CPUC Staff Proposal: Methodology for ~~2019 IRP~~ Resource-to-Busbar Mapping & Assumptions for the 2021-2022 TPP

CPUC Energy Division

~~March 30~~October 23, 2020

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1. Document Purpose

Resource-to-busbar mapping ("busbar mapping") is the process of refining the geographically coarse portfolios produced in the California Public Utilities Commission's (CPUC) Integrated Resource Plan (IRP) proceeding, into plausible network modeling locations for transmission analysis in the California Independent System Operator's (CAISO) annual Transmission Planning Process (TPP). The purpose of this methodology document is to memorialize and communicate the steps the CPUC, CAISO and California Energy Commission (CEC) will take to implement the process and provide transparency and opportunity for stakeholder comment.

The busbar mapping methodology outlined in this document is focused on achieving effective and timely busbar mapping of the utility-scale ~~generation~~ resources in ~~2019~~ IRP portfolios, which need to be adopted via a CPUC decision in early ~~2020~~2021 to be able to inform the CAISO's ~~2020-~~2021-2022 TPP.

2. Document Revisions

Version	Revision Notes
October 23, 2020	Staff Proposal for the 2021-2022 TPP
March 30, 2020[1]	Addition of methodology for battery resources
February 21, 2020[2]	Improvements informed by stakeholder feedback on the Staff Proposal, and staff experience during implementation of the process
October 18, 2019[3]	Staff Proposal for the 2020-2021 TPP

3. IRP & TPP Context

Through the IRP process, the CPUC generates portfolios of electrical generation, distributed energy resources, storage, and transmission resources designed to meet the state's ~~2030~~ greenhouse gas emission reduction targets for the electric sector while minimizing cost and ensuring reliability. ~~Specifically,~~In order to ensure alignment between the planning and development of generation, storage, and transmission resources, where the ability to serve the grid is often interdependent, the CPUC's IRP process coordinates closely with the CAISO's TPP. The IRP process develops a ~~Reliability Base Case,~~resource portfolio(s) annually as a ~~Policy-Driven Base Case and Policy-Driven Sensitivities (the "IRP~~key input to the TPP base case studies, which includes a reliability base case portfolio and a policy-driven base case portfolio. The CPUC may also transmit additional resource portfolios~~") every year.~~ as inputs for sensitivity studies that test the implications of various policy futures. These are collectively referred to as "IRP portfolios."

The ~~2-year~~IRP cycle ~~of IRP involves~~can involve developing these portfolios with different approaches~~, depending on the year: in odd-numbered years~~. RESOLVE,[4]~~,~~ a capacity expansion model, is used~~; in even-numbered years~~ to develop portfolios for the Reference System Plan, whereas Load Serving Entities' (~~LSE)~~LSEs') IRP plans are used~~. In any year,~~ to develop a Preferred System Plan portfolio, and a hybrid approach may be used to supplement specific portfolio development. Upon formal CPUC adoption of the IRP portfolios, they are transmitted to the CAISO to be used as inputs to the TPP. The adopted IRP portfolios include a mix of existing resources, resources under development and scheduled to come online (or retire) in the near term, as well as generic future candidate resources. However, the locational specificity of the selected generic candidate resources is limited because of the geographically coarse planning zones used in IRP modeling.

[1] ftp://ftp.cpuc.ca.gov/energy/modeling/Busbar_Mapping-Methodology-2020-03-30.pdf
[2] ftp://ftp.cpuc.ca.gov/energy/modeling/Busbar_Mapping-Methodology-2020-02-21.pdf
[3] https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/2018/IRP_Busbar_Mapping-Methodology-2019-10-18.pdf
[4] Further information on RESOLVE is available here: https://www.cpuc.ca.gov/General.aspx?id=6442459770

In order to more accurately study the performance of the IRP portfolios at the high voltage system level, the CAISO needs to model the selected generic resources in representative sizes at specific transmission substation locations within each renewable planning zone identified in the IRP portfolios. Consequently, the selected generic resources need to be remapped outside of RESOLVE or LSEs' plans to specific busbars[5] in the transmission system before the portfolios can be transmitted to the CAISO and be considered as inputs to the TPP.

In order to disaggregate the zonal resource amounts into allocations to specific busbars, CPUC staff and CEC staff translate the tabular format of the portfolios into geographic map format, while considering higher resolution information about transmission infrastructure and land use. This methodology identifies the guiding principles, busbar mapping steps, and the associated criteria for making these considerations.

4. Scope of 2019 IRP Busbar Mapping for 2021-2022 TPP

Deep decarbonization of the electric sector to meet California's climate goals is likely to require a transformation of the state's electrical infrastructure, i.e., significant investment in solar, wind and storage, including the associated transmission. In turn, the requirements placed on planning processes, including busbar mapping, are likely to be significant due to the need to co-optimize economic, land use, transmission, and interconnection issues associated with the amount of renewables and storage needed to be online in 2030; and for California to be on the trajectory to achieve the state's SB 100 goal[6] of 100% clean electricity by 2045, as well as 80 percent below 1990 emissions by 2050.

The busbar mapping methodology outlined in this document is narrowly focused on achieving effective and timely busbar mapping of the utility-scale generation resources in 2019 IRP portfolios, which need to be adopted via a CPUC decision inby early 2020in the 2021 calendar year to be able to inform the CAISO's 2020-2021-2022 TPP. Consequently, it is likely that thisThis busbar mapping methodology willmay need to be revisited in 2020future years to ensure that the co-optimization issues identified above are fully incorporated in the busbar mapping methodology in time to inform the 2021-2022annual TPP modeling.

Further, the 2019 methodology is focused on resources within CAISO and other Californian Balancing Authority Areas (BAA) selected to serve CPUC IRP jurisdictional LSEs. Selected resources outside CAISO and other Californian BAAs are represented at CAISO boundaries so that their in-CAISO effects can be studied in the TPP.

The methodology outlined in this document builds on what was used by the agencies in prior years: For 2017 IRP portfolios, the busbar mappingfor 2020-2021 TPP.[7] That methodology proof-of-

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[5] "Busbar" and "substation" are used interchangeably in this document. A busbar, a specific connection point within a substation, is the more accurate term. The mapping process need only identify the applicable substation to connect a resource, so long as the availability of a feasible busbar there has been considered.

[6] Detailed at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100 Detailed at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

[7] Available at: https://www.cpuc.ca.gov/General.aspx?id=6442464144

concept was posted to CEC Docket 17-MISC-03[8] on February 15, 2018. For 2018 IRP portfolios, the busbar mapping methodology and results were posted to CEC Docket 17-MISC-03 on February 28, 2019, and updated on March 19, 2019.[9] It is furtherwas informed by stakeholder feedback on the Staff Proposal for the 2020-2021 TPP, and staff experience during implementation of the process for 2019 IRP portfoliosthe portfolios transmitted for 2020-2021 TPP. It contains details of the processes used in prior years.

