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

Order Instituting Rulemaking to Oversee the Resource Adequacy Program, Consider Program Reforms and Refinements, and Establish Forward Resource Adequacy Procurement Obligations.	Rulemaking 25-10-003 (Filed October 9, 2025)

LONG DURATION ENERGY STORAGE CHARGING SUFFICIENCY PROPOSAL OF THE CALIFORNIA ENERGY STORAGE ALLIANCE, FORM ENERGY, HYDROSTOR, AND FOURTH POWER

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In accordance with the Rules of Practice and Procedure of the California Public Utilities Commission ("Commission"), the California Energy Storage Alliance ("CESA"), Form Energy, Hydrostor, and Fourth Power ("Joint Parties") hereby submit these joint comments and Track 1 Party Proposal ("Proposal") pursuant to the scope and schedule in the Assigned Commissioner's Scoping Memo And Ruling ("Ruling") filed on December 12, 2025, for parties' and the Commission's consideration. This joint filing is submitted by CESA, which is authorized to file on behalf of the undersigned joint parties.

I. Introduction

These comments address the critical need for a clear and functional Resource Adequacy ("RA") accreditation framework for Long-Duration Energy Storage ("LDES") systems. LDES resources, which, for purposes of these comments mean technologies capable of discharging at full capacity for more than eight hours, are expected to be brought onto the California system in increasing amounts in the near future. And, they are a vital component of California's future grid.

As the state integrates higher levels of intermittent renewables, and experiences rapid load growth, these assets provide the extended reliability, effective load-carrying capability, and multi-day balancing necessary to ensure resource adequacy for the state.

While the Commission has established important procurement targets for LDES,[1] a significant regulatory gap remains: there is currently no methodology for how Load-Serving Entities ("LSEs") should represent LDES resources in their "slice-of-day" ("SOD") showings under the RA program. This gap exists primarily because the current SOD framework is centered on distinct 24-hour periods in each month, a structure that cannot capture the value of assets like LDES, which are designed to operate across much longer time horizons.

These comments are intended to bridge this gap, by presenting a principled, logical, and implementable solution. The proposal laid out in these comments is the result of several parties repeatedly grappling with how LDES resources can be integrated into California's unique RA program. The proposal has benefitted from significant proactive outreach to stakeholders, including ratepayer advocates, Commission Staff, and LSEs. The goal of these comments is to provide a methodology that ensures LDES resources are appropriately valued while strictly safeguarding grid reliability.

Without an immediate and clear RA participation pathway for LDES resources, LSEs cannot accurately value or utilize an important group of assets the state expects them to build, and a group of assets that will be critical to unlocking tremendous value for the state in meeting its energy goals while maintaining reliability. The Commission should use this proceeding to adopt a workable and principled approach for including LDES resources in its slice-of-day RA program.

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[1] *See, e.g.*, Decision 24-08-064 (August 22, 2024) (establishing central procurement of up to 1 GW of 12+ hour storage and 1 GW of multi-day energy storage).

I. The Commission should use this proceeding to finally clarify how Load-Serving Entities can reflect LDES resources in their slice-of-day showings.

In prior tracks of the Commission's review of the RA program, Form Energy proposed that LDES resources, and specifically multi-day storage ("MDS"), should be shown in LSE's SOD compliance filings at their maximum output across all 24-hours of the slice-of-day period. Under Form's proposal, there would not be a specific accounting of the energy used to charge multi-day systems because the duration of MDS resources exceeded the slice-of-day period, and because the charging for such resources was expected to come from outside the slice-of-day period. The Commission ultimately rejected that proposal, and found that there should be some method for accounting for the energy used to charge such resources.

Despite its rejection, the Commission noted that there was "some merit in Form Energy's proposal, as these resources are being developed to provide long durations of discharge similar to [pumped storage hydro] and may be able to charge/discharge when needed." However, the Commission agreed with Cal Advocates that some methodology should be developed to show that there is an accounting for the energy used to charge LDES / MDS resources. The Commission ordered additional workshops on, and party consideration of several questions around the charging of MDS resources, including:

- Whether MDS should have limitations on its ability to charge;
- How such resources could fit into the slice-of-day approach; and
- Whether various extended-duration resources should be treated differently from each other, and how.

