Resource Adequacy Slice-of-Day Showing Template User's Guide



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California Public Utilities Commission

Energy Division

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# Introduction

As the Resource Adequacy program transitions to the new slice-of-day framework, the existing filing process requires updating. As directed in D.23-06-029, Energy Division has developed a template for showing slice-of-day resources based on sample templates provided by two Load-Serving Entities (LSEs). This document describes the overall design of the template and includes general instructions on how to input a showing.

# Workbook Layout

The template consists of an Excel workbook containing 14 visible worksheets and 17 hidden worksheets. All information required for developing a valid resource adequacy showing should be available in the visible worksheets, but the hidden worksheets may be helpful for investigating specific issues especially pertaining to validation tests.

The worksheets are color-coded to help distinguish between their uses. Each set of worksheets is discussed in subsections below.

In addition to the visible and hidden workbooks, many of the calculations in the workbook are performed using Excel’s Power Query utilities, which load and transform data to and from tables in the worksheets. The Power Query editor is accessible from the “Data” tab of the ribbon menu by clicking on “Queries and Connections” to open a sidebar, and finally double-clicking on any of the listed queries. The Queries and Connections sidebar can be used to manually refresh queries if necessary.

Finally, the workbook includes a tool to help shape showings for storage resources by optimizing shown hours to best meet LSE requirements given the remaining need after other resources are shown. The optimization routine is set up in Power Query, exported to a worksheet, and then uses Solver to determine optimal hourly capacities. A Visual Basic script, triggered from a button in the worksheet, defines the optimization problem parameters and calls Solver. Please make sure Solver is enabled in Excel by navigating to the Ribbon Menu🡪File🡪Options🡪Add-ins🡪Manage: Excel Add-Ins🡪Go…, and verifying the box next to “Solver Add-in” is checked. Excel will need to be restarted after enabling Solver.

Worksheets are hidden to help the general user navigate areas of the workbook most critical to the typical workflow, but all data, queries, and Visual Basic code are freely accessible within Excel, and users are welcome to explore the workbook.

## Information Worksheets (greyscale)

Four visible sheets and three hidden sheets constitute a set of “informational” worksheets.

README – The first worksheet in the workbook contains basic information about how to navigate and use the template.

Hourly Availability Chart – Three charts included in the template show the capacity contributions of each resource type towards meeting the LSE’s hourly resource adequacy requirements. The bars show the combined capacities of resources from each group in different colors, while the line shows the hourly Resource Adequacy System Requirements less demand response (DR) and CAM Allocations with the exception of CAM Storage. The hourly availability chart may be helpful in determining whether a showing meets requirements, hours where additional capacity may be needed, and when battery storage systems may be charged using excess capacity.  
The resource groups are “Battery Storage,” “Solar Fixed,” “Solar Thermal,” “Solar Tracking,” “Wind,” “Unspecified Imports,” and “Other,” and are primarily based on the Resource Type for each resource listed in the Master Resource Database. Resources that don’t otherwise map to a profile category will be labelled “Other” or “Unspecified Imports” if so indicated on the LSE Showing worksheet. The same resource groupings are used across all three charts.

Hourly Availability (hidden) – This sheet contains the underlying data for the Hourly Availability Chart. The Table is loaded from Power Query, generated by the query named HourlyAvailability.

Local Availability Chart – This chart shows the shown capacity attributed to each local capacity area, along with the LSE’s local capacity requirements (if applicable). Resources are grouped similarly to the Hourly Availability Chart.

Local Availability (hidden) – This sheet contains the underlying data for the Local Availability Chart. The Table is loaded from Power Query, generated by the query named LocalAvailability.

Flex Availability Chart – This chart shows the shown capacity attributed to each flexible resource adequacy category, along with the LSE’s flex requirements. Resources are grouped similarly to the Hourly Availability Chart.

Flex Availability (hidden) – This sheet contains the underlying data for the Flex Availability Chart. The Table is loaded from Power Query, generated by the query named FlexAvailability.

## Load-Serving Entity Input Worksheets (blue)

In general, LSEs should only need to edit the visible blue-colored worksheets when preparing a showing, and these should be completed in the order they appear in the workbook from left-to right.

Certification – This worksheet will be partially completed when the template is sent to each LSE, but LSEs will be responsible for ensuring the sheet is current, accurate, and complete. This certification attests that the resource adequacy showing contained in the rest of the book, upon submission to CPUC, is accurate.

Ensure that the correct showing month is entered before entering data since this determines which monthly LSE requirements are used in the compliance tests.

Certification Table (hidden) – This worksheet reshapes the input data from the Certification worksheet into a Table for use in Power Queries.

LSE Showing – This worksheet contains one table constituting most of the information required from LSEs for their showing. This information includes a contract and resource identifiers, and specific information about each resource’s contract capacity. The workbook matches shown resources against the Master Resource Database worksheet for additional information used in validating the showing.

Resource Custom Profiles – Users are able to manually input custom hourly capacity profiles for certain shown resources in a single table in this worksheet. The Resource ID and Resource SubID for each row of the table should match an entry in the LSE Showing worksheet. A custom profile must be entered for all Unspecified Imports.

Profile Optimization – This worksheet is automatically populated with resources from the LSE Showing worksheet for which the Use Default Profile field is False and where no matching entry in Resource Custom Profiles is found. The worksheet contains four tables and a single buttons used to prepare the optimization problem and run Solver. The worksheet also contains some instructions for running the optimizer.

## Showing Results Worksheets (gold)

Showing results worksheets are intended to help users develop a valid and compliant showing. This group includes two visible and 11 hidden worksheets.

Validation Overview – This worksheet is a dashboard presenting the results of various validation tests shown in the subsequent hidden worksheets.

Check Capacity (hidden) – This worksheet contains the Hourly System Capacity test. The table shows the difference between requirements and shown capacity for each hour and is generated by the CheckCapacity query.

Check Local (hidden) – This worksheet contains the Local Capacity test. The table shows the capacities and requirements for each shown resource and all local capacity areas. The test is considered to pass if the sum of each column is nonnegative, indicating greater capacity than required. The table is generated by the CheckLocal query.

Check Flex (hidden) – This worksheet contains the Flexible Capacity test. The table shows the capacities and requirements for each shown resource and the three flexible capacity categories. The test is considered to pass if the sum of each column is nonnegative, indicating greater capacity than required. The table is generated by the CheckFlex query.

Check Contract Dates (hidden)– This worksheet contains the Contract Date test. The table shows the contract start and end dates for each resource and a column indicating whether the current month is fully contained within the date range. The table is generated by the CheckContractDate query.

Check Custom Profiles (hidden)– This worksheet contains the Custom Profile test. The table shows the resources for which custom profiles have been input, with the difference between each resource’s Net Qualifying Capacity (NQC) under contract and the custom shown capacity for each hour. The NQC value is the lower value from between the NQC Under Contract in the LSE Showing worksheet or the NQC for the showing month in the Resource NQC worksheet. The table is generated by the CheckCustomProfiles query.

Check Shown Hours (hidden) – This worksheet contains the Shown Hours test. The table shows each resource with its shown hours of use, its available hours of use as listed in the Master Resource Database worksheet if available, and a check of shown vs. available hours. The table is generated by the CheckShownHours query.

Check Storage Excess Capacity (hidden) – This worksheet contains the Storage Excess Capacity test.

Check Storage SOC (hidden)– This worksheet contains a table used in both the Storage Minimum and Maximum State-of-Charge tests. The table shows each shown resource determined to be a battery storage resource, along with an hourly estimate of the resource’s state-of-charge in terms of MWh energy stored, assuming the resource starts at hour ending 1 with zero available stored energy. The table is generated by the CheckStorageSOC query.

