MEMORANDUM

TO: **UTILITIES ADVISORY COMMISSION**

FROM: **UTILITIES DEPARTMENT**

DATE: **April 9, 2019**

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SUBJECT: Discussion of Carbon Emissions Accounting Options for the City's Electric Supply Portfolio

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REQUEST

Staff seeks UAC feedback on the accounting methodology to use in assessing the electric supply portfolio's annual carbon emissions. No action is required at this time. A follow-up report will be presented in the next few months, and an action will be requested at that time.

EXECUTIVE SUMMARY

In the City's 2018 Electric Integrated Resource Plan (EIRP), approved by Council in December 2018, Initiative #4 of the Work Plan called for staff to evaluate the carbon content of the electric supply portfolio using hourly grid emissions intensity data, to consider the merits of buying carbon offsets to ensure the carbon content of the cumulative hourly portfolio is zero on an annual basis, and to reevaluate the manner in which the City communicates with customers about the carbon content of the electric portfolio. This report satisfies the first objective of Initiative #4, while beginning a discussion of the second and third objectives that will continue in the coming months.

This report calculates the carbon content of the City's actual 2018 electric portfolio under a total of six different carbon accounting methodologies: two different annual accounting methodologies (which differ in the way they treat unbundled renewable energy certificate (REC) purchases), and four different hourly accounting methodologies (which employ two different types of hourly carbon emissions intensity values, and again, two different treatments of unbundled REC purchases).

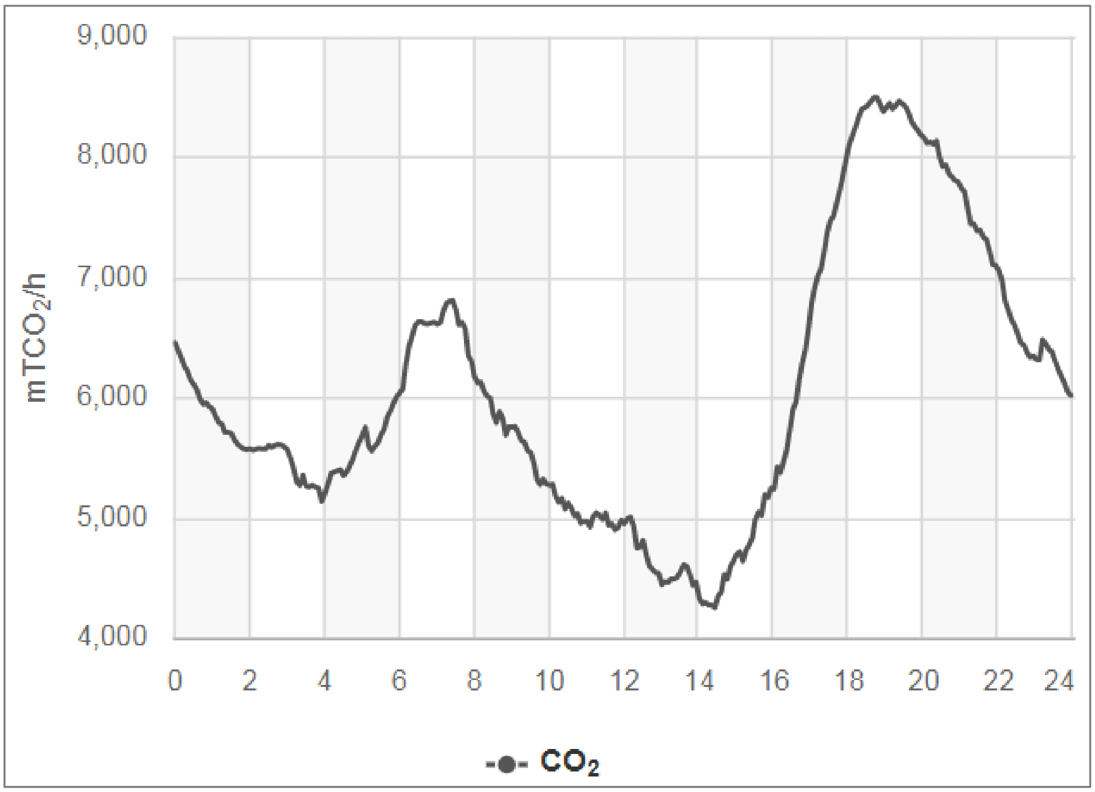
For 2018, although the City's portfolio had significant surpluses of carbon neutral power (from long-term contracts) in some hours and significant deficits of carbon neutral power in others, staff's analysis shows that the City's electric portfolio was 99.6% covered by carbon neutral resources: out of a net load of 906,251 MWh the City had net purchases of short-term (and carbon emitting) market power of 3,638 MWh. Despite this, depending on the emissions accounting approach chosen, the City's electric portfolio can be found to contribute anywhere from -2,038 mT to +17,675 mT of net CO_2 emissions over the course of the year.

BACKGROUND

In 2013, City Council approved the Carbon Neutral Electric Supply Plan (Staff Report 3550, Resolution 9322). The accounting methodology adopted in that Plan simply required that the

City's annual net purchases of carbon neutral supply resources equal its annual load at Citygate. At the time, this was a fair and reasonable approach—since the carbon emissions intensity of the overall electric grid didn't vary significantly at the time, it didn't matter very much whether (or when) the City had periodic surpluses or deficits of carbon neutral power, so long as the City's portfolio was balanced on an annual basis. But more recently, with the surge of solar PV installations in the state, it has become apparent that the emissions intensity of grid power varies significantly on both an hourly and a seasonal basis. See Figure 1 below for a representative graph of the emissions associated with energy delivered across the California Independent System Operator (CAISO) footprint for one recent day.

Figure 1: Hourly Average Carbon Emissions Rates of CAISO Electricity for March 6, 2019



Given that the City receives a significant fraction of its electricity supplies from solar and other summer-peaking resources, it routinely has excess power (during the middle of the day and in the summer months) as well as periods with large deficits of power (at night and in the winter months). (See Attachment A for more details on the City's daily and monthly load and resource balances.) Given this seasonal imbalance and the changing emissions profile of grid electricity (as shown in Figure 1), it is a good time to re-evaluate the City's assessment of the carbon impact of its electricity supply, as the UAC has noted several times over the past few years.

Most recently this issue was discussed in June and September 2018, when staff presented reports related to the EIRP. Those discussions occurred in the context of considering whether to rebalance the City's portfolio of long-term electric supply resources in order to better match the City's electric supplies with its load.[1] At these meetings, UAC Commissioners also touched on the need for staff to be clear and accurate in public messaging related to the carbon content of the electric supply portfolio.

Another relevant discussion on this topic occurred in December 2017, when staff delivered a report to the UAC on potential changes the City could make to its strategy for complying with its Renewable Portfolio Standard (RPS) and Carbon Neutral Plan objectives. In that discussion, UAC Commissioners made clear that they feel the City should focus on minimizing the cost and the carbon content associated with the electric supply portfolio, and not to focus on its RPS level.

