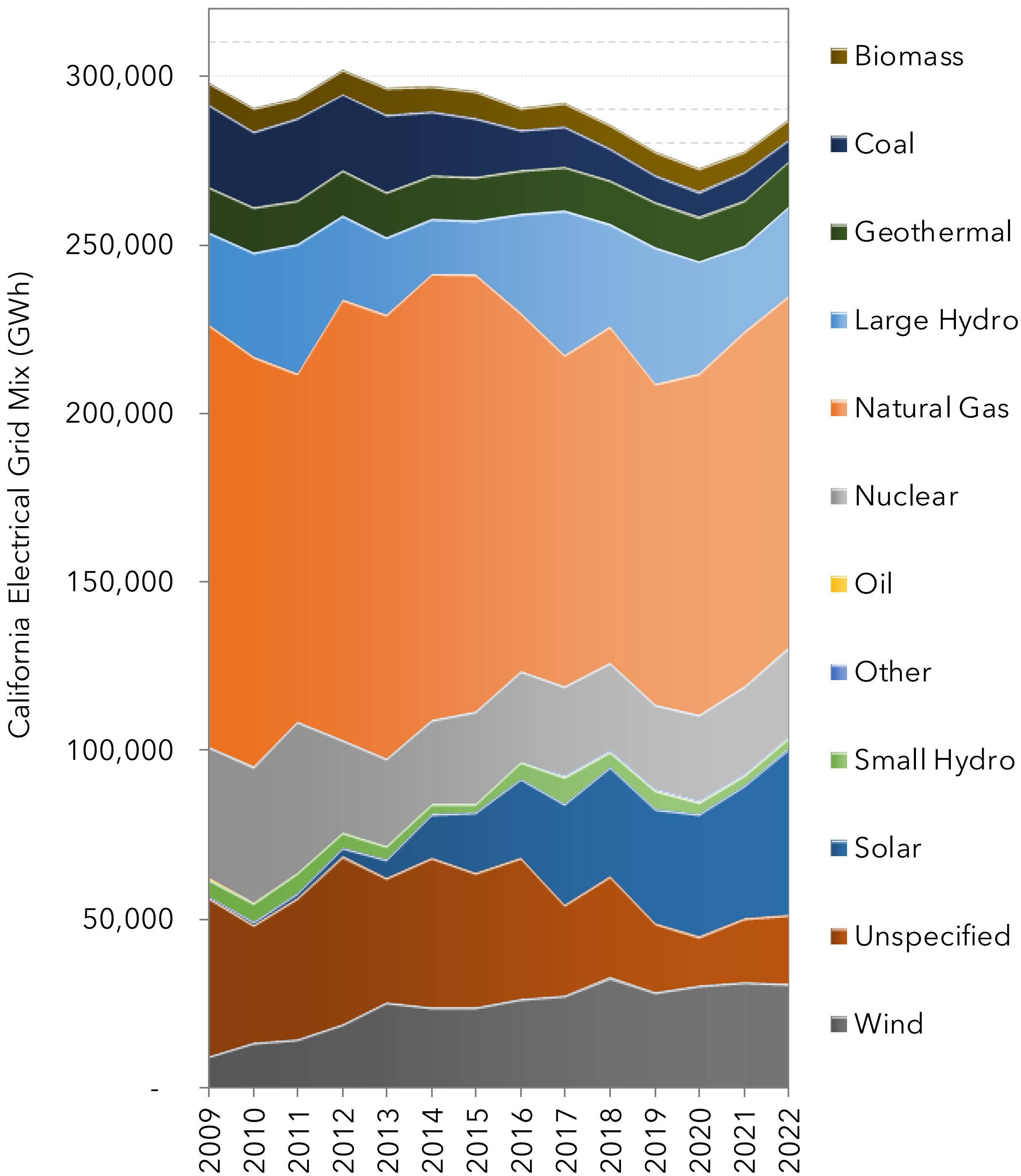

Figure 1. Total System Electric Mix in California in Gigawatt Hours (GWh)

II. Pathway Details, Assumptions, and Calculations

1. California Grid Electricity Mix

Pursuant to the Lookup Table Pathways Technical Support Documentation (August 13, 2018), the "Power Generation" stage of the California average grid electricity pathway is modeled in CA-GREET3.0 using the Total System Electric Generation dataset provided by the California Energy Commission (CEC).