Check Grouped Resources (hidden) – This worksheet contains the Grouped Resource Interconnection test. The table shows groups of shown resources which the Master Resource Database indicates are either co-located or hybrid, with the group’s total hourly capacity and the interconnection power limit. The table is generated by the CheckGroupedResources query.

Check Hybrid Deliverability (hidden)– This worksheet contains the Hybrid Deliverability test. The table shows each shown hybrid pair of resources and whether hourly capacities shown for the solar resource are consistent with its deliverability status.

Check MCC Bucket 4 (hidden) – This worksheet contains a clone of the Storage Excess Capacity test applying only to storage resources flagged as “TRUE” in the MCC Bucket 4 column on the LSE Showing worksheet.

LSE Showing Complete – This worksheet constitutes the showing information that will be considered by CPUC in its resource adequacy process. The table is synthesized from the LSE’s inputs, the requirements and allocations assigned to the LSE, and general information about the resources.

## Requirement and Allocation Worksheets (orange)

Requirements and Allocations – This worksheet contains a table representing all system, local, and flexible requirements, and specifies all CAM allocations for a given LSE and month. These are used in evaluating the compliance of a filing.

## Resource Description Worksheets (green)

Resource Database – This worksheet contains a snapshot of the official Master Resource Database maintained by CPUC’s Energy Division. The included data are used in validating a slice-of-day showing.

Resource Default Profiles – This worksheet contains default slice-of-day profiles for certain resources that may be shown.

Resource Profile Categories (hidden)– This worksheet is a lookup table used in mapping a shown resource to a default profile. The table includes Resource Types as listed in the Master Resource Database, and Profile Categories as appearing in the Resource Default Profiles worksheet.

Regions (hidden) – This worksheet is a lookup table used in mapping a shown resource to a default profile. The table includes Path 26 Designations and Balancing Authority Areas as listed in the Master Resource Database, and Regions as listed in the Resource Default Profiles worksheet.

# How to Input Resources

Many components in the template use Excel Tables rather than regular Ranges and Cells. This helps structure the data for use across worksheets and facilitates automated input or extraction. Tables can be recognized in the template by banded blue or green rows with dark blue or green headers with white text.

When adding data to a Table, the Table will automatically resize within the worksheet to include new rows. Table rows should be removed by either overwriting the contents entirely or by deleting the entire row, rather than deleting the contents of the cells. When done working with a Table, users should ensure that no rows within the Table’s boundaries are empty.

## Certification Worksheet

The Certification Worksheet contains basic information about the Load Serving Entity and its representatives, along with the date and type of showing.

The cells labeled “Load Serving Entity Abbreviation”, “Showing Type”, and “Showing Month” must be filled in with valid values corresponding to the Requirements and Allocations worksheet—make sure the same value for LSE is used in both the Certification worksheet and the Requirements and Allocations worksheet. The Showing Type cell must either contain “Year Ahead” or “Month Ahead”—the selected value is used to determine whether 90% or 100% of the system and flexible requirements listed in the Requirements and Allocations are used in validation tests and charts. The Showing Month cell should be the first day of the month for which resources are to be shown, and the applicable requirements will be applied.

The remaining cells should be filled in with all relevant information. This worksheet represents the Load Serving Entity’s certification of their showing and attestation to its accuracy.

## LSE Showing Worksheet

The simplest showing can be entered exclusively on the LSE Showing worksheet. LSEs will receive a fresh template each month with updated resource information and the current month’s requirements and allocations. A CAM storage allocation, reflective of the allocation specified on the Resource and Allocations worksheet, should also be present on the LSE Showing worksheet. Additional resources should be entered in subsequent, contiguous rows, using the following procedure:

1. Enter a Contract ID in Column A reflecting the contract for resource adequacy capacity in a new row of the LSE Showing worksheet.
2. Check that the table boundaries automatically expanded to include the new row. Also check that no empty rows appear in the table or before the new row.
3. Enter a Resource ID matching an entry in the Resource Database worksheet in Column B. The ID can either be typed in, pasted from the Master Resource Database worksheet or another source. Unspecified import resources need not be listed in the Resource Database worksheet. If the specified Resource ID does not correspond to a hybrid resource, default values should be loaded into the remaining cells in the same row.
4. For most resources, the Resource SubID (Column C) should be left empty. For hybrid resources, enter or select from the drop-down menu a SubID. Once a SubID is input, default values should be loaded into the remaining cells in the same row.
5. In column D (NQC Under Contract (MW)), enter the Slice-of-Day NQC value under contract[[1]](#footnote-1) for each resource. Alternatively, the default value retrieved from the Resource Database may be used. When the default profile is selected in column L, the template will provide hourly shown MW values based on stored hourly profile shapes. For VERs, the input NQC under contract is scaled by the resource’s Pmax divided by the monthly Slice-of-Day NQC value before applying the hourly shape factors.
6. Fill in the Local RA capacity, and Committed Flexible RA capacity shown for the resource, all in units of MW, in Columns E and F. Alternatively, the default values of 0 may be used.
7. Fill in the Capacity Effective Start Date and End Date as listed in the contract for the resource in the new row in Columns G and H. Alternatively, the default values based on the showing month may be used.
8. Fill in the SCID or Counterparty if applicable in Column I.
9. In Column J, type in or select “TRUE” for storage resources being shown in MCC Bucket 4 in 2024 compliance showings.
10. In Column K select “TRUE” if the resource is an Unspecified Import.
11. Type in or select “TRUE” in Column L from the dropdown menu to use the Default Profile for the resource. For battery storage, the default profile is a single daily discharge cycle at full capacity from HE18-HE21.
12. When finished entering custom profiles, open the LSE Showing Complete worksheet and refresh the table by right-clicking on it and selecting “Refresh”.
13. Verify the resource appears in the table as entered, and the Profile Source column indicates “Default”.

Selecting “TRUE” for Default Profile will apply a slice-of-day profile from the Resource Default Profiles worksheet to the shown resource, based on the shown NQC or total VER MW Under Contract. When a default profile is selected, the resource is fully specified by the user’s input in the LSE Showing worksheet, and the default profile will be applied to all validation tests and will be represented in the LSE Showing Complete worksheet.

If a resource does not map to a default to a default profile, or the default profile, the user may need to input a custom profile according to the next section.

Custom profiles must be used for all Unspecified Imports. Ensure that “FALSE” is selected under Use Default Profile for these resources.

Aside from Unspecified Imports, Custom Profiles and Profile Optimization will primarily be used for battery storage resources. The user may select whether to use the Default Profile, a Custom Profile where the user inputs a specific daily profile or the Optimization tool which will shape storage showings to meet the LSE’s hourly RA needs.

## Custom Profiles

Users may manually specify hourly profiles for resources by setting Default Profile to “FALSE” in the LSE Showing worksheet and filling in the Resource Custom Profiles worksheet. This may be useful where the default profiles do not apply to a specific resource and the user has more detailed information about a given resource’s capabilities.

Use the following procedure to input a custom profile:

1. Enter a new resource as described for Basic Resources, but input “FALSE” for Use Default Profile.
2. Copy the desired Resource ID and Resource SubID from the LSE Showing worksheet into a new row of the table in the Resource Custom Profiles worksheet.
3. Check that the table boundaries automatically expanded to include the new row.
4. Enter the hourly capacities to be shown in the MW HE \_\_ columns, making sure no hours exceed the value listed in the corresponding NQC listed on the LSE Showing worksheet.
5. When finished entering custom profiles, open the LSE Showing Complete worksheet and refresh the table by right-clicking on it and selecting “Refresh”.
6. Verify the resource shows the custom profile as entered, and the Profile Source column indicates “Custom”.

