CALIFORNIA
TECHNICAL FORUM

Memorandum

To: Cal TF Members

Re: Calculating CO_2 Reductions in eTRM

From: Roger Baker

Date: December 11, 2019

A. Introduction and Overview

During the development of the eTRM, the POUs raised the issue of calculating carbon reductions for each measure into the eTRM. Subsequent policy developments (including the CPUC OIR on building decarbonization[1]) has escalated the need to incorporate the ability to properly estimate carbon reductions associated with deemed measures into the eTRM.

This memorandum describes current approaches to calculating carbon reductions for energy efficiency in California, and proposes an approach for the eTRM.

B. Current Approaches, Guidance and Issues Related Calculating CO_2 Reductions

1. IOU Current Approach to Calculating CO_2 reductions in the CPUC-Approved Cost-Effectiveness Calculator (CET)

The CET uses the CO_2 reduction calculation methodology contained in the CPUC-adopted Avoided Cost Calculator[2] (ACC). The ACC starts with an assumed reference heat rate and associated CO_2 reduction for a combined-cycle combustion turbine. It then uses forecast market price for electricity and natural gas price as proxies for annual heat rate and CO_2 for

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[1] CPUC Rulemaking R.19-01-011.

[2] The Avoided Cost Calculator (ACC) is an Excel-based tool that is maintained by Energy+Environmental Economics Inc., for the CPUC. The version referenced in this white paper is ACC_2019_v1b.xlsx; this version, which includes the 2019 updates, were adopted by Resolution E-5014 on August 1, 2019.

each year in the forecast period[3]. The forecasted changes in market price reflect the increasing amount of renewables on the grid and its expected impact on annual average emissions rates.

The ACC then converts this average emissions value into hourly values for each of 8,760 hours per year, over a 31 year time horizon. This is done by using the hourly forecast market price of energy as a proxy to adjust the hourly emissions rates in a similar manner to the approach used to determine annual average emissions rates. These hourly CO_2 reductions are then multiplied by hourly end-use profiles for each utility (DEER 2011 load profiles, which do not cover all end uses) to arrive at annual hourly (8760) hourly CO_2 reduction values for each measure. Note that the annual CO_2 reductions values are specific to the load shape being used.

The current approach to calculating CO_2 reductions in the CET calculator assumes market prices for electricity and natural gas are a good proxy for heat rate and the generation mix. However, market prices can fluctuate widely for a variety of reasons, so market prices are arguably not the best proxy for heat rates/generation mix/CO_2 reductions. Furthermore, the ACC heat rate calculation (set forth in Fn3) is based on a less-than-intuitive formula with inputs that require several assumptions that could vary depending on who is making the assumptions. Finally, as a Cal TF member pointed out[4], the ACC approach is statewide and assumes common emissions rates for all utilities, a flawed assumption given that a statewide approach ignores transmission constraints and the differences in generation mix across different IOU and POU service territories.

2. <u>POU Current Approach to Calculating CO_2 Reductions</u>

For POUs, the process for calculating CO_2 reductions can vary by individual utility. The 2017 POU guidelines[5] provide four recommendations on how POUs could calculate CO_2 reductions:

1) Use CEC forecasted emission rates;[6]
2) Use the GHG methodology and emission rates developed by CARB for two state agencies;[7]

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[3] From the "2019 Avoided Cost Update Documentation" (p.47): Assuming that natural gas is the marginal fuel in all hours, the hourly emissions rate of the marginal generator is calculated based on the day-ahead market price curve (with the assumption that the price curve also includes the cost of CO_2):

HeatRate[h] = (MP[h] – VOM) / (GasPrice + EF * CO_2Cost)

Where

MP is the hourly market price of energy (including cap and trade costs)
VOM is the variable O&M cost for a natural gas plant
GasPrice is the cost of natural gas delivered to an electric generator
CO_2Cost is the $/ton cost of CO_2
EF is the emission factor for tons of CO_2 per MMBTU of natural gas

[4] Armen Saiyan, LADWP.
[5] 2017 California POU Energy Efficiency Reporting Guidelines, available at www.cmua.org.
[6] More research needs to be done to better understand the CEC forecasted emissions rates. Are they POU-specific or statewide? Are they 8760 or more aggregated? How far out is the forecast? Are they updated regularly?
[7] CARB developed a GHG reduction calculation methodology for the Department of Water Resources and Department of Community Services and Development. The methodology uses 2013 statewide inventory data to develop a single average GHG value, which is then divided by the statewide total electric

3) Develop POU-specific avoided emission rates;[8]
4) Adopt IOU-specific emission rates based on E3 analyses for IOUs.

