

**BEFORE THE PUBLIC UTILITIES COMMISSION  
OF THE STATE OF CALIFORNIA**

Order Instituting Rulemaking Regarding Policies,  
Procedures and Rules for the California Solar  
Initiative, the Self-Generation Incentive Program  
and Other Distributed Generation Issues

Rulemaking 12-11-005  
(Filed November 8, 2012)

**COMMENTS OF THE CALIFORNIA ENERGY STORAGE ALLIANCE  
ON ASSIGNED COMMISSIONER'S RULING ON IMPLEMENTATION  
OF ASSEMBLY BILL 1637**

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In accordance with Rules of Practice and Procedure of the California Public Utilities Commission (“Commission”), the California Energy Storage Alliance (“CESA”)<sup>1</sup> hereby submits these comments on the *Assigned Commissioner’s Ruling on Implementation of Assembly Bill 1637* (“Ruling”), issued by Commission President Michael Picker on December 30, 2016 (“Ruling”).

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<sup>1</sup> 8minutenergy Renewables, Adara Power, Advanced Microgrid Solutions, AES Energy Storage, AltaGas Services, Amber Kinetics, Aquion Energy, Bright Energy Storage Technologies, Brookfield, California Environmental Associates, Consolidated Edison Development, Inc., Cumulus Energy Storage, Customized Energy Solutions, Demand Energy, Doosan GridTech, Eagle Crest Energy Company, East Penn Manufacturing Company, Ecoult, Electric Motor Werks, Inc., ElectrIQ Power, ELSYS Inc., Energy Storage Systems Inc., Enphase Energy, GE Energy Storage, Geli, Gordon & Rees, Green Charge Networks, Greensmith Energy, Gridscape Solutions, Gridtential Energy, Inc., Hitachi Chemical Co., Ice Energy, IE Softworks, Innovation Core SEI, Inc. (A Sumitomo Electric Company), Invenergy LLC, Johnson Controls, K&L Gates, LG Chem Power, Inc., Lockheed Martin Advanced Energy Storage LLC, LS Power Development, LLC, Mercedes-Benz Research & Development North America, National Grid, Nature & PeopleFirst, NEC Energy Solutions, Inc., NextEra Energy Resources, NEXTracker, NGK Insulators, Ltd., NRG Energy LLC, OutBack Power Technologies, Parker Hannifin Corporation, Powertree Services Inc., Qnovo, Recurrent Energy, RES Americas Inc., Saft America Inc., Samsung SDI, Sharp Electronics Corporation, Skylar Capital Management, SolarCity, Southwest Generation, Sovereign Energy, Stem, Sunrun, Swell Energy, Trina Energy Storage, Tri-Technic, UniEnergy Technologies, Wellhead Electric, Younicos. The views expressed in these Comments are those of CESA, and do not necessarily reflect the views of all of the individual CESA member companies. (<http://storagealliance.org>).

## I. INTRODUCTION.

In these comments, CESA emphasizes the importance of the Self-Generation Incentive Program (“SGIP”), recommended improvements to the recent *2014-2015 SGIP Impacts Evaluation Report* prepared by Itron (“Itron Report”),<sup>2</sup> and CESA’s responses to the questions posed in the Ruling. These comments can be summarized as follows:

- The Commission should approve commitment of the full amount of increased SGIP revenues authorized by Assembly Bill (“AB”) 1637.
- In accordance with the express intent of the Legislature, the Commission should allocate *at least 75%* of authorized new funding to energy storage technologies.
- The Commission should allocate the additional funding for energy storage evenly across the contemplated five steps in accordance with D.16-06-055.
- The Commission should quickly make a determination as to allocation of additional funding before Step 1 is opened.
- Better data on the greenhouse gas (“GHG”) emission impacts of energy storage operations are needed before making specific changes to existing operational or performance requirements of energy storage projects.
- The Commission should direct development of CESA’s opt-in, or “bolt-on” GHG Reduction Tariff for Energy Storage Charging.
- The Commission should modify the developer cap to reflect new steps in budget allocation.
- The Commission should direct or clarify that performance-based incentives adopted in D.16-06-055 should apply to both existing and new energy storage projects.
- The Commission should account for and anticipate potential delays in implementing new California supplier requirements.

The SGIP has been, and remains, a critical ratepayer-funded program that is needed to transform the market for distributed generation (“DG”) technologies, such as energy storage,

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<sup>2</sup> *Final Report: 2014-2015 SGIP Impacts Evaluation*, submitted to SoCalGas and the SGIP Working Group and prepared by Itron on November 4, 2016.

while contributing to the reduction of GHG emissions and providing overall grid support in California. This SGIP has contributed substantially to California becoming a feasible market for residential and non-residential energy storage in the United States, with many energy storage companies seeking to consider or to deploy DG projects in the state.<sup>3</sup> It is important for this market to continue to grow because the energy storage market in California requires further transformation to support energy storage becoming a mainstream energy resource. Market transformation of energy storage will allow it to provide critical electric grid benefits, support customer energy management needs, and help address renewables integration and overgeneration issues.

Assembly Bill (“AB”) 1637, which authorizes the Commission to increase the annual collection of funds for the SGIP to be up to double the amount authorized for the program in the 2008 calendar year and through December 31, 2019, creates a key opportunity to expand the SGIP.<sup>4</sup> CESA strongly supports the doubling of funds for SGIP through 2019 and provides responses below to the questions posed in the Ruling to guide implementation of AB 1637. In these comments, CESA specifically addresses and focuses on how AB 1637 implementation bears on deployment of energy storage technologies.

**II. THE COMMISSION SHOULD APPROVE THE FULL AMOUNT OF INCREASED SELF-GENERATION INCENTIVE PROGRAM REVENUES AUTHORIZED BY ASSEMBLY BILL 1637.**

Below are CESA’s responses to the questions posed in the Ruling related to overall funding:

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<sup>3</sup> Research highlights how California is one of the greater areas of focus for energy storage deployments. See, GTM Research, *U.S. Energy Storage Monitor: Q2 2016 Executive Summary*. June 2016, p. 5.

<sup>4</sup> Public Utilities Code Section 379.6(a)(2).  
[https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill\\_id=201520160AB1637](https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB1637)

**Question 1: Should the CPUC approve the full amount of increased SGIP revenue authorized by AB 1637, and allow the utilities to collect double the 2008 level of SGIP funding on an annual basis through 2019. If so, why? If not, why not?**

**CESA's Response:**

The Commission should approve the full amount of increased SGIP revenue authorized by AB 1637 because the clear intent of the Legislature was to increase deployment of distributed generation and energy storage systems to facilitate the integration of those resources into the electrical grid, improve efficiency and reliability of the distribution and transmission system, and reduce emissions of GHGs, peak demand, and ratepayer costs.<sup>5</sup> By not approving the SGIP funding in the full amount authorized by AB 1637, CESA believes that the Commission would be falling short of the unambiguous intent of the Legislature. There would otherwise be fewer dollars invested in the deployment of DG and energy storage systems if the Commission were to decide to increase the SGIP budget by a lesser amount than authorized by AB 1637. By extension, the reduced deployment of SGIP-funded DG and energy storage projects would lead to fewer GHG emissions avoided.