## Storage Resources and Hourly Profile Optimization

The Profile Optimization worksheet is designed to facilitate showing storage resources based on the LSE’s requirements, allocations, and other shown resources, while accounting for the physical limitations of battery energy storage systems. Storage resources can be input according to the following procedure:

1. Enter a new storage resource into the LSE Showing worksheet, selecting “FALSE” for Use Default Profile. Make sure the corresponding entry in the Master Resource Database worksheet has values for the following fields Daily Storage Cycle Physical Capability, Storage Efficiency, Maximum Continuous Energy, and Storage Maximum Daily MWh.
2. Input any custom profiles in the Custom Resource Profile worksheet as described in the previous section.
3. When finished entering resources into the LSE Showing and Custom Resource Profile worksheets, open the Profile Optimization worksheet.
4. Click on the button labelled “Optimize” to update the three tables on the worksheet, reset the Fractional Showing values to zero, and run Solver to attempt to optimize the showing.
5. The following preconditions must be met before the optimization routine will attempt to find a solution:
   1. The total sum of the Maximum Capacities (MW)of all storage resources to be optimized must be greater than the highest value of the Deficit (MW) column in the Capacity Deficits table.
   2. The total sum of the Maximum Daily Energies (MWh) of all storage resources to be optimized must be greater than the sum of all Deficits (MW).
   3. If these conditions are not met, no solution exists that can meet the optimization criteria; however, if they are met, a solution is not guaranteed to exist.
6. A cell to the left of the button will display progress during the optimization routine, and each of the four tables will turn grey, then orange while refreshing, then green indicating they have finished refreshing.
7. Once Solver has completed, if Solver was able to find a solution, the status cell will indicate “Optimization Complete”. If sufficient capacity is shown in the default and custom profiles to allow for a compliant optimized storage showing, the Objective column of the table labeled “Capacity Deficits” should be all zeros. The table in the LSE Showing Complete worksheet, and the Hourly Availability Chart will update automatically. Open the LSE Showing Complete worksheet and verify that the resource is correctly shown with the Profile Source listed as “Optimized” and corresponding hourly capacities based on the optimization results.
8. If Solver ran but no solution was found, either no solution exists due to state-of-charge constraints or the Solver algorithm became stuck in a local optimum regime with no viable solution. A solution may be found by either:
   1. Manually adjusting the starting conditions for the decision variables in the Fractional Showing column of the Optimization table (column G) and running Solver manually; or
   2. Adding resources to the showing—additional storage resources may help overcome some constraints in the optimization problem, and additional non-storage resources can reduce the hourly deficits.
9. Note that the optimization routine does not include a Storage Excess Capacity check, so make sure all applicable validation tests pass after optimizing storage resources.

There should be positive values in the Shown MW column of the table labelled “Unshown Resource Adequacy” in each row with a positive value in the Remaining Required MW column of the same table.

In most cases, users need only click the “Optimize” button, but users are welcome to adjust the Objective Function to suit their needs, or to run Solver manually using the Solver Dialog. The buttons trigger Visual Basic scripts which users are further welcome to modify. The Visual Basic editor can be opened by pressing <alt>+<F11> or accessed from the Developer tab of the Ribbon menu.

The optimization worksheet works with both physical storage resources and CAM storage allocations, however debits must use either default or custom profiles. See the later section on CAM Storage Allocations and Debits for more information.

## Hybrid Resources

Hybrid resources typically consist of a solar resource and a battery energy storage system resource sharing the same Resource IDs and different Resource SubIDs. Hybrid resources should be listed in pairs with both solar and storage resources appearing on the LSE Showing worksheet. Both individual resources in hybrid pairs may be entered using the LSE Showing, Resource Custom Profiles, and Profile Optimization worksheets according to the procedures listed above.

Two validation tests check that the hybrid resources are shown within constraints defined in the Master Resource Database.

## Co-Located Resources

Co-Located resources can be input into the LSE Showing worksheet according to any of the procedures above, but a validation test will check that each group of co-located resources do not exceed their interconnection MW limits.

## MCC Bucket 4

For the 2024 Test Year, in which the existing RA framework is binding, an LSE may show storage capacity in MCC Bucket 4 if it demonstrates sufficient charging capacity on the Slice-of-Day showing template. As such, storage resources in MCC Bucket 4 are subject to their own version of the Storage Excess Capacity test. Inputting “TRUE” in the MCC Bucket 4 column on the LSE showing will include the resource in this test. The MCC Bucket 4 column only affects standalone storage resources and should be set to “FALSE” for all others. Hybrid and co-located storage may already be shown in MCC Bucket 4 so demonstration of charging sufficiency is not necessary for these resources.

## Unspecified Imports

Unspecified imports will not be included in the Master Resource Database. Such resources will thus trigger an informational validation message to this effect. Users should input the resource normally on the LSE Showing sheet, indicating NQC Under Contract, Capacity Effective Start and End Dates, and SCID, and set MCC Bucket 4 to “FALSE”, Unspecified Import to “TRUE”, and Use Default Profile to “FALSE”. Hourly availability of the import should then be reported on the Custom Profile tab. Note that if Unspecified Import and Use Default Profile are both set to “TRUE”, the workbook will attribute zero capacity for all hours.

## Demand Response

Demand response should be entered similarly to basic physical resources, with the Use Default Profile column set to “TRUE”. Note this feature has not been implemented at this time. Resources will be added to the Master Resource Database when final 2024 values are available.

## Resources Currently Under Construction

Load Serving Entities are allowed in their year-ahead submissions to show resources that are currently under construction. These resources may not appear in the Resource Database, which may result in erroneous outputs to the LSE Showing Complete worksheet. Such resources must be added manually to the Resource Database worksheet.

# RA Allocations

CAM and DR resources will be allocated by resource type. For resources with a fixed hourly profile, allocations will be made as an aggregate unit and debited or credited to an LSE’s hourly RA requirement.

## CAM Storage Allocations and Debits

CAM storage resources will be allocated as resources that can be shown flexibly by LSEs similarly to other storage resources. Allocations are defined in the Requirements and Allocations worksheet, and corresponding resources are added to both the Resource Database worksheet and as the first entries in the LSE Showing worksheet. CAM storage resources are grouped according to certain characteristics, namely physical daily cycle capability and charging efficiency, which must be considered when assigning shown hourly capacities. The Profile Optimization worksheet uses these characteristics as constraints in the optimization problem for Solver, and validation tests compare the showing against the characteristics regardless of how the slice-of-day profile is defined.

IOUs will be assigned CAM storage debits, consisting of negative capacity and energy requirements equivalent to the CAM storage allocations provided to other LSEs. IOUs are responsible for fully showing the entire debit, but are not required to anticipate the same hours as the other LSEs. The Profile Optimization worksheet is not able to determine optimal showings for negative capacities at this time, so IOUs must either use the default profile or input a custom profile for CAM storage debits. Note that the default profile for storage only shows 4 hours, so multi-cycle storage debits must be input as custom profiles. Ideally, the storage debit will be shown in the same hours that the IOU shows the associated CAM resource(s). However, in the case of resource replacement, the debit must be shown during the availability assessment hours.

The template should include a completed row in the LSE Showing worksheet to reflect the CAM Storage Allocations listed in the Requirements and Allocations worksheet. Either default or optimized profiles may be applied, although the default profile for storage resources does not reflect multi-cycle capabilities. Storage validation tests apply to CAM storage.

CAM Peaker Allocations

Some CAM peakers are available for a limited number of hours per day, but may be shown in any hours. LSEs may elect to use a default or custom profile for these resources.

