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May 10, 2018

Via Electronic Submission

Clerk of the Board
California Air Resources Board
1001 I Street
Sacramento, CA 95812

Re: Powerex Comments on April 26, 2018 Workshop to Continue Informal Discussion on Potential Amendments to Cap-and-Trade Regulation

Dear Chairwoman Nichols and Members of the California Air Resources Board,

On behalf of Powerex Corp., I submit the enclosed comments on the California Air Resources Board ("CARB") April 26, 2018 Workshop to Discuss Possible Revisions to the Cap-and-Trade Regulation (the "Workshop"). Powerex submits these comments with respect to the portion of the Workshop related to aligning CARB's greenhouse gas accounting policy and the energy imbalance market.

Powerex would like to thank the Members of the Board as well as the ARB Staff for their consideration of these comments and for their continued efforts to improve the Cap-and-Trade Program. If you have any questions, please do not hesitate to contact the undersigned.

Kind regards,

/s/

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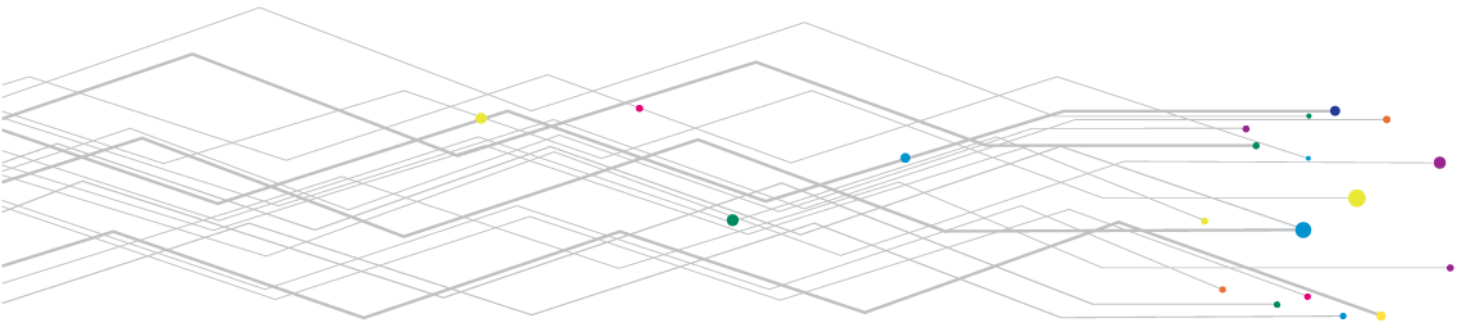
Encl.



Comments of Powerex Corp. on April 26, 2018 Workshop to Continue Informal Discussion on Potential Amendments to Cap-and-Trade Regulation

I. About Powerex

Powerex Corp. ("Powerex") is a corporation organized under the *Business Corporations Act* of British Columbia, with its principal place of business in Vancouver, British Columbia, Canada. Powerex is the wholly-owned energy marketing subsidiary of the British Columbia Hydro and Power Authority ("BC Hydro"), a provincial Crown Corporation owned by the Government of British Columbia. Powerex sells wholesale power in the United States pursuant to market-based rate authority granted by the Federal Energy Regulatory Commission ("FERC") in September 1997, renewed most recently on January 25, 2018.

Powerex sells power from a portfolio of resources in the United States and Canada, including Canadian Entitlement resources made available under the Columbia River Treaty, BC Hydro system capability, and various other power resources acquired from other sellers within the United States and Canada. Powerex has been delivering power to California since shortly after receiving its market-based rate authorization and is currently registered with CARB as an Asset Controlling Supplier ("ACS"). In April 2018, Powerex began participating in the Energy Imbalance Market ("EIM") administered by the California Independent System Operator Corp. ("CAISO"), as a Canadian EIM Entity.

II. Introduction

Powerex submits the following comments on the California Air Resources Board's ("CARB's") April 26, 2018 Workshop to Continue Informal Discussion on Potential Amendments to Cap-and-Trade Regulation.[1] Specifically, Powerex's comments relate to portions of the workshop that focus on aligning CARB greenhouse gas ("GHG") accounting policy and the EIM operated by the CAISO.[2]

Accurate accounting for GHG emissions in the EIM is critical to ensuring that the EIM operates in a manner consistent with CARB's Cap and Trade Program for wholesale electricity serving load in California. This requires accurate tracking of GHG emissions of out-of-state EIM resources serving California load, ensuring that the correct quantity of GHG emission allowances are reported to CARB and retired, in support of statewide GHG emission targets. However, accurate GHG treatment in the EIM requires more than just retiring the right quantity of GHG emission allowances after the fact. It also requires ensuring that the EIM dispatch appropriately considers GHG emission rates from external resources serving California load, and that California real-time electricity prices accurately reflect GHG emissions costs. At the

[1] CARB presentation, *Workshop to Continue Informal Discussion on Potential Amendments to Cap-and-Trade Regulation* (Apr. 26, 2018) ("CARB April 26 Presentation").

[2] CARB April 26 Presentation at 35-37.

same time, the EIM is a regional electricity market that also operates *outside* of California, in states where California's GHG programs and environmental policies do not apply. Hence it is equally important that the EIM not implicitly extend California's rules and environmental policies to the dispatch of resources, and pricing of wholesale electricity, to serve load *outside* of California.

It is now widely recognized that the current EIM algorithm is resulting in significant inaccuracy in the way it attributes GHG emissions of out-of-state resources to California load. Specifically, the EIM algorithm is able to "deem" the output of low- and non-emitting resources to serve California load, even where those resources do not increase output in the EIM above their originally-scheduled levels, while the output of high-emitting resources is increased in the EIM. The ability to increase output from one set of resources while deeming a different set of resources to serve California load has led to a range of unintended consequences, including:

1. GHG emissions for serving CAISO load in the EIM are greatly understated. Absent corrective measures,[3] this leads to too few California GHG emissions allowances being retired, meaning too many GHG emissions allowances remain in circulation and available to support additional emissions under California's Cap and Trade Program.
2. The current EIM algorithm does not efficiently select which resources to dispatch to serve CAISO load.
3. California in-state resources are inefficiently displaced by out-of-state generation.
4. GHG shadow prices—and hence real-time wholesale electricity prices within California—are understated.