DISCUSSION

Carbon Accounting Methodologies

This report will assess the total carbon content of the City's actual electricity supplies over the past two calendar years under six different accounting methodologies. Two of these are annual accounting methodologies, and two utilize hourly carbon accounting. In addition, the two hourly accounting methodologies can utilize two different types of carbon emissions intensity data—a distinction that will be discussed further below. The four major carbon accounting methodologies are the following:

1. The City's Current Method (Method A) – This approach, which is based on The Climate Registry's (TCR's) Electric Power Sector (EPS) protocol, entails a comparison of annual electric supplies and load. If the annual quantity of carbon neutral resources is at least as great as the annual load, then the portfolio is deemed carbon neutral for the year. In addition, unbundled Renewable Energy Certificates (RECs) can be purchased in order to make generic market energy purchases effectively carbon neutral.
2. The Proposed Power Content Label (PCL) Method (Method B) – The California Energy Commission (CEC) has proposed an accounting methodology, in order to implement Assembly Bill (AB) 1110,[2] that is similar to the City's current method (it involves an annual summation of resource supplies and load). Except under the CEC's proposal, unbundled REC purchases would not be allowed to neutralize the carbon content of generic market energy purchases.
3. Hourly Accounting Method #1 (Method C) – This approach entails an hourly comparison of the City's supplies and load, rather than an annual one. Each hourly net energy value would be assigned an hourly carbon emissions intensity (in metric tonnes of CO_2 per megawatt-hour, mT CO_2/MWh) to convert it to an hourly emissions total. These hourly emissions totals would then be summed across the hours in a year. In addition,

[1] This topic has been a focus for others in the electricity sector recently as well. Google, for example, announced its intentions in October 2018 to match its global data center load with carbon-free energy supplies on a 24x7 basis. https://www.blog.google/outreach-initiatives/sustainability/internet-24x7-carbon-free-energy-should-be-too/

[2] AB 1110 (2016) requires that every load-serving entity (LSE) include an annual average carbon emissions intensity factor associated with its electricity supplies on its Power Content Label, starting with the 2019 PCL (which will be published in 2020). For details on the CEC's proposed accounting methodology, see the latest draft regulations and rulemaking documents here: https://www.energy.ca.gov/power_source_disclosure/16-OIR-05/.

unbundled REC purchases *would* be allowed to neutralize the carbon content of generic market energy purchases.

4. Hourly Accounting Method #2 (Method D) – This approach is the same as Hourly Accounting Method #1, except that unbundled REC purchases would not be allowed to neutralize the carbon content of generic market energy purchases. This is essentially the hourly accounting analog of the Proposed Power Content Label Method discussed above.
5. Hourly Accounting Method #1a (Method E) – Identical to Method C, except that it uses marginal instead of average hourly emissions factors, as discussed below.
6. Hourly Accounting Method #2a (Method F) – Identical to Method D, except that it uses marginal instead of average hourly emissions factors, as discussed below.

Marginal versus Average Hourly Emissions Factors

In addition to deciding whether to use annual or hourly accounting approach, another important consideration in this discussion (if the City opts for the hourly approach) is whether to use hourly *average* or hourly *marginal* emissions factors. Average emissions factors look at the total carbon emissions occurring in an entire system (in this case, the CAISO balancing area) in an hour, and the total amount of electricity generated in that time—the ratio of the two is the hourly average emissions rate. Marginal emissions factors are a measurement of how the grid's emissions change with a small change in electricity load. In other words, if one were to add one MWh of load to the grid during a given hour, the marginal emissions factor would be the emissions factor of the power plant whose output would increase to serve that one MWh. Marginal emissions rates take into account the operating cost of different types of power plants, telling you that when total demand is low the units with the lowest operating costs (which are typically the most efficient and least polluting units) are the ones that stay online; and as demand ramps up, the grid operator calls on increasingly costly (and higher polluting) units to meet the incremental demand.

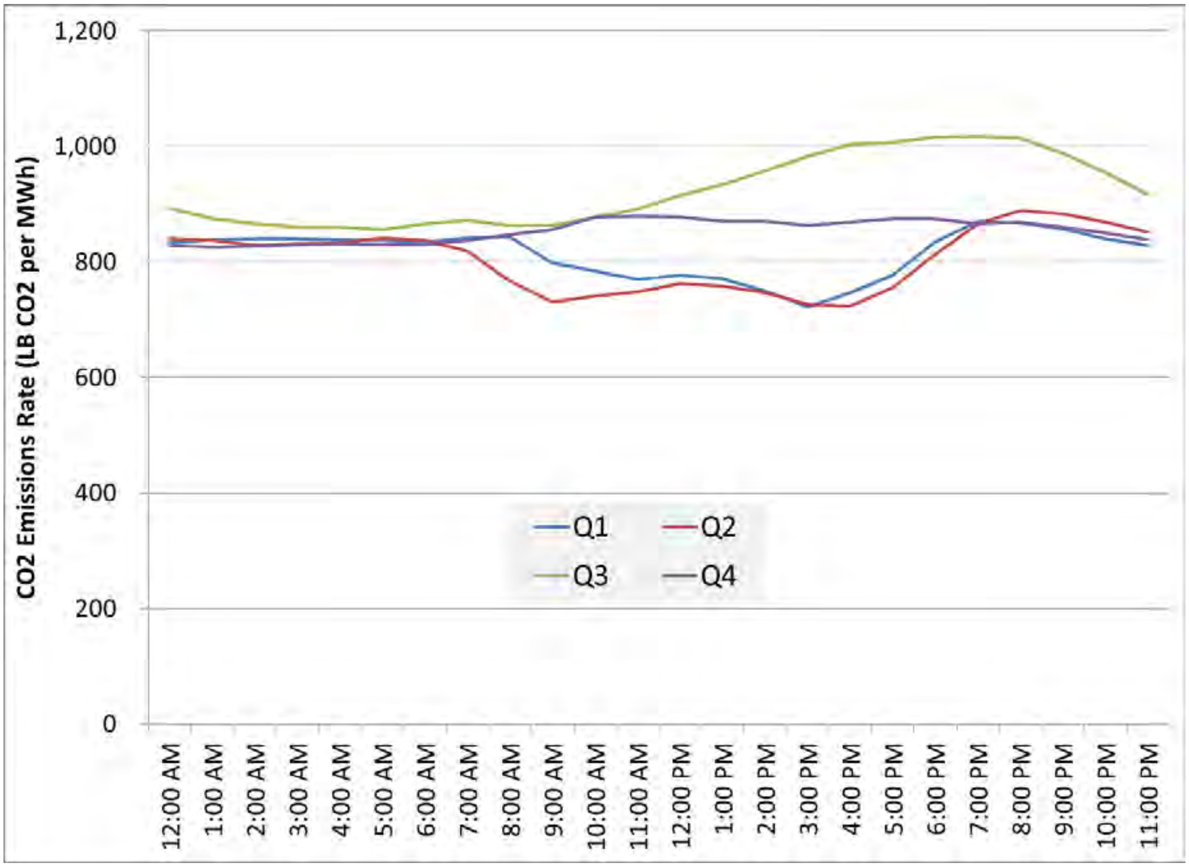
Although the distinction may appear inconsequential, the two values often differ greatly and therefore the choice of which one to use has a large effect on the total emissions calculation. Figure 2 below depicts the hourly *marginal* CO_2 emissions rates[3] in CAISO for 2018 (with each line representing the average value for a given quarter), while Figure 3 depicts the hourly *average* values.[4] Clearly, both the shape and the overall emissions levels differ significantly between the two sets of data. The hourly marginal emissions rates, shown in Figure 2, are not only higher overall than the average rates, but much flatter as well. (Although, this being an average of all emissions rates in a given hour for each quarter, this representation masks a significant amount of variability in the dataset.) This indicates that, no matter the month or the

[3] Marginal emissions data was obtained from WattTime, a nonprofit that uses software to track marginal emission rates across the US power grid every five minutes. They have developed an Automated Emissions Reduction (AER) tool that allows utilities and other end users to reduce emissions from energy by shifting the timing of flexible electricity use to sync with times of cleaner energy and avoid times of dirtier energy.