## Demand Response and Other CAM Allocations

DR Allocations and Other CAM Allocations are applied to showings through queries. These allocations apply default profiles which LSEs are not permitted to modify in their showings.

# Reviewing a Showing

Once a set of resources are defined in the worksheets with blue tabs, users can check whether the showing is compliant by reviewing the worksheets with golden tabs. The process for developing a valid showing may involve iteratively adjusting the shown resources, including custom and optimized resources, and reviewing the validation test results, charts, and complete showing.

## Validation Overview

The Validation Overview worksheet lists all validation tests performed within the workbook. Each test result, indicating “Pass” or “Fail,” represents a summary of a Power Query output on a hidden worksheet. If all tests pass, the showing may be ready to submit. The worksheet offers a brief description of each test, and users may investigate test results by un-hiding the corresponding worksheets, listed in Column D, which may provide information about the cause of a failed test. Buttons labeled “Go to Sheet” unhide and navigate to the listed worksheets. Users can use the buttons labeled “Refresh” to update the data supporting each test in order to ensure test results reflect the current showing. Additional information may be found by inspecting the pertinent query in the Power Query editor.

The descriptions for each test is copied from the Validation Overview worksheet below, followed by additional explanation.

### Hourly System Capacity

“Checks whether the total MWh shown available across all 24 hours meet the hourly requirements.”

This test sums total capacities across all shown resources along with allocations (positive or negative), and subtracts requirements, for each slice-of-day hour. Each hourly total must be greater than or equal to zero for the test to pass. Capacities from energy only resources, i.e., where Deliverability Status is “EO”, are excluded from the calculation.

See the Check Capacity worksheet for more granular results and the CheckCapacity query to review calculations step-by-step.

### Local Capacity

“Checks whether shown local capacity meets local requirements.”

This test sums total capacities across all shown resources less requirements for each local area. The total for each local area must be greater than or equal to zero for the test to pass. The local areas are defined as LA Basin, Big Creek-Ventura, San Diego-IV, Bay Area, Fresno, Sierra, Stockton, Kern, Humboldt, NBNC. Capacities from energy only resources, i.e., where Deliverability Status is “EO”, are excluded from the calculation.

See the Check Capacity worksheet for more granular results and the CheckCapacity query to review calculations step-by-step.

### Flexible Capacity

“Checks whether shown local capacity meets flex requirements.”

This test determines countable capacity for each Flexible Category, and compares against Flexible Capacity requirements. The summed countable capacities for Flexible Categories 1 and 2 must be greater than the summed flexible requirements for the same Flexible Categories, as per the following formula

Where:

is the total countable capacity in Flexible Category 1 shown across all resources, allocations, and debits, calculated as

is the total countable capacity in Flexible Category 2 shown across all resources, allocations, and debits, capped at the Flexible Category 2 Requirements, calculated as

is the total countable capacity in Flexible Category 3 shown across all resources, allocations, and debits, calculated as

is a resource, allocation, or debit in the set comprising all resources, allocations, and debits,

is the required capacity for Flexible Category 1,

is the required capacity for Flexible Category 2,

is the required capacity for Flexible Category 3,

is the flexible capacity shown by resource, allocation, or debit for Flexible Category 1,

is the flexible capacity shown by resource, allocation, or debit for Flexible Category 2, and

is the flexible capacity shown by resource, allocation, or debit for Flexible Category 3.

Capacities from energy only resources, i.e., where Deliverability Status is “EO”, are excluded from the calculation.

See the Check Capacity worksheet for more granular results and the CheckCapacity query to review calculations step-by-step.

### Contract Date

“Checks that each shown resource is available for the current showing month according to the contract period.”

This test compares the contract start and end dates for each resource in the LSE Showing worksheet against the current filing month as defined on the Certification worksheet. Each contract must start on or before the first day of the filing month, and end on or after the last day of the filing month.

See the Check Resource Availability worksheet for more granular results and the CheckResourceAvailability query to review calculations step-by-step.

### Shown Hours

“Passes if the shown hours of usage for each resource are within those allowed in the resource database.”

This test determines which hours are shown with non-zero capacity for each resource and compares the first and last shown hours against the first and last available hours as defined in the Resource Database worksheet. If any resource has shown capacity before its first available or after its last available hour, the test fails.

See the Check Resource Availability worksheet for more granular results and the CheckResourceAvailability query to review calculations step-by-step.

### Custom Profile

“Checks whether any custom slice-of-day profiles exceed their resource’s NQC or VER value.”

This test compares the capacities input into the Resource Custom Profiles worksheet against various maximum capacity measures according to the type of resource shown, as follows:

* Unspecified Imports – hourly capacities must be less than or equal to the NQC Under Contract input in the LSE Showing worksheet;
* Solar or Wind resources – hourly capacities must be less than or equal to the resource’s Pmax defined in the resource database;
* Resources with negative NQC Under Contract - hourly capacities should be nonnegative and must be greater than the lower of the NQC Under Contract input in the LSE Showing worksheet or the current filing month NQC defined in the Resource Database worksheet.
* All others – hourly capacities must be less than the lower of the NQC Under Contract input in the LSE Showing worksheet or the current filing month NQC defined in the Resource Database worksheet.

If any resource at any hour exceeds its associated maximum capacity, the test fails.

See the Check Custom Profiles worksheet for more granular results and the CheckCustomProfiles query to review calculations step-by-step.

### Storage Excess Capacity

“Checks that sufficient excess capacity above system requirements across all hours are shown to supply the total storage charging needs, accounting for efficiency losses.”

This test calculates the sum of all shown hourly capacities for non-storage resources and allocations less system requirements, which is considered excess capacity expressed in MWh. Separately, the sum of shown storage capacities divided by their storage efficiencies represents the energy required to charge the storage resources, also in MWh. Excess capacity must be greater or equal to the required charging, or the test fails. The following formula describes the conditions required for a showing to pass this test:

Where:

is a resource, allocation, or debit in the set of resources, allocations, and debits excluding storage resources in set ,

is a resource in the set of storage resources ,

is a slice-of-day hour among 24 hours, indicating the hour ending label,

or is the shown capacity for resource, allocation, or debit or for hour , where a debit is valued less than zero,

is the system requirement for hour ending , and

is the storage efficiency of storage resource .

See the Check Storage Excess Capacity worksheet for more granular results and the CheckStorageExcessCapacity query to review calculations step-by-step.

### MCC Bucket 4 Storage Excess Capacity

“Applies the Storage Excess Capacity test only to Storage Resources indicated with the MCC Bucket 4 flag.”

This test is calculated identically to the regular Storage Excess Capacity test but only applies to storage resources flagged as MCC Bucket 4 on the LSE Showing worksheet. Other storage resources are ignored, contributing neither toward nor against excess capacity. The following formula differs from that in the previous test only by summing the right-hand side across the intersection of resources that are both storage resources and in the set of resources designated as in MCC Bucket 4:

While complimentary sets of resources and appear on either side of the inequality in the full Storage Excess Capacity test, this test limits storage resources to those in MCC Bucket 4, thus excluding storage resources other than MCC Bucket 4 from consideration. Note that these other storage resources are also not then included in the sum of shown capacities, so they do not contribute toward excess capacity available for charging MCC Bucket 4 storage resources.

See the Check MCC Bucket 4 worksheet for more granular results and the CheckMCCBucket4StorageExcessCapacity query to review calculations step-by-step.

### Storage Minimum State-of-Charge

“Checks the state-of-charge for each hour across two consecutive days to ensure storage resources maintain greater than zero stored energy.”