The newly-developed POU Energy Efficiency tool adopts recommendation #4, the approach developed by E3 for the ACC, but differs in that it uses IOU-specific emissions rates.

3. Recent Commission Guidance on Calculating CO_2 Reductions; Fuel Switching

The Commission addressed one issue related to calculating carbon reductions in the recent decision modifying the fuel substitution test, D.19-08-009 (Decision modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution). In that decision, the Commission agreed with parties that the existing GHG methodology used in the ACC may not be appropriate for load-building measures associated with fuel substitution. The ACC uses system average emissions rates for energy efficiency measures while the emissions impact associated with fuel substitution should be based on long-term marginal rates. This is not an immediate issue as the Decision adopts the existing, average emission rate, until such time as the affected software tools can be updated to incorporate more sophisticated emissions calculations that have hourly marginal emissions rates vs. hourly average emissions rates.[9] The CAISO Clean Net Short tables contain hourly average emissions rates. Cal TF is unaware of a source that includes hourly marginal emissions rates that go out 40 years. However, CAISO has historic hourly rates (marginal) and the near-term Clean Net Short tables could be calibrated using historical marginal rates to develop marginal hourly emissions rates. This would require cooperation between CAISO and the CPUC.

4. Current Challenge in Calculating Accurate CO_2 Reductions: Outdated and Incomplete Hourly Load Profiles for Statewide Deemed Measures

A key challenge for calculating accurate carbon reductions for deemed measures is the absence of current, comprehensive hourly energy savings profiles for the variety of deemed measures in the eTRM. The most recent CPUC effort to develop updated IOU end-use load profiles was conducted by the DEER team in 2011; these profiles are still used for many of the current tools including the CET. The DEER 2011 profiles only address a limited set of end-uses and measures; Residential profiles only address CFL lighting, refrigerators, home envelope, clothes washers, dishwashers and air conditioners, while commercial profiles address indoor lighting, chillers and packaged HVAC. These profiles do not address different building types within the two sectors (e.g., a hospital and a restaurant would use the same lighting profile, as would single-family and multi-family residential homes).

In 2019, ADM developed end-use profiles for the CEC to support its load forecasting process, and these profiles are available upon request from the CEC. The utilities and the CPUC ex ante consultants have reviewed those profiles to determine whether they can and should be used for

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consumption to arrive at a single rate. This approach, while simple to use, does not reflect marginal emissions rates associated with energy savings.

[8] Developing POU-specific emissions rates would be expensive if they were developed to the level of granularity used by the IOU CET – hourly forecasts for thirty years.

[9] D.19-08-009, p. 27

the statewide deemed measure, and found gaps in the number and types of building prototypes and end-use categories as well as the geographic alignment between the CEC forecast zones and the Title 24 climate zones relied upon for energy efficiency measures. Finally, per CPUC Resolution E-5009, The DEER team is planning to develop new load shapes as part of its 2021-2023 activities[10].

C. Cal TF Staff Proposed Approach to Calculating CO_2 Reductions

1. Overview

Cal TF Staff's proposed approach to sourcing CO_2 Reductions for the eTRM is similar to the approach used by the current cost-effectiveness calculators, but differs in one key respect. Specifically, Cal TF Staff propose using the CO_2 Reductions by MWh contained in CAISO's "Clean Net Short"[11] calculator, which is used to calculate GHG impacts by load-serving entities as part of the biennial Integrated Resource Planning (IRP) process.[12] This alternative is proposed instead of the rather complex calculation of carbon reductions in the ACC that assumes carbon reductions are a function of heat rate, and uses market prices for gas and electricity as a proxy for heat rate. This approach is arguably flawed given that market prices vary for many reasons other than the generation mix at a particular time.