[4] Average emissions data was obtained, also on a five-minute basis, directly from CAISO: http://www.caiso.com/TodaysOutlook/Pages/emissions.aspx.

time of day, for the most part combined-cycle natural gas units tend to be the marginal resources in CAISO, being turned up or down depending on fluctuations in overall demand.[5]

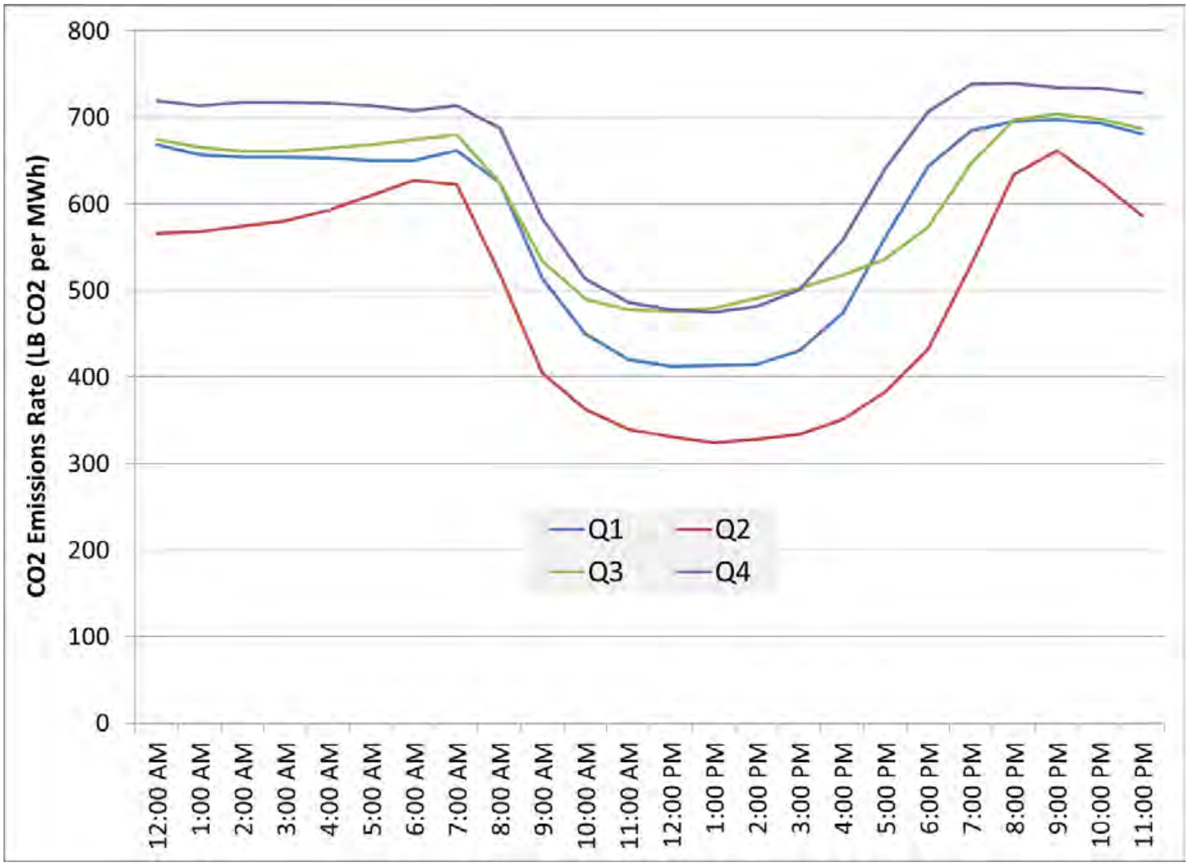
Figure 2: Hourly Marginal CO_2 Emissions Rates for CAISO in 2018



The hourly average emissions rates shown in Figure 3, on the other hand, more clearly demonstrate the impact of all of the solar generation on the grid—resulting in a lower overall value, and a huge dip in the middle of the day when the sun is out.

[5] The middle-of-the-day dip in the lines for Q1 and Q2 in Figure 2 indicates that once in a while during these quarters it is the solar units that are the marginal units on the grid. In these instances, demand is likely so low that market prices across the grid are negative, resulting in some solar units voluntarily curtailing their output, even though they have zero marginal cost to operate. Similarly, the hump in the Q3 line for the evening hours indicates that this tends to be a time of stress on the grid—when demand is rather high and solar production is in decline—and therefore less efficient "peaking" generators are brought online.

Figure 3: Hourly Average CO_2 Emissions Rates for CAISO in 2018



For the purpose of calculating the City's total emissions over the course of a year, staff recommends that *average* CO_2 emissions rates should be used. Although marginal emissions values are a useful indicator for an individual to use in deciding when to use electricity—say, when to charge their electric vehicle or turn on their air conditioner—or for regional energy planning purposes, they are less useful in this situation. The City cannot simply switch its entire load on or off, and it certainly cannot do so for periods in the past; therefore staff will primarily use hourly average emissions data throughout the remainder of this report. For determining the contribution of a portion of the grid to the overall emission occurring on the grid—particularly for a period of time in the past—average emissions intensities are a much more appropriate indicator.

Carbon Accounting Analysis Results

The City's current electric supply portfolio is comprised of the following major types of resources:

- Hydroelectric resources (both federal hydro and City-owned hydro);
- RPS-eligible resources (solar, wind, and landfill-gas resources);
- Distributed energy resources (DERs), including energy efficiency and rooftop solar; and
- Market power purchases, matched with RECs, for monthly/hourly portfolio balancing.

For purposes of this analysis, DERs will not be explicitly considered. The analysis focuses on resources that are delivered to the Citygate meter; DERs are considered behind-the-meter and simply reduce the City's load as measured at Citygate. The 2017 and 2018 net annual volumes (in MWh) of each of these types of resources are summarized in Table 1 below.

Table 1: Palo Alto Electric Supply Resources in MWh (2017-2018)

	CY 2017	CY 2018
Hydroelectric	667,772	342,419
Solar	329,938	342,640
Wind	97,239	107,414
Landfill Gas	107,495	110,140
Net Market Power	(255,795)	3,638
Total Load	946,649	906,251
Carbon Neutral Supplies (% of Total Load)	127.0%	99.6%

2017 was an extremely wet year, with hydroelectric generation totals far above average levels. As a result, the City sold 255,795 MWh of surplus electricity in the market. 2018 saw much closer to average hydroelectric conditions, so this analysis will focus primarily on data from that year. In 2018 the City bought 3,638 MWh (net) in the market over the course of the year, and needed to buy 3,638 MWh in unbundled RECs to meet the requirements of the Carbon Neutral Plan.