This test approximates the state-of-charge of all shown storage resources to ensure the state-of-charge never falls below zero. An initial state-of-charge of 100% is assumed for all resources at the beginning of hour ending 1 of the first day (i.e., HE 24 for an assumed day 0). Any hour when non-zero capacity is shown, the shown capacity divided by the resource’s maximum continuous energy is subtracted from the prior state-of-charge. Any hour during which zero capacity is shown, it is assumed the resource will recharge at a rate of either its maximum capacity or, when grid charging is not allowed, the shown slice-of-day capacities of its collocated non-storage resources divided by its efficiency up to a maximum state-of-charge of 100%. The state-of-charge of each storage resource is calculated for two consecutive 24 hour days with identical shown capacities to help account for initial states-of-charge less than the assumed 100%. Note that maximum continuous and daily energy values are scaled based on the contracted capacities, and that, because CAM storage debits are expected to have negative power capacities and energy maximums, the absolute values of these terms are used throughout.

The assumptions and calculations used in this test are identical to those used in the Profile Optimization worksheet, but apply to all storage resources regardless of the source of the slice-of-day profile. See the later section titled Storage Resource Optimization, which includes a mathematical definition of the state-of-charge calculations.

See the Check Storage SOC worksheet for more granular results and the CheckStorageSOC query to review calculations step-by-step.

### Storage Energy

“Checks that storage resources do not show more than their listed maximum daily energy capacities.”

This test calculates the sum of each resource’s shown hourly slice-of-day capacities, which must be less than or equal to the associated maximum daily energy defined in the Resource Database worksheet.

See the Check Storage SOC worksheet for more granular results and the CheckStorageSOC query to review calculations step-by-step.

### Grouped Resource Interconnection

“Checks that groups of resources--either hybrid pairs or co-located resources--do not exceed interconnection limits.”

This test aggregates any co-located or hybrid resources and sums the shown capacities of each group. The summed capacities must not exceed the maximum capacity of the interconnection as defined in the Resource Database worksheet.

See the Check Grouped Resources worksheet for more granular results and the CheckGroupedResources query to review calculations step-by-step.

### Hybrid Deliverability

“Checks hybrid solar resources against their paired storage according to their deliverability statuses.”

This test identifies shown resources which are part of hybrid pairs and evaluates their shown capacities of hybrid solar sub-resources based on the Deliverability Status of defined in the Resource Database worksheet:

* “FC” – shown capacities must not exceed the Pmax defined in the Resource Database worksheet scaled by the ratio of the input NQC Under Contract divided by the total NQC for the current showing month defined in the Resource Database worksheet.
* “EO” – shown capacities must not exceed the interconnection limit as defined in the Resource Database worksheet.
* “ID” – shown capacities must not exceed the Deliverable % multiplied by Pmax, both defined in the Resource Database worksheet, scaled by the ratio of the input NQC Under Contract divided by the total NQC for the current showing month defined in the Resource Database worksheet.
* “PD” – shown capacities must not exceed the Deliverable MW defined in the Resource Database.

The query supporting this test also checks whether both sub-resources in a hybrid pair are shown together, but doing so is not required.

See the Check Hybrid Deliverability worksheet for more granular results and the CheckHybridDeliverability query to review calculations step-by-step.

### Demand Response

“Checks that shown demand response capacity does not exceed 8.3% of requirements in any hour.”

This test calculates the sum of all shown capacities among demand response resources and allocations for each hour. The shown demand response must be less than or equal to the hourly system requirements multiplied by 8.3%

See the Check Demand Response worksheet for more granular results and the CheckDemandResponse query to review calculations step-by-step.

## LSE Showing Complete

After completing all relevant worksheets with blue-colored tabs (LSE Showing, Resource Custom Profiles, and Profile Optimization), the LSE Showing Complete worksheet will contain a summary of all information about the showing. Once submitted, the CPUC will extract data from the table in this worksheet as the data source used when validating the showing.

## Availability Charts

The three availability charts allow users to compare the capacities shown for each hour and for local and flexible resource adequacy against their requirements.

The Hourly Availability chart shows groups of resources as stacked bars contributing towards the total capacity shown during each slice-of-day hour. A black line overlaying the bars indicates the system requirements adjusted for any CAM and DR allocations aside from CAM storage and peakers. A compliant showing must have capacities at or above the requirements for each hour plus sufficient excess capacity to account for storage charging and losses.

The Local and Flex Availability charts show the same groupings of resources as stacked bars with the contributing capacities toward each local capacity area and flexible capacity category. Black points indicate the local and flexible RA requirements. A compliant showing must have capacities at or above the requirements for each applicable local area and meet the flexible RA requirement.

# Power Query

The template contains 34 queries organized into six groups based on their use. All queries are available for inspection in the Power Query Editor. To access the Power Query Editor from the Excel Ribbon Menu select:

Data 🡪 Queries and Connections 🡪 Double-click on any listed query

Power Query is primarily an extract, transform, and load (ETL) utility that has been built into Excel since 2010. The tool allows for queries to be written in Microsoft’s proprietary M language and translates these queries to connect to a variety of underlying data sources, such as external flat files and offsite SQL servers.

Although capable of managing external connections, Power Query is used in this case to work with data contained within the single Excel workbook constituting the Resource Adequacy Slice-of-Day Showing template. Power Query provides some advantages over cell-based formula calculations particularly when handling variably-sized data tables. Specifically, Power Query is designed to operate on data tables rather than individual values, so table and column references tend to be more intuitive and readable in calculations than equivalent calculations in cell formulas. Furthermore, complicated calculations can be presented as a sequence of table operations within the Power Query editor, presented as Steps, available for inspection but otherwise out of the way for users interested only in the outputs. Similar calculations in cell formulas may require either convoluted formulas in a small number of cells or a large number of cells with less complicated formulas which are nonetheless difficult to read and understand across steps.

One downside of Power Query is its speed. Users accustomed to immediate results when updating formulas or values in Excel cells may find the need to refresh tables generated by queries cumbersome or be put off by the comparatively slow loading times to and from Power Query. While query performance was a consideration when developing the template and designing the queries, some tables may still take several seconds to refresh. We recommend avoiding using the “Refresh All” tool, and instead refreshing individual tables only when necessary as this significantly improves processing speed. VBA scripts are included to control when queries refresh using manual button controls and worksheet events. These should help limit the number of queries refreshing at a given time and minimize time spent waiting for queries. Additionally, it may be possible to further optimize the queries in future versions of the template to improve loading times.

The queries are grouped according to their purpose, with each group described in the following subsections.

## Resource Information

The five queries in this group correspond to the two visible and three hidden worksheets with green tabs, extracting data from the tables contained therein and applying filters and transformations to make the data useable in later queries.

### ResourceDatabase

This query loads data from the Master Resource Database worksheet and joins the table to the ResourceDefaultProfiles query, using the ResourceProfileCategories and Regions queries as intermediate lookup tables. The resulting table is used throughout the queries discussed in later subsections.

### ResourceDefaultProfiles

This query loads data from the Resource Default Profiles worksheet. The table is designed to allow many resources to match each profile, based on several resource properties listed in the ResourceDatabase query, as described for the ResourceProfileCategories and Regions queries below.

### ResourceProfileCategories

This query loads data from the Resource Profile Categories worksheet. The query is a small lookup table that matches the Resource Type values listed in the ResourceDatabase query and the ProfileCategory values listed in the ResourceProfileCategories query.

### Regions

This query loads data from the Regions worksheet. The query is a small lookup table that matches combinations of Path 26 Designation and Balancing Authority Area values listed in the ResourceDatabase query and Region values listed in the ResourceDefaultProfiles query.

## Requirements and Allocations

The seven queries in this group include one query which extracts data from the Requirements and Allocations worksheet with an orange tab, and six queries which filter the data for specific uses.