These comments support a proposed methodology that would address the Commission's stated questions and meet its goals to develop a method to account for charging energy used by LDES resources.

II. The proposal set forth here addresses key objectives of the RA program on a principled basis, and addresses key objectives identified by the Commission in its prior orders.

The proposal set forth here is designed to bridge the gap between the Commission's reliability mandates and the unique physical characteristics of LDES resources. Specifically, the proposed framework centers on the following key assumptions and objectives:

- **Recognition of physical capabilities, supported by charging**: LSEs should be permitted to show LDES resources for their full physical duration (up to the current 24-hour SOD limit), provided that they can demonstrate a realistic expectation of sufficient charging energy.
- **Reflection of operations**: The determination of energy sufficiency for LDES resources should be grounded in how LDES systems actually function—specifically their purpose and ability to move energy from prior periods into grid stress periods, which occurs over multiple days.
- **Methodological consistency**: The accounting methodology should be principled and broadly applicable to various types of LDES resources.
- **Safeguarding customers and reliability**: The methodology should protect customers from unnecessary costs and must contribute to ensuring resource adequacy.
- **Implementability**: The accounting for LDES resources must be straightforward for LSEs to implement, and for Commission Staff to verify.

As the Commission considers how to account for LDES, it should seek a methodology that recognizes the fundamental purpose of LDES: shifting energy from periods of relative abundance to periods of grid stress. Like short-duration storage, LDES is designed to move energy across time. But, LDES is uniquely engineered to perform this task over extended horizons. The longer the duration of a resource, the broader the timeframe over which it can bank energy during periods of oversupply to meet loads during periods of scarcity. Any principled methodology must recognize these fundamental attributes to remain in the best interest of California's ratepayers and the grid's stability.

III. Customers will benefit most from a method that reflects the most likely charging behavior of LDES resources, and does not artificially "force" it into periods of grid stress.

Principled approaches that reflect operational realities work best to protect customers and send the appropriate signals in a market. This also holds true for the Commission's slice-of-day construct. To this end, the Commission should adopt a methodology that aligns with how LDES resources physically operate on the grid rather than forcing them into a rigid, daily cycle.

Some parties have advocated for "forcing" a charging assumption for LDES resources into the slice-of-day period (the most grid-stressed days of the month), even when the actual operation of those resources is likely to play out over a period much longer than the 24-hour window under the program. Doing so would ignore the primary design and purpose of LDES. Unlike short-duration storage, LDES is specifically engineered to bridge extended, and even multi-day reliability gaps by decoupling the timing of energy generation from the timing of grid stress. Forcing these resources to show a full recharge within the same 24-hour slice they are dispatching for reliability would nullify their unique benefits and purpose and send the wrong signal to California's market participants.

More importantly, forcing LDES charging into the 24-hour slice-of-day period would create artificial scarcity by requiring energy for charging when it is most problematic to find. Requiring "charging capacity" during the worst day would force LSEs to buy extra energy precisely when it is most scarce and expensive. This "overpaying"—paying for the LDES capacity itself and then paying for redundant peak-day charging resources—would be economically inefficient, serves no additional reliability purpose, and would unnecessarily increase costs for California ratepayers.

Although the Commission has ordered the exploration of the CalAdvocates "MDESR proposal," that proposal suffers from these same flaws. The MDESR proposal applies a "multiplier" to recognize greater access to energy by LDES resources. But it applies this multiplier to excess energy *within* the slice-of-day period. This means that, under the CalAdvocates proposal, an LDES resource's value becomes wholly dependent on the availability of, or procurement of energy during the highest grid stress events. This methodology unrealistically assumes LDES resources will enter a stress event empty and must be filled using energy from the most constrained hours of the month. This is completely contrary to the intended and expected operations of LDES resources.