The "Feedstock Production" stage is modeled using the U.S. average mix from the U.S. EPA Emissions & Generation Resource Integrated Database (eGRID2014v2). Only the "Power Generation" stage of the life cycle is updated using the CEC Total System Electric Generation data for the 2022 reporting year. [5] The CEC's California Power Mix for 2021 and 2022 data years are compared in Table 3.

Table 3. California Power Mix for Data Years 2021 and 2022

	2021 CEC		2022 CEC	
	% Mix	**GWh**	**% Mix**	**GWh**
Residual oil	0.2%	502	0.1%	380
Natural Gas	44.7%	124,243	43.5%	124,923
Coal	3.0%	8,272	2.1%	6,170
Nuclear	9.3%	25,758	9.2%	26,366
Biomass	2.3%	6,271	2.1%	6,162
Hydro	10.3%	28,491	10.4%	29,757
Geothermal	4.8%	13,214	4.7%	13,411
Wind	11.4%	31,555	10.8%	31,100
Solar	14.2%	39,458	17.0%	48,950
Total	**100.0%**	**277,764**	**100.0%**	**287,219**

As described in the Technical Support Documentation, to harmonize resources reported by CEC with those in CA-GREET3.0, the "Other Petroleum Sources" category from CEC's mix was treated as "Residual Oil", while the "Unspecified Sources of Power" category was assumed to be from "Natural Gas" in CA-GREET3.0.

Table 4 details the updated contribution of each power resource in energy input, emission factor to calculate an average CI for electricity, which will be used for reporting in 2024 after completion of a public comment period.

[5] 2022 California Total System Electric Generation data from California Energy Commission (CEC). Accessed 12/2023. https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2022-total-system-electric-generation

Table 4. 2022 California Average Grid Electricity CI for 2024 Reporting[6]

	Electricity Resource Mix	Energy Inputs, Btu Feedstock /MMBtu Electricity	Feedstock Production, gCO_2e/MMBtu Electricity	Electricity Generation, gCO_2e/MMBtu Electricity
Residual Oil	0.1%	4,428	66	378
Natural Gas	43.5%	1,015,868	14,043	61,350
Coal	2.1%	66,211	365	6,643
Nuclear	9.2%	98,181	356	0
Biomass	2.1%	104,771	235	214
Hydro	10.4%	110,805	0	0
Geothermal	4.7%	49,940	0	1,332
Wind	10.8%	115,807	0	0
Solar PV	17.0%	182,274	0	0
Total	**100%**	**1,748,285**	**15,065**	**69,918**
2022 CA Average Grid CI, gCO_2e/MJ			**14.28**	**66.27**
			80.55	

The resulting average CI for California grid electricity for use in 2024 reporting is **80.55 gCO_2e/MJ**, a decrease from the previous CI of 81.00 gCO_2e/MJ certified for use in 2023 reporting.

2. California Grid Electricity CI for Smart Charging or Smart Electrolysis

2.1. Smart Charging or Smart Electrolysis CI Values

The CI values for smart charging or smart electrolysis provisions are calculated based on the marginal emission rates determined using the Avoided Cost Calculator developed by the California Public Utilities Commission.[7] A set of algorithmically neutral CI values are determined for each hour of the day, for the four quarters of the year, to represent the average marginal emission rates for EV charging or electrolytic hydrogen production that takes place during these times. Shifting EV charging or electrolysis could result in additional emission reductions as compared to Average Grid Electricity CI during the periods when the marginal emission reductions are low.

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[6] Values may not sum to the total due to rounding.