### RequirementsAndAllocations

This query loads data from the Requirements and Allocations worksheet and reshapes the table to have 24 value columns representing each slice-of-day hour, along with one additional value column for non-slice of day requirements and allocations.

### SystemRequirements

This query contains a subset of the RequirementsAndAllocations query, filtered to the single row with the Name column containing “System Requirements”.

### LocalRequirements

This query contains a subset of the RequirementsAndAllocations query, filtered to include only rows where the Name column contains “Local Requirement”.

### FlexRequirements

This query contains a subset of the RequirementsAndAllocations query, filtered to include only rows where the Name column contains “Flexible Requirement”.

### StorageAllocations

This query contains a subset of the RequirementsAndAllocations query, filtered to the single row with the Name column containing “CAM Storage Allocation”.

### DRAllocations

This query contains a subset of the RequirementsAndAllocations query, filtered to the single row with the Name column containing “DR Allocation”.

### OtherAllocations

This query contains a subset of the RequirementsAndAllocations query, filtered to the single row with the Name column containing “Other CAM Allocation”.

## Showing Information

The three queries in this group represent the information completed by LSEs in the worksheets with blue tabs.

### Certification

This query loads data from the hidden CertificationTable worksheet which itself pulls data from the Certification worksheet into a table format.

### ResourceCustomProfiles

This query loads data from the Resource Custom Profiles worksheet.

### LSEShowingProfilesUnoptimized

This query loads data from the LSE Showing worksheet and joins the table to the ResourceDatabase and ResourceCustomProfiles queries.

## Exports for Optimization

This group of five queries prepares showing and storage resource data from groups described above for hourly showing optimization using Solver in the Profile Optimization worksheet.

### SODCapacityDeficits

This query filters the resources in the LSEShowingProfilesUnoptimized query for resources that use either default or custom profiles. The query then evaluates the hourly differences between the SystemRequirements query results and the sum of the shown capacities of the filtered resources. The results are then reshaped to be loaded into the Profile Optimization worksheet under the label “Capacity Deficits”.

### StorageProperties

This query loads the LSEShowingProfilesUnoptimized query results, applies the complementary filter to the SODCapacityDeficits query to include only resources requiring optimization, and loads required information for each resource into the table labeled “Storage Properties” on the Profile Optimization worksheet.

### SODProfilesForSOC

This query expands the list of storage resources from the ResourceOptimizationGroupMap query to show 24 slice-of-day hours for each group. The query calculates the maximum capacities and available charging capacities in each hour for each resource based on paired or collocated resources and whether grid charging is allowed. The results are loaded into the table labelled “Optimized Showings” on the Profile Optimization worksheet.

### LSEShowingProfilesOptimized

This query re-loads the table exported by the SODProfilesForOptimization query in the Profile Optimization worksheet with additional columns including the “Shown MW” column which is used in later queries.

## Exports for Validation Tests

The 11 queries in this group represent different aspects of the complete Resource Adequacy showing, including shown resources with their default, custom, or optimized profiles. Each query is exported to a worksheet with a golden tab, with all but one hidden by default.

### LSEShowingComplete

This query combines the resource listed in the LSE Showing tab with whichever slice-of-day profile is selected and appends Demand Response and Other CAM allocations. The results are loaded to the LSE Showing complete worksheet.

### CheckCapacity

This query compares system requirements and allocations against the total shown capacities of resources. A compliant showing must show positive values for each row in the Delta Capacity (MW) column. The results are loaded to the hidden Check Capacity worksheet.

### CheckLocal

This query lists each resource and Local RA requirements, with the required or shown capacities for each local capacity area. The sum of capacities within each local capacity area must be positive in a compliant showing. The results are loaded to the hidden Check Local worksheet.

### CheckFlex

This query lists each resource and Flexible RA requirements, with the required or shown capacities for the three flexible categories. The sum of capacities within each flexible category must be positive in a compliant showing. The results are loaded to the hidden Check Flex worksheet.

### CheckContractDates

This query compares the contract Effective Start and End Dates for each shown resource against the current showing month listed in the Certification worksheet and checks whether the capacity will be available throughout the showing month. The results are loaded to the Check Contract Dates worksheet.

### CheckCustomProfiles

This query compares shown capacities in any custom profiles against the NQC or total VER MW Under Contract listed in the LSE Showing worksheet and the NQC MW in the ResourceDatabase query to ensure the custom profile does not exceed either value during any hour. The results are loaded to the Check Custom Profiles worksheet.

### CheckShownHours

This query determines the hours during which the active profile for each resource shows capacity. The shown hours are compared against the first and last available hours listed in the Master Resource Database worksheet. The results are loaded to the Check Shown Hours worksheet.

### CheckStorageExcessCapacity

This query compares excess capacity from non-storage resources and allocations shown above hourly system requirements against the total storage capacity shown, accounting for efficiency losses. Compliant showings must provide sufficient excess capacity to charge shown storage resources. The results are loaded to the Check Storage Excess Capacity worksheet.

### CheckStorageSOC

This query estimates the state-of-charge for each storage resource at each slice-of-day hour in terms of MWh available energy. The query assumes starting at 0 MWh and cannot exceed the resource’s Maximum Continuous Energy (MWh) listed on the Master Resource Database worksheet. The results are loaded to the Check Storage SOC worksheet.

### CheckGroupedResources

This query identifies co-located or hybrid resources which share an interconnection and calculates the combined capacities for each hour. A compliant showing must not exceed the interconnection limit. Results are loaded to the Check Grouped Resources worksheet.

### CheckHybridDeliverability

This query identifies hybrid resources, which share a Resource ID and have unique Resource SubIDs and determines the deliverable capacity for the solar resource based on its Deliverability Status and the attributes of both resources in each hybrid pair. The results are loaded to the Check Hybrid Deliverability worksheet.

## Exports for Charts

The three queries in this group serve as the backing datasets for each of the three charts. Each of the queries load to hidden worksheets with grey tabs. Resources are grouped using labels consistent across all three charts to reduce clutter and to maintain the chart formatting as the data changes.

### HourlyAvailability

This query groups resources and combines requirements with DR Allocations and Other CAM Allocations. The hourly shown and required less allocated capacities are loaded to the Hourly Availability worksheet.

### LocalAvailability

This query groups resources and shows local requirements for each local capacity area. The results are loaded to the Local Availability worksheet.

### FlexAvailability

This query groups resources and shows local requirements for each flexible category. The results are loaded to the Flex Availability worksheet.

# Storage Resource Optimization

This section provides additional details on the storage resource optimization worksheet and associated queries and Visual Basic script.

The optimization problem is defined by the following equations:

Where:

is a storage resource in the set of resources requiring optimization ;

is a slice-of-day hour among 24 hours, indicating the hour ending label;

is the required capacity and allocations less the sum of capacities shown among resources with default or custom profiles in hour ending ;

is the decision variable adjusted by the optimizer, representing the shown capacity of storage resource in hour ending ;

is the calculated maximum capacity for storage resource in hour ending , accounting for interconnection limits and shown capacities of collocated resources where applicable;

is the storage efficiency of resource group ;

is the maximum daily energy rating for storage resource ;

is the state-of-charge of resource group on day in hour ending , calculated as follows:

Where:

is the possible change in stored energy in storage resource due to charging or discharging during hour ending (state-of-charge is capped at 100%, thus is not guaranteed to yield equivalent changes in );

is the maximum continuous energy rating for storage resource ;

is the maximum overall capacity of storage resource (e.g., NQC under contract), applicable when grid charging is allowed; and

is the sum of shown capacities of resources paired or collocated with storage resource in hour ending where grid charging is not allowed for storage resource .