As indicated above, the importance of accurate GHG accounting in the EIM goes far beyond simply ensuring that the correct number of GHG emissions allowances is retired. Indeed, the process of procuring and surrendering GHG allowances is merely a mechanism through which the goals of the Cap and Trade Program are achieved; it is not the goal in itself. Powerex understands that one of the core purposes of California's Cap and Trade program, as applied to the electricity sector, is for the cost of GHG emissions to be accurately and consistently reflected in the price of wholesale electricity serving California load. When this occurs, it provides powerful incentives for California load to be served from existing low- and non-emitting resources, and for more of these resources to be developed. But when GHG emissions are not accurately reflected in California wholesale electricity prices, these critical incentives are dampened, or eliminated altogether.[4]

Powerex believes it is also important for CARB to consider that flaws in the EIM's recognition of GHG emissions and the resulting distortions to prices have significant economic implications for a wide range of market participants. For example, these flaws result in all external and in-state suppliers of non-emitting generation to the CAISO grid receiving lower compensation for their

[3] Powerex notes that CARB implemented an interim "bridge solution" to retire additional GHG emission allowances in proportion to the EIM Outstanding Emissions under the current EIM approach. *See* CARB April 26 Presentation at 36-37.

[4] Moreover, due to the inter-related nature of CAISO's organized market, factors that affect outcomes in the real-time market may also affect outcomes in the day-ahead market.

clean generation output and associated investments. In contrast, external GHG-emitting resources participating in the EIM receive materially increased compensation and expanded opportunities to sell their generation output to California, compared to an EIM design that accurately accounts for these resources' emissions. Finally, load-serving entities inside California benefit from wholesale electricity prices that are depressed by the failure to properly reflect GHG emissions from out-of-state resources that serve California load in CAISO's real-time market. Powerex believes that the often diverging interests and objectives of entities have added to the challenge of considering potential technical solutions to an already complex issue.

The extent of the inaccuracy under the current EIM algorithm has been examined in numerous other forums, including CAISO's stakeholder process on this topic. Appendix B contains an analysis submitted as part of Powerex's comments to CAISO in December 2017. As demonstrated by this analysis, the current EIM algorithm has resulted in the large majority of EIM imports serving California load deemed from non-emitting resources, with some imports deemed from natural gas resources and virtually none from coal-fired resources. In stark contrast, an examination of data on EIM transfers between balancing authority areas ("BAAs") shows that, during the intervals that the CAISO BAA was importing EIM energy, the BAAs that comprise the large majority of EIM net exports are the PacifiCorp East and Arizona Public Service Company BAAs. While both PacifiCorp and Arizona Public Service Company have invested in significant quantities of renewable non-emitting resource additions in recent years, the resource mix in their respective BAAs continues to consist predominantly of coal and natural gas generation. Consequently, it is highly likely that the external resources that are actually serving California load in the EIM are mostly coal and natural gas resources, with an average GHG emissions rate that may be materially higher than the default emission factor for unspecified electricity imports. If this is true, then CARB's calculation of "EIM Outstanding Emissions" is likely to materially understate the actual GHG emissions associated with EIM imports serving California load.[5]

Since 2016, CARB, CAISO and stakeholders have invested extensive effort to identify enhancements to the EIM algorithm that would ensure more accurate treatment of GHG emissions. Powerex has been an active stakeholder participant in these efforts, and believes that significant progress has been made in recognizing the unintended consequences of the current EIM design, and in identifying potential improvements. CAISO recently published its proposed approach to improving how the EIM will recognize and account for GHG emissions from out-of-state resources dispatched in the EIM to serve load in California. Powerex is hopeful that the proposal will improve the attribution of GHG emissions in the EIM.

As CARB's April 26 Presentation notes, however, CAISO's proposal "addressed some, but not all GHG accounting issues[.]"[6] This is consistent with CAISO's recognition that its latest proposal will reduce, but not eliminate, the potential for GHG emissions leakage. Powerex strongly supports CAISO's proposal as a significant improvement over the *status quo,* and

[5] *See* CARB Mandatory Reporting Regulations § 95111(h)(1), which calculates "EIM Outstanding Emissions" based on applying the default emission factor for unspecified electricity imports to EIM imports serving California load.

[6] CARB April 26 Presentation at 36.

believes the proposed enhancements should be implemented as soon as possible. That said, Powerex believes that the remaining opportunities for inaccurate deeming of GHG emissions are likely to be substantial, and continued vigilance and improved monitoring will be vital to ensuring the EIM performs in a manner consistent with the rules and objectives of CARB's Cap and Trade Program.

To support this critical oversight function, Powerex believes that CARB should implement a more accurate methodology for assessing the GHG emissions for California loads served through the EIM (i.e. Total California EIM Emissions[7]). This will permit CARB to accurately assess on an ongoing basis:

1. The current extent of EIM GHG inaccuracies, by comparing the actual average emissions rate of the external resources that increase their output during intervals when the CAISO BAA is importing to the GHG emissions attributed under the EIM's "deemed delivered" approach;
2. The magnitude of improvements in EIM GHG accuracy resulting from implementation of the CAISO's proposed EIM design enhancements; and
3. The extent of GHG emissions leakage that occurs after these enhancements are implemented.

A methodology that objectively and accurately measures residual EIM GHG emission leakage can be used to:

1. Inform CARB on the amount of additional GHG emission allowances that need to be retired, either by CARB itself or by "EIM Purchasers";
2. Inform CARB's decisions regarding whether additional measures are required to address EIM GHG emission leakage and hence whether further improvements to the EIM design may need to be pursued; and
3. Provide CARB with insights that may be useful in the context of a potential day-ahead regional market.