Table 2 below summarizes the total emissions (and emissions intensities) calculated for the City's 2018 electric portfolio (including a hypothetical purchase of 3,638 additional unbundled RECs to neutralize the net market power purchases) under each of these different approaches. Depending on the accounting approach taken, the City's portfolio can be found to contribute anywhere from -2,038 mT to +17,675 mT of net CO_2 emissions over the course of the year.

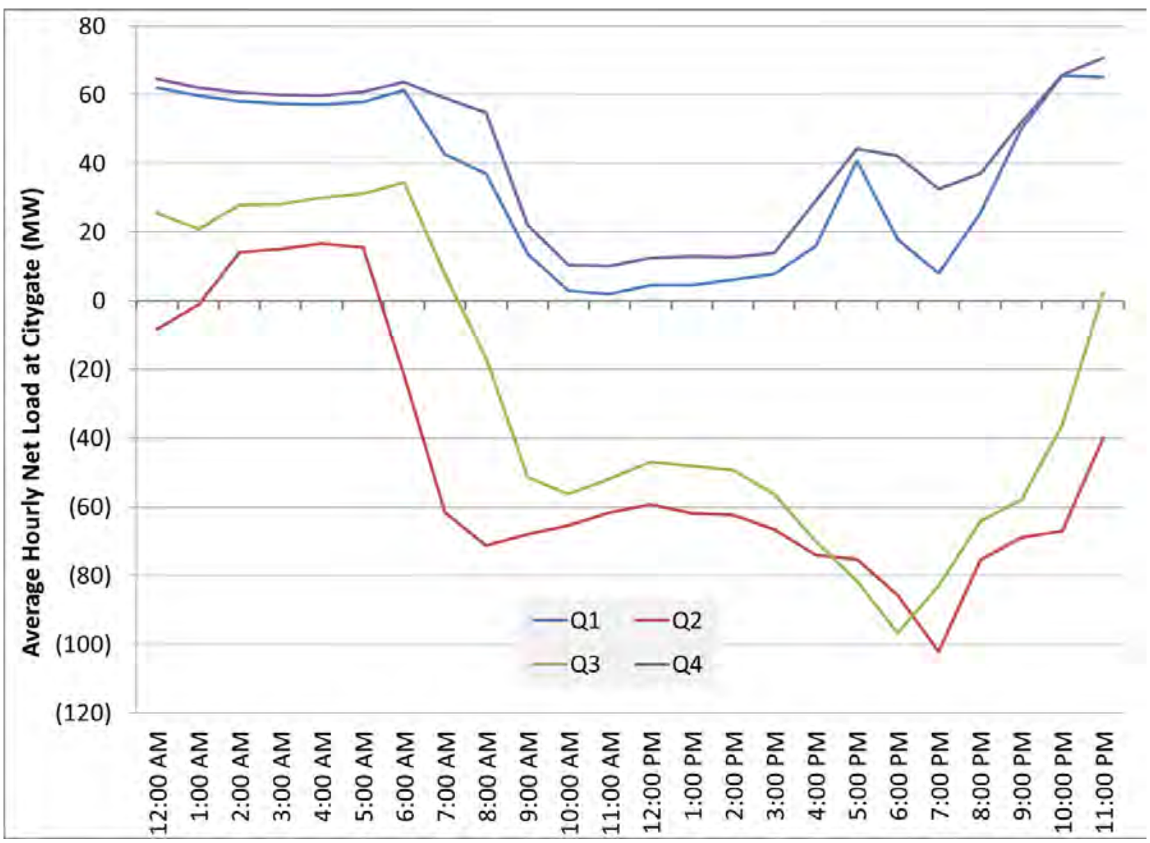
Table 2: Annual Net CO_2 Emissions and Emissions Intensity for the Electric Portfolio in 2018 under Six Accounting Methodologies, with Purchase of 3,638 Unbundled RECs

	Unbundled RECs = Carbon Neutral			***Unbundled RECs = Market Power***		
	Method	**Net Emissions (mT)**	**Emissions Intensity (lb/MWh)**	***Method***	**Net Emissions (mT)**	**Emissions Intensity (lb/MWh)**
Annual Accounting	***A***	0	0	***B***	1,557	3.8
Hourly Accounting (Average Emissions Factors)	***C***	16,118	39.2	***D***	17,675	43.0
Hourly Accounting (Marginal Emissions Factors)	***E***	(2,038)	(5.1)	***F***	(526)	(1.3)

For 2018, based on the generation and load data in Table 1, under the City's current carbon accounting method, the supply portfolio would be considered carbon neutral if 3,638 RECs (a volume equal to the number of MWh of net market power purchased that year) are procured. This corresponds to "Method A" in Table 2 above. However, under the CEC's proposed PCL methodology—which does not permit unbundled RECs to be counted as carbon-neutral resources—the City's portfolio would not be considered carbon neutral ("Method B"). Under the CEC's current draft regulations, an emissions factor of 0.428 mT CO_2/MWh would be applied to the City's net market power purchases for this year, resulting in an annual average emissions intensity of 3.8 lb CO_2/MWh (and total emissions of 1,557 mT CO_2) for the overall supply portfolio.

Using hourly metered generation and load data for 2017 and 2018, along with the five-minute interval emissions data described above, staff also calculated the City's total annual emissions under the hourly accounting approaches. Staff first acquired hourly load data at Citygate and subtracted from that the hourly generation data for all resources in the City's portfolio. The result—the net load at Citygate—is plotted in Figure 4 below for 2018, with each line representing the average hourly net load profile for a given quarter of the calendar year.