[7] Energy and Environmental Economics, Inc. [Avoided Cost Calculator](), May 2018. Incorporated by reference into the LCFS Regulation, section 95481(a)(10). Accessed 12/2023. Available from the California Public Utilities Commission website at: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/idsm

2.2. Normalized Average Marginal Emission Rates

For calculation of marginal emission rates in the Avoided Cost Calculator, natural gas is assumed to be the marginal fuel for electricity generation in California in all hours and the hourly emissions rate of the marginal generator is calculated based on the day-ahead market price curve. Higher market prices enable lower-efficiency (i.e., less economical) generators to operate, resulting in corresponding, increased rates of emissions at the margin.

This relationship holds for a reasonable range of prices but breaks down when prices are extremely high or low. For this reason, the avoided cost methodology bounds the maximum and minimum emissions rates based on the range of gas turbine technology heat rates. Additionally, if the implied heat rate is calculated to be at or below zero, it is then assumed that the system is in a period of over generation and therefore the marginal emission rate is correspondingly zero as well.

The Avoided Cost Calculator estimates marginal emission rates for utilities in Northern and Southern California, which are based on the normalized hourly day-ahead heat rate profiles for CAISO NP-15 and SP-15 regions. Statewide average marginal emission rates for 2024, are calculated based on the load profile of large load serving entities (LSE) in the two geographical areas, Pacific Gas and Electric (PG&E) in Northern California and Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) in Southern California.

Based on the CAISO OASIS data[8] for all three utilities from January 1, 2022 through December 31, 2022, approximately 45% of the annual average hourly load is served in Northern California and 55% is served in Southern California (includes SCE and SDG&E), as shown in Table 5.

Table 5. LSE Average Hourly Load and Share of Total Load in California for 2022

Load-Serving Entity	Average Hourly Load (MW)	% of Load
PG&E	11,445	45.1%
SCE	11,722	46.2%
SDG&E	2,222	8.8%
Total	**25,389**	**100%**

The statewide average marginal emission rates for California Grid Average Electricity are normalized to the annual average California Grid emissions rate over the year for each hourly window for the four quarters of the year, as shown in Table 6.

[8] CAISO Demand Forecast – Actual. Accessed 12/2023. http://oasis.caiso.com/mrioasis/logon.do

Table 6. Normalized Marginal Emission Rates for California Grid Electricity for 2024

	Q1	Q2	Q3	Q4
12:01 AM – 1:00 AM	1.0642	1.0750	1.1134	1.1852
1:01 AM – 2:00 AM	1.0637	1.0515	1.0742	1.1348
2:01 AM – 3:00 AM	1.0637	1.0510	1.0664	1.1069
3:01 AM – 4:00 AM	1.0637	1.0507	1.0633	1.1013
4:01 AM – 5:00 AM	1.0637	1.0660	1.0618	1.1253
5:01 AM – 6:00 AM	1.1343	1.1752	1.0882	1.2706
6:01 AM – 7:00 AM	1.4189	1.1576	1.2338	1.5561
7:01 AM – 8:00 AM	1.3966	0.3681	1.1846	1.5376
8:01 AM – 9:00 AM	0.8285	0.0297	0.7468	1.2649
9:01 AM – 10:00 AM	0.3789	0.0215	0.0917	0.5065
10:01 AM – 11:00 AM	0.0053	0.0387	0.1593	0.4057
11:01 AM – 12:00 PM	0.0000	0.6150	0.2688	0.0993
12:01 PM – 1:00 PM	0.0000	0.6545	0.3967	0.1182
1:01 PM – 2:00 PM	0.0000	0.6788	0.5565	0.1474
2:01 PM – 3:00 PM	0.0000	0.7249	0.6838	0.5227
3:01 PM – 4:00 PM	0.3716	0.7866	1.2949	0.9649
4:01 PM – 5:00 PM	0.8253	0.3389	1.3620	1.6122
5:01 PM – 6:00 PM	1.3731	0.3948	1.6885	1.8787
6:01 PM – 7:00 PM	1.7832	0.9788	1.8426	1.9175
7:01 PM – 8:00 PM	1.7188	1.9046	1.9343	1.8659
8:01 PM – 9:00 PM	1.5893	1.9183	1.8313	1.7802
9:01 PM – 10:00 PM	1.3241	1.6277	1.5639	1.5948
10:01 PM – 11:00 PM	1.1447	1.2288	1.3339	1.4198
11:01 PM – 12:00 AM	1.0703	1.1002	1.1861	1.2403

APPENDIX:
Carbon Intensity Calculations in Table 4

Table A.1 provides emission factors, combustion technologies, and energy conversion efficiencies derived from CA-GREET3.0 for calculations in Table 4.