III. Proposed Method for Assessing Accuracy of Reported EIM GHG Emissions Serving California Load

Under the current EIM design, the reporting of GHG emissions associated with serving California load in the EIM has been the direct result of the algorithm used by the EIM software to "deem" or assign the output of out-of-state resources to either (a) serving California load; or (b) serving non-California load.[8] The problem is that the designation of whether an out-of-state resource (and its GHG emissions) serve California load, as opposed to non-California load, has a direct impact on the total production costs of EIM dispatch, which the EIM software attempts to minimize. Currently, the EIM algorithm can minimize these total costs either by actually

[7] *Supra* note 5.

[8] *Supra* note 3. Powerex recognizes that CARB has implemented an interim "bridge solution" to retire additional GHG emission allowances in proportion to the "EIM Outstanding Emissions".

dispatching resources with lower GHG emissions, or by simply "deeming" California load to be served by the lowest-emitting resources in the footprint. The former genuinely takes GHG emissions into account when serving California load—as intended under the Cap and Trade Program—whereas the latter merely gives the appearance of doing so.

CAISO's recent proposal to improve how the EIM incorporates GHG emissions into its dispatch algorithm should materially reduce the extent to which out-of-state non-emitting resources can be deemed to serve California load. Specifically, a resource would be able to be deemed to serve California load only up to the available "headroom" above the resource's base scheduled (*i.e.*, scheduled to serve load prior to EIM dispatching) output level. For instance, a 100 MW hydro resource that is fully base scheduled prior to the EIM timeframe would have no upward "headroom" that could be dispatched in the EIM, and hence none of its output could be deemed to serve California load. This is a significant improvement over the *status quo,* in which the entire 100 MW output of the resource could be deemed to serve California load, even though all of this output had been scheduled in advance of the EIM to serve load outside of California.

While Powerex is hopeful that this approach will improve the alignment between the resource output that is deemed to serve California load and the resource output that is actually dispatched in the EIM, the potential for substantial misalignment will remain. For instance, if a 100 MW hydro resource is base scheduled for 60 MW, then it could be deemed to serve up to 40 MW of California load, *even if its output is entirely unchanged in the EIM.* In this case, there would still be an opportunity for the EIM software to (1) increase the output from a GHG-emitting resource such as a gas or coal unit by 40 MW; (2) import 40 MW to serve California load; and (3) deem the 40 MW of imports to the non-emitting hydro plant—rather than to the resource that actually increased output—and thus report that there were no GHG emissions associated with serving California load in the EIM in this interval.

CARB's Mandatory Reporting Regulations provide for a comparison of the EIM's "deemed delivered" attribution of GHG emissions to an estimate based on the emission factor for unspecified electricity imports. However, Powerex believes the results of the EIM reporting of GHG emissions associated with serving California load can and should be compared to the GHG emissions of out-of-state EIM participating resources *actually dispatched to increase output*. Powerex believes such a calculation would more accurately reflect "the full GHG emissions experienced by the atmosphere from imported electricity under [the] EIM[.]"[9] This more accurate calculation would facilitate a more accurate retirement of additional GHG emission allowances associated with actual residual leakage in the EIM.

This calculation should be performed for each 5-minute interval in which the CAISO BAA is a net importer of EIM transfers (*i.e.,* when CAISO load is served by the output of EIM participating resources located outside of the CAISO BAA). Specifically, for each 5-minute interval that the CAISO BAA has a net EIM transfer in, the following would be calculated:

- The average incremental EIM GHG emission rate, which would be equal to:

[9] CARB April 26 Presentation, at 35.

    - The increased GHG emissions (in $MTCO_2$) from each EIM participating resource's incremental EIM dispatch level (for those EIM resources with a dispatch level above their respective base schedule quantity); divided by
    - The sum of the incremental EIM dispatch level (in MWh) above the base schedule quantity (for those EIM resources with a dispatch level above their respective base schedule quantity).
- The average incremental EIM GHG emission rate, calculated above, would then be multiplied by the net EIM transfer into the CAISO BAA (in MWh) to yield an estimate of the GHG emissions associated with serving California load in that interval.[10]
- The above would be summed over all intervals with net EIM transfers into the CAISO BAA in a particular period of interest (*e.g.,* month, quarter, or year) to yield both the total GHG emissions and the average GHG emission rate of California load served in the EIM.

Appendix A provides a more detailed explanation of this proposed methodology, including an illustrative example of how this calculation would be performed in each interval, and how those results could be aggregated to provide an estimate of the incremental EIM GHG emissions associated with serving California load. Powerex understands that some of the required data is public while the remaining data would need to be extracted from the CAISO's systems.

IV. Potential Applications of Proposed Calculation

The proposed methodology simply calculates the average GHG emission rate for *all* additional output that is dispatched in the EIM in a particular interval. To the extent that the EIM algorithm determines that the GHG emissions to serve California load were substantially lower than this value, this could indicate that the EIM algorithm is inaccurately deeming lower-emitting resource output to California load, and that GHG leakage is occurring. If, for instance, the EIM algorithm deems California load to be served with an average GHG emission rate of 0.2 $MTCO_2$/MWh but the above methodology indicates that the average GHG emission rate for all EIM incremental dispatch[11] of 0.7 $MTCO_2$/MWh, this could indicate that there is significant residual GHG emission leakage occurring. Under such circumstances, CARB could determine that additional GHG allowances should be required to be retired, and that additional steps may be necessary to reduce GHG leakage in the EIM.

If, on the other hand, both methods yield similar GHG emissions rates, this implies that the potential for residual GHG emission leakage may be limited, and no additional steps may be necessary to further align the EIM with the rules and objectives of the Cap and Trade Program.

The importance of such an independent assessment of EIM GHG emissions is not limited to the aggregate quantity of total emissions or emissions allowances, however. Since a critical

[10] In the unlikely event that net EIM transfers into the CAISO BAA exceeds the sum of the incremental output of out-of-state EIM participating resources, the difference could be assumed to incur the default GHG emission rate for unspecified source imports (i.e., currently 0.428 MTCO2/MWh).