Cal TF Staff's proposed approach is similar to the approach used in the IOU and POU CET calculators in that it uses hourly load profiles and hourly emissions rates[13]. It proposes using the DEER 2011 end use profiles, as used in the IOU CET calculator, even though the load profiles are incomplete (they represent only a limited set of end uses) and are also out-of-date[14]. Cal TF Staff also proposes using statewide CO_2 values, as does the IOU CET calculator, rather than utility-specific CO_2 reductions values, given that the existing data is insufficient to calculate utility-specific values.[15] Finally, Cal TF's proposed approach is similar to existing approaches in that the hourly values are *average* hourly emissions rates, not *marginal* hourly emissions rates.

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[10] Resolution E-5009, page A-20.

[11] The Clean Net Short (CNS) calculator is an Excel-based tool that allows load-serving entities to estimate emissions over the IRP time horizon; The emissions rates in the CNS calculator are developed using RESOLVE, which is an electric resource investment and operational model designed to inform long-term planning for the electric sector.

[12] The most recent IRP process (2017-2018) required all load-serving entities to use the CNS calculator as part of its filing process. More information on IRP, including filed plans from 2017-2018, can be found at www.cpuc.ca.gov/IRP.

[13] The IOU CET tool does not directly use hourly emissions data or load profiles. The hourly-level data is pre-processed prior to integration into the tool for use by program administrators.

[14] Efforts are underway to develop updated load profiles, including from CEC (California Investor-Owned Utility Electricity Load Shapes, 2019) and NREL (End-use Profiles for the U.S. Building Stock, 2019).

[15] Cal TF Staff concurs with the observation made by Armen Saiyan, Cal TF member, LADWP, that statewide values may not be as accurate as utility-specific values given some variations in utility-specific generation mixes given transmission constraints, and some native utility load. There is insufficient information, however, to assess whether there are meaningful differences in marginal emissions rates across utility territories or balancing-authorities in California.

Marginal hourly emissions rates would be more accurate,[16] but the marginal hourly emissions rates do not currently exist.

2. <u>Proposed Calculation Methodology</u>

Cal TF Staff proposes calculating CO_2 reductions for the eTRM using an "array multiplication" function to calculate measure-level GHG impacts. Each measure (or permutation) would be assigned an 8,760 hour savings profile from a library of available profiles that will be housed in the eTRM data library. Within the profile, each of 8,760 hourly records will contain a fraction representing the amount of annual savings that would occur during that hour. The sum of all hourly fractions would sum to 1.0 (100%). This approach is deliberate, as it would allow the same profile to be assigned to measure permutations that have different annual energy savings.

Along with the hourly savings profile, a similar set of 8,760 hourly CO_2 emission reductions tables will also reside within the eTRM. This data could be sourced from various places. For now (until marginal hourly emissions rates are developed) Cal TF Staff proposes using CAISO's "Clean Net Short" calculator that the CPUC uses in the IRP to calculate GHG reductions. This table (partly shown below) provides 12-month x 24-hour average emissions reductions based on CPUC/CAISO's forecast of its generation mix. The CNA produces four such tables, which it updates every two years as part of the biennial IRP cycle, each representing a multi-year future timeframe (2018-21, 2022-25, 2026-29 and 2030+).

Average Thermal Emission Factor by Month-Hour (tCO2/MWh)