A doubling of funds will certainly support a greater number of energy storage projects deployed. SGIP program goals can be achieved with greater certainty through the application of materially larger funding. While the energy storage market is expanding, it remains nascent in some ways. A larger SGIP program will most assuredly secure the important benefits and market transformation goals of SGIP.

The role and importance of energy storage deployment grows as California moves toward a high-renewables future that creates grid integration challenges related to overgeneration and ramping. For instance, a study by the National Renewable Energy Laboratory (“NREL”)

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<sup>5</sup> Assembly Bill 1637 (Low). Section 379.6(a)(1).

estimated that, depending on other flexibility options used, between 15 GW and 28 GW of additional energy storage is needed to effectively integrate solar photovoltaic (“PV”) penetration levels up to 50% in California and minimize renewables curtailment.<sup>6</sup> A number of other studies have also similarly highlighted the urgent need for flexibility options such as energy storage. It is therefore important to transform the market for energy storage to become a mainstream resource *now* to maximize renewables investments that minimize GHG emissions by fully doubling the SGIP funds.

**Question 2: If doubling of SGIP funding is not recommended, what change to the level of funding is recommended? If no increase is sought, explain why? If only a portion of the available doubling is to be approved, why?**

**CESA’s Response:**

CESA believes doubling of SGIP funding is necessary to transform the market for energy storage and other DG technologies. CESA emphatically *does not* recommend that the Commission decline to change the level of funding or to only approve a portion of the available doubling.

**Question 3: How likely is the circumstance where disbursements of SGIP funds will exceed the amount collected in a given calendar year? If disbursements exceed collections at any given time, how should that shortfall be handled?**

**CESA’s Response:**

Given that the collection of SGIP funds is done on an annual basis while the disbursement of SGIP funds is done on a continuous basis reflecting market demand, there is potential for timing issues between the inflow and outflow of funds. CESA generally anticipates

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<sup>6</sup> *Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California.* National Renewable Energy Laboratory, August 2016.

that this should be a manageable issue for the SGIP Program Administrators (“PAs”) and should not affect how the additional funds authorized by AB 1637 should be allocated across the proposed technology categories or incentive steps.

CESA believes the Commission may have anticipated this mismatch of funds available and funds dispersed in developing the more continuous disbursement structure in D.16-06-055. This situation can be managed using existing accounting mechanisms. Investor-Owned Utilities (“IOUs”) have typically used balancing accounts to conduct an *ex post* true-up for cost recovery in these situations. Southern California Edison Company (“SCE”), for example, uses the Self-Generation Program Incremental Cost Memorandum Account (“SGPIC”), while other customer-side incentive programs such as those for demand response are recovered through comparable balancing accounts (*e.g.*, the Demand Response Programs Balancing Account). Similarly, the discrepancy between funds available and funds dispersed can be managed in this balancing accounting approach to be trued up over a five-year period. CESA therefore believes that this issue is manageable using existing accounting mechanisms and should not affect how additional funds authorized by AB 1637 are allocated across technology categories and incentive steps.

**III. THE COMMISSION SHOULD ALLOCATE AT LEAST 75% OR MORE OF PROPOSED NEW FUNDING TO ENERGY STORAGE TECHNOLOGIES.**

Below are CESA’s responses to the questions from the Ruling related to the distribution of potential new funding amongst technology sectors:

**Question 4: Should the proposed new funding be distributed among technology categories as currently designated? Should the existing carve-outs for residential storage and renewable generation be used for the proposed new funding as well, or should different carve-outs for these sectors be used for the proposed new funding?**



**CESA's Response:**

At minimum, CESA recommends that the proposed new funding be distributed among technology categories as currently proposed – *i.e.*, with 75% of new funds being directed to the energy storage “bucket” and 25% of new funds being directed to the distributed generation bucket. D.16-06-055 justified this allocation of funds across technology buckets because energy storage represented the fastest-growing source of SGIP projects and the most scalable set of technologies, as well as fitting within the program’s goals of supporting renewables integration and reducing GHG emissions.<sup>7</sup> Since the issuance of D.16-06-055, there has not been any change in terms of the recent and forward expectations of grid conditions and needs, nor has there been any change in terms of historical program spending and operations and its trajectory going forward.

**Question 5: If the proposed new funding is not distributed among technology sectors according to current rules, what should the modifications be? What would be the justification for these modifications? Please provide evidence that supports these justifications?**

**CESA's Response:**

If an alternative funding allocation were to be considered, CESA believes that the funding allocation for energy storage should be greater than the 75% allocated as currently required by D.16-06-055. Specifically, CESA believes that it would be reasonable for 100% of the proposed new funding authorized under AB 1637 to be allocated to energy storage and 100% renewable technologies.

AB 1637 authorized adoption of explicit rules to support deployments of some non-storage technologies which are currently listed under the SGIP “generation bucket.” As these

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<sup>7</sup> D.16-06-055, p. 23.

technologies now face a new policy landscape and alternative to the SGIP, the Commission may warrant directing a greater proportion of funds towards energy storage. Historical SGIP data shows that energy storage would have accounted for 80% of SGIP funds in 2015 without pure electric fuel cells, which face tighter GHG emission requirements and the introduction of minimum zero-emissions blending requirements. Based on this data, a case can readily be made to set the energy storage budget allocation at 80% or higher, particularly when adopting rules that are expected to exist multiple years into the future.

Furthermore, what is more urgently needed in California is not necessarily additional or block-loaded generation but additional flexibility solutions such as energy storage that can help address renewables integration and ramping challenges of the state's electricity grid. As California also shifts to default TOU rates and to more sophisticated, dynamic rates, more energy storage technologies will be needed to manage this transition.

**IV. BETTER DATA ON THE GREENHOUSE GAS EMISSION IMPACTS OF ENERGY STORAGE OPERATIONS IS NEEDED BEFORE CHANGING OPERATIONAL OR PERFORMANCE REQUIREMENTS.**

CESA understands, and fully appreciates, the importance of the GHG emissions reduction goal of the SGIP. Fundamentally, energy storage technologies have the potential to dramatically reduce GHG emissions by more effectively and more significantly integrating renewables generation and by helping to reduce system peak demand, which often requires natural gas peaker plants to be fired to meet ramping and peak capacity needs. However, to realize these environmental benefits, energy storage systems need economic signals to charge during off-peak periods or periods of low marginal emissions (*e.g.*, mid-day overgeneration of PV solar) and to discharge during peak periods or periods of high marginal emissions. In other

words, a rate structure mis-aligned with marginal emissions could result in suboptimal GHG emissions performance by energy storage systems.

CESA raises these points in light of the recent Itron Report, which showed that (albeit with poor available data) some energy storage projects may have increased GHG emissions for the 2014-2015 program years and that some energy storage projects fell short of expectations for roundtrip efficiency and capacity factors. CESA finds the prospect for suboptimal performance from energy storage systems to be concerning and has worked with the Commission and other stakeholders to support further Measurement and Evaluation (“M&E”) efforts. These efforts, including new and annual “audits” as proposed in the Commission’s final M&E Plan on January 13, 2017, will ensure appropriate monitoring of energy storage projects, which may also show maturation of the industry as well as responsiveness of storage resources over time to evolving retail rates.