This optimization problem allows the decision variables , to be set by the optimization algorithm, which attempts to minimize the objective function while matching the deficit capacities, limiting the maximum charge and discharge rates in each hour, and respecting the state-of-charge and daily energy constraints. The objective function applies a cost to showing capacity, with capacity shown by less efficient storage resource costing more than the same MW shown by more efficient storage resource. The decision variables appear in the “Shown MW” column of the table labeled “Optimized Showings” and are constrained between 0 MW and the calculated maximum capacities listed in the “Maximum Capacity (MW)” column of the same table.

A valid solution will not allow any values in the “State-of-Charge Day 1” and “State-of-Charge Day 2” columns of the “Optimized Showings” table to fall below 0%. These columns represent calculated states-of-charge across two days with identical shown capacities, assuming 100% state-of-charge at the beginning of the first hour of the first day, and allowing charging during any hour where no capacity is shown at the rate listed in the “Capacity Available for Charging (MW)” column. Additionally, each storage resource should not exceed its “Maximum Daily Energy Capacity (MWh)”, listed in the “Storage Properties” table, which is equal to its “Maximum Continuous Energy (MW)” multiplied by daily storage cycle capability.

After pressing the “Optimize Showings” button in the top left of the Profile Optimization worksheet, the optimization script first refreshes the three queries which output to the tables within the worksheet, then performs two checks to make sure the optimization problem is not clearly unsolvable:

1. The deficit MW for each hour must not exceed the sum of the maximum capacities across all storage resources for the same hours; and
2. The sum total deficit MW across all hours must not exceed the total maximum daily capacities of all storage resources.

If both these checks pass, the script then executes an optimization algorithm consisting of four distinct stages, which are repeated iteratively as needed or up to a configurable maximum number of iterations:

1. Increase shown capacities for a resource with high efficiency and available state-of-charge;
2. Redistribute shown capacities to minimize overextended daily energies (skipped if no resources have negative “Difference Daily Energy (MWh)” in the “Storage Properties” table);
3. Redistribute shown capacities to reduce negative states-of-charge (skipped if the overall minimum state-of-charge is nonnegative); and
4. Reallocate any differences between the “Deficit (MW)” and “Shown MW” listed in the “Capacity Deficits” table.

Steps 2 and 3 may repeat up to 10 times within each iteration before progressing to step 4. The four steps are designed to work together to enforce the problem constraints and improve the objective function through each iteration. Every adjustment to a single resource and hour in steps 2 and 3 is balanced by opposite and approximately equal in aggregate adjustments to all other resources in the same hour. Adjustments to shown capacities will not exceed the associated maximum capacity or fall below zero, thus differences between the deficit capacities and total shown capacities may accumulate through each iteration—these differences are addressed in step 4. Generally, the objective function should improve (i.e., decrease) each iteration and converge to an optimal and valid solution, although certain conditions may cause the script to fail. Note that passing the two checks prior to optimization does not guarantee a valid solution exists, as the checks do not account for state-of-charge limitations. The optimization script may thus exit after the maximum number of iterations with either invalid states-of-charge, capacities exceeding the relevant maximum, or both, either indicating that no solution exists or additional iterations are required. Alternatively, the script may exit with a valid solution that is suboptimal after the maximum number of iterations, with optimality defined by consecutive iterations resulting in similar objective function values within a threshold. In these cases, the user may attempt any combination of the following:

* Manually adjust the values in the “Shown MW” column of the “Optimized Showings” table to find a valid solution;
* Adjust the maximum iterations setting and/or other settings to help the optimization algorithm find a solution; or
* Show additional resources or capacities to make the optimization problem more readily solvable, either by reducing the deficit or by increasing the storage capacity available for optimization.

Ideally, the optimization algorithm will find a valid solution with close to the lowest possible objective function value, indicating full prioritization of more efficient resources. Expect this outcome in most straightforward cases.

The optimization algorithm applies a few user-configurable settings, located in the outlined range below the “Capacity Deficits” table:

* Maximum Iterations – an integer number defining the maximum number of iterations for the algorithm to execute before exiting even if constraints or optimality conditions are not satisfied. Default value: 24.
* Objective Threshold Coefficient – a coefficient which, multiplied by the total deficit across all hours, defines the minimum difference between the objective function values evaluated at the ends of two consecutive iterations to trigger the exit criteria. Default value: 0.001.
* SOC Adjustment Coefficient – a coefficient applied to adjustments to hourly shown capacities when enforcing the state-of-charge constraint. A value of 1.0 will reduce the showing of a resource with a negative minimum state-of-charge such that its minimum state-of-charge will be zero immediately following its adjustment (when multiple discharge/charge cycles are present, only the cycle containing the minimum state-of-charge is affected, so the resource may still have a negative minimum state-of-charge during a separate cycle). Since multiple resources may require adjustment, it is recommended to use a value greater than 1 but not greater than 1.5, so that adjustments slightly overshoot to yield a slightly positive state-of-charge. Default value: 1.05.
* Daily Energy Adjustment Coefficient – a coefficient applied to adjustments to all shown capacities for a resource when enforcing the maximum daily energy constraint. A value of 1.0 will reduce the applicable resource’s overall showing by exactly the amount of unused energy represented by its minimum state-of-charge multiplied by its maximum continuous energy. Since the daily energy adjustment impacts all hours and resources, potentially causing other resources to become invalid, a value between 0.5 and 1 is recommended. Default value: 0.65.
* Efficiency Prioritization Coefficient – a coefficient applied to adjustments to the resource identified as having the greatest potential impact on the objective function. The potential impact is determined based on a combination of the unused daily energy and minimum state-of-charge, and accounts for storage efficiency. The optimizer adjusts each resource with higher than the lowest efficiency in the group, and to keep adjustments from negating each other, a value between 0.5 and 1 is recommended. Default value: 0.85.

As the optimizer runs, adjustments among all four steps should get smaller in magnitude, indicating convergence toward a solution. If the user finds values start exploding or oscillating, adjusting a combination of these settings may stabilize the problem and allow a solution to be found.

# Conclusion

We hope this template is helpful for developing compliant resource adequacy showings in the slice-of-day framework and anticipate further refinement as it is used by more people throughout the upcoming year. We look forward to your feedback and questions as you begin to use the template.

# Changelog

## Revision 16

First Public Release

## Revision 17

Internal Revision

* New validation test, labelled “Demand Response” on Validation Overview worksheet, calculates total shown demand response capacity (DR allocations and any resource with Resource Type="Demand Response") divided by required capacity (without Other CAM allocations) for each hour and compares against 8.3%--if any hour exceeds 8.3%, the test indicates "Fail".
* Added "Demand Response" as a capacity category in the charts.
* Added new section in User's Guide regarding Resources Under Construction.
* Consolidated buttons on the Profile Optimization worksheet.
* Added fourth table to the Profile Optimization worksheet showing only resources and hours where additional capacity is needed beyond shown default and custom profiles, reducing the number of independent variables for Solver and increasing the number of resources that can be optimized before grouping.
* Implemented two-day state-of-charge calculations on the Profile Optimization worksheet, assuming 100% stored at midnight of day 1, still constraining SOC to greater than 0 across both days.
* Implemented the same two-day state-of-charge calculations in SOC validation test, replacing original version assuming 0% initial SOC with one day.
* Wrote definition of the optimization problem in mathematical terms with text explanation in a new section of the User’s Guide.
* Added Resource SubID field to Resource NQC worksheet to allow correct joining to Resource Database table.

## Revision 18

Internal Revision

* The Profile Optimization worksheet and SOC Validation both apply proportional energy storage (maximum continuous and daily) weighted by the input NQC or VER Under Contract divided by the showing month's NQC MW in the Resource NQC worksheet rather than the entire resource energy storage capacity.