Table A.1. Emission Factors, Combustion Technology Shares and Energy Conversion Efficiencies for Grid Electricity Used as Transportation Fuel in California

	Electricity Generation Emissions, gCO_2e/kWh	Technology Share	Electricity Generation Efficiency
Residual Oil			
Boiler	902	77.2%	32.3%
Internal Combustion Engine	800	4.6%	36.3%
Gas Turbine	987	18.2%	29.4%
Weighted Average	*912*		*32.0%*
Natural Gas			
Boiler	792	3.3%	25.7%
Simple-cycle Gas Turbine	483	12.6%	42.0%
Combined-cycle Gas Turbine	429	83.2%	47.3%
Internal Combustion Engine	637	1.0%	36.5%
Weighted Average	*450*		*45.8%*
Coal			
Boiler	987	99.9%	34.7%
IGCC	986	0.1%	34.8%
Weighted Average	*987*		34.7%
Biomass			
Boiler	32	100.0%	21.9%
Nuclear	1		
Hydro	0		
Geothermal	0		
Wind	0		
Solar PV	0		

The following calculations show truncated values for easier visualization. However, the results in the tables of this document are calculated with non-truncated values, which may cause slight variations in results.

1) Calculation of Contribution to Emissions from Residual Oil

Residual oil (RO) fired power plants use three combustion technologies: boiler, internal combustion engine, and gas turbine. The combustion technology shares and their energy conversion efficiencies were calculated from CA-GREET3.0.

For each MMBtu of California grid electricity delivered, the RO fuel input is:

$$\frac{1{,}000{,}000 \text{ Btu RO}}{0.32 \text{ MMBtu Electricity Generated}} \times \frac{0.13\%}{(1 - 6.5\%)} = \frac{4{,}428 \text{ Btu RO}}{\text{MMBtu Grid Electricity}}$$

where:

Electricity resources mix share of residual oil = 0.13% (Table 3)
Weighted average RO electricity generation efficiency = 32.0%
Loss in electricity transmission = 6.5% (CA-GREET3.0)

The contribution of RO to the feedstock production CI in Table 4 is:

$$\frac{4{,}428 \text{ Btu RO}}{\text{MMBtu Grid Electricity}} \times \frac{0.01482 \text{ gCO}_2\text{e}}{\text{Btu RO}} = \frac{66 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Upstream EF of RO use in power plant = 14,820 gCO_2e/MMBtu RO (CI value of the “Petroleum” tab, RO and Crude sections).

The contribution of RO to the electricity generation CI is:

$$\frac{912 \text{ gCO}_2\text{e}}{\text{kWh}} \times \frac{293.07 \text{ kWh}}{\text{MMBtu}} \times \frac{0.13\%}{1 - 6.5\%} = \frac{378 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Electricity generation emission factor = 912 gCO_2e/kWh (Weighted average emissions factor of each RO combustion type from ‘EF’ worksheet of CA-GREET3.0)

2) Calculation of Contribution to Emissions from Natural Gas

Natural gas (NG) fired power plants use one of four combustion technologies: boiler, simple-cycle gas turbine, combined-cycle gas turbine and internal combustion engine. The combustion technology shares and their energy conversion efficiencies were calculated using aggregated data from the 2022 Form EIA-923 dataset for NG plants located in California that produced electricity for the grid.[9] In prior annual updates, the 2017 Form EIA-923 national dataset for NG plants was used to calculate the weighted average conversion efficiency.