This 2019 methodology for mapping resources in IRP portfolios for the 2021-2022 TPP aims to improve on past efforts by:

- ProposingUpdating guiding principles to guideensure the busbar mapping methodology
- Establishing is aligned with latest policies and incorporates latest stakeholder input (for example scoring criteria that should be used when mapping resources to busbarsdefinitions have been updated to capture stakeholder comments, and battery mapping methodology has been updated to incorporate policy goals)
- Identifying for stakeholders the specific busbar mapping steps performed by CPUC, CEC, and CAISO staff
- Establishing an iterative interagency review process that allows the CAISO to identify transmission-related issues with the mapping results before the CPUC transmits the portfolio(s) to the CAISO
- Using commercial interest identified in interconnection queues to validate the RESOLVE resource potential

- Including and updating the criteria that are used when mapping resources to busbars as well as describing how the criteria are implemented (for example, the thresholds for level 3 non-compliance with the "distance to transmission" criterion have been updated based on staff's review of existing and planned wind and solar facilities and their proximity to existing transmission infrastructure). For the 2020-2021 TPP, staff described the process of implementing the criteria only in the reports transmitting the busbar mapping results to the CAISO.
- Updating the battery energy storage mapping methodology to incorporate policy considerations such as minimizing ratepayer cost and minimizing air quality impacts, as well as incorporating CAISO Local Capacity Technical study (LCT) results regarding battery charging capability in local capacity requirement (LCR) areas.
- Inclusion of the methodology CPUC staff use to specify in the transmitted portfolios which existing thermal generation units should be assumed as retired, an assumption required by the CAISO in addition to the portfolio and busbar mapping assumptions. For the 2020-2021 TPP, CPUC staff instead provided the CAISO with guidance on how to determine thermal generator retirement within the TPP process. Prior to 2020-2021 TPP this guidance had been communicated in a document called the "Unified Inputs & Assumptions."

Where applicable, improvements on past efforts are noted [NEW] in section 6the sections below.

[8] Available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-MISC-03
[9] Ibid.

5. Guiding Principles

The following principles are intended to guide the busbar mapping process. Later sections of this document detail how to implement these principles, and criteria with which to assess whether the implementation is effective.

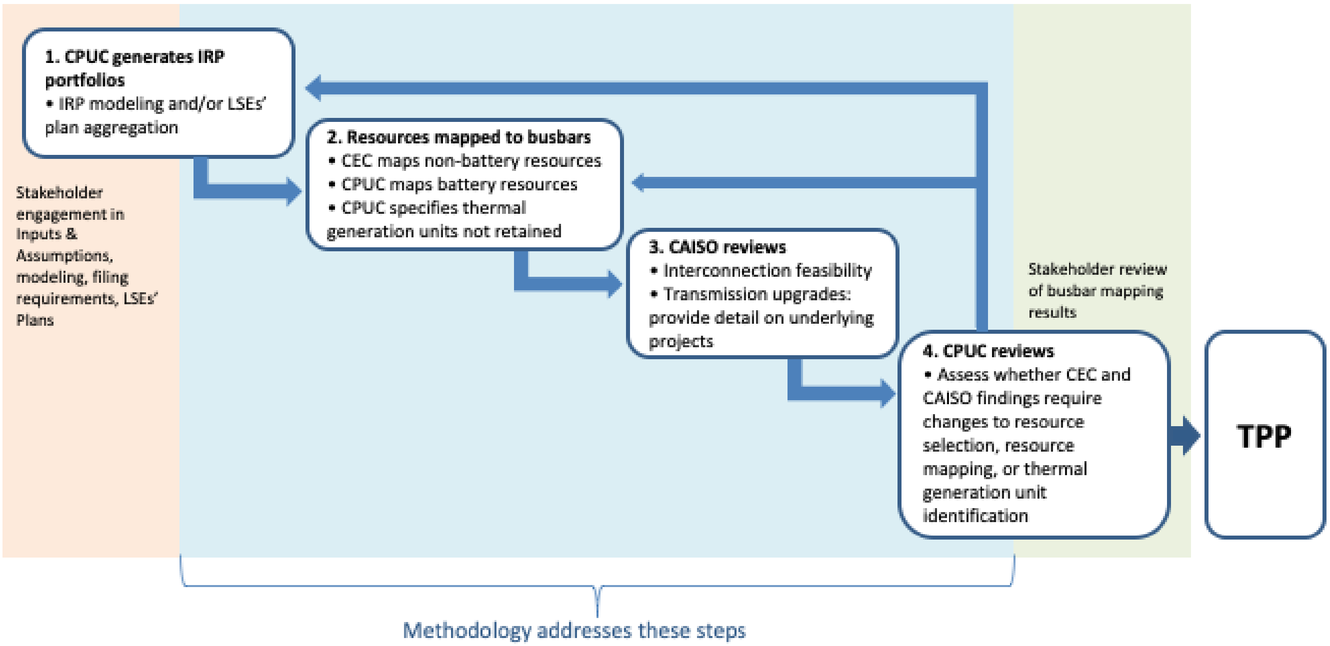
- The more granular resource and transmission cost, land use, and interconnection optimization done in the busbar mapping process should be consistent to the extent practical and feasible with the higher-level optimization that occurs during the IRP portfolio development process
- Busbar allocations should generally represent the expected outcome of LSE procurement activity in response to policy requirements, maintaining reliability, and minimizing cost to ratepayers. This is achieved by observing to the extent practical and feasible the planned procurement indicated in LSEs' plans and the level of commercial interest in the CAISO and other relevant interconnection queues.
- The allocations should avoid, or at least minimize, intra-zonal congestion that would otherwise be addressed – depending on the specific projects ultimately procured – through local transmission upgrades identified in the Generation Interconnection and Deliverability Allocation Process (GIDAP). This principle can be followed by respecting the transmission sub-zone capability limits, as well as zone limits.[10]
- Successful busbar mapping process should result in IRP portfolios that ~~do not need additional~~minimize post processing in the CAISO's TPP~~ after the CPUC has transmitted the CPUC adopted portfolios to the CAISO~~.
- Consistency with prior year mapping results for equivalent TPP cases is important to the IRP and TPP processes. Staff should consider whether changes are occurring due to exogenous factors (e.g., demand or resource cost shifts) or due to modeling margin of error. Where significant changes are proposed in the resource mapping from one year to the next, these should be explicitly justified.

6. High-level Busbar Mapping Steps

The ~~2019~~ busbar mapping process is completed through a sequenced transfer of information between the CPUC, CEC, and CAISO. ~~The~~It is an iterative process, as demonstrated by Figure 1.

Figure 1. ~~currently focuses on generation resources, with~~Flowchart of the ~~approach for storage resources still under development by staff, informed by stakeholders.~~ busbar mapping process

[10] Further described in the CAISO's May 2019 White Paper "Transmission Capability Estimates as an input to the CPUC Integrated Resource Plan Portfolio Development" available at: http://www.caiso.com/Documents/TransmissionCapabilityEstimates-CPUC-IRP-PortfolioDevelopmentRedacted.pdf



7. Non-Battery Busbar Mapping Steps

Information transfers related to ~~generation~~non-battery resources follow this sequence:

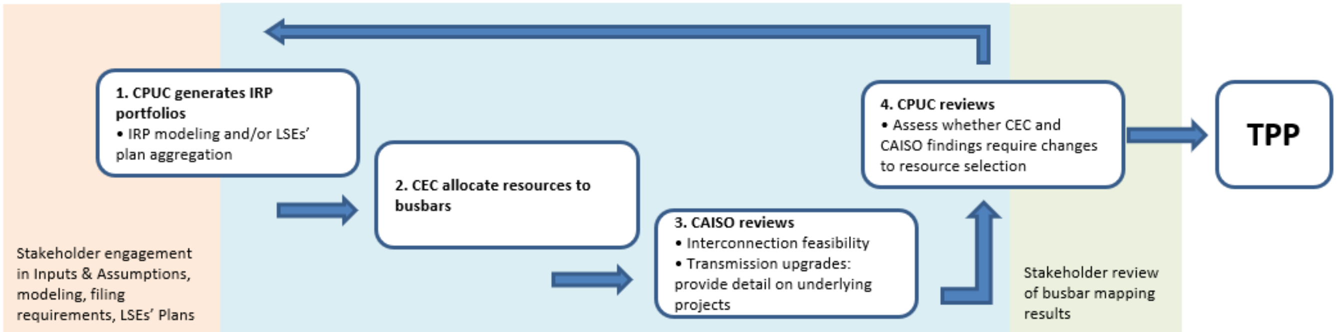
Step 1 - Draft portfolio(s) submitted to CEC for busbar mapping (CPUC)
Step 2 - Draft busbar mapping performed (CEC)
Step 3 - Observations and recommended revisions (CAISO)
Step 4 - Vet mapping results from CEC staff, as well as observations and recommendations from CAISO staff (CPUC)

- Note: Steps 1-4 make up a "round" of busbar mapping.