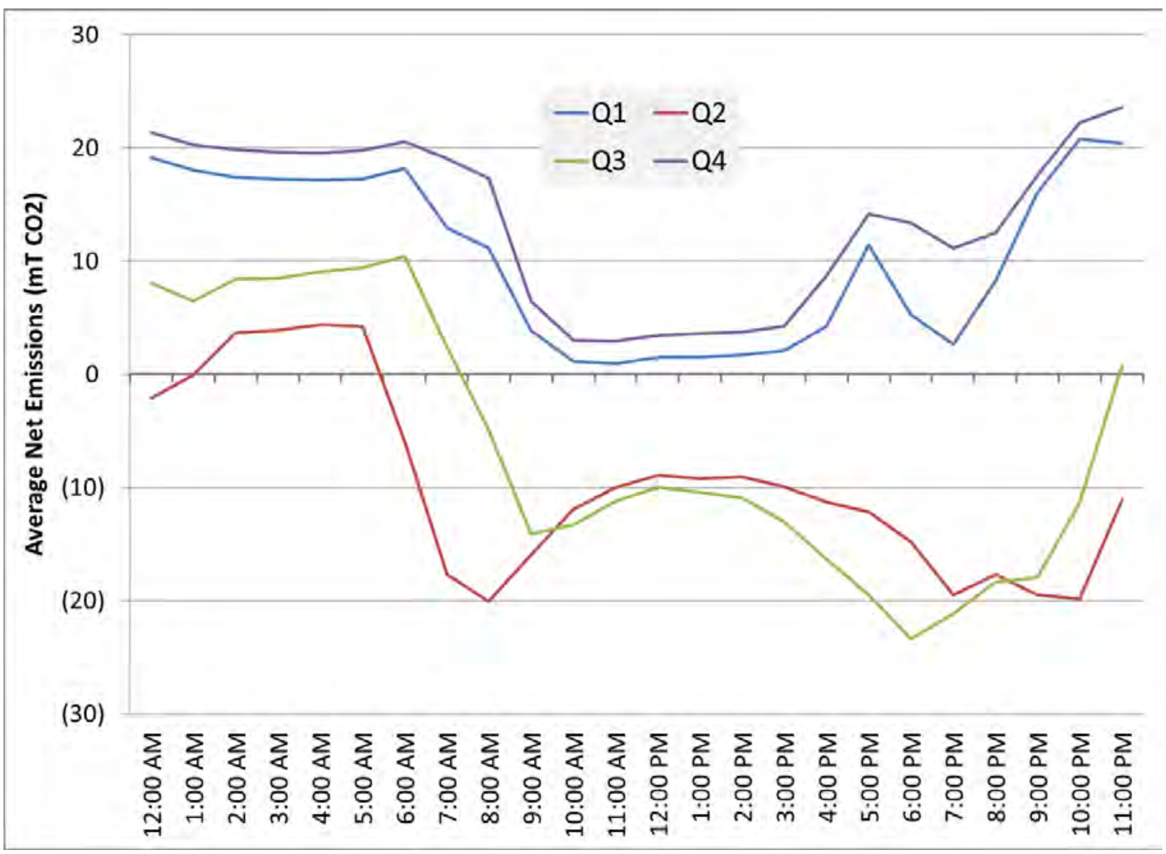
Figure 4: Average Hourly Net Load Profile at Citygate in 2018 (MW)



In this data, a positive value reflects an energy deficit, with the City being a net purchaser of market power from the CAISO grid; conversely, a negative value represents the City have a surplus of carbon neutral energy that is sold into the CAISO grid. Here one can clearly see the distinct mid-day dip in net load created by the generation from the City's solar resources, as well as a second, sharper dip in the evening hours. The latter is the product of the City's dispatchable hydroelectric generation being shaped into these high-value hours, when market prices tend to surge with the decline in daily solar output and the rise of system-wide net demand.

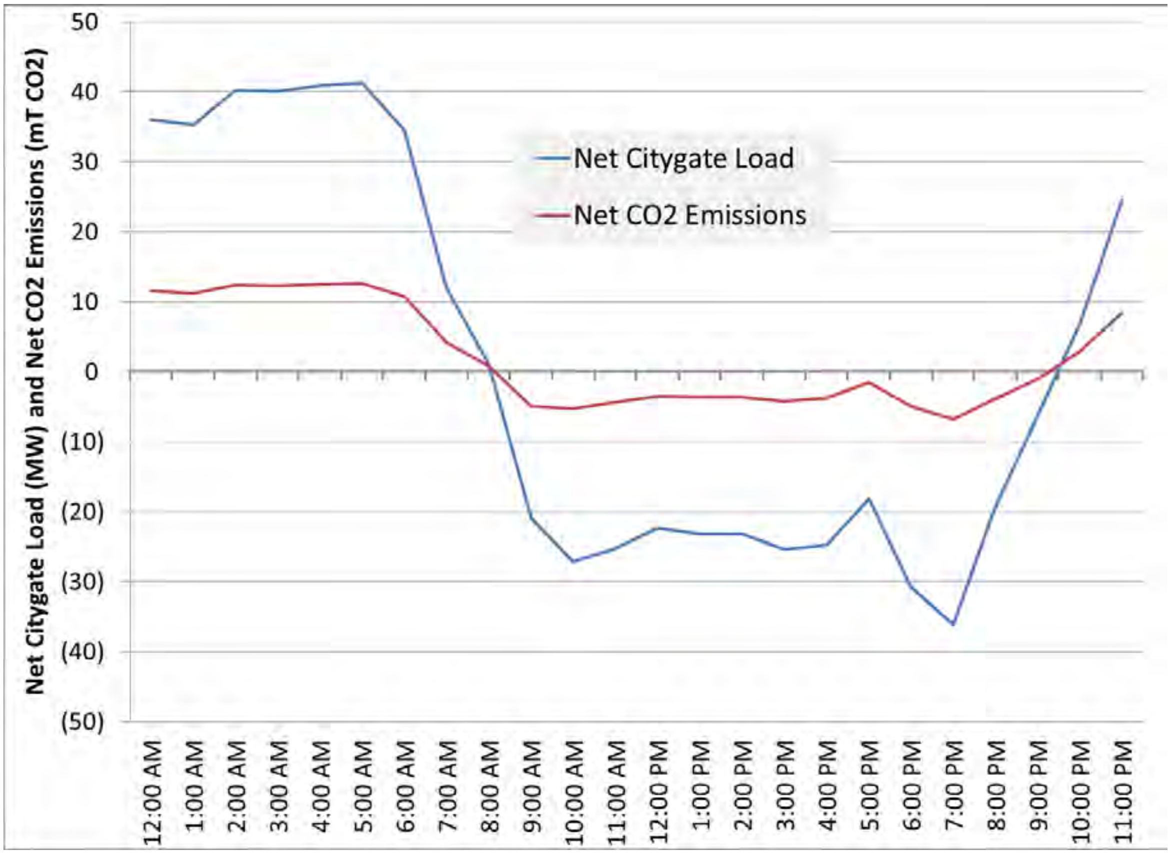
Each of these hourly net position values—whether deficit (positive net load) or surplus (negative net load)—was then weighted by the average CAISO emissions intensity factor (graphed in Figure 3 above) for that particular hour. The result—the hourly carbon emissions impact of the City's electric supply and load profiles—is shown below in Figure 5 for 2018. For the most part, the net emissions profiles in this graph closely mirror the profiles of the City's net load, in Figure 4 above. The primary difference is that in the summer months when the bulk of the City's solar generation occurs (Q2 and Q3), the major mid-day dip is blunted significantly due to the much lower average emissions intensities in this period. This means that the City's portfolio is not receiving as much of an emissions reduction benefit from this excess generation as it would during other periods, because the overall grid is so much cleaner during this period when the City's major surpluses of energy are occurring.

Figure 5: Average Hourly Emissions Profile at Citygate in 2018 (mT CO_2)



For the year as a whole, Figure 6 below presents a combination of the two datasets discussed above (net Citygate load, in MW, and net CO_2 emissions, in mT CO_2), for the "average day" in 2018.

Figure 6: Annual Average Hourly Net Load and Net CO_2 Emissions for 2018



Summing across all hours in the year, this calculation shows that under this accounting approach the City's electric supply portfolio is responsible for 17,675 mT of CO_2 emissions for 2018 (which translates to 43 lb of CO_2 emissions per MWh consumed). This corresponds to "Method D" in Table 3 above. For comparison, Table 3 below shows that if *marginal* hourly emission factors were used in this calculation, rather than average emissions factors, the City's electric supply portfolio was responsible for slightly reducing emissions across the grid—despite the fact that the City was a net purchaser of market power for the year. This corresponds to "Method F" in Table 3 above. This reflects the fact that hourly marginal emissions factors (shown in Figure 2 above) are much flatter, and therefore do not discount the emissions benefits of the City's excess solar generation. Marginal emissions factors also peak in the summer evening hours, when a significant amount of the City's hydroelectric generation occurs. So under this accounting treatment, the City's hydroelectric generation is credited with displacing dirtier grid power, while the City on average uses more energy in somewhat lower carbon hours.