2018	1	2	3	4	5	6	7	8	9	10	11	12
1	0.40	0.41	0.41	0.41	0.39	0.41	0.36	0.37	0.37	0.37	0.37	0.37
2	0.40	0.41	0.41	0.41	0.39	0.41	0.36	0.37	0.37	0.37	0.37	0.36
3	0.40	0.41	0.41	0.41	0.40	0.41	0.37	0.37	0.37	0.37	0.37	0.37
4	0.40	0.41	0.41	0.41	0.39	0.41	0.37	0.37	0.37	0.37	0.37	0.36
5	0.40	0.41	0.41	0.41	0.40	0.41	0.36	0.37	0.37	0.37	0.37	0.36
6	0.40	0.41	0.41	0.41	0.40	0.41	0.37	0.37	0.37	0.38	0.37	0.36
7	0.40	0.41	0.41	0.41	0.40	0.40	0.37	0.37	0.37	0.37	0.37	0.36
8	0.39	0.40	0.41	0.41	0.39	0.40	0.37	0.37	0.37	0.37	0.37	0.37
9	0.38	0.41	0.41	0.39	0.39	0.39	0.37	0.38	0.37	0.37	0.37	0.37
10	0.38	0.41	0.40	0.39	0.31	0.40	0.37	0.38	0.37	0.38	0.38	0.38
11	0.38	0.40	0.40	0.39	0.32	0.40	0.37	0.38	0.37	0.38	0.38	0.38
12	0.38	0.40	0.40	0.39	0.31	0.39	0.37	0.38	0.37	0.38	0.38	0.38
13	0.38	0.40	0.40	0.38	0.31	0.39	0.36	0.37	0.37	0.38	0.38	0.38
14	0.38	0.39	0.40	0.38	0.32	0.39	0.37	0.37	0.38	0.38	0.38	0.38
15	0.38	0.40	0.40	0.39	0.32	0.39	0.37	0.38	0.38	0.37	0.38	0.38
16	0.38	0.40	0.41	0.41	0.32	0.40	0.37	0.39	0.38	0.37	0.37	0.38
17	0.40	0.40	0.41	0.41	0.40	0.41	0.38	0.39	0.39	0.38	0.38	0.37
18	0.40	0.40	0.41	0.41	0.40	0.40	0.39	0.39	0.40	0.39	0.39	0.38
19	0.41	0.41	0.42	0.42	0.40	0.41	0.39	0.39	0.40	0.39	0.39	0.39
20	0.41	0.41	0.42	0.42	0.40	0.41	0.39	0.39	0.40	0.39	0.39	0.38
21	0.40	0.41	0.41	0.42	0.40	0.41	0.39	0.39	0.39	0.39	0.39	0.38
22	0.40	0.41	0.41	0.41	0.40	0.41	0.38	0.38	0.39	0.38	0.39	0.38
23	0.40	0.41	0.41	0.41	0.40	0.40	0.37	0.37	0.38	0.37	0.38	0.37
24	0.40	0.41	0.41	0.41	0.39	0.40	0.36	0.37	0.37	0.37	0.37	0.37

[16] The marginal hourly emissions rates may be zero if renewables are at the margin. However, the hourly average emissions rates produced by the ACC and the Clean Net Short calculator are average, so the values are not zero.

This profile can be expanded to 8,760 hours within eTRM. Such an expansion would also support more granular data in the future if it becomes available. Once the hourly load shapes (by end use) and the hourly emissions reductions tables from the Clean Net Short Calculator are uploaded into the eTRM, the eTRM could apply an array calculation to calculate pounds of CO_2 emissions reductions by year per measure or permutation, as demonstrated in the example below.

3. Proposed Calculation: Example

In the sample calculation below, the deemed measure saves 45 kWh/year. The measure is associated with a particular end use load shape. The savings from the hourly load profile table are multiplied by the CO_2 reduction table to yield (fractions of pounds, in the case below) CO_2 reductions by hour. The CO_2 Reductions per hour are added up (8760 hours) to yield the pounds of CO_2 reduced per year by the particular deemed measure. This array calculation can be replicated for each year of the measure life, and the resulting data can be summed to provide a lifecycle GHG impact.

Measure Savings: 45 kWh

Hourly Profile Table X CO2 Table = Hourly Reduction

M	D	H	ES		M	D	H	CO2		M	D	H	CO2
1	1	1	0.02%		1	1	1	0.030		1	1	1	0.00027
1	1	2	0.02%		1	1	2	0.025		1	1	2	0.00023
1	1	3	0.04%		1	1	3	0.025		1	1	3	0.00039
1	1	4	0.05%		1	1	4	0.025		1	1	4	0.00056
…	…	…	…		…	…	…	…		…	…	…	…
12	31	24	0.01%		12	31	24	0.040		12	31	24	0.00018
										Sum:			2.45

M = Month of year
D = Day of month
H = Hour of day
ES = Energy Saving fraction for Hour
CO2 = CO2 Rate for Hour

Note that different measures will have different end use profiles. Thus, a measure that saves 45 kWh per year may have very different GHG reduction values. Similarly, the annual kWh savings varies by measure; the CO_2 reduction by measure will vary based on the measures load profile and the amount of energy savings it produces.