Step 5 - Repeat steps 1-4 if mapping results do not conform with mapping criteria
Step 6 - Successfully mapped IRP portfolio(s) formally transmitted to the CAISO (CPUC)

~~The steps for busbar mapping and the stakeholder review process are outlined in figure 1 below~~The mapping of batteries is conducted by CPUC staff under Step 2 in parallel with the mapping of non-battery resources by CEC staff. The detailed battery mapping steps are outlined in Section 8: Battery Storage.

Figure 1. Flowchart of the 2019 busbar mapping process



CPUC – Step #1

The CPUC staff will provide the following materials to the CEC and CAISO staff for the annual busbar mapping process:

- Draft Reference System PlanIRP portfolios generated by RESOLVE and/or draft Preferred System Plan portfolios resulting from the aggregation of LSEs' plans, as applicable.
    - Baseline resources: megawatts (MW), by unit, by point of interconnection
    - Selected new resources: MW, by resource type, by transmission zone (tabular format)[11]. Where the baseline set of resources has been updated after the portfolio of selected resources was formed, CPUC staff should reconcile the two sets of resources to avoid double-counting.
    - Resource potential estimates (geographic information system (GIS) data format – polygons and associated attribute tables) to give the CEC further information about the selected resources[12]
        - Prior to the selection of candidate resources in RESOLVE the total capacity (MW) and online date of resource potential will have been validated by comparing the resource potential in the RESOLVE planning zones with the commercial interest as indicated by the interconnection queues in those planning zones [NEW]
- Transmission capability information (GIS data format)

[11] For examples from the 2017-18 IRP cycle, see Excel workbooks "Reliability and policy-driven base case," and "Policy-driven sensitivity cases", available at https://www.cpuc.ca.gov/General.aspx?id=6442460548 For example, see Excel-based results viewer, dated March 23, 2020, available at https://www.cpuc.ca.gov/General.aspx?id=6442464143. See "Portfolio Analytics" tab

[12] For examples from the 2017-18 IRP cycle For example, see GIS Data available at http://www.cpuc.ca.gov/General.aspx?id=6442453965

- Transmission upgrades triggered in RESOLVE (tabular format)[13]

Stakeholder participation:

- Stakeholders will be provided an opportunity to comment on the RESOLVE inputs and assumptions (including CAISO transmission capability and cost values), RESOLVE functionality, and the proposed Reference System Portfolio (year 1) and proposed Preferred System Portfolio (year 2)
- Given the current IRP schedule, there is insufficient time for stakeholdersStakeholders will be provided opportunities to vet thecomment on this busbar mapping of the IRPmethodology and to review the mapped resource portfolios prior to input to TPP. However. Further, stakeholders' feedback during TPP may demonstrate the opportunity to better fulfilfulfill the guiding principles outlined in this document. Small changes to allocations may be made during TPP at CAISO staff's discretion, whereas other changes would need to be considered during the subsequent IRP busbar mapping process.

CEC – Step #2

The CEC staff will provide the following materials to the CPUC and CAISO staff after each round of busbar mapping:

- Draft CEC busbar mapping results
  - See February and March 2019 report2020 CEC Busbar Mapping Results workbooks for exampleexamples of prior work[14]

The CEC is using a busbar mapping methodology that is similar to the methodology used in 2018prior years:

1) CEC staff will use the information described in Step #1 above from the CPUC to develop a geographic map for the renewable energy resource technologies and for each portfolio, consistent with the RESOLVE model inputs and assumptions developed by the CPUC.
2) CEC staff will create a GIS layer to identify the potential environmental and land use implications of the RESOLVE-selected renewable resources. The layer is a combination of the following statewide data and information:

   - Terrestrial Landscape Intactness (California Energy Commission and Conservation Biology Institute, 2016)[15]

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13 For examples from the 2017-18 IRP cycleexample, see RESOLVE Results Viewer, Excel-based results viewer, dated March 23, 2020, available at https://www.cpuc.ca.gov/General.aspx?id=6442464143 https://www.cpuc.ca.gov/General.aspx?id=6442460548 See "Portfolio Analytics" tab, available at https://www.cpuc.ca.gov/General.aspx?id=6442457210

14 CEC Docket 17-Misc-03, TN# 227311, UPDATED 2019 IRP Portfolio Allocations to Substations, filed March 11, 2019, available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-MISC-03 Available at https://www.cpuc.ca.gov/General.aspx?id=6442464144

15 Available at https://databasin.org/datasets/e3ee00e8d94a4de58082fdbc91248a65

- Areas of Conservation Emphasis, version 3.0 (ACE III) (California Department of Fish and Wildlife, 2018)[16]
- Terrestrial Connectivity[17]
- California Agricultural Value (California Energy Commission and Conservation Biology Institute, 2018)[18]

3) The datasets above will be normalized and summed to create a comprehensive layer with numerical scores that represent the degree of potential environmental and land use implications if resources are utilized. The California Agricultural Value data will either be incorporated into the model or used as a separate overlay to compare different substation allocations.

4) The environmental and land use layers will be overlain with the renewable resource potential geographies to identify the environmental implications (low and high) of developing renewable resources, particularly solar resources and where necessary, wind energy resources.

5) Available transmission substations, including those that are planned and approved as well as existing, will be identified ~~and a suitable standard radius will be established around each substation.~~. Available substations include those in Californian BAAs, as well as CAISO. Available substations are a subset of substations which are considered when assigning the portfolios. This subset of substations is identified in the following manner:

   i. GIS datasets for California substations are combined with the GIS data set for U.S. substations to help identify available substations for out-of-state resources.[19]

   ii. The combined set of substations is queried to select substations that meet the following criteria:

      1. part of the CAISO

      2. identified as currently operational

      3. identified as having both multiple buses and bus voltages of 161 kV and above

   iii. Project documents for new, approved powerline projects are examined to identify the mapped locations of proposed substations and they are hand-digitized to add them to the available substation dataset.

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[16] Available at https://www.wildlife.ca.gov/Data/Analysis/Ace
[17] Available at- https://www.wildlife.ca.gov/Data/Analysis/Ace#523731772-connectivity
[18] Available at https://databasin.org/datasets/f55ea5085c024a96b5f17c7ddddd1147
[19] Available at:
https://cecgis-caenergy.opendata.arcgis.com/datasets/california-electric-substation
https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-substations

iv. The substation data is overlain with the CPUC RESOLVE transmission zone GIS layer and substations that fall within one of the transmission zones are retained in the available substation data subset.

v. During iterative rounds of busbar mapping, individual substations from the identified data sources may be added if additional substation mappings are needed.