For each MMBtu of California grid electricity delivered, the NG fuel input is:

$$\frac{1{,}000{,}000\text{ Btu NG}}{0.458\text{ MMBtu Electricity Generated}} \times \frac{43.5\%}{(1 - 6.5\%)} = \frac{1{,}015{,}868\text{ Btu NG}}{\text{MMBtu Grid Electricity}}$$

where:

Weighted average 2023 generation efficiency = 0.458 (Table A.1)
Resources mix share of NG-derived electricity = 43.5% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

The contribution of NG to the feedstock production CI in Table 4 is:

$$\frac{1{,}015{,}868\text{ Btu NG}}{\text{MMBtu Grid Electricity}} \times \frac{13{,}824\text{ gCO}_2\text{e}}{\text{MMBtu NG}} = \frac{14{,}043\text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Upstream EF of NG used in power plant = 13,824 gCO_2e/MMBtu NG (CI value of the "Natural Gas for Electricity Generation" in the NG tab)

The contribution of NG to the electricity generation CI in Table 4 is:

$$\frac{450\text{ gCO}_2\text{e}}{\text{kWh}} \times \frac{293.07\text{ kWh}}{\text{MMBtu}} \times \frac{43.5\%}{1 - 6.5\%} = \frac{61{,}350\text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Electricity generation emission factor = 450 gCO_2e/kWh (Weighted average emissions factor of each NG combustion type from 'EF' worksheet of CA-GREET3.0)

[9] U.S. Energy Information Administration. Form EIA-923 detailed data, accessed 2017. http://www.eia.gov/electricity/data/eia923

3) Calculation of Contribution to Emissions from Coal

Coal fired power plants use two combustion technologies: boiler and integrated gasification combined cycle (IGCC). The combustion technology shares and their energy conversion efficiencies were calculated using CA-GREET3.0.

For each MMBtu of California grid electricity delivered, the coal fuel input is:

$$\frac{1{,}000{,}000 \text{ Btu Coal}}{0.347 \text{ MMBtu Electricity Generated}} \times \frac{2.1\%}{(1 - 6.5\%)} = \frac{66{,}211 \text{ Btu Coal}}{\text{MMBtu Grid Electricity}}$$

where:

Weighted average 2023 generation efficiency = 0.347 (Table A.1)
Electricity resources mix share of Coal = 2.1% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

The contribution of coal to the feedstock production CI is:

$$\frac{66{,}211 \text{ Btu Coal}}{\text{MMBtu Grid Electricity}} \times \frac{5{,}514 \text{ gCO}_2\text{e}}{\text{MMBtu Coal}} = \frac{365 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Upstream EF of coal use in power plant = 5,514 gCO_2e/MMBtu Coal (CI value of the "Coal" tab)

The contribution of coal to the electricity generation CI is:

$$\frac{987 \text{ gCO}_2\text{e}}{\text{kWh}} \times \frac{293.07 \text{ kWh}}{\text{MMBtu}} \times \frac{2.1\%}{1 - 6.5\%} = 6{,}643 \text{ gCO}_2\text{e/MMBtu Grid Electricity}$$

where:

Electricity generation emission factor = 987 gCO_2e/kWh (Weighted average emissions factor of each coal combustion type from 'EF' worksheet of CA-GREET3.0)

4) Calculation of Contribution to Emissions from Nuclear

CA-GREET 3.0 model assumes electricity from nuclear is generated in the light water reactor and uranium is U-235. Emissions are from feedstock production (uranium mining and transport); no emissions are modeled for electricity generation.

For each MMBtu of California grid electricity delivered, the nuclear emissions are:

$$\frac{98{,}181 \text{ Btu Nuclear}}{\text{MMBtu Electricity}} \times \frac{85{,}662 \text{ gCO}_2\text{e}}{6{,}926 \text{ kWh}} \times \frac{293.07 \text{ kWh}}{\text{MMBtu}} = \frac{356 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Resources mix share of nuclear-derived electricity = 9.2% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)
Conversion factor = 6,926 kWh/g U-235 (CA-GREET3.0)
Uranium EF = 85,662 gCO_2e/g U-235 (CA-GREET3.0)

5) Calculation of Contribution to Emissions from Biomass

For each MMBtu of California grid electricity delivered, the biomass fuel input is:

$$\frac{1{,}000{,}000 \text{ Btu Biomass}}{0.219 \text{ MMBtu Electricity Generated}} \times \frac{2.1\%}{(1 - 6.5\%)} = \frac{104{,}771 \text{ Btu Biomass}}{\text{MMBtu Grid Electricity}}$$

where:

