LOW CARBON FUEL STANDARD
ANNUAL UPDATES TO LOOKUP TABLE PATHWAYS

California Average Grid Electricity Used as a Transportation Fuel in California and Electricity Supplied under the Smart Charging or Smart Electrolysis Provision

Posted: January 08, 2020
Revised: January 16, 2020

I. Summary

This document provides the proposed carbon intensity (CI) values and a detailed description of the 2020 annual update to two Lookup Table pathways for electricity 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 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 are expected to be available for reporting transactions that occur during the first quarter (Q1) of 2020. The proposed CI values are shown in Table 1 and 2.

Table 1. Proposed CI Values for 2020 Annual Update to Electricity Lookup Table Pathways

Fuel Pathway Code	Fuel Pathway Description	CI gCO_2e/MJ
ELC000L00072020	California average grid electricity used as a transportation fuel in California (subject to annual updates)	82.92
ELCT	Electricity supplied under the smart charging or smart electrolysis provision (subject to annual updates)	See Table 2

Table 2. Proposed CI Values (gCO2e/MJ) for Smart Charging or Smart Electrolysis in 2020

Hourly Window	Q1	Q2	Q3	Q4
12:01 AM – 1:00 AM	80.41	80.41	81.33	83.96
1:01 AM – 2:00 AM	80.41	80.28	80.19	81.82
2:01 AM – 3:00 AM	80.41	79.35	80.14	80.99
3:01 AM – 4:00 AM	80.41	80.55	80.12	80.84
4:01 AM – 5:00 AM	80.41	80.38	80.09	81.80
5:01 AM – 6:00 AM	82.00	84.17	80.29	89.17
6:01 AM – 7:00 AM	98.41	96.98	87.77	109.90
7:01 AM – 8:00 AM	104.82	67.86	84.52	107.45
8:01 AM – 9:00 AM	76.88	2.24	81.50	88.44
9:01 AM – 10:00 AM	53.96	1.63	56.55	83.29
10:01 AM – 11:00 AM	53.17	2.43	58.89	55.67
11:01 AM – 12:00 PM	51.95	46.30	64.80	58.91

[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. Available at: http://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm

Table 2 continued

Hourly Window	Q1	Q2	Q3	Q4
12:01 PM – 1:00 PM	27.30	49.10	72.69	60.26
1:01 PM – 2:00 PM	27.30	50.80	83.29	84.98
2:01 PM – 3:00 PM	52.06	54.05	90.27	86.40
3:01 PM – 4:00 PM	53.27	58.50	106.12	93.52
4:01 PM – 5:00 PM	65.10	24.38	112.30	115.80
5:01 PM – 6:00 PM	106.97	29.38	120.40	138.98
6:01 PM – 7:00 PM	124.44	98.70	134.00	140.88
7:01 PM – 8:00 PM	120.98	139.24	143.40	134.74
8:01 PM – 9:00 PM	110.01	138.55	128.41	124.81
9:01 PM – 10:00 PM	92.22	112.15	108.21	110.57
10:01 PM – 11:00 PM	81.84	85.84	91.66	97.45
11:01 PM – 12:00 AM	80.41	81.22	83.62	86.71

These updates are designed to reflect the decreasing CI of California grid electricity driven by rapidly increasing contributions from renewables in the California electricity mix (Figure 1) due to mandates driven by the Renewable Portfolio Standard (RPS), the inclusion of Cap-and-Trade carbon pricing in dispatch models, as well as other structural or systemic changes.