Despite the data challenges of the Itron Report – in which data limitations resulted in an assessment of only very few energy storage projects for the 2014-2015 period, and without clear information on neither solar-plus-storage projects nor residential projects<sup>8</sup> – CESA strongly believes further monitoring is in order. In line with the M&E Plan, and given the dearth of data on performance of energy storage projects, CESA supports the idea that the Commission should not enact new program rule reforms at this time, instead relying on the program reforms adopted pursuant to D.16-06-05 last year. CESA also recommends that the Commission better enforce existing rules, both to ensure robust data gathering as well as to ensure that the technologies

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<sup>8</sup> Only 12 projects had corresponding load data due to delayed provision of customer load data from the utilities and the anonymization of customer data by one energy storage vendor, requiring Itron to draw some conclusions on performance without much matchable data. Also, the authors of the report noted that charge and discharge data from multiple residential vendors proved to be inaccurate or flawed (*e.g.*, several projects exhibited roundtrip efficiencies greater than 100%).

being deployed are meeting existing program requirements. For example, the Itron Report specifically found that only 5% of the non-residential, non-PBI projects evaluated met the program’s round-trip efficiency requirements.<sup>9</sup> In instances where the equipment deployed routinely or systematically fails to meet basic program requirements, at a minimum, developers should not be allowed to continue to deploy that equipment until such time as they can demonstrate that it will meet program requirements.

Perhaps most importantly, the Itron Report also highlights how SGIP projects often respond to retail rates, yet when those rates are mis-aligned with grid needs, GHG savings may not always meet expectations.<sup>10</sup> It can therefore be deduced that better rate designs are helpful to ensure that SGIP projects achieve the performance goals for SGIP-funded energy storage projects. In particular, if subject to high non-coincident demand charges, non-PBI energy storage projects will often be programmed to operate to avoid these high charges to the benefit of the customer. Holistic rate reform with reasonably wide time-of-use (“TOU”) spreads, TOU periods aligned with system peak and off-peak periods, and coincident demand charges would serve to guide energy storage charge and discharge schedules to match system energy and capacity needs. Importantly, “forced cycling” without an eye toward system needs to be avoided. Until such rate reforms happen, it will be difficult for the Commission to fairly evaluate SGIP-funded energy storage projects on their GHG emissions performance.

Going forward, CESA also recommends several improvements to the assessment methodology used by Itron to measure GHG performance of energy storage systems. CESA supports the use of marginal emissions data but is uncertain as to the baseline used for the

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<sup>9</sup> Itron Report, p.1-8

<sup>10</sup> Itron Report, p. 1-11.

marginal heat rate and marginal emissions data. The Itron Report does not explicitly state the method of estimating these factors, but appears to suggest that they are derived from an assumption-driven cost-based model.<sup>11</sup> Presumably, such a model makes the usual simplifying assumptions, including optimal dispatch and fixed marginal costs for operations and maintenance.

However, newer economic models are now available that no longer rely on this potentially inaccurate assumptions-driven approach, and instead use empirical techniques to measure actual realized marginal emissions in practice. To further improve this assessment, CESA believes that further analysis should keep the same analytic framework, but base its marginal emissions factors on actual marginal unit dispatch data rather than assumptions-driven modeling. A list of publicly available models of this type derived from peer-reviewed journal articles is provided in Appendix A to these comments. For even greater certainty, actual marginal unit dispatch data could be simply made available by the California Independent System Operator (“CAISO”). When multiplied by actual GHG emissions data that are publicly available from Air Markets Program (“AMPD”), a data source administered by the U.S. Environmental Protection Agency (“EPA”),<sup>12</sup> such data would produce an extremely robust and accurate source of marginal emissions data derived fully from real data.

CESA therefore recommends that CAISO data be made available to Itron or another reputable contracted third party, and that empirical marginal GHG emissions data be used to improve the assessment. If CAISO data are unavailable, CESA recommends using dispatch data from any of the publicly available empirical models mentioned in Appendix A be used.

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<sup>11</sup> Itron Report, pp. C-2, C-5.

<sup>12</sup> <https://ampd.epa.gov/ampd/>

Additionally, consistent with generally accepted GHG emissions analysis protocols such as the Greenhouse Gas Protocol's guidelines,<sup>13</sup> estimating a "build-margin" effect would ideally be included in any analyses. This could be based on an expectation of appropriate energy storage cycling in future years, for example, when rate reforms recommended in these comments are adopted and implemented.

Overall though, CESA supports the intent of the type of assessment in the Itron Report, which is being done for the first time for energy storage projects in the SGIP as energy storage operational data is now becoming available. CESA appreciates the helpful efforts of Itron and its broader team. While the assessment framework is workable, the assessment is limited without better and more data. CESA plans to work with the Commission to improve the analysis.

**V. THE COMMISSION SHOULD DEVELOP AN OPT-IN GREENHOUSE GAS REDUCTION TARIFF FOR ENERGY STORAGE CHARGING.**

Below are CESA's responses to the questions from the Ruling related to the distribution of potential new funding amongst technology sectors:

**Question 6: Should the proposed new funding be used to create incentives to address the concerns surrounding the net greenhouse gas (GHG) emissions of storage systems and non-renewable generation as documented in the 2014-2015 Impact Evaluation report? If so, how should they be designed?**

**CESA's Response:**

CESA does not support creating new rules to address the GHG emission concerns discussed in the Itron Report at this time. As noted in Section II above, the quality of the data and the sample size in Itron's assessment was insufficient to determine any specific corrective

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<sup>13</sup> *The Greenhouse Gas Protocol: Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*. World Resources Institute, Aug. 2007.  
[www.ghgprotocol.org/files/ghgp/electricity\\_final.pdf](http://www.ghgprotocol.org/files/ghgp/electricity_final.pdf)

action to take regarding the existing SGIP rules. Additionally, the systems that were included in the sample were not subject to reforms the Commission has adopted since 2015, including the reforms adopted in D.16-06-055, as well as the tariff and/or operational requirements imposed on residential systems pursuant to Resolution E-4717 (discussed further below).

Fundamentally, SGIP is a technology deployment program with GHG emissions performance driven by underlying tariffs that produce economic signals to charge and discharge at certain times of the day. The Commission should therefore focus on ensuring that rates are properly designed to economically incentivize energy storage projects to avoid peak demand and GHG emissions – *e.g.*, develop coincident demand charges rather than 24-hour non-coincident demand charges. The Itron Report similarly concludes that mis-aligned rate design as one of the main causes for observed poor GHG performance by energy storage systems. Understandably, rate reform in General Rate Case (“GRC”) proceedings occur over a long time frame and may not coincide with the Commission’s intent to ensure that GHG reduction goals are met with energy storage projects funded with immediately available AB 1637 funds. Therefore, if the Commission desires a tool or incentive to better promote GHG reductions via SGIP-funded energy storage projects, CESA recommends that the Commission require each of the IOUs to file Advice Letters (or some comparable process) implementing a special opt-in off-peak charging tariff (“GHG Reduction Tariff for Energy Storage Charging”) for energy storage systems.