~~5)~~6) A suitable standard radius will be established around each available substation. The standard radius will be set to approximate the longest distance that economically feasible interconnection power lines (gen-ties) typically fall within. This standard radius, as well as busbar voltage - the other key driver of interconnection cost - will be used when mapping each resource type as follows:

a. Solar – calculate the ~~share~~amount of renewable resources with lower environmental implications within each substation radius. Allocate the transmission planning area-level solar resources to substations based on the available ~~weight of~~ lower environmental implication area within the substation radius.

b. Wind - compare the location of wind energy resources to each substation radius and allocate the transmission planning area-level wind resources to substations in closest proximity. High- and low-environmental-implication information will be identified, but options for moving the resource to a different substation will be more limited for wind, given the site-specific nature of the resource.

c. Geothermal – compare the location of geothermal energy resources to each substation radius and allocate the transmission planning area-level geothermal resources to substations in closest proximity.

d. Biomass - compare the location of biomass energy resources to each substation radius and allocate the transmission planning area-level biomass resources to substations in closest proximity.

e. For resources which fall outside the standard substation radius, staff will compare their interconnection cost assumed in the supply curve, and the gen-tie distance it allows, ~~will be compared~~ to the distance to the ~~substation.~~busbar identified in busbar mapping. If the distance to the substation is greater, then depending on the busbar voltage, this ~~means~~may mean a criterion has not been met; refer to the Busbar Mapping Criteria section ~~7~~ below.

~~6)~~7) CEC staff will review the CAISO's Transmission Capability Estimates to check that resources are not mapped in such a way that departs from the high level allocation of the IRP portfolios, which should already be respecting capability limits - the existing system "Estimated ~~FCDS~~Full Capacity Deliverability Status Capability (MW)" and the "Estimated ~~EODS~~Energy Only Deliverability Status Capability (MW)" for each overarching transmission zone and the nested constraints within, or triggering upgrades where intended. Any triggered transmission upgrades will be highlighted by CEC staff and examined by the CAISO and CPUC staff in Steps #3 and #4 ~~[NEW]~~.

~~7)~~8) CEC staff will develop a spreadsheet to report out the results of the megawatt allocations by substation, for each renewable energy resource, in each transmission zone. It will include details of the specific methodology applied, enabling reporting against the criteria outlined in the Busbar Mapping Criteria section ~~7~~ below ~~[NEW]~~, and any notes needed to interpret and understand the allocation outputs.

Stakeholder participation:

- ~~Given the current IRP schedule, there is insufficient time for stakeholders~~Stakeholders will be provided opportunities to ~~vet the~~comment on this busbar mapping ~~of the IRP~~methodology and to review the mapped resource portfolios ~~prior to input to TPP. However~~. Further, stakeholders' feedback during TPP may demonstrate the opportunity to better ~~fulfil~~fulfill the guiding principles outlined in this document. Small changes to allocations may be made during TPP at CAISO staff's discretion~~, whereas other changes would need to be considered during the subsequent IRP busbar mapping process.~~.

CAISO – Step #3

During each round of busbar mapping the CAISO staff will provide the CEC and CPUC staff the following:

- Without new modeling or formal assessments, if the CAISO staff determines conceptual transmission upgrades are likely to be required based on the mapping in Steps #1 and/or #2, the CAISO will provide an estimate of the conceptual transmission upgrades' in-service date.
  - This is important because the theoretical in-service date for the upgrade might not align with the on-line date for the selected candidate resources that triggered the transmission upgrade ~~[NEW]~~
  - If the transmission upgrades likely to be required are at a scale that exceeds any that has been studied by the CAISO, there is unlikely to be any further information available, and this will be noted ~~[NEW]~~
- The CAISO staff will provide feedback on the CEC's draft busbar allocations, including verifying:
  - Transmission zone and sub-zone capability limits
    - The CAISO will assess whether the selected new resources by transmission zone (MW) are consistent with the CAISO transmission capability estimates[20]. If not, then the CAISO staff will provide

[20] http://www.caiso.com/Documents/WhitePaper-TransmissionCapabilityEstimates-InputtoCPUCIntegratedResourcePlanPortfolioDevelopment.pdf

interpretation, which may include reference to the latest CAISO Business Practice Manual deliverability methodology[21].

- Interconnection feasibility, including electrical suitability and physical space availability at each substation, if this information is available from the transmission owner
- Status of active and previously queued resources as indicated by interconnection queues; which is a supplemental check to the upstream validation of resource potential performed by the CPUC staff as described in Step #1 above

- If the CEC staff maps portfolio resources to substations in BAAs other than the CAISO, then the CAISO staff will consult appropriate planning entities during the resource modeling phase of TPP. These planning entities may recommend adjustments to locations and size of resources in their BAAs mapped by the CEC staff. In such cases, the CAISO will consult the CPUC and CEC staff before incorporating any subsequent busbar allocation changes to the portfolios. Staff will engage with TPP stakeholders and/or IRP stakeholders if the changes may result in a materially different transmission outcome, in terms of constraints or upgrades. All changes will be publicly documented.
- Observations, problems encountered, recommended portfolio modifications needed

Stakeholder participation:

- ~~Given~~Stakeholders will be provided opportunities to comment on this busbar mapping methodology and to review the ~~current IRP schedule, there is insufficient time for stakeholders to vet the mapping of the IRP~~mapped resource portfolios ~~prior to input to TPP. However~~. Further, stakeholders' feedback during TPP may demonstrate the opportunity to better ~~fulfil~~fulfill the guiding principles outlined in this document. Small changes to allocations may be made during TPP at the CAISO staff's discretion~~, whereas other changes would need to be considered during the subsequent IRP busbar mapping process~~.
- ~~CAISO~~The CAISO's observations and any recommended modifications to identified transmission upgrades will be reported in the CEC's mapping results and/or in the CPUC's report

CPUC – Step #4

CPUC staff will review the draft mapping by CEC staff, as well as observations and recommendations from CAISO staff. Using the busbar mapping criteria, described in the Implementation of the Busbar Mapping Criteria section ~~7~~0 below, CPUC staff will determine whether the mapping results are ready to be transmitted to the CAISO for TPP, or require a further round of mapping. Resource selections with multiple high priority criteria violations will be considered for adjustments or further rounds of mapping.

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[21] https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Generator%20Interconnection%20and%20Deliverability%20Allocation%20Procedures

If a further round of mapping is required, CPUC staff may reallocate resources between transmission zones. Such inter-zonal changes should not result in material changes to the expected cost, reliability or emissions performance of the portfolio. This can be implemented and demonstrated by using RESOLVE directly, or manually while mirroring the resource optimization criteria RESOLVE uses.

Stakeholder participation:

- ~~Given~~Stakeholders will be provided opportunities to comment on this busbar mapping methodology and to review the ~~current IRP schedule, there is insufficient time for stakeholders to vet the mapping of the IRP~~mapped resource portfolios ~~prior to input to TPP. However~~. Further, stakeholders' feedback during TPP may demonstrate the opportunity to better ~~fulfil~~fulfill the guiding principles outlined in this document. Small changes to allocations may be made during TPP at CAISO staff's discretion~~, whereas other changes would need to be considered during the subsequent IRP busbar mapping process~~.