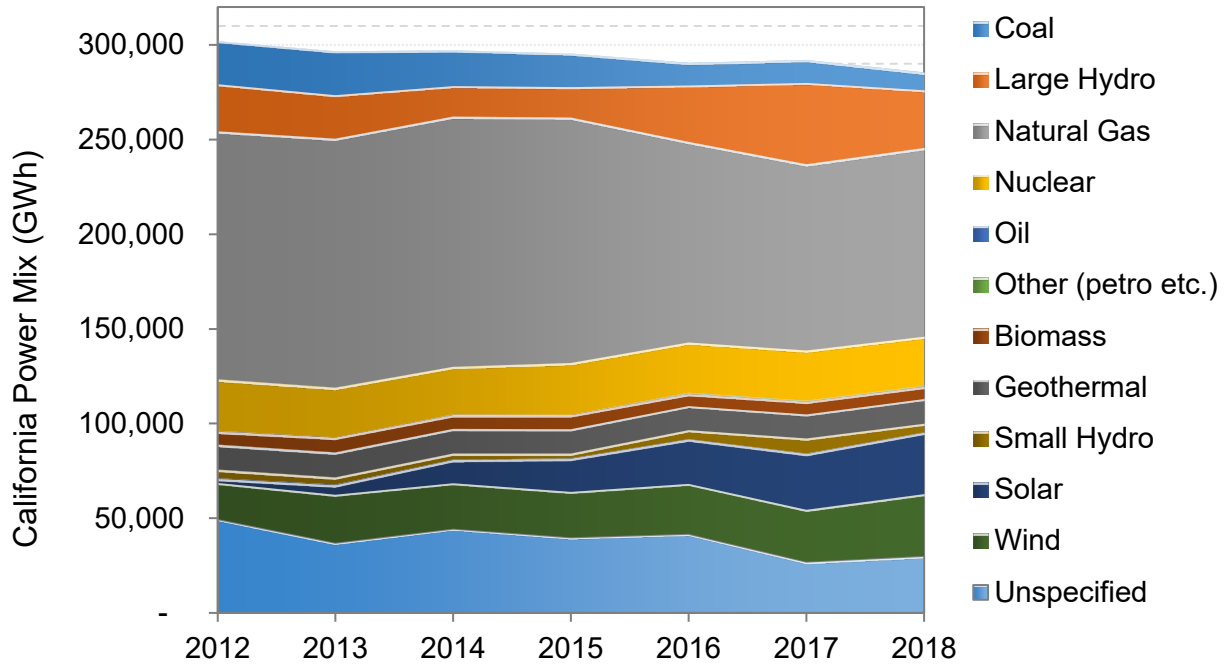

Figure 1. Total System Electric Mix in California in Gigawatt Hours (GWh)[3]

[3] Data source: Total System Electric Generation, 2012-2018. California Energy Commission. Accessed 8/2019. https://www.energy.ca.gov/almanac/electricity_data/total_system_power.html

II. Pathway Details, Assumptions, and Calculations

1. California Average Grid Electricity Used as a Transportation Fuel in California

Pursuant to the methodology specified in the Lookup Table Pathways Technical Support Documentation (August 13, 2018), the California average grid electricity pathway is modeled in CA-GREET3.0 using the California Power Mix from the Total System Electric Generation dataset by the California Energy Commission (CEC) for the "Power Generation" stage. 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 Total System Electric Generation for the 2018 data year. The CEC's California Power Mix for 2017 and 2018 data years are compared in Table 1-1. The resulting CI for use in 2020 reporting is calculated, as described below, to be 82.92 gCO_2e/MJ, an increase over the CI of 81.49 gCO_2e/MJ used in 2019.

Table 1-1. California Power Mix for Data Years 2017 and 2018[4]

	2017 CEC		2018 CEC	
	% Mix	GWh	% Mix	GWh
Residual oil	0.15%	442	0.17%	474
Natural Gas	42.93%	125,332	45.44%	129,739
Coal	4.13%	12,075	3.30%	9,433
Nuclear	9.08%	26,519	9.05%	25,841
Biomass	2.35%	6,874	2.35%	6,707
Hydro	17.41%	50,854	12.29%	35,082
Geothermal	4.35%	12,705	4.54%	12,968
Wind	9.40%	27,442	11.46%	32,711
Solar	10.20%	29,796	11.40%	32,533
Total	100%	292,039	100%	285,488

As described in the Technical Support Documentation, in order to harmonize the 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 uses "Natural Gas" as a surrogate in CA-GREET3.0.
Table 1-2 details the updated contribution of each power resource in energy input, emission factor and CI. Refer to the Lookup Table Pathways Technical Support Documentation for details and example calculations for the emission factors shown in Table 1-2.

[4] 2017 California Total System Electric Generation data from California Energy Commission (CEC) website, accessed 08/2018: https://www.energy.ca.gov/almanac/electricity_data/total_system_power.html

Table 1-2. Summary of CI for California Average Grid Electricity Used as a Transportation Fuel in California *

	Electricity Resources Mix	Energy Inputs, Btu/MMBtu	Feedstock Production Emission Factor, gCO_2e/MMBtu	Feedstock Production Contribution to CI, gCO_2e/MMBtu	Power Generation Emission Factor, gCO_2e/MMBtu	Power Generation Contribution to CI, gCO_2e/MMBtu
Residual Oil	0.17%	5,277	14,820	78	253,578	450
Natural Gas	45.44%**	1,010,078	13,824	13,963	123,600	60,074
Coal	3.30%	101,841	5,515	562	279,776	10,240
Nuclear	9.05%	96,808	3,625	351	0	0
Biomass	2.35%	111,178	2,242	249	8,713	219
Hydro	12.29%	131,427	0	0	0	0
Geothermal	4.54%	48,582	0	0	26,669	1,296
Wind	11.46%	122,545	0	0	0	0
Solar PV	11.40%	121,878	0	0	0	0
Total	100%			**15,203**		**72,280**
Total CI, gCO_2e/MJ				**14.41**		**68.51**

* Values may not sum to the total due to rounding.
** In the CA-GREET3.0 model, all undefined energy resources are assumed to be from natural gas. This value represents the sum ozf the reported natural gas used in the electricity mix (34.90%) and the undefined energy categories (10.54%), as the total share of natural gas (45.44%) in the CA Electricity Resources Mix. Similarly, other petroleum in the CEC power mix was treated as Residual Oil in the CA-GREET3.0.