CESA proposes the GHG Reduction Tariff for Energy Storage Charging as a simple opt-in tariff that would include ultra-low rates during a super-off-peak period to incentivize energy storage charging during this time and would be “bolted on” – *i.e.*, implemented in conjunction with the electric service customer’s existing TOU or demand charge tariff. The super-off-peak periods and rates could be determined by a study group including the Commission, the CAISO,

and other rate analysts using, for example, wholesale locational marginal prices (“LMPs”) in each IOU service territory. By setting a time-constrained super-off-peak period in the mid-day, for example, the Commission would have better assurance that energy storage systems on these rates are charging 100% from on-site or grid-connected PV solar. With reasonable super-off-peak periods and sufficiently low rates during this period, many energy storage projects would be incentivized to opt into this tariff as well. CESA is prepared lead and/or facilitate this study group and has already begun data analysis on hours of the day and days in the week in which marginal emissions are lowest.

To this end, CESA partnered with WattTime, a nonprofit organization dedicated to enabling electricity-consuming equipment to lower its GHG emissions footprint by deliberately syncing its energy consumption to moments of lower marginal GHG emissions. WattTime is able to do this because its unique software tools can measure the marginal GHG content of a grid in any U.S. market in five-minute intervals, using strictly empirical methods based on the latest academic literature. WattTime’s analyzed the last three years of EPA emissions data for the CAISO region to determine that charging energy storage during a period between 12 a.m. and 6 a.m. on a daily basis (regardless of season or day of the week) would ensure the lowest possible GHG content for standalone energy storage (see Appendix A for results and methodology). WattTime therefore concluded that incentivizing a shift in energy storage charging to such times via the bolt-on tariff mechanism described above would reduce GHG emissions from energy storage systems in the CAISO’s balancing authority area.

Importantly, this tariff can be developed outside of GRC proceedings and be implemented within several months, which would meet the Commission’s goal of more immediately incentivize GHG reductions from SGIP-funded energy storage systems in the



interim until new rates are developed in the ongoing GRCs. The Commission could then approve the tariff in relatively short order once filed as Advice Letters by each IOU.

**Question 7: What, if any, operational requirements should be tied to the proposed new funding to help ensure that GHG reduction goals are met? Should the recommendations made to improve the GHG performance of storage systems in the 2014-2015 Impact Evaluation report be tied to the proposed new funding?**

**CESA's Response:**

In addition to implementing the optional tariff discussed above, CESA recommends that the PAs better enforce any existing rules. Rather than creating any new eligibility rules, CESA recommends that the Commission and the PAs focus on enforcing existing rules and improving data collection and analysis. For example, Resolution E-4717, issued on June 12, 2015, revised the SGIP Handbook to require residential energy storage projects to include a signed Affidavit that binds these systems to cycling and data reporting requirements to protect against using these systems solely for backup emergency purposes.<sup>14</sup> This Resolution also approved requirements for host customers to subscribe to a TOU rate or critical peak pricing type rate and have the tools to feed energy back to the grid at times of peak demand. Placing further operational requirements on SGIP-funded energy storage systems only serve to limit the flexibility provided by the technology and the value proposition for the customer. Rather, CESA recommends that the Commission first explore whether these existing rules are being effectively enforced and if not, identify means to do so.

In addition, the Commission's Energy Division Staff recently published its final M&E Plan on January 13, 2017, as required by D.16-06-055, Conclusion of Law Number 46, which

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<sup>14</sup> Resolution E-4717 to approve Advice Letters PG&E 3552-G/4563-E, CSE 55, SCE 3165-E, and SCG 4741, issued on June 12, 2015.

will better enforce data collection and improve the sample size of energy storage operational data to inform reasonable corrective actions, if any. The M&E Plan makes clear that all SGIP projects are expected to report data in a timely manner that will allow evaluators to make findings and propose substantiated program changes. This plan also creates additional evaluation metrics for SGIP-funded energy storage projects to determine the extent to which they provide ancillary services to the IOUs and grid operators and the extent to which they facilitate a less GHG-intensive electric grid – *e.g.*, timing of charge and discharge. This information will be documented and analyzed in annual reports on the impacts of SGIP-funded energy storage projects. With more robust data on the performance of SGIP-funded energy storage projects, the Commission will then be better positioned to determine courses of action to address any *substantiated* operational issues, if any.

CESA recommends that tests for *substantiated* operational issues be compared against marginal emissions data that are: (1) empirical, as described above; and (2) periodically updated as grid conditions in California evolve over time. CESA notes that published empirical analyses of marginal emissions rates between 2006 and 2017 reveal different marginal emissions rates and timing over time in many grids across the United States. As the California grid continues to evolve, there will be a need to periodically update marginal GHG emissions estimates based on actual observed grid conditions. Such estimates would ideally be based on empirical data released by the CAISO, but at the very least, based on the latest peer-reviewed academic publications on marginal GHG emissions rates or a real-time database such as that of WattTime.

In any event, CESA urges the Commission to not delay opening of the SGIP in order to develop any new tariff or optimal rate design, or implement the M&E plan. CESA very strongly supports the GHG reduction goals of the program, but as discussed previously, the quality of the

data and the sample size in Itron's assessment was insufficient to determine a corrective action. CESA believes it is more prudent to open the program in a timely fashion to avoid too much market disruption for a program that has been closed to new applicants for over a year (*i.e.*, since February 2016). There are a number of energy storage projects that are unable to be deployed given this prolonged closed program period. Rather, CESA recommends that the Commission enforce current rules, develop a consensus methodology to measure GHG performance of energy storage systems, ensure greater and better data provision of energy storage operations, and develop an opt-in Energy Storage Charging Tariff to address any concerns about energy storage systems not meeting GHG reduction goals of the program. Deeper changes can be made as necessary upon a clearer conclusion of GHG performance of SGIP-funded energy storage systems, but program opening should not be tied to coming to this clearer conclusion.

**Question 8: Should priority for the new funding be given to residential customers that install storage systems and agree to take service under one of the following rates, depending on their investor-owned utility?**

**CESA's Response:**

As noted in CESA's response to Question 7, above, it may not be necessary for the Commission to establish a priority for new funding tied to residential customers installing energy storage systems and taking service under any TOU rates for the IOUs, in part because, the Commission has already instituted requirements for residential systems pursuant to Resolution E-4717 under which customers must either be on a TOU tariff, other dynamic tariff or program or, if not, then discharge their energy storage systems during peak hour or peak day events. Establishing a new lottery priority, as contemplated by this question, is not only unnecessary given existing rules and requirements in place, but would also not ensure that all residential customers serviced by the IOUs to be on TOU, critical peak, or other dynamic rates. This

priority only factors in when there is single-day oversubscription of funds and therefore may not achieve the GHG reductions as only a few projects in certain program opening scenarios are subject to take service under these rates.