~~7.~~8. Battery Storage Mapping Steps

~~The following section describes the methodology used to map battery storage to busbars for transmission planning in the CAISO for the first time.~~

~~Types of battery storage considered in-scope:~~

1. ~~Both hybrid or co-located, and standalone~~
2. ~~Both inside and outside Local Capacity Requirements (LCR) areas~~

~~Criteria and Prioritization~~

Introduction

Mapping battery storage to busbars differs significantly to the methodology for ~~generation~~non-battery resources described earlier in this document for reasons including: RESOLVE provides no locational information about selected new batteries[22]; RESOLVE provides flexibility in siting storage due to not directly linking the battery storage to solar, wind or other input resources;~~ and~~ land use considerations and environmental implications associated with siting batteries are very different in nature~~. Accordingly, the methodology outlined here is distinctly different. It does, however, draw upon two criteria common across all resource types:~~

~~[22] However LSE IRP plans may include locational information, in which case the mapping methodology for an IRP portfolio based on those would need to take this into account~~

consideration of commercial interest; and consideration of transmission capability limits. The methodology addresses LCR areas as a particularly important consideration for battery storage due to the value that batteries can provide but also due to the challenges that may arise., and busbar mapping of battery storage provides the opportunity to consider local values not modeled in RESOLVE.

Commercial Interest

In accordance with the guiding principles outlined in section 5 above, higher accuracy in mapping resources within planning processes to locations in which projects are likely to be developed, improves both the CPUC's and the CAISO's ability to plan for a more reliable and cost-effective system.

This methodology for busbar mapping of The 2020-2021 TPP battery storage is generally guided by mapping effort relied entirely on commercial interest asdata indicated by the CAISO Generator Interconnection Queue[23] and supplemented by the material modification assessment (MMA) requests received by CAISO on December 2, 2019, to add energy in December 2019. The benefits of this methodology were two-fold: it was a simple approach that allowed for completion of the mapping effort within the short timeframe, and it satisfied the CAISO requirement that locations should be specified for all resources in the portfolio. However, because this method was not directly related to specific policy objectives, it was difficult to demonstrate how the battery mapping effort could be used to achieve a range of state-wide goals.

For the 2021-2022 TPP the battery mapping exercise will be centered around the intersection of policy objectives and commercial interest. The feedback from stakeholders and the lessons learned from the previous mapping effort highlighted a few reasons why this update to the methodology is necessary. They include:

- Busbar mapping of batteries presents an opportunity for proactive planning that helps ensure that the battery storage development contributes to achieving the range of state policy goals – like GHG reduction, reliability, and cost minimization – for which the battery resources were selected in RESOLVE;
- Busbar mapping of batteries also allows batteries to contribute to achieving additional policy goals which were not optimized for in the RESOLVE model (i.e. policy goals that require locational specification of batteries); and
- Busbar mapping of batteries can contribute to addressing issues related to operations and retirements of specific plants located in disadvantaged communities (DACs) and locations with high air quality health impacts.

The execution of the battery mapping effort to achieve the policy objectives will be completed in such a way that they are in accordance with the guiding principles outlined in Section 5: Guiding Principles above and also address some of the specific issues highlighted during feedback from the battery mapping effort for the 2020-2021 TPP portfolios. The following sections highlight the proposed policy objectives, the issues to be addressed, and the data required to ensure the execution of the battery mapping will achieve the desired results.

Stakeholders will be provided opportunities to comment on the battery busbar mapping methodology and to review the mapped resource portfolios. Further, stakeholders' feedback

[23] http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx

during TPP may demonstrate the opportunity to better fulfill the guiding principles outlined in this document. Small changes to allocations may be made during TPP at CAISO staff's discretion.

Battery Mapping Policy Objectives

The RESOLVE model selects a least-cost optimized portfolio that meets a range of system-level policy goals. To remain consistent, it is important that the battery mapping effort is also grounded in a policy directive that ensures costs are minimized.

Policy Objective #1: Minimizing Ratepayer Costs

The first policy directive that will be achieved by this battery mapping effort is a minimization of ratepayer costs. This will be done by maximizing the value of the storage ~~to existing and active queued projects~~[24]~~.~~ MW and durations selected by RESOLVE as needed to meet system needs, by considering additional locational benefits.

~~Under the material modification assessments~~[25]~~:~~

- ~~Adding resources such as storage that do not exceed existing or queued plant output from a site may qualify as additions that are not material modifications, and can proceed outside of the ISO interconnection process – for projects that are in the queue or online~~

~~Options are available~~ Issues Addressed:

The execution of the battery mapping effort to achieve this policy directive will address the following issues:

- Increasing the amount of co-located battery resources. Generally, co-located batteries are cheaper than stand-alone batteries.[26] Stakeholder comments from the 2020-2021 TPP battery mapping effort identified a need to increase the amount of co-located battery resources. The mapping exercise will be executed in such a manner that siting of co-located batteries will be maximized to the limits of available solar resource for charging and without triggering a need for new transmission development. The meaning of the term "co-located", as used in this busbar mapping methodology, is not as narrow as the definition used by the CAISO[27]. The granularity of the information available does not allow CPUC staff to delineate whether these resources are "hybrid" or "co-located" based on the CAISO definition.
- Reducing congestion. In the CAISO analysis of LCR areas some battery resources are proposed as solutions for allowing increased imports into constrained areas during off peak periods. An additional benefit of siting battery storage resources in LCR

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[24] ~~http://www.caiso.com/Documents/OpportunitiesAddingStorageExisting-NewGenerationSitesCall101019.html~~

[25] ~~http://www.caiso.com/Documents/Presentation-OpportunitiesforAddingStorageatExistingorNewGenerationSites.pdf~~

[26] 2018 U.S. Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark, Ran Fu et al. NREL. November 2018. https://www.nrel.gov/docs/fy19osti/71714.pdf

[27] Hybrid Resources Final Proposal. CAISO. October 2020. http://www.caiso.com/InitiativeDocuments/FinalProposal-HybridResources.pdf

areas, particularly LCR areas with solar resources with which the battery resource can be co-located, is to reduce transmission congestion and curtailment. The mapping exercise will be executed in such a way that these benefits will be evaluated, to the extent possible, when assigning battery resources to LCR areas with congestion.

- Reducing opportunities for market power. For certain LCR areas, local RA price premiums exist when natural gas-fired power plants are needed to provide capacity to local areas. In LCR areas with, or approaching, tight load/resource balances, these power plants may have the opportunity to exert market power (for instance, by seeking market exit but necessitating a reliability must run agreement). The execution of the battery mapping exercise will seek to site battery storage resources in such local capacity areas, which can reduce market power and the local price premiums paid to such resources. Concerns around reliability, particularly given the August 2020 rotating outages, require that some additional consideration will need to be given to the impact of the elimination of such premiums on resource retention needed for both local and system reliability.

Policy Objective #2: Minimizing Criteria Pollutants

The second policy directive is borne out of a desire to use the battery mapping effort to achieve additional policy goals which are not necessarily yet considered explicitly in the RESOLVE modeling. The minimization of criteria pollutants is proposed to utilize the batteries, especially the stand-alone resources, to address a range of localized issues which are not represented in the RESOLVE optimization.