## Revision 19

Public Release

* More visual feedback while refreshing tables for optimization and charts.
* Various formatting changes throughout.

## Revision 20

Internal Revision

* Revised default profile capacity calculations for wind and solar resources, calculating VER based on resource NQC and Pmax if Fuel field indicates “SUN” or “WIND”.
* Revised hybrid deliverability test to use Pmax scaled by input NQC divided by resource total NQC for current showing month.
* Updated column header and hint for column “NQC Under Contract (MW)” (previously “NQC or VER Under Contract (MW)”).
* Renamed “NQC or VER Under Contract (MW)” to “NQC Under Contract (MW)” in LSE Showing worksheet and queries.
* Renamed “NQC MW” to “NQC (MW)” in Resource NQC worksheet and queries.
* Added weighting columns to the “Optimized Showings” and “Capacity Deficits” tables on the Optimization worksheet to prioritize higher efficiency storage, and set initial values of variable cells to 50% instead of 0%.
* Applied absolute values to state-of-charge calculations in both optimization worksheet and validation tests to accommodate CAM storage debits.
* Updated text on README worksheet to reflect recent changes.
* Updated user’s guide to reflect recent changes and merged changelog into user’s guide.

## Revision 21

Internal Revision

* Imported data from latest Master Resource Database.
* Replaced numeric values with lookup formulas for CAM storage and peaker allocations in LSE Showing and Resource Database worksheets.
* Reformulated storage profile optimization problem.
* Updated user’s guide to reflect changes to optimization.

## Revision 22

Public Release

* Modified HourlyAvailability query to include negative capacities to accommodate CAM debits.
* Modified OptimizationGroupMap query to exclude storage resources with capacities less than or equal to zero to accommodate CAM debits.
* Added Showing Type field to the Certification worksheet to select Year Ahead or Month Ahead and apply correct requirements.
* Applied new coefficient in SystemRequirements and FlexRequirements queries, equal to 0.9 if Showing Type is “Year Ahead” and 1.0 otherwise.
* Added validation hints to the Certification worksheet.

## Revision 23

Public Release

* Excluded hours with negative excess capacities from Storage Excess Capacity tests.
* Revised Flexible Category test according to program requirements.
* Implemented a pre-check into the storage resource optimization routine to inform the user when insufficient power or energy capacities are shown.
* Added explanation of minimum criteria for running storage resource optimization in User’s Guide.
* Revised and expanded explanation of the Flexible Capacity test according to revised calculations.
* Added details to User’s Guide regarding the Storage Excess Capacity tests.
* Removed “Table.StopFolding” expressions from queries for backward compatibility.
* Added buttons to each chart to navigate to supporting data table.

## Revision 24

Internal Release

* Applied “Table.Distinct” expression to the ResourceOptimizationGroupMap query to ensure no duplicate resources (e.g., two contracts for portions of the same resource).
* Added “Chart Category” column to Resource Profile Categories worksheet.
* Revised HourlyAvailability, LocalAvailability, and FlexAvailability queries to use “Chart Category” instead of “Profile Category” values.
* Modified specification for Resource and Allocations worksheet to calculate System Requirements based on Load Forecast and PRM instead of direct input.
* Revised default load profile calculations for VER resources consistent with stored profiles calibrated for Pmax.

## Revision 25

Public Release

* Revised storage optimization objective function and various cell formulas.
* Set initial conditions for optimizer to meet requirements.
* Updated User’s Guide with revised optimization problem definition.

## Revision 26

Public Release

* Clarified explanation for inputting VERs into LSE Showing template in User’s Guide.
* Added signature line on Certification worksheet.
* Clarified NQC entries use SOD NQC rather than Compliance NQC in User’s Guide.
* Added conditional formatting to optimization to highlight unfavorable conditions.
* Fixed error in Chart Label evaluation in the LSEShowingComplete query which had been applying Profile Category instead of Chart Category. The query is loaded into the “LSE Showing Complete” worksheet and used in hidden worksheets for charts.
* Fixed error in lookup formulas for CAM Storage Allocation Multi Cycle in “Resource Database” which had not correctly been retrieving the current month from the “CertificationTable” worksheet.
* Fixed labelling error for CAM Peaker Allocations so their capacities now count toward Requirements and Allocations in charts.
* Added checks in the Year column in the Requirements and Allocations worksheet against the showing year on the Certification worksheet throughout workbook. Previously, only checked showing month.
* Fixed errors in the ResourceDefaultProfile query so that region=“Any” now expands to all regions listed in the Regions worksheet and month=0 now map to all 12 months.
* Added VBA script to facilitate clearing input data from workbook.
* Added VBA script to replace resource database and default profiles from selected Master Resource Database file.
* Removed “Resource NQC” worksheet and added monthly NQC columns to “Resource Database” worksheet, and updated queries accordingly
* Rebuilt the storage optimizer
  + Removed usage of Solver and implemented fully custom script for optimizing storage showing.
  + Removed Optimization table.
  + Removed “Nongrid Charging Capacity (MW)” column from optimized showings table.
  + Added “Capacity Available for Charging (MW)” to “Optimized Showings” table, indicating either non-grid or maximum grid charging rate.
  + Added “Maximum Capacity (MW)” to “Optimized Showings” table.
  + Renamed the “Group Definitions” table to “Storage Properties”.
  + Updated capacity check to consider hourly maximum capacities rather than NQC under contract.
  + Removed resource grouping functionality and instead use “Resource ID” and “Resource SubID” throughout.
  + Removed fractional showing column, instead adjusting hourly capacities directly, constrained between zero and the resource’s hourly maximum capacity.
  + Added optimization status and settings panel below the “Capacity Deficits” table.
* Reformatted validation output tables.
* Made “Resource Group ID” values more readable in “Check Grouped Resource” validation output table.
* Excluded Energy-Only resources (indicated by value “EO” in Deliverability Status column of Resource Database) in CheckCapacity query, removing their shown capacities from all system, local, and flexible capacity checks.
* Modified Storage Excess Energy and Storage Excess Energy for MCC Bucket 4 tests to limit capacity from Energy-Only resources to offset charging requirements collocated storage resources.
* Recategorized labels for charts, defined in the hidden “Resource Profile Categories” worksheet, and sorted labels so that “Battery Storage” appears at top of stack.
* Applied color scheme to chart labels based on CAISO’s Today’s Outlook charts.
* Applied rounding to two decimal places in validation checks.
* Added script to filter for resource sub-ids in validation rules on LSE Showing worksheet and auto-populate fields with default values from Resource Database after inputting Resource ID and SubID.

## Revision 27

Public Release

* Modified storage optimization script to prevent divide-by-zero errors when optimizing small numbers of resources.
* Modified queries to ensure storage resources in optimizer worksheet don’t overwrite default profile when “Use Default Profile” is selected.
* Resolved error in CheckStorageSOC query causing capacities of co-located resources to be ignored in calculating available capacity for charging.
* Added NP 26 designations for non-CAISO BAAs on Regions worksheet to map default profiles to updated Master Resource Database entries.
* Added checkbox on README worksheet to switch auto-filling default values on or off for LSE Showing worksheet.
* Updated Refresh Resource Database script to generate resource types for demand response programs to apply correct default profiles.
* Fixed errors in Refresh Resource Database script causing duplicate demand response resources and misaligned deliverable percentage and capacity values.

1. Slice-of-Day NQC Under Contract can be calculated as [Compliance NQC Under Contract] \* [Total Slice-of-Day NQC] / [Total Compliance NQC]. [↑](#footnote-ref-1)