Even if the Commission establishes this type of priority, CESA does not believe the existing TOU rates deliver enough value to incentivize energy storage charge and discharge schedules, nor do they necessarily align with the marginal emissions profile of the California system grid. Pacific Gas and Electric Company's ("PG&E") E-TOU-A and E-TOU-B rate schedules offer rate differentials of approximately \$0.10/kWh or less on summer weekdays,<sup>15</sup> while PG&E's EV-A rate schedule offers higher rate differentials closer to \$0.20/kWh but sets a seven-hour peak period from 2 p.m. to 9 p.m., which is too long for any commercially available behind-the-meter energy storage system to offset peak energy charges.<sup>16</sup>

However, CESA does see potential in some of the opt-in TOU pilot rate schedules, such as SCE's opt-in pilot TOU-DPP Option 2, which includes summer peak and off-peak rate differentials of \$0.26/kWh and a three-hour peak period from 5 p.m. to 8 p.m.,<sup>17</sup> as well as San Diego Gas Electric Company's ("SDG&E") opt-in pilot TOU-DR-E1 and TOU-DR-E2, includes summer peak and off-peak rate differentials between \$0.23/kWh to \$0.26/kWh and a four-hour peak period from 4 p.m. to 9 p.m.<sup>18</sup> Despite these relatively more beneficial rate schedules, which could be implemented when default TOU rates are implemented in 2019, these rate structures were designed around marginal generation costs, which do not perfectly coincide with

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<sup>15</sup> PG&E Schedule E-TOU. [http://www.pge.com/tariffs/tm2/pdf/ELEC\\_SCHEDS\\_E-TOU.pdf](http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_E-TOU.pdf)

<sup>16</sup> PG&E Schedule EV-A. [http://www.pge.com/tariffs/tm2/pdf/ELEC\\_SCHEDS\\_EV.pdf](http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_EV.pdf)

<sup>17</sup> SCE Schedule TOU-DPP: Time of Use Domestic Pilot Program. <https://www.sce.com/NR/sc3/tm2/pdf/ce378.pdf>

<sup>18</sup> SDG&E Schedule TOU-DR-E1. [http://regarchive.sdge.com/tm2/pdf/ELEC\\_ELEC-SCHEDS\\_TOU-DR-E1.pdf](http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_TOU-DR-E1.pdf). SDG&E Schedule TOU-DR-E2. [http://regarchive.sdge.com/tm2/pdf/ELEC\\_ELEC-SCHEDS\\_TOU-DR-E2.pdf](http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_TOU-DR-E2.pdf)

marginal emissions. As a result, the Commission may not fully address GHG performance issues with SGIP-funded residential energy storage projects, which is the apparent implication of some of the questions posed in this Ruling, even though these TOU rates would align with the grid support objective of the program. Instead of creating lottery priorities for residential energy storage projects taking service under TOU rates, CESA recommends that the Commission develop a GHG Reduction Tariff for Energy Storage Charging that would both support the grid and help the program achieve its GHG reduction goals.

**Question 9: For Sacramento Municipal Utility District and Los Angeles Department of Water and Power residential customers that install storage systems, taking service under which rates, if any, should be tied to priority for new funding?**

**CESA's Response:**

Similar to CESA's response to Question Number 8, above, it may not be necessary for the Commission to establish a priority for new funding tied to residential customers of Sacramento Municipal Utility District ("SMUD") and Los Angeles Department of Water and Power ("LADWP") installing energy storage systems and taking service under TOU rates.

**VI. THE COMMISSION SHOULD ALLOCATE ADDITIONAL FUNDING FOR ENERGY STORAGE EVENLY ACROSS THE FIVE STEPS IN ACCORDANCE WITH DECISION 16-06-055.**

The Ruling proposes to allocate a majority of the additional funds authorized under AB 1637 to be reserved for later steps in the SGIP program in order to "ensure that developers, particularly in the storage market, have sufficient time to refine their technology for a much larger pool of funds."<sup>19</sup> This proposal diverges somewhat from D.16-06-055, which equally divided total SGIP funding across each step (including Step 1), and is specified as below:

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<sup>19</sup> Ruling, p. 3.

Technology Category	Step 1	Step 2	Step 3	Step 4	Step 5
Generation	33.3%	33.3%	33.4%	--	--
Energy Storage	0%	25%	25%	25%	25%

Below are CESA’s responses to the questions from the Ruling related to the distribution of new funding across steps, which includes a proposal that differs from what has been proposed in the Ruling:

**Question 10: Is it appropriate to distribute the proposed new funding in different amounts across different steps as described above? If so, why? If not, why not?**

**CESA’s Response:**

CESA recommends that the authorized new funding be allocated evenly across all steps – *i.e.*, 20% of the total proposed new funding for energy storage in each of the five steps – to be consistent with the legislative intent of AB 1637 and the funding allocations already approved by D.16-06-055. CESA does not find a compelling reason to exclude additional funding from being allocated in the Step 1 budget as proposed in the Ruling. D.16-06-055 already reduced the proposed incentive rate to \$0.50/Wh for a two-hour energy storage systems from the \$1.20/W (or \$0.60/Wh) from the Energy Division’s Staff Proposal,<sup>20</sup> and while time has passed and market conditions may have changed to some degree, access to Step 1 funding remains a critical need for many projects. Such projects, if financeable, could influence the energy storage landscape while also supporting customer needs. Step 1 funding continues to be the most compelling funding level for would-be energy storage market entrants, and removing this incentive would diminish the competitiveness of the market, once SGIP opens. Concerns about the Step 1 budget being exhausted expeditiously due to incentive rates being too high in Step 1 are understandable

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<sup>20</sup> *Energy Division Staff Proposal*, November 23, 2015, p. 25.

yet unsubstantiated and less applicable given higher deposit requirements and other “hurdles” to SGIP participation pursuant to D.16-06-055. For example, the February 23, 2016 partial program opening is further evidence that there is pent-up market demand for behind-the-meter energy storage projects and that past market structures promoted “stampedes” but not necessarily viable projects. D.16-06-055 set the Step 1 incentive rate with the understanding that it is necessary to spur the market for energy storage deployment at this time.

Furthermore, given the lottery priorities set by D.16-06-055, excluding additional funding to be allocated to the Step 1 budget may in effect exclude standalone energy storage projects from receiving Step 1 incentive rates. D.16-06-055 granted the PAs discretion to set criteria for “priority access to rebates” based on whether the projects provided relatively more grid support or GHG reduction,<sup>21</sup> which the PAs determined to be solar-plus-storage systems and those systems located in the LADWP and West Los Angeles Basin areas. While the PAs are well within their authority to set these lottery priorities, the Commission may not have intended to lock out standalone storage projects along with the grid and environmental benefits that they provide. By excluding any additional funds from being allocated to Step 1, the Commission risks denying standalone storage projects access to Step 1 incentive rates. CESA therefore recommends that the Commission follow the intent of the Legislature and D.16-06-055 by allocating the additional funding authorized by AB 1637 evenly across the five steps for energy storage.

**Question 11: Is the reasoning that the proposed new funding should be used to lengthen that later steps of SGIP to allow for more refined versions of SGIP technologies to take advantage of more of the funding acceptable? If so, why? If not, why not?**

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<sup>21</sup> D.16-06-055, p. 51.

**CESA's Response:**

CESA does not find this reasoning to be valid. There is no compelling reason to lengthen the SGIP through later years (*i.e.*, through 2019) to allow for more “refined technologies” since one of the purposes of this program is to deploy more technologies that help to bring their costs down and familiarize customers with the technology, while also providing grid support and GHG reductions. After all, this is a technology deployment program. For this reason, D.16-06-055 adopted the requirement for SGIP-funded technologies to be commercially available, as demonstrated by a system certification from a Nationally Recognized Testing Laboratory (“NRTL”) or supported by a 10-year warranty consistent with Rule 21 interconnection standards.<sup>22</sup> Such energy storage technologies are available today, and CESA therefore sees no reason why the program should be back-loaded to artificially lengthen the program.