Table 3: Hourly Total Emissions and Emissions Intensities under Average and Marginal Emissions Factors for 2018 (mT CO_2 and lb CO_2/MWh)

	Average	Marginal
Total CO_2 Emissions (mT CO_2)	17,675	(526)

CO_2 Emissions Intensity (lb/MWh)	43.0	(1.3)

Treatment of Unbundled RECs

The final issue to address in selecting a carbon accounting methodology is how to treat purchases of unbundled RECs in the calculation. As discussed above, the City's current accounting framework treats purchases of generic market power, when matched with an equal volume of unbundled RECs, as equivalent to a purchase of carbon-free renewable energy. However, the approach proposed by CEC staff for calculating a utility's average annual emissions intensity would not credit these REC purchases with any emissions benefit at all.

Staff firmly believes that the CEC's proposed approach of discounting the emissions benefits of unbundled RECs is flawed and will create confusion for customers—and staff has submitted formal comments (through the Northern California Power Agency) to the CEC expounding on this argument.[6] Among other reasons, the CEC's proposed approach is problematic because it fails to recognize that the state legislature has specifically authorized utilities to use RECs and imported renewable energy to meet their renewable energy compliance mandates. This approach also ignores industry practices that recognize that unbundled RECs represent all of the environmental attributes—including the emissions profile—of the underlying resource that produced them, and are acquired at a premium for that reason.

Still, staff recognizes that if the CEC formally adopts their proposed accounting methodology when the AB 1110 implementation regulations are finalized later this year, it could present customer communications challenges if the City adopts a different accounting approach that recognizes the full environmental benefits of unbundled RECs.

The alternatives to treating purchases of unbundled RECs as carbon neutral resources in a carbon accounting framework are: (1) authorize the purchase of an alternative type of resource, such as carbon offsets, for neutralizing whatever net positive emissions the City's resources are found to be responsible for, (2) purchase *bundled* RECs and energy, on a short-term basis, to offset any net market power purchases, or (3) simply accept that in some years, particularly dry hydro years, the City's electric supply portfolio will not be carbon neutral. However, using the carbon offset approach—just as the City's natural gas utility currently does—would lead to the same types of communications challenges as the unbundled REC approach does. For example, in a dry hydro year a customer would likely receive a Power Content Label informing them that their electricity supply for the prior year had a net positive emissions profile, even though the utility's public messaging indicated that the electricity supply was carbon neutral.[7] And the bundled REC purchase approach would be logistically challenging,

[6] "NCPA Comments re: Revised Staff Proposal on AB 1110 Implementation," submitted February 23, 2018. https://efiling.energy.ca.gov/GetDocument.aspx?tn=222716&DocumentContentId=25474.

[7] Additionally, the CEC has strict guidelines on the language that may be included on Power Content Labels, and would likely prevent the City from displaying any messaging on the PCL that attempted to provide context for the

because the precise volume of bundled energy and RECs that would be needed to eliminate the portfolio's carbon emissions would not be known until a couple of months after the end of the year, while bundled energy and REC purchases need to be executed during the year. As a result, the City would almost certainly over- or under-buy on these purchases. This method would also be rather expensive, as bundled energy and REC purchases carry a large premium (about $18/MWh) compared to unbundled RECs and generic power.

With the City's existing electric supply portfolio, the issue of how to treat unbundled RECs in carbon accounting is of relatively low importance, except in very dry hydro years. As shown in this analysis, in a normal year the City has enough generation from renewable and hydroelectric resources under long-term control to achieve carbon neutrality (or get very close to it) without the use of unbundled RECs. However, if the City elects to change its current RPS compliance strategy—for example, by selling off some of its surplus renewable resources, and/or swapping some of its more valuable in-state renewable resources for less costly unbundled RECs—this issue will become much more important.

CONCLUSION

Based on the analysis results, it is clear that in the era of the Duck Curve, the choice of carbon accounting methodology makes a significant difference in whether the City's electric supply portfolio can be considered carbon neutral or not. Altogether staff evaluated six different carbon accounting methodologies in this report—an annual accounting approach and two hourly accounting approaches, each with two different ways of treating unbundled REC purchases.

Staff's preferred carbon accounting approach is Method C—hourly carbon accounting using average emissions factors and allowing unbundled REC purchases to count as carbon neutral—because it is more accurate than an annual approach, given the current grid power mix, and therefore bestows greater validity on the City's carbon neutral supply claims. This method also treats unbundled RECs in a manner that conforms to both logic and standard industry practice. However, staff recognizes that, depending on the direction ultimately taken by the CEC in the AB 1110 rulemaking process (which we may not know until early 2020), adopting this accounting methodology could lead to messaging consistency issues and customer confusion.

And finally, all of these issues may become much more apparent and take on greater import if the City alters its RPS compliance strategy, selling excess renewable supplies and relying more on unbundled RECs in order to reduce costs.

NEXT STEPS

Staff is seeking feedback from the UAC on the carbon accounting analysis presented in this report. Staff anticipates returning to the UAC this summer to present a follow-up report that provides more detail on the options for mitigating any emissions associated with the City's electric portfolio, and that addresses the financial impacts to the utility associated with the

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non-zero emissions intensity figure.

various carbon accounting methodologies and emissions mitigation options. This follow-up report will also look in more detail at the impact of changing the City's RPS compliance strategy on the carbon accounting results, and present a forecast of CAISO emissions intensities in 2030 prepared for the City by WattTime.

Staff will also continue to closely follow (and comment upon) the CEC's AB 1110 rulemaking process. Depending on the accounting methodology the CEC finally adopts, staff will work to understand how the City's methodology can be aligned with the CEC approach, and, to the degree that it cannot, determine how to explain this difference to customers.

RESOURCE IMPACT

Staff will develop a full assessment of the resource impact of changing the City's carbon accounting methodology in a subsequent report to the UAC. Preliminary indications are that switching to an hourly carbon accounting methodology, using average hourly emissions intensity factors, could result in an increase in supply costs on the order of $5,000 to $10,000 in an average hydrological year, if the City chooses to recognize the emissions reduction benefits of unbundled RECs. If the City were to choose to use carbon offsets rather than unbundled RECs to neutralize its net emissions, the increase in annual supply costs would likely be on the order of $25,000 to $50,000.

POLICY IMPLICATIONS

This report satisfies Initiative #4 of the EIRP Work Plan. This report is also in line with the Sustainability and Climate Action Plan goals of continuing to lower the carbon footprint of the community.

ENVIRONMENTAL REVIEW

The Utilities Advisory Commission's discussion of the City's carbon accounting methodology does not meet the definition of a project under Public Resources Code 21065 and therefore California Environmental Quality Act (CEQA) review is not required.