The proposal described below avoids these problems by providing a logical accounting of the energy actually used to charge LDES resources. By recognizing that LDES resources charge during periods of relative abundance in the days leading up to a stress event, as set forth in the proposal, the Commission can fulfill its desire for energy sufficiency without imposing artificial and costly constraints on the grid.

IV. The Commission should adopt the below-described proposal, which accounts for the sources of energy that are most reasonably expected to be used to charge LDES resources.

Much like a fuel tank, LDES resources are able to carry energy that may be deposited at various times, and make it available for use at various times, and for extended durations. At their core, LDES resources are used to receive massive amounts of energy from the grid, and store it until needed for extended periods. In this way, they are excellent resources for meeting loads during the slice-of-day period.

In the case of LDES resources that are operational and connected to the grid, they are expected to store energy to meet the slice-of-day peak system needs from three general categories, or sources of energy. The first would be residual energy that is expected to be carried within such systems, at a general baseline level. Because LDES resources are designed to operate for extended periods, up to multiple days, they are not likely to be empty on any particular day, especially prior to a month's "worst-day." Rather, they should be expected to contain some residual, baseline energy, or, in other words, a deemed "Initial State of Charge" (ISOC).

The second category of energy expected to be contained by LDES systems would be energy that is expected to be added to an LDES resource in the days leading up to a system stress event. This energy is added for the purposes of being ready for a particular grid stress event. Under the proposal, this is characterized as "Shifted Energy," because the LDES resource banks this energy from the immediate days leading up to the period of grid stress, so that it can shift it into the period of grid stress (*i.e.* into the slice-of-day period).

Finally, LDES resources, like short-duration energy storage resources, can make use of excess energy that may be available within the grid stress period, to the extent that exists. This energy is termed "Slice of Day Excess Energy" under the proposal.

By accounting for these three categories, or "buckets" of energy that support an LDES resource's ability to discharge in the slice-of-day period, the Commission can then determine how long an LDES should be deemed available to meet loads in the slice-of-day period. By implementing a framework that does this, the Commission has a path to treating LDES resources comparably with other resources under the slice-of-day program. Put simply, the Commission should allow an LSE to show LDES resources as able to meet loads to the extent they are expected to have enough total energy (from the Initial State of Charge, Shifted Energy, and

Slice-of-Day Excess Energy) to be dispatched, up to their full physical capacity during the slice-of-day period. **A detailed proposal for how these energy values are proposed to be calculated, and how the dispatch periods under slice-of-day would be calculated is provided as Attachment 1. Additionally, the proposal is summarized in the following section**.

A. Establishing a Reasonable Initial State of Charge

Because LDES resources are expressly designed to carry charge across multiple days to meet system demands, they are expected to carry a significant state of charge into most operating days. Under the proposal, this requires a calculation of a resource's "**Initial State of Charge**" (ISOC).

Because not much operational data is available to determine an appropriate Initial State of Charge for LDES resources, the proposal seeks to make reasonable assumptions that can be further refined over time. To be somewhat conservative, and for purposes of simplicity, the proposal suggests an ISOC assumption of 50%. This represents a reasonable and balanced mid-point. In simple terms, an assumption of 0% charge leading up to the days prior to the "worst-day" would be unrealistic for resources specifically procured to safeguard reliability, while a 100% assumption may be too optimistic for a robust program that guards resource adequacy. This 50% assumption splits the difference, represents a mid-point value, and appears conservative when compared to available studies. For example, a recent study completed by the California Energy Commission (CEC), E3, and Form Energy provides an indication that LDES resources may maintain an average state of charge closer to 70% leading toward grid stress periods.[2]

[2] *See* Go, Roderick, Jessie Knapstein, Sam Kramer, Amber Mahone, Arne Olson, Nick Schlag, John Stevens, Karl Walter, and Mengyao Yuan. 2024. *Assessing the Value of Long-Duration Energy Storage in California*. California Energy Commission. Publication Number: CEC-500-24-003 at pp. 30-31, *available at*

Under the proposal, this Initial State of Charge forms an important part of the energy deemed available for dispatch across the slice-of-day period. As more LDES resources are integrated into the grid and their specific operational characteristics are better understood, the Commission can revisit this default value to reflect real-world performance.