[11] Weighted by the volume of net EIM transfers into the CAISO BAA.

objective of accurate GHG emissions tracking in the EIM is to ensure emissions are appropriately reflected in electricity prices, the results of such a comparison can also be examined for specific intervals, and compared to the GHG "shadow price" component of electricity prices. For example, if the proposed calculation shows that a large volume of EIM incremental electricity production was from coal-fired resources, but the GHG shadow price in the EIM was $2/MWh, then it is likely that in this interval electricity prices failed to accurately reflect the cost of GHG emissions experienced by the atmosphere in connection with serving California load. More specifically, at a typical GHG emissions allowance cost of $15/MTCO$_2$, the GHG emissions from a coal resource would add approximately $15/MWh to the price of electricity in California. A GHG shadow price of only $2/MWh could imply that the price of electricity in California may have been suppressed by as much as $13/MWh in this interval.[12] This distortion would apply to *all* real-time California supply and load in this interval, however, and is not limited just to the quantity of energy that was imported from the rest of the EIM footprint outside of California. To the extent such outcomes occur frequently or are otherwise systemic, CARB could consider the need for further improvements to the EIM's GHG framework to better align that market with the rules and objectives of the Cap and Trade Program.

V. Next Steps

Powerex believes that it would be valuable for CARB to enhance its reporting and analysis framework to more accurately gauge the GHG emissions in the EIM during intervals that EIM transfers serve California load. Such a framework can provide CARB with a sound analytical basis to evaluate the proposed improvements to the EIM, and to assess the performance of the EIM going forward. Powerex believes it would be beneficial for CARB to request CAISO to provide to CARB the detailed data necessary to perform this analysis for calendar year 2017, both to demonstrate the feasibility of the calculation and to provide a historical benchmark against which to evaluate ongoing performance.

Until and unless CARB can truly assess the extent of the residual GHG leakage problem in the EIM, Powerex believes it may be premature to develop programs such as the "EIM Purchaser" framework or to further evaluate additional steps related to the EIM. The extent of any such measures should be proportional to the magnitude of the residual GHG emissions leakage that needs to be addressed; high levels of residual leakage may warrant more extensive measures, whereas modest levels of leakage may only warrant limited measures.

Similarly, Powerex agrees with CARB's emphasis that nothing in its current informal discussions concern a day-ahead market or grid regionalization. Powerex does believe, however, that any consideration of a day-ahead organized market must be informed by the GHG-related challenges of the EIM, and whether these have been satisfactorily addressed. The volume of potential transactions in a day-ahead market is far greater than the volumes in the EIM, and hence the potential magnitude of GHG emissions leakage is far greater as well. Powerex

[12] An alternative, but no less troubling, interpretation is that electricity should not have been imported into California under such conditions in the first place, since such imports may appear economic only because the full GHG emissions costs were not recognized by the EIM algorithm.

therefore believes that taking steps now to develop a CARB framework for assessing the accuracy of GHG emissions tracking in the EIM will provide valuable information if and when this issue must be addressed by CARB, CAISO and stakeholders in the context of a potential day-ahead or regional organized market.

Appendix A:

Proposed Methodology for Calculating Incremental EIM GHG Emissions Associated with Serving California Load

The proposed methodology consists of two basic steps. The first step is to calculate the increase in GHG emissions associated with resources located outside of the CAISO BAA that are dispatched by the EIM to an output level that is greater than the base schedule quantity for the resource. A hypothetical example for a single interval is shown below.

Interval 1

[1]	[2]	[3]	[4]	[5]	[6] =Max(0,[5] - [4])	[7] =[6]/12	[8] =[7] * [3]	
Resource ID	Type	Emission Factor (MTCO2/MWh)	Base Schedule (MW)	RTD Dispatch (MW)	EIM Inc. Output (MW)	EIM Inc. Output (MWh)	EIM Inc. GHG (MTCO2)	
1	Coal	0.92	60	100	40	3.3	3.07	
2	Coal	0.96	80	120	40	3.3	3.20	
3	Gas	0.43	80	100	20	1.7	0.72	
4	Gas	0.51	100	100	-	-	-	
5	Wind	0.00	50	45	-	-	-	
6	Hydro	0.00	-	-	-	-	-	
					100	8.3	6.98	0.84

For each resource, the increase in output (Column 6) is calculated from the positive difference between the Real-Time Dispatch (RTD) instructed output quantity (Column 5) and the base schedule quantity for the resource (Column 4). Since this change in output applies to only a 5-minute interval, representing one-twelfth of an hour, Column 7 calculates the increase in *energy* production (in MWh) by dividing Column 6 by 12. The increase in GHG emissions (Column 8) is equal to the increase in output (Column 7) multiplied by the resource's emission factor (EF), in metric tons of CO_2 equivalent per megawatt-hour, or $MTCO_2$/MWh (Column 3).

After calculating the increased GHG emissions from resources that are dispatched to increase output in the EIM, the total incremental EIM GHG emissions can be calculated as the sum of Column 8 over all EIM participating resources. This total can be divided by the total incremental energy production from EIM participating resources (sum of Column 7) to yield an average GHG emission rate for incremental EIM production in that interval.

In the above example, EIM dispatches resulted in a 40 MW increase in output from each of two coal-fired resources plus a 20 MW increase in output from a gas-fired resource. Other EIM participating resources were dispatched either to the same level as their base schedule output (*e.g.,* Resources 4 and 6) or were dispatched to a level below their base schedule output (*e.g.,* Resource 5). The sum of the additional GHG emissions from resources that were dispatched to a level above their base schedules is nearly 7 $MTCO_2$ in this example. The output of these resources was 100 MW higher than their base schedules during this interval, implying an average GHG emission rate of 0.84 $MTCO_2$/MWh for this additional output.

The table below shows this same approach applied to four additional hypothetical intervals, each consisting of different levels of resource base schedule output and EIM dispatch.