Issues Addressed:
The execution of the battery mapping effort to achieve this policy directive will address the following issues:

- Reduction of local emissions, particularly in areas with high air quality impacts. Siting batteries in these areas can reduce local price premiums for the criteria air pollutant emitting fossil-fuel resources, yet those resources may still be required for system RA needs. However, even if emitting plants do not retire, siting batteries in areas with acute air quality concerns has the potential to reduce local power plant emissions, especially in transmission-constrained LCR areas. Similarly, a consideration is the necessity of the emitting resources for system reliability needs.
- Reduction of emissions in DACs. Siting of battery resources specifically within DACs may enable pollution reduction in these communities, as well as potential economic benefits from battery storage development. PU Code Section 454.51 requires the CPUC to "*...adopt a process for each load-serving entity…to file an integrated resource plan…to ensure that load-serving entities do the following… Minimize air pollutants with early priority on disadvantaged communities...*" among other requirements. LSEs can procure batteries in DACs to prioritize the minimization of air pollutants in these specific communities.

The battery mapping for the 2020-2021 TPP considered LCR areas and the mapping of batteries to ameliorate the issues in those areas. However, the possibility of using batteries to reduce the air quality issues in DACs was not addressed. This is being considered because not all DACs fall within LCR areas. This round will consider the alignment of LCR opportunities with disadvantaged communities and/or those facing air quality concerns.

Battery Mapping Steps

The battery mapping steps detailed below will holistically consider the policy directives described in the previous section. The steps represent a direction for assigning both co-located and stand-alone batteries. To complete this task, information on battery opportunities in LCR areas, local air quality, and characterization of DACs will be used. Additionally, the battery mapping effort will coordinate with the non-battery busbar mapping effort to optimize for collocation with solar resources, and to account for availability of transmission headroom, to avoid triggering unnecessary transmission development. The CalEnviroScreen dataset provides information on emissions, air quality, and DAC assignments. Ozone and PM nonattainment areas data from the EPA Green Book also provide information on air quality burdens for areas outside of DACs. GIS level data on local emissions, DACs, and LCR areas will be needed to ensure the mapping effort is consistent with the available data being used in the non-battery mapping efforts. CAISO Local Capacity Technical studies provide information on opportunities to displace LCR resources with battery storage. The non-battery mapping exercise will provide information on the amount of solar that is mapped to a busbar and the available transmission headroom.

Outline of Battery Mapping Steps

1. Identify primary substation list – substations to be considered and their assigned transmission zones
    a. All substations located in transmission constraint zones, with voltage >= 230 kV
2. Identify the transmission headroom available for the transmission zone
    a. This step will consider the transmission headroom available for the transmission of each busbar using the most recent TPP base scenario, prior to any non-battery busbar mapping
    b. This step will utilize the CAISO whitepaper data
    c. This step will recognize the nested zones transmission constraints
3. Identify commercial interest at ~~present regarding managing~~ that substation
    a. This step will use the CAISO Interconnection Queue data
    b. This step will also utilize information from the non-battery busbar mapping exercise
    c. This step will also utilize the planned procurement indicated in LSEs' plans, if possible within the available time
4. Identify how much full capacity deliverability~~, that change if and when~~ status (FCDS) solar is assigned to the substation
    a. This step will utilize information from the non-battery busbar mapping exercise
5. Identify whether the substation is located in LCR Area
    a. Batteries mapped to LCR areas will be prioritized based on the CAISO's ~~proposed deliverability methodology goes into effect~~ Draft 2030 Local Capacity Technical

study results[28], which show the level of 4-hour battery storage that the CAISO states can provide both system and local capacity value within each LCR area

On October 10 and November 4, 2019, the CAISO presented opportunities for adding storage to existing or new generation sites. Stakeholders submitted over 10,000 MW of requests which have been aggregated at or near their points of interconnection and posted publicly.[29]

Due to the limitations of the publicly available MMA list, CPUC Staff does not have details regarding which Interconnection Queue projects the MMA MW are modifying. This lack of knowledge includes information such as what phase of the interconnection process the queue project of origin is currently at.

6. CPUC Staff will use the data sourcesIdentify whether the substation is located in a DAC
    a. This step will utilize the CalEnviroScreen DAC status
7. Identify whether the substation is located in an air quality standard non-attainment area
    a. This step will utilize the EPA Greenbook data
8. Allocate batteries based on identifications 1-7 using the following order
    a. Co-located batteries will be given priority. The co-located batteries will be sized to a maximum of 60% of the solar resource[30]. Batteries will first be assigned to substations with transmission headroom, FCDS solar resources, and commercial interest.
        i. If there are multiple substations meeting these criteria, priority will be given based on LCR areas, DACs status, and non-attainment status areas.
    b. After the co-located battery assignments, stand-alone batteries will be assigned to substations without any solar resources using the following order
        i. Substations contained within DACs, non-attainment status areas, and LCR areas with transmission headroom.
        ii. Substations contained within LCR areas with transmission headroom.
        iii. Substations contained within DACs with transmission headroom.
        iv. Substations contained within non-attainment status areas with transmission headroom.
    c. Assignments of nameplate capacity of battery resources will be up to a maximum of 90% of available transmission headroom to not trigger transmission upgrades

If there are battery resources still unassigned after the steps described in steps a through c above to analyze the commercial interest and allocate battery storage to busbars using objective criteria.

Local Capacity Requirements Areas

    d. Recent IRP results have found that most thermal generation, not , then assess whether any transmission zones already scheduled to retire, will be needed to stay online through 2030 to maintain system reliability. However, reductionat the transmission capability limit meet all of reliance on thermal generation in local capacity areas can provide two benefits: ratepayer savings, and reductions in the

[28] http://www.caiso.com/Documents/Presentation-2020-2021TransmissionPlanningProcess-Sep242020.pdf

[29] http://www.caiso.com/Documents/MMARequestsReceived-AddStorage-Existing-NewGenerationSites.pdf

[30] 2018 U.S. Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark. NREL. Fu et al. November 2018. https://www.nrel.gov/docs/fy19osti/71714.pdf

following criteria ~~air pollutants and GHG emissions. California has prioritized minimizing pollution in Disadvantaged Communities (DAC)s, and this can in part be accomplished by reducing reliance on power plants in local capacity areas, many of which overlap with DACs. Battery storage may provide an opportunity to achieve that. Considering the significant amount of commercial interest for battery storage projects in LCR areas, the opportunities batteries provide, but also the existing challenges, the methodology includes two distinct steps~~:

i. ~~Step 1: CPUC staff will transmit to~~ Contain a high quantity of commercial interest for co-located solar and battery resources
ii. Have been filled primarily with solar resources
iii. No transmission has been approved by the CAISO ~~as inputs~~to accommodate resource development in this transmission zone

e. Assign batteries to transmission zones identified under step d.
f. For transmission zones/sub-zones with headroom, assess whether any substations with collocation commercial interest did not have any solar mapped to them in the base case portfolio transmitted for the 2020-~~21 TPP, battery~~ 2021 TPP. Identify whether other substations in the same transmission zone were assigned solar resources to their limit. If so, redistribute the solar resources among the substations within the same transmission zone and sub-zone to allow for colocation of batteries before adding more solar.
g. If there are battery resources still unassigned after the steps described in steps a through f above, then batteries will be assigned to the "Ex" zones using the same order described in a through f above.

Alternative Option – battery mapping steps:

The above text is based on the assumption that storage ~~mapped to LCR areas. However, the methodology for~~is eligible to be co-located with solar only (and not with wind).

An alternative option is to additionally consider co-location of battery storage ~~busbar mapping is iterative and includes flexibility due to the evolving nature of~~ with wind resources.