B. Calculating "Shifted Energy" from Preceding Days

In addition to the baseline ISOC, the methodology in the proposal accounts for energy captured in the days leading up to a grid stress event. This energy represents a core operational purpose of LDES resources–to carry charge into grid stress periods. The Proposal defines this as "**Shifted Energy**," because it represents energy that, consistent with the fundamental purpose of LDES resources, is shifted from prior periods (of higher supply relative to demand) into the critical slice-of-day period. Under the proposal, energy is able to be "shifted" from these prior periods to the extent an LSE's total resource capacity exceeds its loads in those preceding days. In other words, the amount of available energy that can be shifted by an LDES resource from a given prior day is the difference between that day's demand profile (which is lower than the worst-day demand) and an LSE's shown non-storage RA resources.

These amounts could be calculated by each LSE developing these values from specific hourly Integrated Energy Policy Report (IEPR) forecasts. This data could be used to determine aggregate load served in 8 prior days to the slice-of-day period. This, coupled with the maximum output from non-storage resources on peak days, would result in the excess energy that could be used in each of the 8 days prior to the worst-day. As described further below,

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https://www.energy.ca.gov/sites/default/files/2024-01/CEC-500-2024-003.pdf (Showing LDES and multi-day storage dispatch, modeled during grid stress events, including heat waves and solar "droughts," and noting that multi-day storage values are above 50% and as much as 70% leading toward such events).

simplifying assumptions could also be used to make this calculation even less difficult and more streamlined.

By factoring in each LSE's shown non-storage RA resources, LSEs will be properly incented under this proposal to procure sufficient resources to be used to charge LDES resources, if that were to become necessary. To the extent that LSEs include LDES resources on their plan, those LDES resources are used to capture a portion of this prior day available excess energy, consistent with those LDES resource design capabilities further described in the next section.

Importantly, the Proposal recognizes that a resource's ability to "shift" energy increases with its duration. The methodology in the proposal therefore utilizes a resource-specific period of between 2 to 8 days, over which the amount of available Shifted Energy is determined. Under the proposal, depending on their duration, LDES resources are deemed to have access to excess energy (*i.e*. energy that is produced from capacity in excess of loads during those prior days) over the 2- to 8-day period preceding the slice-of-day period. For example, resources with a 100-hour duration would be deemed to have access to 8 prior days' worth of excess energy, whereas resources in the 8- to 12-hour category would be deemed to have access to 2 days' worth. Resources under 8 hours (non-LDES, short-duration storage resources) should be treated consistent with how the CPUC currently implements the slice-of-day construct. The table below shows the proposed number of days prior to the slice-of-day period that each LDES resources should be deemed to have access to for purposes of calculated the Shifted Energy available to charge the resource.

Storage Duration (hours)	*Excess Energy Available (# of prior days)*
[≥8-<12)	2
[≥12-<16)	3
[≥16-<20)	4
[≥20-<24)	5
[≥24-<48)	6
[≥48-<72)	7
≥72+	8

The proposal recommends a 2- to 8-day period for LDES look-back periods for several reasons. First, major grid stress events—such as heatwaves or prolonged renewable lulls—are typically forecastable 1 to 2 weeks in advance. This provides ample time for LSEs and operators to accumulate charge over a period that directly matches the proposal's timeframe. Additionally, grid stress periods result in higher wholesale prices, providing a natural economic incentive for operators to begin charging resources several days in advance of a forecasted event when energy is relatively inexpensive.