Interval 2

Resource ID	Type	Emission Factor (MTCO2/MWh)	Base Schedule (MW)	RTD Dispatch (MW)	EIM Inc. Output (MW)	EIM Inc. Output (MWh)	EIM Inc. GHG (MTCO2)	
1	Coal	0.92	80	100	20	1.7	1.53	
2	Coal	0.96	100	120	20	1.7	1.60	
3	Gas	0.43	60	100	40	3.3	1.43	
4	Gas	0.51	50	100	50	4.2	2.13	
5	Wind	0.00	50	40	-	-	-	
6	Hydro	0.00	60	80	20	1.7	-	
					150	12.5	6.69	0.54

Interval 3

Resource ID	Type	Emission Factor (MTCO2/MWh)	Base Schedule (MW)	RTD Dispatch (MW)	EIM Inc. Output (MW)	EIM Inc. Output (MWh)	EIM Inc. GHG (MTCO2)	
1	Coal	0.92	100	100	-	-	-	
2	Coal	0.96	100	80	-	-	-	
3	Gas	0.43	130	130	-	-	-	
4	Gas	0.51	180	100	-	-	-	
5	Wind	0.00	60	55	-	-	-	
6	Hydro	0.00	20	100	80	6.7	-	
					80	6.7	0.00	0.00

Interval 4

Resource ID	Type	Emission Factor (MTCO2/MWh)	Base Schedule (MW)	RTD Dispatch (MW)	EIM Inc. Output (MW)	EIM Inc. Output (MWh)	EIM Inc. GHG (MTCO2)	
1	Coal	0.92	100	70	-	-	-	
2	Coal	0.96	100	90	-	-	-	
3	Gas	0.43	20	100	80	6.7	2.87	
4	Gas	0.51	30	120	90	7.5	3.83	
5	Wind	0.00	50	60	10	0.8	-	
6	Hydro	0.00	40	70	30	2.5	-	
					210	17.5	6.69	0.38

Interval 5

Resource ID	Type	Emission Factor (MTCO2/MWh)	Base Schedule (MW)	RTD Dispatch (MW)	EIM Inc. Output (MW)	EIM Inc. Output (MWh)	EIM Inc. GHG (MTCO2)	
1	Coal	0.92	85	100	15	1.3	1.15	
2	Coal	0.96	80	100	20	1.7	1.60	
3	Gas	0.43	60	100	40	3.3	1.43	
4	Gas	0.51	70	100	30	2.5	1.28	
5	Wind	0.00	75	60	-	-	-	
6	Hydro	0.00	80	80	-	-	-	
					105	8.8	5.46	0.62

The second step in the calculation is to multiply the average incremental GHG emission rate by the quantity of EIM transfers serving California load in that interval. Since California load is served by out-of-state EIM resources only during intervals that the CAISO BAA is a net recipient

of EIM transfers, intervals in which the CAISO BAA is a net supplier of EIM transfers need not be considered in this step.[13]

The table below shows how this second step in the calculation works. Columns 1-4 simply report the values calculated in the prior step, discussed above. Column 5 is the volume of net EIM transfers into the CAISO BAA (*i.e.,* the volume of California load served by out-of-state resources dispatched in the EIM). Note that this is the rate of EIM transfers in each 5-minute interval (in MW); to obtain the total energy of the EIM transfers (in MWh), this value must be divided by 12, which is shown in Column 6. Column 7 multiplies the energy of EIM transfers by the EIM average incremental GHG emission rate (Column 4), yielding the quantity of GHG emissions associated with serving California load from out-of-state resources in the EIM in that interval.

[1]	[2]	[3]	[4]	[5]	[6] =[5]/12	[7] =[6] * [4]	
Interval	EIM Inc. Output (MW)	EIM Inc. GHG (MTCO2)	EIM Inc. EF (MTCO2/MWh)	CAISO Net EIM Transfer In (MW)	CAISO Net EIM Transfer In (MWh)	EIM GHG for CA Load (MTCO2)	
1	100	6.98	0.84	80	6.7	5.59	
2	150	6.69	0.54	100	8.3	4.46	
3	80	0.00	0.00	20	1.7	0.00	
4	210	6.69	0.38	180	15.0	5.74	
5	105	5.46	0.62	80	6.7	4.16	
					38.3	19.94	0.52

The results from individual intervals can be aggregated over time (*e.g.,* a day, month, quarter or year). This is accomplished by summing the GHG emissions to serve California load from EIM resources (Column 7) over all relevant intervals in the period, and dividing by the total energy of EIM transfers into the CAISO BAA in those intervals (Column 6). In this example, the total GHG emissions to serve California loads from EIM resources over all five intervals was just under 20 $MTCO_2$, and the total quantity of net EIM transfers into the CAISO BAA was 38.3 MWh. As a result, the average GHG emission rate associated with serving California load from out-of-state EIM resources was 0.52 $MTCO_2$/MWh in this example.

One possible, albeit unlikely, circumstance is an interval in which net EIM transfers into the CAISO BAA are greater than the sum of incremental dispatch of EIM resources. This might occur if there are net EIM transfers into the CAISO BAA in the same interval that other EIM entities experience load that is substantially less than base schedule levels, or if EIM entities experience renewable generation output that is substantially greater than base schedule levels. In such a scenario, there could be EIM transfers into the CAISO BAA without requiring that EIM

[13] Reductions in the GHG emissions of out-of-state resources resulting from exports of California energy are not part of CARB's Cap and Trade Program, but the proposed analytical approach could also be used to estimate the out-of-state GHG emissions reductions during intervals of net EIM transfers out of the CAISO BAA.

participating resources increase output above base schedules. In other words, the need to dispatch EIM resources upward to produce electricity for import into the CAISO BAA could be more than offset by the need to dispatch EIM resources downward to balance the additional out-of-state renewable generation or to balance the lower-than-anticipated out-of-state load. EIM transfers into the CAISO BAA tend to be large and occur at fairly predictable times (*e.g.,* during the morning and evening net load ramps), however, and Powerex believes it would be highly unlikely for energy imbalances in other EIM entity areas to exceed these imports.