ATTACHMENTS

A. Details of the City's Load and Supply Resource Balance

PREPARED BY: **JIM STACK,** Senior Resource Planner
LENA PERKINS, Acting Senior Resource Planner

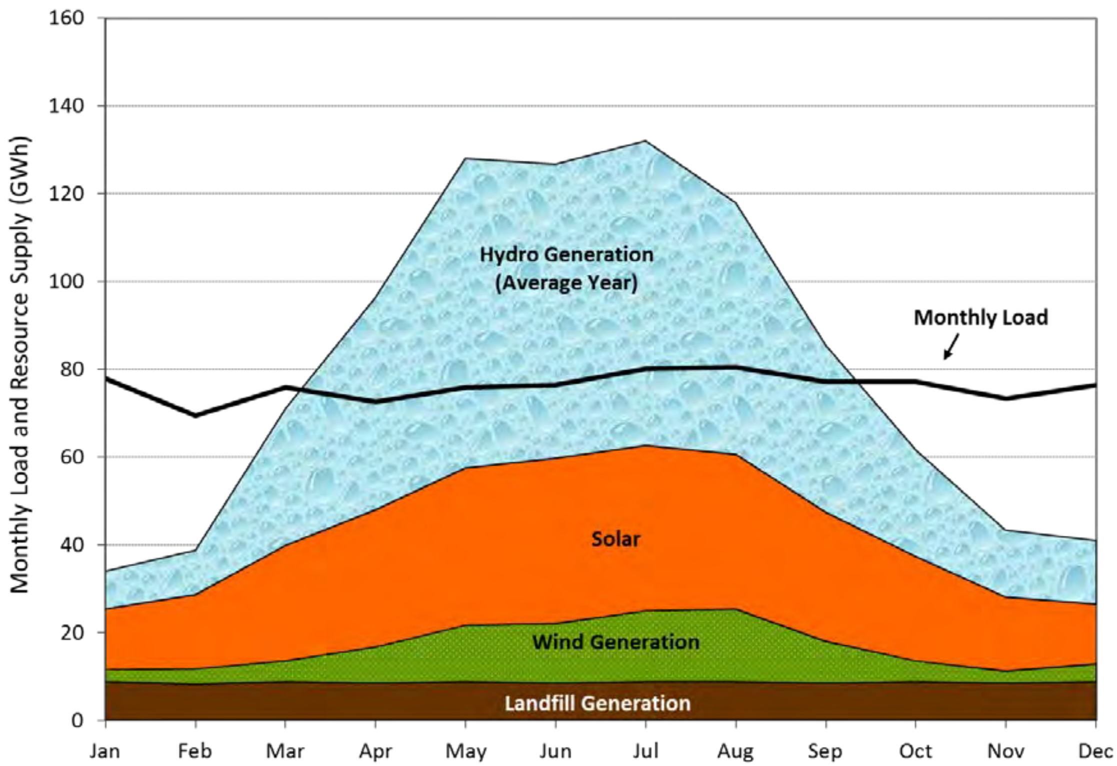
REVIEWED BY: **JONATHAN ABENDSCHEIN,** Assistant Director, Resource Management

APPROVED BY: ____________________________
DEAN BATCHELOR
Interim Director of Utilities

APPENDIX A: Details of the City's Load and Supply Resource Balance

Figure A-1 below presents the City's load and supply resources on a monthly basis for a year with average hydrological conditions, demonstrating the significant net deficit positions that exist in the winter months and the significant surplus positions that exist in the summer months.

Figure A-1: Monthly Total Load and Supply Resource Balance for an Average Hydro Year



And for a more granular look at this data, shown below are two daily/hourly load and resource balance graphs from an average hydro year—for a typical day in January (Figure A-1), when hydro and solar output are both minimal, and for a typical day in July (Figure A-2), when hydro and solar are both in abundance.[8]

[8] These graphs include only the City's hydro and long-term PPA resources; not shown are DERs (which reduce the City's load) and market purchases (which make up the differences, positive or negative, between the City's total purchases and its load).

Figure A-2: Daily Load and Hydro/PPA Supplies for a Typical January Day in an Average Year