C. Integrating Slice-of-Day Period Excess Energy

The proposal outlined in these comments defines a tranche of energy that can be used to charge LDES resources under the accounting framework of the slice-of-day, in the days *leading up* to that slice-of-day period. It would operate in conjunction with the way the slice-of-day is implemented today, and would leave other aspects of the program untouched. For example, "Excess Energy" *within* the slice-of-day period would continue to be treated as it is today–it could be used by LSEs for charging short-duration systems on that day, or it could be used by LDES systems for recharging within the slice-of-day period in the same ways already allowed. Because this energy could, consistent with how short-duration batteries are accounted for today, also be used by LDES resources, that energy is termed "**Slice-of-Day Period Excess Energy**" under this proposal simply to distinguish it from the Initial State of Charge and Shifted Energy, but its proposed treatment is the same as is currently provided for short-duration resources.

D. Accounting for Resource Efficiency

Finally, to ensure the proposed accounting is physically accurate, the proposal incorporates a resource's Round-Trip Efficiency (RTE). Both "Shifted Energy" and "Slice-of-Day Period Excess Energy" are multiplied by the resource's RTE. This ensures that only the energy that can actually be delivered back to the grid is credited toward a resource's value in the program.

E. Determining the period over which LDES resources can be shown as available to meet load in the slice-of-day period.

Once an LDES resource's available energy has been calculated (Initial State of Charge + ((Shifted Energy + Slice of Day Excess Energy) * RTE)), then an LSE can show, in its slice-of-day filing, the operation of an LDES resource consistent within its design capabilities, as justified by the energy deemed available for discharge, like any other storage resources used in the worst day. Further details on limits and appropriate assumptions in calculating each LDES resource's stored energy going into the "worst-day" are laid out in the proposal attached.

V. The proposal advanced in these comments balances all of the critical goals of LDES accreditation under the slice-of-day program, is workable, and serves customers' interests.

By adopting the proposed framework, the Commission can establish a clear framework for LDES resources that reflects their operational characteristics, their purpose, and their benefits to the grid, while also accounting for the energy required for them to operate. This approach would also send appropriate signals for the types of resources that can deliver firm energy when it is needed most in the state.

The proposal should be adopted because it meets the goals of the RA program and is responsive to the Commission's and other parties' goals. First, the proposal provides for a rigorous energy accounting, as desired by the Commission and Cal Advocates. Rather than assuming LDES resources are always fully charged in the slice-of-day period, this framework requires a concrete demonstration that energy for charging the LDES resources is expected to be available. Under this approach, LSEs may only show LDES resources as available to meet loads up to their physical capability if they can justify that assumption with a sufficient showing of energy. This ensures that the dispatch assumptions in slice-of-day filings are grounded in reasonable expectations.

Second, the proposal protects customers by avoiding the harms associated with creating an artificial energy scarcity that would result from the other energy sufficiency proposals made to date. By acknowledging that LDES resources charge during periods in the days preceding a stress event, the methodology prevents the over-procurement of energy during peak periods—the times when such procurement would be most costly to customers. This prevents an inefficient outcome where ratepayers would pay for both the capacity of the LDES resource and unnecessary peak-day charging resources.

Third, the proposal utilizes a single, reasonable methodology that reflects the unique operational realities of LDES resources with different durations and different round-trip efficiencies. It recognizes that the longer a resource's duration, the longer the timeframe over which it can capture and store energy, and the reverse principle.

Fourth, this methodology directly incentivizes the deployment of the very types of resources needed to meet California's long-term reliability goals. By providing a clear and fair accounting for LDES resources under the slice-of-day approach, the Commission will encourage the building of LDES resources that are specifically tailored to meet loads during the most grid-stressed periods. This serves the dual purpose of strengthening resource adequacy and ensuring that the most cost-effective and capable technologies are brought to bear for the benefit of the grid.

Finally, because the proposal addresses a methodology for accounting for any LDES resource, and relies on clearly defined categories of energy availability, it would be a durable construct that can apply over time.

VI. The proposal is, in certain ways, conservative in favor of resource adequacy, and can be refined over time as needed.