Nevertheless, such a scenario could be readily accommodated under the proposed methodology by applying the default emission factor for unspecified-source energy imports to any quantity by which net EIM transfers into the CAISO BAA exceed the sum of incremental dispatch of EIM resources. This is shown in the table below. If Interval 1 included net EIM transfers into the CAISO BAA of 120 MW (Column 8), but there was only 100 MW of incremental dispatch from EIM resources (Column 2), then an additional 20 MW of EIM supply would need to be inferred in this interval (Column 4). This would add 0.71 $MTCO_2$ using the default emission factor for unspecified electricity imports (Column 5) resulting in an adjusted quantity of GHG emissions from EIM supply serving California load (Column 6). This leads to an adjusted emission factor for EIM supply (Column 7), which, when applied to the energy of EIM transfers serving California load (Column 9) yields the total GHG emissions for such EIM transfers in that interval (Column 10).

[1]	[2]	[3]	[4] =MAX(0,[8]-[2])	[5] =[4]/12*0.428	[6] =[5]+[3]	[7] =[6]/([2]+[4])*12	[8]	[9] =[8]/12	[10] =[9] * [7]
Interval	EIM Inc. Output (MW)	EIM Inc. GHG (MTCO2)	Inferred EIM Imbalance Supply (MW)	GHG Emissions of Inferred EIM Imbalance Supply, at Unspecified Rate (MTCO2)	Adjusted GHG Emissions from EIM (MTCO2)	Adjusted EIM EF (MTCO2/MWh)	CAISO Net EIM Transfer In (MW)	CAISO Net EIM Transfer In (MWh)	EIM GHG for CA Load (MTCO2)
1	100	6.98	20	0.71	7.70	0.77	120	10.0	7.70

Appendix B:

Pages 7-12 of Powerex's December 18, 2017 Comments on CAISO's GHG Attribution Reports

Original document available at http://www.caiso.com/Documents/PowerexComments-GHGAttributionAccuracyReportDemonstration.pdf

B. During the morning, evening and over-night hours, the predominant EIM activity is the CAISO BAA importing external fossil resource output that is used to displace California natural gas output, without the proper application of California's Cap and Trade Program.

The CAISO BAA is a recipient of sub-hourly EIM imports from the other areas participating in that market outside of the mid-day hours. This is particularly common during the morning and evening peak hours. In fact, the total quantity of EIM imports into the CAISO BAA is approximately 1.5 times the total quantity of EIM exports out of the CAISO BAA. The EIM has therefore also expanded opportunities for sub-hourly imports into the CAISO BAA of generation from out-of-state resources, reducing the cost of meeting California's needs. Figure 3 and Figure 4, below, show the quantity of net EIM exports by BAA during the intervals that the CAISO BAA was a net importer, as well as the resource mix in the two BAAs with the greatest EIM exports during these intervals.

Figure 3. EIM Net Exports, by BAA, during intervals with CAISO EIM imports, October 1, 2016 - September 30, 2017

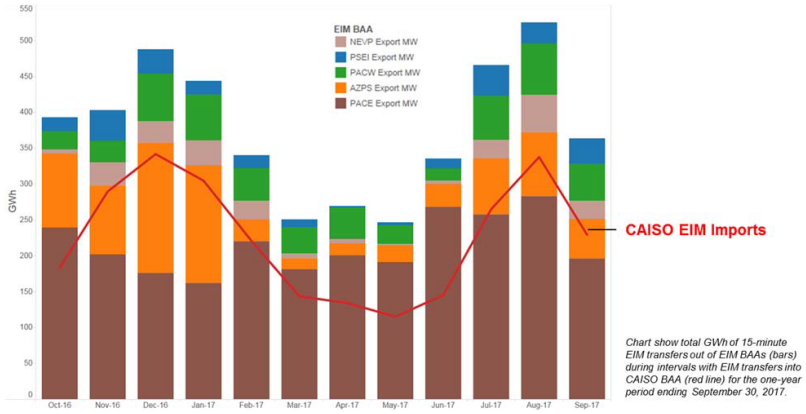
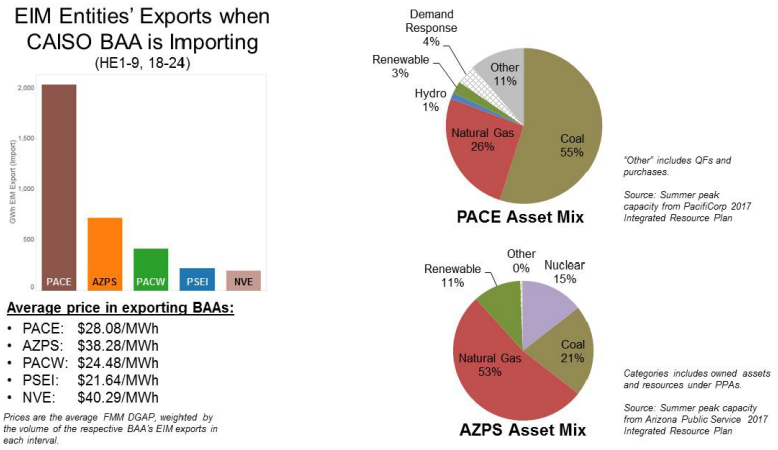


Figure 4. EIM Exports During Early Morning and Evening Intervals of CAISO EIM Imports, by Entity



Sources: EIM transfers and prices in Fifteen-Minute Market from CAISO OASIS. Resource mix from public resource planning documents for each entity.

PacifiCorp East is the BAA with the greatest quantity of net EIM exports during intervals of CAISO BAA net EIM imports over the one-year period covered by the analysis; Arizona Public Service Company is the BAA with the second-largest quantity. Both the PacifiCorp East and the Arizona Public Service Company BAAs participate in the EIM with a resource mix consisting primarily of coal and natural gas resources (although Powerex believes it is important to acknowledge that entities in these BAAs have also invested in substantial quantities of renewable, non-emitting resources in recent years). The fact that CAISO's EIM imports are primarily associated with EIM exports from BAAs with predominantly fossil resources appears to imply that CAISO load in those intervals is being served by increases in fossil resource output. This is further supported by the average EIM prices in these BAAs during the relevant intervals, which were between $28.08/MWh and $40.29/MWh, as shown above in Figure 4. Such price levels strongly indicate that it is likely coal and/or natural gas resources that are the resources supporting EIM exports to the CAISO BAA, since the non-emitting resources in these BAAs are largely nuclear and renewable resources that would be running anyway (*i.e.*, in the absence of CAISO EIM Imports and lower EIM prices). Put another way, it is almost certainly coal and natural gas resources in these BAAs that are predominantly the "marginal resources" supporting EIM transfers to California, and are the resources that would have operated at a lower output level in the absence of their BAAs' exports serving load in the CAISO BAA.