Staff proposes to co-locate battery storage ~~information available.~~ with solar only, due to the guiding principle of minimizing ratepayer costs. Batteries co-located with solar are eligible for the federal Investment Tax Credit, but batteries co-located with wind would not receive the Production Tax Credit, and so staff expects that co-locating storage with wind would be less cost-effective.

~~Step 2: The busbar mapping of storage in LCR areas provided by CPUC Staff, to the degree possible, will be supplemented by the CAISO with two additional sources of information.~~

~~First, the 2020-21 TPP assessments can be supplemented by the work CAISO previously conducted on the ability of storage projects to reduce reliance on gas-fired generation capacity in LCR areas and sub-areas.~~[31]

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[31] ~~http://www.caiso.com/Documents/AppendixG-BoardApproved2018-2019TransmissionPlan.pdf~~

In the 2018-2019 TPP, the CAISO explored and identified alternatives for reducing reliance on local gas-fired generation capacity in most of the areas and sub-areas. Several of these alternatives were transitioned to the CAISO's economic study phase in this transmission planning cycle for further consideration as potential economic-driven transmission solutions.

The CAISO did not study the economics of "resource substitution", e.g. replacing one form of local capacity resource with another, as that is a resource procurement decision falling under the CPUC's procurement processes. However, CAISO's findings can still be utilized to prioritize which LCR areas and sub-areas would benefit most from battery storage projects.

Second, the 2020-21 TPP assessments can be supplemented by the Local Capacity Technical (LCT) study the CAISO expects to complete by May 2020. Additional consideration is needed for storage being considered in meeting local capacity requirements. For all requirements and contingencies other than extreme event considerations, the CAISO expects that for batteries that qualify as local capacity resource adequacy resources, the transmission and the other local capacity resources must be sufficient to recharge the batteries in anticipation of the outage continuing into the next day's peak load period. As part of the ongoing LCT study, the CAISO expects to identify by May 2020 the amount of energy storage devices that can be seamlessly integrated in local areas and sub-areas such that the peak capacity needs and the off-peak charging needs are both met under contingency conditions. Due to the current unavailability of these results, CPUC Staff is not able to consider this important information in this phase of the battery storage busbar mapping effort.

9. Busbar Mapping Criteria and Implementation

~~8.~~ Busbar Mapping Criteria

The busbar mapping process should result in plausible network modeling locations for the portfolios, assuming the portfolios do not violate predetermined busbar mapping criteria. If the busbar mapping results in any of the criteria not being met, then the violation(s) would require interagency discussion and potentially necessitate the remapping of the IRP portfolios. The busbar mapping criteria are as follows:

- Distance to transmission
  - Selected candidate resources should fall within an economically viable distance to transmission; and the resource interconnection path should be viable from an environmental and land use perspective (i.e., path that does not cross high-environmental implication areas or dense urban areas)
  - CEC will flag applicable resources for which the recommended busbar allocation results in an exceedance of a predetermined standard radius[32]~~.~~ (explained below). As described in Section ~~6~~7: Non-Battery Busbar Mapping Steps, the exceedance of the predetermined standard radius does not necessarily mean the busbar allocation is not plausible because the resources might still be economically viable with a longer/higher cost gen-tie.
- Transmission capability limits
  - Busbar allocation in given area should abide by the estimated transmission capability in each zone and sub-zone, triggering only those upgrades which are determined to be cost-effective during the formation of the IRP portfolios
  - Where busbar mapping utilizes planned substations rather than existing substations, this will be highlighted because of the inherently higher uncertainty regarding the substation in-service date
  - Busbar mapping process might also identify resources that cannot interconnect to an existing or planned substation because the resource is triggering a transmission upgrade that has not been previously studied by the CAISO. Such resources will be highlighted, and CAISO staff input will be sought per Step #3, with assumptions and implications documented. During the TPP that follows, the specific assumed interconnection and transmission solutions for those resources should be tested.
- Land use and environmental constraints
  - Allocation in each area should not exceed available land area to accommodate the resources, based on environmental information applied in Step #2 above

~~[32] For reference, a radius of 15 miles was used in the 2018 busbar mapping process~~

- If available land area is insufficient to accommodate selected resources within reasonable distance to the substation, or if the resources have high environmental implications, then these issues will be flagged and addressed in a further round of mapping. Possible solutions may include: increasing the gen-tie beyond the standard radius for the particular resources if their interconnection cost estimates allow; or re-optimizing the IRP portfolio(s) with updated assumptions about resource potential informed by this busbar mapping process.

- Commercial interest
  - Busbar allocations should reflect the planned procurement indicated in LSEs' plans and the level of commercial interest in the CAISO and other relevant interconnection queues

- Consistency with prior year
  - Busbar allocations for equivalent TPP cases should be relatively consistent year to year. For: for example, Base Cases from one year to the next; and Policy-driven Sensitivity Cases exploring the same issue from one year to the next. Where large changes are necessary, the reasons for these should be clear. Staff should consider whether changes are occurring due to exogenous factors (e.g., demand or resource cost shifts) or due to modeling margin of error. Where significant changes are proposed in the resource mapping from one year to the next, these should be explicitly justified.

Implementation of the Busbar Mapping Criteria

Staff use a "dashboard" to identify whether busbar allocations of a particular round of mapping of a portfolio comply with the five key criteria described above. This informs whether changes to the allocation may be required. An assessment using the criteria will be implemented and reported in the dashboards as follows below. "Level 1" refers to strong compliance; "Level 2" to possible or moderate breach of a criterion; and "Level 3" to a likely or material breach, indicating that a further round of mapping is required to improve compliance. Blank cells are shown in the dashboards where there is insufficient data to assess compliance.

1. Distance to transmission of an appropriate voltage
   a. Level 3 non-compliance threshold (i.e., exceedance of this threshold results in Level 3 assessment):
      i. Resources for which the busbar allocation results in gen-tie lengths that exceed the following thresholds (standard radius):[33]
         1. Solar: 19.8 mi[34] (90th percentile, planned facilities) [NEW]

[33] 90th percentile of planned facilities, per publicly available filings: EIA (last) (2019). Preliminary Monthly Electric Generator Inventory (Based on FormEIA-860M as a Supplement to Form EIA-860).[Online]. Available at: https://www.eia.gov/electricity/data/eia860m/.11

[34] Spatial analysis was performed to check the interconnection distances for existing and planned solar facilities in the U.S. Source data for existing solar facilities: USGS "National Solar Arrays" https://www.sciencebase.gov/catalog/item/57a25271e4b006cb45553efa. Source data for planned facilities: U.S. Energy Information Administration, Form 860, public filings https://www.eia.gov/electricity/data/eia860m/.11

2. Wind: 18.7 mi[35] (90th percentile, planned facilities) [NEW]

b. Level 2 non-compliance threshold:

i. Resources for which the busbar allocation results in gen-tie lengths that exceed the following thresholds (standard radius):

1. Solar: 10.7 mi (75th percentile, planned facilities) [NEW]

2. Wind: 10.3 mi (75th percentile, planned facilities) [NEW]

Consideration of busbar voltage: When assessing distance staff will check the voltage of the busbar to ensure the combination of gen-tie length and interconnection voltage broadly align with the interconnection cost allowed for in the resource's selection. Accordingly, assessment of compliance with this criterion should not be based solely on the standard radius; in general, the thresholds above apply to busbar voltages in the range of 161-230kV. Further, staff should look for opportunities to minimize expected costs for ratepayers, for example by mapping to a busbar that may be more distant yet with a lower voltage than the alternative busbar. [NEW]

c.