The proposal advanced in these comments is, in some ways, conservative, prioritizing grid reliability while offering a pathway that can endure over time, and be informed with additional operational data over time. For example, even though LDES resources are expected to charge during periods of relatively abundant energy, compared to the slice-of-day period, the proposal, if implemented under the current RA rules, would only recognize resources as available to charge LDES if they have "Full Capacity Deliverability Status" (FCDS). These are the strict standards for resource availability that apply to the slice-of-day period–the period of highest grid stress under today's RA program rules. Under this framework, energy is only counted as available to charge LDES resources if it originates from resources already deemed fully deliverable for RA purposes, if the current RA construct is not improved on that point. This would be a conservative restriction, given that a far greater pool of energy from non-FCDS and "energy only" resources would likely be available for charging, especially during the days leading up to a grid stress event.

Additionally, the proposal assigns zero incremental value to resources capable of discharging beyond the 24-hour slice-of-day window. Although many LDES and multi-day storage resources are physically capable of meeting loads for many days before recharge, they are only credited for up to 24 hours of availability under this proposal. This alignment with the current SOD 24-hour scope ensures that LDES resources are integrated into the program without disrupting its existing 24-hour accounting structure. While a formal multi-day RA standard was deemed out of scope for the current proceeding, it remains a potentially desirable future endeavor to ensure that California's grid can withstand extended periods of grid stress. Until such a standard is established, this proposal serves as a solid approach that can be easily adapted to a multi-day framework in the future.

VII. The proposal could reasonably be simplified in various ways.

Under the proposal, LSEs would account for the energy made available to charge LDES resources in the days preceding the slice-of-day period. This requires a practical approximation of the system loads during those prior days, so that the amount of capacity in excess of loads can be determined. A proposed approach for how this can be done is described above and in the attachment. Or, to ensure the methodology is even more streamlined and not burdensome for LSEs, certain simplifications may be reasonable.

For example, the Commission could adopt a monthly "Slack Value" as a simplified path for implementation. The monthly Slack Value would represent the extent to which system loads in non-slice-of-day periods are lower than the peak loads identified in the slice-of-day period. This "slack"—the delta between average monthly load and the slice-of-day peak demand—could serve as a logical estimate of energy availability. Under this simplification, the Slack Value would be used to calculate the amount of Shifted Energy available to charge LDES resources over the specified days associated with each resource's duration. This approach would substitute for a detailed calculation of an LSE's loads in each specific day preceding the slice-of-day period. For instance, if there were a monthly slack value of 80%, an LSE that served 1 GWh of total load during the worst day of the month and procured 1 GWh of shown non-storage RA resources, would have 200 MWh per day of energy available to be shifted by LDES resources[3] (the difference between the shown non-storage RA resources and the demand on the prior days). This approach would essentially leverage the "over-procurement" already inherent in the RA program for non-peak days to align charging assumptions without requiring LSEs to perform complex daily demand calculations.

In addition to these simplifications, the proposal is intended to be open to other ways to make its implementation even less burdensome. Because the amount of LDES resources on the system are expected to increase gradually over time, the Commission could adjust any such

[3] In determining the total Shifted Energy, this Daily Available Energy value will be further limited by the storage capacity of the LSE's procured LDES resources, how many prior days the LDES resource can access available energy, and the RTE of the LDES resource.

simplifying assumptions over time, to better reflect operational learnings, and it could do so without concerns about compromising resource adequacy.

X. Conclusion

For the reasons set forth above, CESA, Form Energy, Hydrostor, and Fourth Power respectfully request that the Commission adopt the proposal set forth in these comments for LDES accreditation in this proceeding.

The proposal offers a principled and workable methodology that aligns the state's Resource Adequacy program with the physical reality of LDES systems. By recognizing the value of energy shifted from periods of less grid stress to the slice-of-day period, the Commission can ensure grid reliability while protecting ratepayers from the unnecessary costs of redundant procurement. This framework fulfills the Commission's desire for an energy accounting, provides a durable path for LSE adoption of LDES resources, and creates appropriate market signals to incentivize the very resources California needs to meet its long-term energy goals.