Additionally, CESA believes that the back-loading of the proposed new funding to later steps risks stalling the market for behind-the-meter energy storage projects. Increased customer familiarity, improvements on permitting and siting, and new business model and financing innovations are still needed to support the market transformation of energy storage. Rather than increasing the pie for all different types of energy storage business models and technologies to have some access to higher incentive rates in Step 1 (or Step 2) by distributing additional funds evenly across the five steps, the back-loading of additional funding to later steps could potentially stall the market by causing the incentive rate to drop precipitously due to oversubscription from pent-up market demand, leading to the program having funds available in later steps but few or no applicants to claim them at the very-low incentive rates.

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<sup>22</sup> D.16-06-055, p. 14.



Finally, another reason to avoid back-loading of additional funding to later steps is the urgency to deploy energy storage systems in the LADWP and West Los Angeles Basin areas to mitigate the reliability concerns from the Aliso Canyon gas storage facility. A reliability assessment conducted jointly by the Commission and other state agencies revealed that risks still exist to the energy infrastructure and that conservation and other mitigation measures are needed to meet the reliability needs through the Winter 2017.<sup>23</sup> While a Summer 2017 assessment is yet to be conducted, the PAs clearly identified the urgency of this situation by placing a lottery priority for the affected regions as a supporting Aliso Canyon mitigation measure. The back-loading of funds would work counter to this objective.

Given all the reasons above, CESA recommends against back-loading of additional funds to later steps in SGIP and instead recommends an evenly distributed allocation of additional funds across all five steps.

**Question 12: Alternatively, should the proposed new funding be distributed equally across steps as mandated for existing SGIP funding? If so, why? If not, why not?**

**CESA's Response:**

Yes. As highlighted in responses to Questions Number 10 and 11, above, CESA recommends that additional funding be distributed equally across the steps, which aligns with D.16-06-055 and balances the need for higher incentive support now while deploying greater number of projects in later steps with lower incentive rates.

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<sup>23</sup> *Aliso Canyon Gas and Electric Reliability Winter Action Plan*, prepared by the Staff of the California Public Utilities Commission, California Energy Commission, California Independent System Operator, and Los Angeles Department of Water and Power on August 22, 2016, p. 3.

**Question 13: If a Decision based on this Ruling is not voted on until after Step 1 (and other steps, if applicable) is completed, how should the funds that otherwise would have been used for Step 1 (and other steps, if applicable) be applied?**

**CESA's Response:**

CESA believes that this situation should be avoided at all costs. It was the intent of the Legislature to authorize the doubling of the funds available to SGIP under rules adopted in D.16-06-55. By approving the allocation of additional funding to the program after Step 1 is completed, the Commission could fail to deliver on the legislative intent by denying additional funds from being allocated to Step 1. The Commission should focus on allocating additional funding in accordance with D.16-06-055, which has already involved deep stakeholder engagement that set the policy guidance for the program. Any delays related to allocating additional funding across technology categories and/or budget steps are unnecessary given the guidance already authorized by the Legislature and D.16-06-055, which stipulated the Step 1 funding level of \$0.50/kWh for energy storage. CESA therefore urges the Commission to approve the allocation of this additional funding before Step 1 is opened.

If the Commission determines to approve a scenario where Step 1 opens prior to a decision approving the allocation of additional funding to the SGIP, CESA recommends that all funds allocated for Step 1 be re-allocated into Step 2 in this situation. For example, if a decision is approved on AB 1637 implementation when the program is currently in Step 2, the 20% of proposed new funding that was supposed to go to Step 1 would be re-allocated entirely to Step 2. As CESA has proposed in its response to Question 10, above, the Step 2 budget would then have a total allocation of 40% of the new proposed funding if a decision is not issued until after Step 1 is completed. CESA believes this is fair and reasonable given that energy storage projects should be eligible for the highest incentive rate available at the time. It would be unclear

whether the exhaustion of Step 1 funds is due to the Step 1 incentive rate being too high, or due to insufficiency of funds at the Step 1 incentive rate. Given the stampede for funds in the February 22, 2016 partial opening, and the pent up year-long demand, CESA believes it is due to the latter. Furthermore, CESA believes this is administratively simple and would not require the PAs to manage multiple steps for the same budget categories.

*CESA's proposed allocation of additional funding across the steps*

Energy Storage	Step 1	Step 2	Step 3	Step 4	Step 5
Per legislative intent, Decision is approved before Step 1 opening	20%	20%	20%	20%	20%
If Decision is approved before Step 3 opening	0%	40%	20%	20%	20%

CESA reiterates the need for immediate action on the doubling of funds pursuant to AB 1637. Without action, the Commission risks weakening or stalling the market for behind-the-meter energy storage versus what could be possible through a quickly directed doubling of funds. Also, with fewer funds available in the earlier steps, it is likely the program will quickly move through those steps and potentially create an accelerated incentive rate decline. To avoid such a situation, CESA therefore urges the Commission to open SGIP prior to the opening of Step 2 to help ensure that additional funds as authorized by AB 1637 are allocated to the Step 2 budget.

**VII. THE COMMISSION SHOULD RE-ADJUST THE DEVELOPER CAP TO REFLECT THE NEW STEP BUDGETS AND EVALUATE WHETHER LOTTERY PRIORITIES SHOULD REMAIN IN PLACE FOR THE FULL DURATION OF THE PROGRAM.**

The Ruling does not propose any changes to the developer cap or any other SGIP rules (e.g., lottery mechanism). Below are CESA's responses to the questions from the Ruling related to the developer cap and other SGIP rules:

**Question 14: Is the proposal to not adjust the developer cap reasonable? If so, why? If not, why not?**

**CESA's Response:**

Although CESA does not believe the developer cap needs to be modified, CESA recommends that the Commission clarify that the dollar amount corresponding to the developer cap will be calculated inclusive of AB 1637 funding. While this appears to be the intent, CESA observes that the current language in the Draft SGIP Handbook recently submitted by the PAs includes language that could result in the dollar amount corresponding to the 20% developer cap being calculated based on the current budget before any additional funding resulting from AB 1637 implementation. Specifically, the Draft SGIP Handbook states “The Developer cap will be established by budget step and posted prior to program opening. The Developer cap will remain fixed for each budget step once the step is opened even if total available funds change”.<sup>24</sup> Should a decision on AB 1637 be issued after the program opens, this language would seem to indicate that the developer caps would not be adjusted to reflect the additional funding made available in the program. CESA recommends instead that the developer cap be readjusted to reflect the new step budgets including any new funding that is allocated across the steps in the program. In D.16-06-055, the Commission set the developer cap at 20% of the *available* funding for a given technology category’s total in each incentive step.<sup>25</sup> Considering the new proposed funding would change the total available funding in each incentive step, CESA finds it reasonable to allow for the developer’s cap to be readjusted.

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<sup>24</sup> Draft 2017 SGIP Handbook, at p. 30.

<sup>25</sup> D.16-06-055, pp. 39-40.

**VIII. THE COMMISSION SHOULD DIRECT OR CLARIFY THAT PERFORMANCE-BASED INCENTIVES ADOPTED IN D.16-06-055 SHOULD APPLY TO BOTH EXISTING AND NEW ENERGY STORAGE PROJECTS.**

As the PAs implement the new operational and performance requirements adopted pursuant to D.16-06-055, CESA recommends clarification that the PAs should immediately begin applying the updated performance-based incentive rules to energy storage projects currently within their five-year compliance period. The PAs would thus benefit from administering a single performance-based incentive calculation methodology, while developers will benefit from avoiding to unnecessarily cycle their energy storage systems to meet outdated operational requirements. Excessively high cycling requirements under the previous operational requirements may also risk forced dispatches of SGIP-funded energy storage systems that are not aligned with grid needs. CESA believes the Commission approved the operational provisions as in D.16-06-055 due to this very concern.