The CAISO's *Market Performance Report* includes information on the percentage of EIM transfers serving CAISO load ***attributed to*** different types of resources under the current EIM algorithm. The information for the same one-year period covered by the above charts is reproduced in Table 1, below:

Table 1. Attribution of CAISO EIM Imports Under Current Algorithm

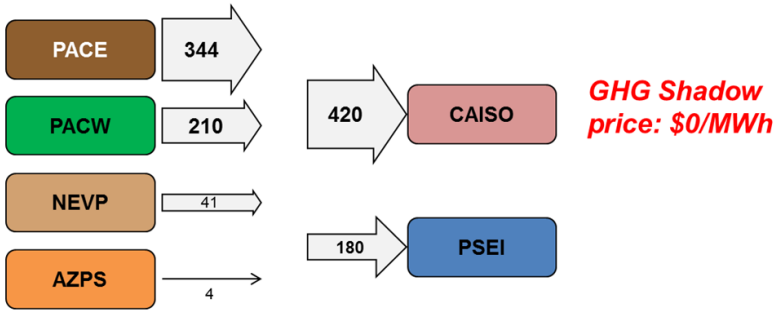
Month	Coal (%)	Gas (%)	Non-Emitting (%)	Total
Oct-16	0.00%	43.82%	56.18%	100%
Nov-16	0.00%	30.74%	69.26%	100%
Dec-16	0.00%	53.77%	46.23%	100%
Jan-17	0.00%	69.88%	30.12%	100%
Feb-17	0.00%	36.42%	63.58%	100%
Mar-17	0.00%	13.37%	86.63%	100%
Apr-17	0.00%	15.47%	84.53%	100%
May-17	0.00%	18.47%	81.53%	100%
Jun-17	0.00%	21.33%	78.67%	100%
Jul-17	0.00%	36.08%	63.92%	100%
Aug-17	0.00%	59.20%	40.80%	100%
Sep-17	0.00%	45.94%	54.06%	100%

Source: CAISO "Market Performance Report" for September 2017, Table 8. Available at:
http://www.caiso.com/Documents/MarketPerformanceReportforSeptember2017.pdf

Notably, the current EIM algorithm avoids attributing *any* EIM imports serving CAISO load to coal-fired resources, and attributes the majority of imports to non-emitting resources in 9 of the 12 months. The results for March 2017 highlight Powerex's concerns regarding the attribution of imports under the current EIM algorithm. Specifically, the *Market Performance Report* shows that the EIM algorithm attributed 86% of imports serving CAISO load to "non-emitting" resources. However, Figure 3, above, shows that the total EIM exports from BAAs *other than* PacifiCorp East were less than the quantity of CAISO's EIM imports, implying that a substantial amount of the CAISO load that was served by EIM imports *must* have been from resources in the PacifiCorp East BAA.

The skewed attribution under the current EIM algorithm is powerfully illustrated by examining a single interval in detail. Figure 5 shows the EIM transfers for each BAA for September 15, 2017, HE7, FMM Interval 3:

Figure 5. Example of Flawed GHG Attribution Under Current EIM Algorithm: September 15, 2017 HE7, FMM Interval 3



Mathematically, it appears clear that at least *some* of the exports from the PacifiCorp East BAA *must* be serving load in the CAISO BAA during this interval. The resources in the PacifiCorp East BAA consist primarily of coal and natural gas-fired generation. The price in the PacifiCorp BAA during this interval was approximately $40/MWh, suggesting it was indeed coal or natural gas resources that were likely increasing their production to support EIM transfers to California (and would be the resources reducing their production if there were no EIM transfers serving California load in this interval). But in this interval, *all* of the imports serving load in the CAISO BAA were deemed to be from "non-emitting" resources, as evident from the GHG shadow price of $0/MWh.

The Brattle Analysis provides additional explanation of how the current EIM algorithm reaches such results, explaining that "The currently-deployed 1-Step Approach creates opportunities for some secondary dispatch and backfilling, and under-allocates external emissions to CAISO load."[6] This "secondary dispatch and backfilling" refers to the fact that external resources may be deemed to serve CAISO load even for the portion of output that was already committed to serve non-CAISO load in the resource base schedules. In other words, the amount of a resource's output that is deemed to serve CAISO load under the current EIM algorithm is not limited to the *additional* output from the resource that is dispatched in the EIM. Resources that would have run with or without EIM imports into the CAISO BAA—resources such as non-dispatchable wind and solar, or economic non-emitting resources such as hydro—are routinely identified by the EIM algorithm as the resources that serve CAISO load in the EIM. This happens even when the output of such resources is base-scheduled ahead of the EIM (and hence already scheduled to serve load *outside* of the CAISO BAA). It is this disconnect that permits the current EIM algorithm to increase the output of external coal or natural gas resources in order to increase EIM imports into the CAISO, but avoid recognizing the additional GHG emissions from those external resources.

The CAISO's GHG Report and the Brattle Analysis also show the multiple types of harmful effects caused by the flaws in the current EIM algorithm:

- **GHG emissions for serving CAISO load are understated.** This leads to too few California GHG emissions allowances being retired, meaning too many GHG emissions allowances remain in circulation and available to support additional emissions under California's cap-and-trade program. Beginning in 2018, Powerex understands that CARB has put in place a bridge solution to address, at least partially, this particular outcome.[7]
- **California in-state resources are inefficiently displaced by out-of-state generation.** As explained in the Brattle Analysis, "Under the [current EIM algorithm], gas plants in CAISO ramp down and are replaced by external gas generation that comes in without CO_2 costs due to secondary dispatch effects."[8] CAISO's GHG Report shows similar

[6] Brattle Analysis, at 12.

[7] *See* CARB's addition of Section § 95852b(1)(D) to the Cap and Trade Regulation.