We respectfully urge the Commission to act in this track of the proceeding to provide the clarity necessary for LSEs to incorporate LDES into their resource adequacy program implementation, for the benefit of the California grid and customers.

This joint filing is submitted by CESA, which is authorized to file on behalf of the undersigned joint parties.

Respectfully submitted,

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ATTACHMENT
Mathematical Calculations Supporting Proposed Accounting for LDES Resources in SOD

Mathematical Formulation

As outlined in this proposal, the concept is to represent how much energy each long-duration storage resource carries into the slice-of-day framework's worst-day. Each load serving entity would be responsible for generating this value for each of the long-duration storage resources in its portfolio from anticipated excess energy that would be available in days prior to the period studied in slice-of-day.

Essentially, under the equations laid out here, the effect is that each load serving entity will justify the amount of state-of-charge in their LDES storage fleet, subject to the framework that is outlined in this proposal. This includes ensuring that no resource is ever assumed to be charged beyond the maximum state of charge and ensuring that round trip efficiencies are observed for resources that are making use of excess energy. To do this, the load serving entity will need to have information about each of their long-duration storage resources and the amount of available excess energy on days prior to the day studied in the slice of day framework.

Using this information, the following set of formulas can be used to determine the state of charge values to go into the worst-day period for each long-duration storage resource in a load serving entity's portfolio.

Input data includes:

- Resource Duration
  - Resource duration, for each resource, is used to determine from how many prior days that resource is eligible to consume excess energy for charging

- Resource Round Trip Efficiency (RTE_r)
  - Round trip efficiency, for each resource *r*, is used to convert available excess energy to energy available for charging a specific resource

- Maximum State of Charge ($\overline{SOC_r}$)
  - Maximum State of Charge, for each resource *r*, is used to determine the upper bound of aggregate state of charge for each specific resource

- Daily Maximum Stored Energy ($\overline{MSE_{d,r}}$)

- Maximum amount of energy a storage resource may be charged by, for each resource *r* on each day *d*. This value will equal zero on prior days where a resource is ineligible to consume excess energy due to its duration, or the minimum between the resource instantaneous charging capability (Pmin) multiplied by 24 and $\overline{SOC}_r$ on days when it is eligible to consume excess energy as outlined in the implementation details below.

- Initial State of Charge ($ISOC_r$)
  - Initial state of charge, for each resource, used to describe the amount of state of charge that a resource begins this analysis with. This proposal assumes that $ISOC_r = .5 * \overline{SOC}_r$, which is an assumption that could be updated in the future with operational experience.

- Excess Energy (EE_d)
  - Excess energy, for each day *d*, prior to period studies in the slice of day framework. This is the difference between an LSE's prior day demand profile and its shown non-storage resource adequacy.

The optimization will then choose an amount of excess energy available on each day that each LDES resource stores:

- Resource Daily Stored Energy ($SE_{d,r}$)
  - MWh amount of Excess Energy resource r stores on day d

An objective of the formula is to maximize the overall Stored Energy ($SE_{d,r}$) from the energy available to charge each resource in a load serving entity's portfolio. This increase in state of charge, for each of the potential days where the resource is eligible for charging is denoted as $SE_{d,r}$, where *d* refers to the day prior to the period studied in the slice-of-day framework and *r* is the resource that is being charged. Thus, the objective function that the formula is attempting to maximize is:

$$\sum_{D}\sum_{R} SE_{d,r}$$

Where *D* is the full set of days prior to the day studied in the slice-of-day paradigm where excess energy can be used, and *R* is the full set of resources in the load serving entity's portfolio.