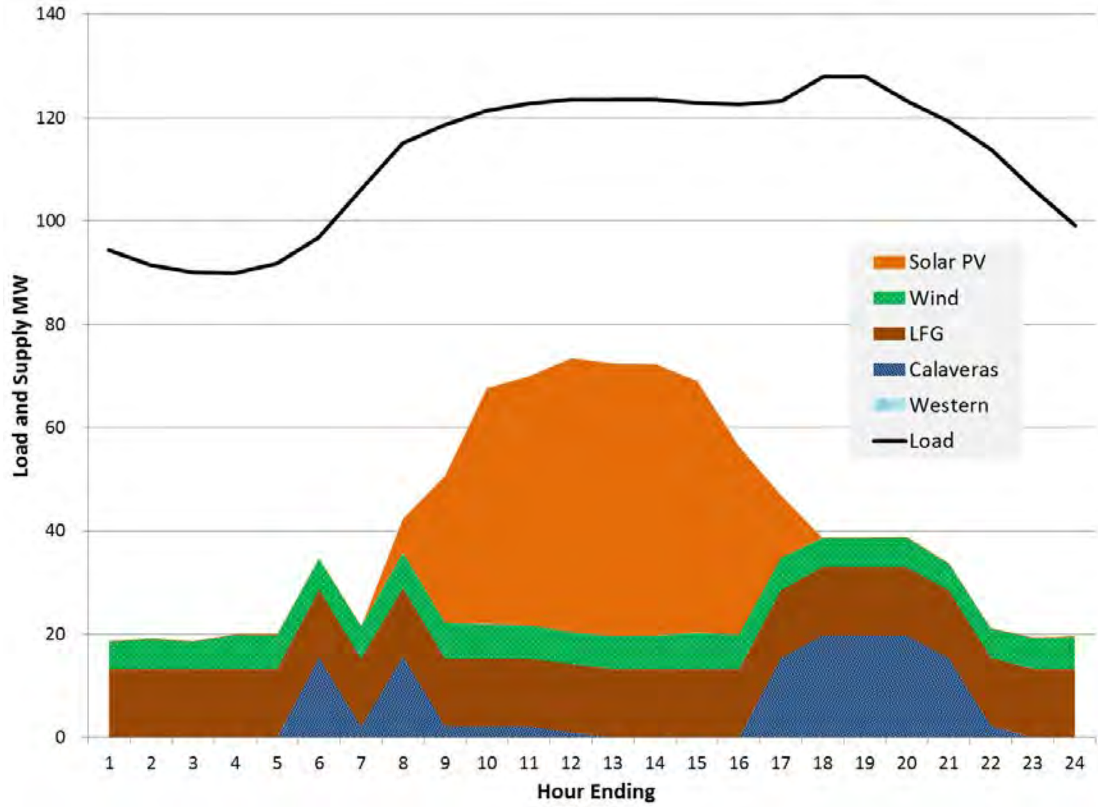
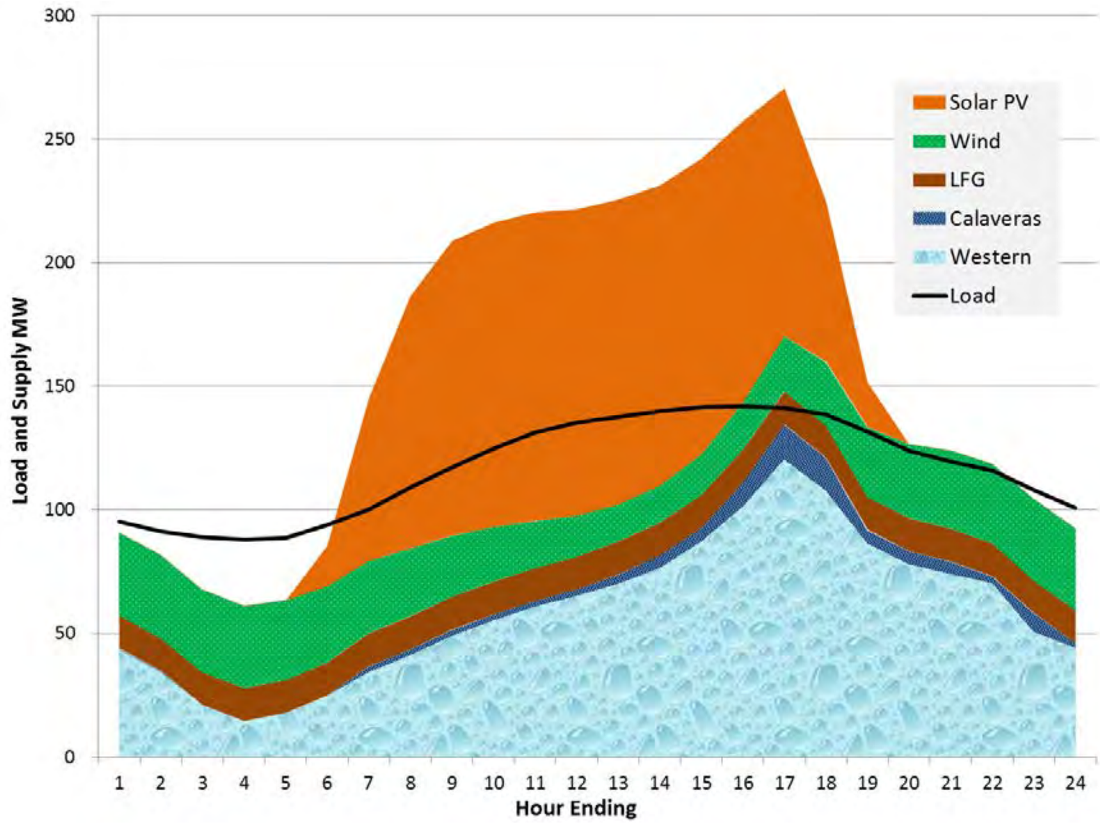
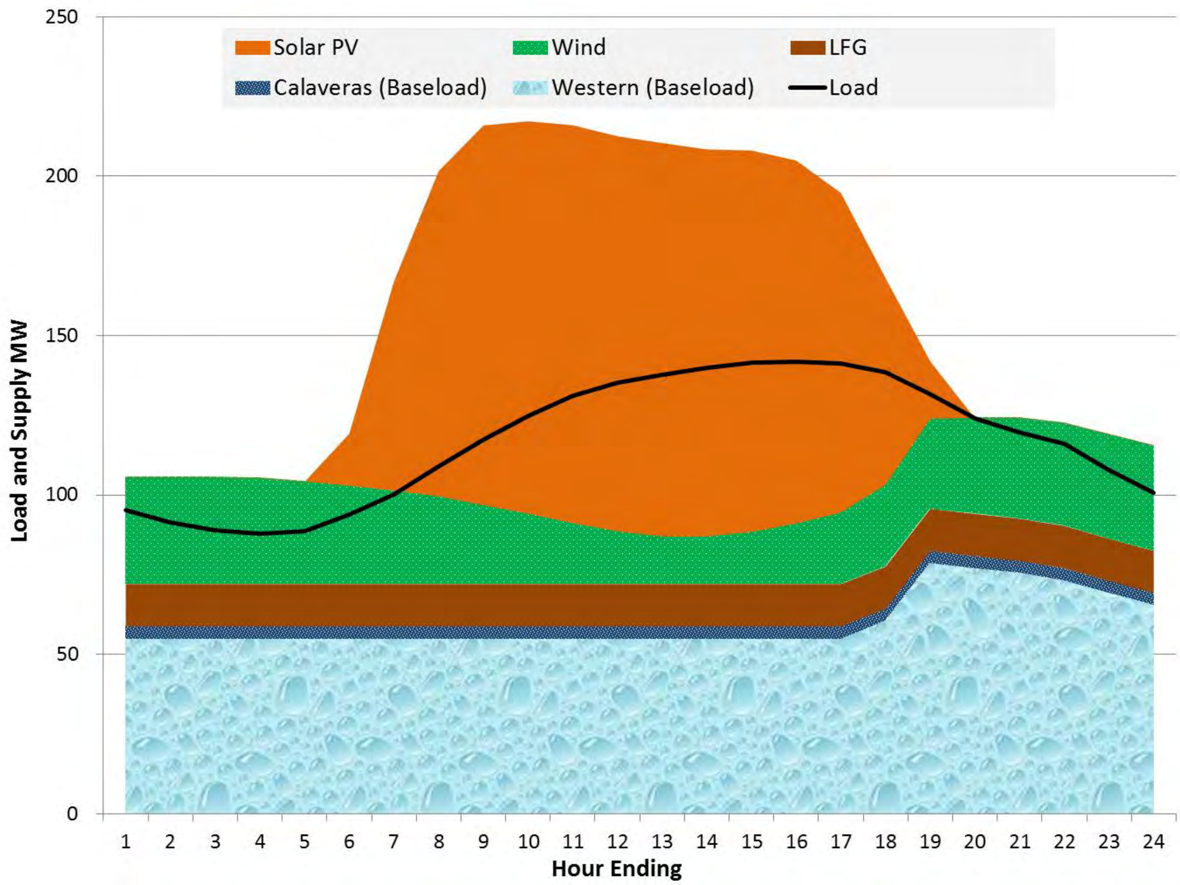


Figure A-3: Daily Load and Hydro/PPA Supplies for a Typical July Day in an Average Year



Note that as hydro is a dispatchable resource, it is currently dispatched to optimize the financial value of the resource, rather than to balance the City's load and supply resources. This explains the odd shape of the July supply profile: market prices tend to peak in the evening hours (when solar output is declining and evening loads are increasing), so the bulk of the hydro generation is concentrated in this period. However, this dispatch pattern could be modified if the City wanted to reduce its reliance on the greater electric grid; for example, the hydro resources could be scheduled like "baseload" resources, which have a steady output level across the day. (However, this output level would still vary seasonally, based on snowpack levels, runoff conditions, and streamflow requirements.) Figure A-3 presents a daily load and resource balance graph for a typical July day where the hydro resources are dispatched in a baseload/load-following manner.

Figure A-4: Load and Resources for a Typical July Day with Hydro as a Baseload Resource



However, it should be noted that although dispatching the City's hydro resources in this manner will likely result in lower net GHG emissions, it would likely result in higher cost to the electric rate payer – preliminarily estimated at a retail rate increase of 1 to 2 percent, or an annual supply cost increase of $1 to $2 M.