2. California Average Grid Electricity Supplied under the Smart Charging or Smart Electrolysis Provision

2.1. Description of smart charging or smart electrolysis CI values:

The carbon intensity values for smart charging or smart electrolysis provisions are calculated based on the marginal emission rates determined using the Avoided Cost Calculator (March 2018) developed by the California Public Utilities Commission.[5] A set of algorithmically neutral carbon intensity 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.

2.2. Calculation of normalized average marginal emission rates for California Average Grid Electricity:

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. The relation between market prices and higher emissions rates is intuitive, higher market prices enable lower-efficiency generators to operate, resulting in 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 heat rates of gas turbine technologies. 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 2020, weighted by load, 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[6] for all three utilities from January 1, 2018 through December 31, 2018, approximately 45% of the

[5] Energy and Environmental Economics, Inc. Avoided Cost Calculator, May 2018. Incorporated by reference into the LCFS Regulation, section 95481(a)(10). Accessed 8/2019. Available from the California Public Utilities Commission website at: http://www.cpuc.ca.gov/General.aspx?id=5267
[6] CAISO Demand Forecast – Actual. Accessed: 12/2019 Available at: http://oasis.caiso.com/mrioasis/logon.do

annual average hourly load is served in Northern California and 55% is served in Southern California, as shown in Table 2-1.

Table 2-1. The average hourly load of the large load serving entities and their share of the overall load in California in 2018.

Load-Serving Entity	Average Hourly Load (MW)[7]	% of Load
PG&E	11,622	45%
SCE	11,820	46%
SDG&E	2,294	9%
Total	**25,736**	**100%**

The resulting 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 2-2.

Table 2-2. Normalized Marginal Emission Rates for California Grid Average Electricity for 2020

Hourly Window	Q1	Q2	Q3	Q4
12:01 AM – 1:00 AM	0.9697	0.9698	0.9809	1.0125
1:01 AM – 2:00 AM	0.9697	0.9681	0.9671	0.9867
2:01 AM – 3:00 AM	0.9697	0.9569	0.9665	0.9768
3:01 AM – 4:00 AM	0.9697	0.9715	0.9663	0.9749
4:01 AM – 5:00 AM	0.9697	0.9694	0.9659	0.9865
5:01 AM – 6:00 AM	0.9889	1.0151	0.9682	1.0754
6:01 AM – 7:00 AM	1.1868	1.1696	1.0585	1.3253
7:01 AM – 8:00 AM	1.2641	0.8184	1.0193	1.2959
8:01 AM – 9:00 AM	0.9271	0.0271	0.9829	1.0665
9:01 AM – 10:00 AM	0.6507	0.0197	0.682	1.0044
10:01 AM – 11:00 AM	0.6413	0.0293	0.7102	0.6714
11:01 AM – 12:00 PM	0.6265	0.5584	0.7815	0.7104
12:01 PM – 1:00 PM	0.3292	0.5921	0.8767	0.7267
1:01 PM – 2:00 PM	0.3293	0.6126	1.0045	1.0249
2:01 PM – 3:00 PM	0.6278	0.6518	1.0886	1.0419
3:01 PM – 4:00 PM	0.6425	0.7055	1.2797	1.1278
4:01 PM – 5:00 PM	0.7851	0.2941	1.3544	1.3965
5:01 PM – 6:00 PM	1.29	0.3544	1.452	1.6761
6:01 PM – 7:00 PM	1.5008	1.1903	1.616	1.699
7:01 PM – 8:00 PM	1.459	1.6792	1.7293	1.625
8:01 PM – 9:00 PM	1.3267	1.6709	1.5487	1.5052

[7] Average hourly load is calculated by taking the average load for the load served for each hour in the year

Hourly Window	Q1	Q2	Q3	Q4
9:01 PM – 10:00 PM	1.1122	1.3525	1.305	1.3335
10:01 PM – 11:00 PM	0.9869	1.0352	1.1054	1.1752
11:01 PM – 12:00 AM	0.9697	0.9795	1.0085	1.0457

2.3. Calculation of smart charging or smart electrolysis CI values:

The carbon intensity values for smart charging or smart electrolysis for a given time period is determined using the California Average Grid Electricity CI and the normalized marginal emission rates for that period. The calculated California grid average electricity CI for the 2020 reporting period is 82.92 gCO_2e/MJ. This calculation gives the estimated average carbon intensity for electricity as a result of shifting EV charging or electrolysis to a specific hourly window during a given quarter. The carbon intensity values calculated for smart charging or smart electrolysis pathways in 2020 are shown in Table 2 on page 2.