D. **Questions for Cal TF Members**

1) **Sources and Options for GHG Emissions Rates for Calculating GHG Reductions.** CAISO tracks dispatch and emissions rates (by utility). Currently, the profiles used by LADWP are utility-specific, while the Clean Net Short calculator uses a single statewide profile, which is developed using the RESOLVE model.
    a. In August 2018, the CPUC Modeling Advisory Group presented a comparison between RESOLVE emissions outputs for 2018 and CAISO actual emissions for 2017; the CAISO emissions value was 28 percent higher than the RESOLVE value. A number of methodological improvements were identified for consideration in the 2019-2020 IRP cycle[17].
    b. RESOLVE uses a simplified dispatch approach, which does not currently provide rates by utility territory. For more precise analyses, RESOLVE data can be ported to the Strategic Energy Risk Valuation Model (SERVM) which conducts a full 8,760 hour probabilistic analysis using 35 years of weather data. However, SERVM is not designed to conduct multi-year studies of the type that RESOLVE does. However, SERVM uses more discrete balancing authority areas and can provide data by utility territory.
2) The Avoided Cost Calculator also relies on the RESOLVE model; however, it does not use emissions rates from RESOLVE. Instead, it uses forecast market prices from RESOLVE as a proxy to derive hourly emissions rates as discussed earlier in this memo. As such, the ACC will provide different emissions values than the CNS.

Is the Clean Net Short data (or is this a calculator) the best option? How often are these values updated? How often should values be updated prospectively in eTRM? Should there be retrospective true-up? When, how frequently, for what purpose?

3. CA GHG Reduction Calculation Approaches. Where else in CA are CO_2 reductions from efficiency being calculated? What is the calculation method? What data sources are the calculation methodologies using? Examples include

a. CPUC proceeding on electrification
b. POU CET calculator
c. CPUC CET calculator
d. GHG methodology and emission rates developed by CARB for two state agencies
e. IRP – CNS Calculator
f. CARB – Cap and Trade program

Calculating GHG Reduction Rates for Gas Measures: How should GHG impacts for natural gas measures be addressed? Should gas consider other GHG producing molecules, other than CO_2? Can a single GHG rate be applied on a per-therm basis? Should multiple GHG emissions rates be

[17] The presentation, along with other documents associated with RESOLVE modeling, can be found at https://www.cpuc.ca.gov/General.aspx?id=6442453968

calculated based on different natural gas load shapes (which would presumably be fewer than electric load shapes)? Should alternative emissions rates may be desired as more bio-methane and H_2 is employed?

4) **Frequency of Updating Carbon Reduction Rates/Updating Retrospectively,** As GHG rate tables are updated, how should those updates be deployed to measures? Should measure-level rates be updated at the same time (triggering a new measure version in eTRM), or should "ex post" GHG impacts be added as separate value? How often should values be updated? Annually? How stable are the GHG reduction values over time?

E. Future Vision

Cal TF should develop a "future vision" for calculating GHG reductions from EE, starting with deemed measures. The key attributes of the "future vision" would include, at a minimum:

- Updated hourly end use profiles for all technology types
  - In development by the Commission's "Group A" consultants
- Hourly and accurate CO emission reductions rates going out at least 20 years (which may exist in the Clean Net Short calculator) that can be "trued up" retrospectively.
- Marginal CO_2 emissions reductions rates
  - Currently, the only hourly emissions rates that exist are average, not marginal, in both the ACC and Clean Net Short calculator.
- Possibly, utility-specific CO2 emissions reductions rates rather than statewide emissions reductions CO_2 emissions reductions rates.

F. Conclusion

Cal TF Staff seeks to finalize the approach for calculating GHG reductions, including the appropriate data sources, so measure-level GHG reductions can be incorporated into the eTRM. The approach proposed by Cal TF can be used with new data (load shapes and emissions rates) as it become available to further refine calculations of CO_2 reductions.