Weighted average 2023 generation efficiency = 0.219 (Table A.1)
Resources mix share of biomass-derived electricity = 2.1% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

The contribution of biomass to the feedstock production CI in Table 4 is:

$$\frac{104{,}771 \text{ Btu Biomass}}{\text{MMBtu Grid Electricity}} \times \frac{2{,}242 \text{ gCO}_2\text{e}}{\text{MMBtu Biomass}} = \frac{235 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Upstream EF of biomass use in power plant = 2,242 gCO_2e/MMBtu Biomass (“EtOH” tab, “Forest Residue” section).

The contribution of biomass to the electricity generation CI in Table 4 is:

$$\frac{32 \text{ gCO}_2\text{e}}{\text{kWh}} \times \frac{293.07 \text{ kWh}}{\text{MMBtu}} \times \frac{2.1\%}{1 - 6.5\%} = \frac{214 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Electricity generation emission factor = 32 gCO_2e/kWh ('EF' worksheet of CA-GREET3.0)

Upstream EF of NG used in power plant = 13,824 $gCO_2e/MMBtu$ NG (CI value of the "Natural Gas for Electricity Generation" in the NG tab)

6) Energy Contribution of Hydro

For each MMBtu of California grid electricity delivered, the hydro input is:

$$\frac{1{,}000{,}000 \text{ Btu Hydro}}{1 \text{ MMBtu Electricity Generated}} \times \frac{10.4\%}{(1 - 6.5\%)} = \frac{110{,}805 \text{ Btu Hydro}}{\text{MMBtu Grid Electricity}}$$

where:

Resources mix share of hydro = 10.4% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

Hydro power is not evaluated as having feedstock production or electricity generation emissions.

7) Calculation of Contribution to Emissions from Geothermal

For each MMBtu of California grid electricity delivered, the geothermal input is:

$$\frac{1{,}000{,}000 \text{ Btu Geothermal}}{1 \text{ MMBtu Electricity Generated}} \times \frac{4.7\%}{(1 - 6.5\%)} = \frac{49{,}940 \text{ Btu Geothermal}}{\text{MMBtu Grid Electricity}}$$

where:

Resources mix share of geothermal = 4.7% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

Geothermal is not evaluated as having feedstock production emissions. The contribution of geothermal to the electricity generation CI in Table 4 is:

$$\frac{49{,}940 \text{ Btu Geothermal}}{\text{MMBtu Grid Electricity}} \times \frac{26{,}669 \text{ gCO}_2\text{e}}{\text{MMBtu Geothermal}} = \frac{1{,}332 \text{ gCO}_2\text{e}}{\text{MMBtu Grid Electricity}}$$

where:

Upstream EF of geothermal use in power plant = 26,669 $gCO_2/MMBtu$ (CA-GREET3.0)

8) Energy Contribution of Wind Turbine

For each MMBtu of California grid electricity delivered, the wind power input is:

$$\frac{1{,}000{,}000 \text{ Btu Wind}}{1 \text{ MMBtu Electricity Generated}} \times \frac{10.8\%}{(1 - 6.5\%)} = \frac{115{,}807 \text{ Btu Wind}}{\text{MMBtu Grid Electricity}}$$

where:

Resources mix share of hydro = 10.8% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

Wind power is not evaluated as having feedstock production or electricity generation emissions.

9) Energy Contribution of Solar Photovoltaics

For each MMBtu of California grid electricity delivered, the wind power input is:

$$\frac{1{,}000{,}000 \text{ Btu Wind}}{1 \text{ MMBtu Electricity Generated}} \times \frac{17.0\%}{(1 - 6.5\%)} = \frac{182{,}274 \text{ Btu Wind}}{\text{MMBtu Grid Electricity}}$$

where:

Resources mix share of hydro = 17.0% (Table 3)
Loss in electricity transmission = 6.5% (CA-GREET3.0)

Wind power is not evaluated as having feedstock production or electricity generation emissions.