Therefore, the Commission should require the PAs to file supplemental advice letters explaining how the PAs plan to address the inconsistency between hours and discharges for existing systems and new system. D.16-06-055 directed that this point be addressed in advice letters revising the SGIP Handbook<sup>26</sup> but it was not addressed there.<sup>27</sup>

**IX. THE COMMISSION SHOULD ACCOUNT FOR AND ANTICIPATE IMPLEMENTATION DELAYS REGARDING THE NEW CALIFORNIA SUPPLIER REQUIREMENTS.**

D.16-06-055 authorized the PAs to adopt modifications to the requirements for the California supplier adder and ordered the PAs to begin enforcing the new rules 12 months after

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<sup>26</sup> D.16-06-055, p. 40.

<sup>27</sup> Advice No. 5049 (Southern California Gas Company – U 904 G), Advice 3773-G/4942-E (Pacific Gas and Electric Company – U 39 M), Advice 3491-E (Southern California Edison Company – U 338 E) Advice 71 (Center for Sustainable Energy), Revisions to the Self-Generation Incentive Program Handbook Pursuant to Decision 16-06-055, filed on October 21, 2016.

the decision was approved. In Draft Resolution E-4824 issued on January 9, 2017, the Commission clarified that qualifying manufacturers must meet the new requirements by the incentive claim stage.<sup>28</sup> However, implementation of rule changes in accordance with D.16-06-055 has taken longer than the reasonably expected timeline, as the PA advice letters revising the SGIP Handbook were suspended to allow for further Commission review. Given the shift in the implementation timeline, CESA recommends that the Commission also consider adjusting enforcement of new California supplier requirements to allow for sufficient time to implement changes. Specifically, the Commission may consider starting the 12-month implementation timeline as of the date that the PA's new supplier certifying program becomes effective.

**X. CONCLUSION.**

CESA aims to ensure the success of SGIP in supporting energy storage projects that provide grid support, reduce greenhouse gas emissions, transforms the energy storage market, and therefore looks forward to working with the Commission, the PAs, and other stakeholders going forward.

Respectfully submitted,



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Counsel for the  
**CALIFORNIA ENERGY STORAGE ALLIANCE**

Date: January 31, 2017

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<sup>28</sup> Draft Resolution E-4824, pp. 6, 36-37.

## **Appendix A:**

Marginal Emissions Modeling for  
Energy Storage Tariff Analysis

# Marginal Emissions Modeling for Energy Storage Tariff Analysis

Gavin McCormick

Executive Director, WattTime.org

## Introduction: Empirical Marginal Emission Modeling

CESA has prepared this proposal using a software analysis tool developed by WattTime, a nonprofit which combines data from power grid operators, the EPA, and other data sources, to detect minutes and hours in the day when using electricity is cleaner and more environmentally friendly, in real time. Today, most marginal GHG emissions models in the industry estimate marginal GHG emissions rates based on assumptions. However, in peer-reviewed journal articles, this approach has largely now been replaced. All six empirical investigations into marginal emissions rates to date concluded similar methodologies were appropriate, and found similar results, across a wide variety of applications, power grids, methodology tweaks, and years.<sup>1 2 3 4 5 6</sup>

For this analysis, WattTime applied the method of Siler-Evans, Azevedo, and Morgan, but also confirmed the key results using two other methods, that of Zivin, Kotchen and Mansur and that of Callaway, Fowlie, and McCormick.

## Ranking Method

Under the new empirically-based approach, analysts can measure how much actual system-level GHG emissions increased in the past each time a megawatt-hour of electricity demand was added to the grid. By carefully measuring cases of randomly fluctuating energy demand or supply under different circumstances (*e.g.*, due to weather variation), analysts can

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<sup>1</sup> Callaway, D., Fowlie, M, and McCormick, G. (forthcoming) Location, Location, Location: The Variable Value of Renewable Energy and Demand-side Efficiency Resources.

Siler-Evans K., Azevedo, I.L., and Morgan, M.G. (2012). “Marginal emissions factors for the US electricity system.” *Environmental Science & Technology*, 46(9): 4742-4748

<sup>2</sup> Cullen, J. (2013). Measuring the environmental benefits of wind-generated electricity. *American Economic Journal: Economic Policy*, 5(4):107{133.

<sup>3</sup> Hittinger, E., and Azevedo, Inês (2015). Bulk Energy Storage Increases United States Electricity System Emissions. *Environmental science & technology*, 2015, 49 (5), pp 3203–3210.

<sup>4</sup> Kaffine, D. T., McBee, B. J., Lieskovsky, J., et al. (2013). Emissions savings from wind power generation in Texas. *Energy Journal*, 34(1):155{175. *American Economic Journal* (2013). Emissions savings from wind power generation in Texas. *Energy Journal*, 34(1):155{175. *American Economic Journal*.

<sup>5</sup> Novan, K. (2015). Valuing the wind: renewable energy policies and air pollution avoided.

<sup>6</sup> Siler-Evans, K., Azevedo, I. L., and Morgan, M. G. (2012). Marginal emissions factors for the US electricity system. *Environmental science & technology*, 46(9):4742{4748.



determine through regression analysis of the GHG emissions, which are caused by changing demand by a given amount at a given time and place. By comparing how these causal effects change across time of day, season, and other power grid conditions, it becomes possible to generate a marginal emissions factor for different grid circumstances.

WattTime did this using the generation-based method of Siler-Evans, Azevedo, and Morgan. However, WattTime updated the estimates in this paper in several ways, by: (1) using 2014-2016 data as opposed to 2006-2011 data; (2) using CAISO-specific data instead of averaging over the entire Western Electricity Coordinating Council (“WECC”) interface; and (3) using CAISO’s Open Access Same-time Information System (“OASIS”) to obtain updated relevant system conditions data for each specific hour of the time period. Other inputs to the model include GHG emissions data and power production data from the EPA’s Continuous Emissions Monitoring System dataset to generate marginal emissions factors.

Once WattTime had found the marginal GHG emissions rates for each hour of 2014-2016, it averaged these rates to generate an average marginal emissions factor for each hour of the day, month, and according to whether the day was a weekend/holiday or workday. WattTime then ranked these hours from 1 (cleanest) to 24 (dirtiest) each day to determine the cleanest times to charge each day.

## **Ranking Results**

WattTime found that the GHG emissions intensity of California’s grid generally has a single peak on any typical day in the late afternoon to the early evening hours as shown on the next two pages.