[8] Brattle Analysis, at 6.

outcomes.[9] Brattle further acknowledges that this may also be external coal resources that replace CAISO gas plant output.[10] Powerex believes this is likely the case, given its historical analysis of which BAAs are exporting in the intervals the CAISO BAA is importing, as well as the relative marginal cost of natural gas generation versus coal generation in those BAAs in recent years. These transfers are inefficient, and occur precisely *because* the GHG emissions of those out-of-state resources are currently not properly recognized in the EIM's dispatch optimization.

- **The current EIM algorithm does not efficiently select *which* external resources to dispatch to serve CAISO load.** The GHG Report shows that the current EIM algorithm dispatches external gas or coal resources to serve CAISO load, even when non-emitting hydro resources are both available and economic, once GHG emissions are properly considered.[11] But because the GHG emissions of the additional production are not fully captured under the current approach, higher-emitting resources artificially appear to be more economic, and are dispatched.
- **GHG shadow prices are suppressed under the current EIM algorithm.** While the Brattle Analysis and GHG Reports do not address the impact of the current EIM algorithm on prices, the GHG attribution of EIM transfers serving CAISO load are directly linked to the GHG shadow prices. This also lowers the CAISO's real-time market prices more generally, across its broader real-time market footprint.

In short, the unintended consequences of the current EIM algorithm go well beyond merely miscalculating the GHG emissions to serve CAISO load. The current algorithm has resulted in the EIM inadvertently creating significant new opportunities for the sale of energy from out-of-state fossil resources to serve California load but without appropriately recognizing their GHG emissions. Conversely, the current algorithm has resulted in the EIM failing to encourage the sale of energy from lower-emitting in-state and lower-emitting out-of-state resources to serve California load. While this has been labeled a "secondary emissions" problem, it is perhaps more accurately described as a "primary emissions" problem, whereby out-of-state fossil resources increase their output specifically as a result of serving California load in the EIM.

Both the Brattle Analysis and the CAISO's GHG Report observe that the unaccounted for GHG emissions due to the flaws in the current EIM algorithm represent a small share of overall GHG emissions. This should provide no comfort, however, nor should it excuse any delay in addressing the issue, for at least two reasons. First, Powerex believes the historical analysis of actual EIM data, contained herein, strongly suggests that both the Brattle Analysis and CAISO GHG Report may significantly understate the extent of the problem that is actually occurring.

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[9] GHG Report at 9, showing that the 2-pass approach would eliminate EIM transfers that result in CAISO gas (and some hydro) output being replaced by external coal and gas generation.

[10] The Brattle Analysis assumes a natural gas price of $4.1/MMcf; whereas current natural gas prices in the major market areas outside the CAISO BAA are appreciably lower. Brattle acknowledges that its "simulations show relatively less coal backfilling under the [current EIM algorithm] than what would be expected with lower gas prices." (Brattle Analysis at 12)

[11] GHG Report at 9. The change in generation in the non-CAISO EIM footprint has an *overall* reduction in generation, consistent with a reduction in EIM transfers to the CAISO BAA, but is also shows an increase in generation from hydro resources. This implies that even when EIM transfers to the CAISO BAA do occur, the dispatch of external resources is distorted under the current EIM algorithm.

Second, the fact that unaccounted for GHG emissions are relatively small is not because the distortions of the EIM algorithm are small, but because the EIM represents a small share of total generation in the footprint. The GHG Report shows that, under the current EIM algorithm, the GHG emissions of EIM transfers serving CAISO load are *understated by a factor of four.*[12] Regardless of whether the actual understatement is much greater, as Powerex believes, an understatement error of the magnitude suggested by the GHG Report, if not meaningfully addressed, represents a potential threat to continued broad support for the EIM, as well as support for extending the EIM framework to the day-ahead timeframe,[13] where the volume of imports affected by the attribution framework would be much larger.

Powerex believes there is now undisputed evidence that the GHG attribution under the current EIM algorithm is fatally flawed, causes significant harm, and is inconsistent with California's environmental policy objectives and programs. Powerex urges CAISO, together with CARB, to take immediate action to meaningfully improve the GHG attribution in the EIM as soon as possible.

IV. Additional work is necessary to identify a comprehensive and accurate framework for GHG attribution in the EIM, and in any future multi-state day-ahead market

CAISO staff have worked diligently to explore potential ways to improve the accuracy of GHG attribution in the EIM. Powerex commends CAISO for dedicating resources both to identifying enhancements and to testing the efficacy of those enhancements through rigorous analysis, such as in the GHG Report and in the Brattle Analysis. These analyses unequivocally demonstrate that the proposed two-pass solution would lead to a major improvement in the performance of the EIM algorithm with regard to incorporating information on GHG emissions for resources serving CAISO load.

Some stakeholders have recently raised concerns about the incentives that may be associated with implementing the two-pass solution as proposed by CAISO. Specifically, the two-pass solution would use a resource's bid price for two purposes: to establish the "GHG base" in the first pass, and to establish the actual dispatch of the resource in the second pass. The concern expressed by some commenters is that sellers of lower-emitting resources would have an incentive to raise their energy offer price to a level high enough to *not* be accepted in the first pass, since this allows more of the resource's actual output can be deemed to serve load in the CAISO BAA, for which it will receive additional compensation in the form of the GHG shadow price.

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[12] GHG Report at 12, showing the average GHG intensity of EIM transfers serving CAISO load of 0.05 $mTCO_2$/MWh under the current algorithm compared to 0.20 $mTCO_2$/MWh under the proposed 2-pass approach. Powerex believes the actual understatement is even larger, as the proposed 2-pass solution does not fully eliminate leakage, and continues to allocate the output from lower-emitting resources preferentially to serving CAISO load.

[13] The *2018 Draft Policy Initiatives Roadmap* at 4-6, discussing initiative to "extend day-ahead market to EIM Entities." With regarding day-ahead GHG attribution, CAISO proposes to "Extend EIM real-time market approach to day-ahead." (*Id.* at 6) *Available at:* http://www.caiso.com/Documents/2018DraftPolicyInitiativesRoadmap.pdf