This optimization is subject to the following three constraints:

$$C1: \quad 0 \leq SE_{d,r} \leq \overline{MSE}_{d,r}$$

$$C2: \quad ISOC_r + \sum_D SE_{d,r} \leq \overline{SOC}_r$$

$$C3: \quad \sum_R \frac{SE_{d,r}}{RTE_r} \leq EE_d$$

Constraint Details

Constraint C1 ensures that the amount of energy an LDES resource r stores on day d is greater than or equal to zero and less than or equal to the maximum energy the resource can store on that day.

Constraint C2 ensures that the LDES resource's initial state of charge plus the total amount of energy it stores over the pre-worst-day horizon is less than or equal to the resource's maximum state-of-charge.

Constraint C3 ensures a resource stores less energy than the total excess energy due to its roundtrip efficiency losses. The sum of the stored energy on each resource divided by each resource's roundtrip efficiency on a given day must be less than or equal to the excess energy available on that day.

Implementation Details

This optimization should be executed prior to the current RA Template's storage optimization, as it relies on pre-defined variables, and its output is an input into the current worst-day showing. Importantly, it does not require any updates to the current storage optimization.

The resource attributes are static and known before running the optimization.

- Resource Duration
- Resource Round Trip Efficiency (RTE_r)
- Maximum State of Charge ($\overline{SOC}_r$)
- Initial State of Charge ($ISOC_r$)

The Excess Energy (EE_d) available on each of the days prior to the worst-day is static and calculated prior to running the optimization and is the aggregate amount of excess energy for that LSE on each of the prior days. For instance, D-8 may have 200 MWh of excess, while D-7 may have 250 MWh of Excess, and so on.

Daily Maximum Stored Energy

The daily maximum stored energy for a resource on a given day ($\overline{MSE}_{d,r}$) is static and derived for each resource prior to running the optimization. This value will equal the resource's Maximum State of Charge $\overline{SOC}_r$ for all prior days the resource is eligible to consume excess energy, or zero otherwise.

For instance, consider that resource RX is a 12-hour duration 300 MWh resource eligible to look back 3 days and that resource RY is 24-hour duration 600 MWh resource that is eligible to look back 6 days. Each resource's daily maximum stored energy will be represented as follows:

$\overline{\boldsymbol{MSE}}_{\boldsymbol{d,r}}$ **(MWh)**								
Resource	d = D-8	d = D-7	d = D-6	d = D-5	d = D-4	d = D-3	d = D-2	d = D-1
RX	0	0	0	0	0	300	300	300
RY	0	0	600	600	600	600	600	600

This table combined with constraint C1 ensures that LDES resources are not used to store energy on prior days for which they are ineligible to store excess energy.

Lookback by Duration

The proposed lookback for a resource of any specific duration is outlined below. For example, the table specifies that a 22-hour storage resource would be eligible to consume excess energy from up to 5 days prior to the slice of day frameworks worst-day, and a 12-hour resource would be eligible to look back 3 prior days.

Storage Duration	Days for LDES to Charge with Excess Energy
≥8 and <12	2 days
≥12 and <16	3 days
≥16 and <20	4 days
≥20 and <24	5 days
≥24 and <48	6 days
≥48 and <72	7 days
≥72	8 days

Prior Day Load Profile

Determining the prior day load profile or determining a rule for how to identify the prior day load profile is an essential component of this proposal. The methodology proposed in this paper outlines that each load serving entity would develop these values from specific hourly – 8,760 –

IEPR forecasts. These could be used to determine aggregate load served in the worst-day for each month and year, and evaluate the aggregate loads in each day during the 8 prior days to the worst-day. This, coupled with the maximum output from non-storage resources on peak days, would result in the excess energy that could be used in each of the 8 days prior to the worst day.

This paper also includes a potential simplification of this proposal, where the CPUC generates 13 multipliers, one for each month and one for the year. These multipliers, applied to the summation of load for the worst day would represent the load for all 8 previous days. These values, combined with potential non-storage generation, could be used to determine excess energy for days prior to the worst day. We note that this simplification results in all 8 prior days having the same assumed amount of excess energy.