Figure 1: GHG Emissions Intensity on Weekdays on the CAISO Grid from 2014-2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12:00 AM	7	7	2	3	6	7	7	6	6	5	6	7
1:00 AM	1	1	1	1	4	5	5	4	4	4	4	5
2:00 AM	2	2	4	4	3	3	3	3	3	1	1	3
3:00 AM	4	3	6	5	1	1	1	1	1	2	3	1
4:00 AM	5	4	5	2	2	2	2	2	2	3	2	2
5:00 AM	3	5	3	6	5	4	4	4	5	5	6	4
6:00 AM	6	6	8	8	7	6	6	7	7	8	7	6
7:00 AM	9	9	9	10	9	8	8	8	9	9	8	8
8:00 AM	15	10	11	11	11	10	10	10	10	11	10	14
9:00 AM	18	15	12	12	12	11	11	12	12	12	11	18
10:00 AM	20	17	13	14	13	13	13	13	13	13	14	17
11:00 AM	19	18	15	16	14	14	14	14	15	15	17	16
12:00 PM	16	13	17	20	15	15	16	16	16	16	16	15
1:00 PM	13	11	14	15	17	17	18	18	18	18	15	13
2:00 PM	12	12	18	21	19	20	20	20	21	19	13	12
3:00 PM	11	19	20	17	22	22	22	22	22	23	18	11
4:00 PM	10	16	16	17	23	24	24	24	24	24	19	10
5:00 PM	17	20	19	18	21	23	23	23	23	20	20	19
6:00 PM	23	22	22	22	20	21	21	21	20	21	24	23
7:00 PM	24	24	24	23	18	19	19	19	19	22	23	24
8:00 PM	22	23	23	24	24	18	17	17	17	17	22	22
9:00 PM	21	21	21	13	16	16	15	15	14	14	21	21
10:00 PM	14	14	10	9	10	12	12	11	11	10	12	20
11:00 PM	8	8	7	7	8	9	9	9	8	7	9	9
<b>Max emissions rate (lbs CO2/MWh)</b>	989	985	969	990	998	1,044	1,077	1,080	1,068	1,021	1,015	1,029
<b>Min emissions rate (lbs CO2/MWh)</b>	875	870	868	870	880	901	915	915	904	911	915	937
<b>Shifting from max to min at 90% RTE (lbs/MWh charged)</b>	15	16	4	21	19	39	54	57	57	8	-1	-11
<b>Recommended multiplier</b>	High	High	High	High	High	High	High	High	High	High	Low	Low

Figure 2: GHG Emissions Intensity on Weekends/Holidays on the CAISO Grid from 2014-2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12:00 AM	9	9	5	1	8	9	9	9	9	8	9	13
1:00 AM	1	1	1	3	6	7	7	7	7	6	1	7
2:00 AM	3	7	2	6	1	6	6	6	5	4	3	5
3:00 AM	4	6	4	5	3	4	4	4	2	1	5	1
4:00 AM	6	4	7	4	4	3	3	1	1	2	2	2
5:00 AM	7	8	8	7	5	2	2	3	3	3	4	4
6:00 AM	5	5	3	2	2	1	1	2	4	5	6	3
7:00 AM	2	2	6	8	7	5	5	5	6	7	7	6
8:00 AM	8	3	9	9	9	8	8	8	8	9	8	8
9:00 AM	13	10	11	11	11	10	10	10	10	11	10	9
10:00 AM	16	13	12	15	12	12	12	12	12	12	12	17
11:00 AM	17	16	13	13	13	13	13	13	14	14	13	16
12:00 PM	15	15	14	16	14	14	15	15	15	15	14	14
1:00 PM	12	14	15	12	16	16	17	16	17	16	15	11
2:00 PM	10	11	16	14	17	17	18	20	19	18	16	12
3:00 PM	11	12	17	17	18	18	21	22	22	19	17	10
4:00 PM	14	17	19	18	19	21	23	24	24	21	19	15
5:00 PM	19	19	20	20	20	24	24	23	23	22	20	19
6:00 PM	22	21	21	21	21	23	22	21	21	23	24	22
7:00 PM	24	24	23	22	22	20	20	19	20	24	23	24
8:00 PM	23	23	24	24	24	22	19	18	18	20	22	23
9:00 PM	21	22	22	23	23	19	16	17	16	17	21	21
10:00 PM	20	20	18	19	15	15	14	14	13	13	18	20
11:00 PM	18	18	10	10	10	11	11	11	11	10	11	18
<b>Max emissions rate (lbs CO2/MWh)</b>	948	930	939	945	958	1,020	1,046	1,043	1,044	1,004	989	1,004
<b>Min emissions rate (lbs CO2/MWh)</b>	882	869	869	867	874	890	914	900	888	914	906	930
<b>Shifting from max to min at 90% RTE (lbs/MWh charged)</b>	-29	-31	-24	-17	-12	27	27	39	51	-10	-15	-27
<b>Recommended multiplier</b>	Low	Low	Low	Low	Low	High	High	High	High	Low	Low	Low

Based on this analysis, the cleanest periods to charge energy storage systems are between 11 p.m. and 7 a.m. every day (including weekends), regardless of the season. This is an empirical result based on the CAISO grid’s operation over the last three years, and could change over time.

### Savings Method

Next, WattTime calculated the GHG emissions savings (or increase) that energy storage might cause by shifting demand. GHG emissions savings were calculating by examining the pounds of CO2/MWh at the dirtiest and cleanest hour of each day on an average day. WattTime modeled the energy impacts based on the Tesla Powerwall (which has an estimated 90% roundtrip efficiency) by measuring the GHG emissions impacts of increasing energy demand by 1 megawatt-hour at the cleanest time each day and reducing it by 0.9 megawatt-hours at the dirtiest time each day.

WattTime used highly conservative assumptions on the benefits of energy storage for this analysis. Only those GHG emissions benefits from battery storage that are directly verifiable using EPA Continuous Emissions Monitoring System emissions data were examined, ignoring many potential benefits from more difficult-to-verify sources such as variable transmission losses, renewables curtailment reductions, and ramping benefits. Given this, the CO2 savings estimated in these results are highly likely to underestimate the actual savings from shifting from the dirtiest to the cleanest hour at 90% roundtrip efficiency.

It would also be possible for an energy storage operator to deliberately achieve still greater GHG emissions savings by adjusting their dispatch schedule to take advantage of real-time variation in marginal GHG emissions rates, using a software tool such as <https://api.watttime.org/> or a marginal fuel data feed that the CAISO could choose to provide.

### Savings Results

WattTime found that energy storage which shifts GHG emissions from the dirtiest to the cleanest hour at 90% roundtrip efficiency would reduce GHG emissions with high certainty on most working days and on many weekends and holidays. Because of the aforementioned highly conservative nature of these estimates, it is WattTime’s assessment that energy storage under these conditions would in fact most likely reduce emission on all days.

*Figure 3: Highest and lowest marginal GHG emissions rates each day, and possible savings from energy storage, on working days on the CAISO Grid from 2014-2016 (in lbs CO2 per MWh)*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dirtiest hour	989	985	969	990	998	1,044	1,077	1,080	1,068	1,021	1,015	1,029
Cleanest hour	875	870	868	870	880	901	915	915	904	911	915	937
Savings	15	16	4	21	19	39	54	57	57	8	-1	-11

*Figure 4: Highest and lowest marginal GHG emissions rates each day, and possible savings from energy storage, on weekends/holidays on the CAISO Grid from 2014-2016 (in lbs CO2 per MWh)*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dirtiest hour	948	930	939	945	958	1,020	1,046	1,043	1,044	1,004	989	1,004
Cleanest hour	882	869	869	867	874	890	914	900	888	914	906	930
Savings	-29	-31	-24	-17	-12	27	27	39	51	-10	-15	-27