Alternative Option - distance to transmission:

The above text is based on publicly available data characterizing planned renewable energy facilities, available through federal Energy Information Administration filings (form 860-M).

An alternative is to use the data for existing solar[36] and wind [37] facilities instead of planned facilities. The mean interconnection distance is slightly higher for planned facilities (5.8 mi for solar, 7.7 mi for wind) than for existing facilities (4.8 mi for solar, 5.7 mi for wind).

Staff proposes to use planned facilities as a more relevant indicator for likely trends in future development.

[35] Spatial analysis was performed to check the interconnection distances for existing and planned wind facilities in the U.S. Source data for existing wind facilities: USGS national wind turbine database "USWTDB" https://doi.org/10.5066/F7TX3DN0. Source data for planned facilities: U.S. Energy Information Administration, Form 860, public filings https://www.eia.gov/electricity/data/eia860m/.11

[36] Carr, N.B., Fancher, T.S., Freeman, A.T., Battles Manley, H.M.,. "Surface Area of Solar Arrays in the Conterminous United States." *U.S. Geological Survey*, June 2016, doi: http://dx.doi.org/10.5066/F79S1P57.

[37] Hoen, B.D., Diffendorfer, J.E., Rand, J.T., Kramer, L.A., Garrity, C.P., and Hunt, H.E. *United States Wind Turbine Database (Ver. 3.1, July 2020)*. 2018, doi: https://doi.org/10.5066/F7TX3DN0.

> ***Alternative Option – interconnection cost:***
> *The above text describes the use of a single standard radius for each of wind and solar to assess distance to transmission, and a focus on considering voltage when the standard is exceeded.*
>
> *An alternative is to define a different standard radius for each typical busbar voltage level, by resource type. This would enable a more granular consideration of interconnection cost and would involve effectively checking distance and voltage together.*
>
> *A further alternative is to review and update, where necessary, interconnection cost assumptions in RESOLVE to reflect the latest expected interconnection costs for each resource or resource zone. This would avoid manual checks and re-optimizations.*
>
> *Staff proposes using a single standard radius, supplemented with checks of voltage by exception, to balance accuracy with the practicalities of implementing a manual process. Staff recommends that RESOLVE's inputs and assumptions are updated with stakeholder input in time for 2022-2023 TPP. There is insufficient time to do this for 2021-2022 TPP.*

d. For out-of-state resources staff will take the following approach:
  i. For out-of-state land area availability [NEW]
    1. Use the spatial wind and solar resource potential information available in the "Low-impact land use pathways to deep decarbonization of electricity" study[38] to assess distance to transmission
    2. Note this source identifies four levels of wind, solar, and geothermal resource potential, based on four levels of environmental screening criteria. Resource potential from any "Siting Level", from 1-4, may be used. Siting Level 1 excludes only those areas where development is legally prohibited, and Siting Level 4 excludes all important habitat, intact landscapes, wildlife corridors, and areas with conservation value. Siting Level 2 will be used for out-of-state resources. This excludes wetlands and designated endangered species habitat but does not exclude big game priority habitat or Audubon Important Bird Areas.

> ***Alternative Option - out-of-state land area availability:***
> *The above text is based on using the publicly available, peer-reviewed, and published "Low-impact land use pathways to deep decarbonization of electricity" study.*

[38] Grace C Wu, Emily Leslie, Oluwafemi Sawyerr, D Richard Cameron, Erica Brand, Brian Cohen, Douglas Allen, Marcela Ochoa and Arne Olson, "Low-impact land use pathways to deep decarbonization of electricity," Environmental Research Letters, vol. 15, no. 7, Jul. 2020. doi: https://doi.org/10.1088/1748-9326/ab87d1. [Online]. Available: https://iopscience.iop.org/article/10.1088/1748-9326/ab87d1

An alternative is to use the data from the 2009 Western Renewable Energy Zones study[39] *(WREZ Report). In the WREZ Phase 1 Report the Qualified Resource Areas (QRAs) were mapped and the WREZ Phase 1 process was identified. QRAs were defined as areas of high quality and dense renewable energy resources with enough capacity to potentially justify the construction of a high voltage transmission line for interstate transmission of renewable energy. QRAs needed to meet size, resource quality, environmental and technical criteria. The WREZ Zone Identification and Technical Analysis (ZITA) working group developed the economic and technical criteria to identify QRAs. The WREZ Environment & Lands (E&L) working group developed the environmental criteria to identify QRAs. Staff believes the resulting spatial data is now outdated, and the spatial granularity is coarse, but notes that the data has been through stakeholder vetting in public forums.*

Staff proposes to use the "Low-impact land use pathways to deep decarbonization of electricity" study because it incorporates and builds upon the WREZ data and methods. Staff believes it provides for an improved method than the WREZ Report because it uses higher spatial resolution, more comprehensive and broader geographic extent, and it incorporates the results of more recent studies such as RETI 2.0[40]*, WECC EDTF*[41]*, BLM WWWMP*[42]*, and Argonne National Lab EZMT*[43]*.*

ii. For out-of-state transmission access [NEW]

1. Staff will review candidate project areas to confirm that land meeting the site suitability criteria is within 20 mi of an existing 230 kV or higher voltage substation, and deliverable via one of the RETI 2.0 "advanced development" transmission projects or equivalent
2. For definition of "advanced development" transmission projects, see RETI 2.0 Western Outreach Report: "While many metrics could be used to identify advanced development of a transmission project, two potential candidates could be: (1) project has received a federal Final Environmental Impacts Statement (FEIS), or greater (e.g., Record of Decision) and (2) project has entered Phase 2 of the WECC Path Rating Process, or greater (i.e., Phase 3). Based on the information collected for this assessment and these criteria, advanced development projects would include Gateway South and West, Southline, SunZia, SWIP North and TransWest Express. These five projects would form a reasonable foundation for near-term scenario analyses. However, all of the projects considered in this report have in-

[39] R. Pletka and J. Finn, "Western Renewable Energy Zones, Phase 1: QRA Identification Technical Report", Black & Veatch and National Renewable Energy Laboratory, Tech. Rep. NREL/SR-6A2-46877, Oct. 2009. [Online]. Available: https://www.nrel.gov/docs/fy10osti/46877.pdf

[40] California Energy Commission's RETI 2.0 report "RETI 2.0 Western States Outreach Project Report" https://efiling.energy.ca.gov/getdocument.aspx?tn=216198

[41] Western Electricity Coordinating Council and ICF, WECC Environmental Data Viewer and Risk Mapping, 00000. [Online]. Available: https://ecosystems.azurewebsites.net/WECC/Environmental/

[42] Bureau of Land Management and Argonne National Laboratory, West-Wide Wind Mapping Project (WWMP), 00000. [Online]. Available: http://wwmp.anl.gov/

[43] *Energy Zones Mapping Tool.* Argonne National Lab, https://ezmt.anl.gov/.

service dates prior to 2030, which would make them all practical candidates for supporting California's 2030 RPS and GHG initiatives."[44]

2. Transmission capability limits
   a. Level 3 non-compliance threshold:
      i. Selected resource exceeds transmission capability (Full deliverability or energy only)
         1. Applied first to all sub-zones
         2. Applied next to all super-zones

3a. Available land area
   a. Level 3 non-compliance threshold:
      i. Exceeds 100% of candidate project area land within the standard radius [NEW]
   b. Level 2 non-compliance threshold:
      ii. Resources for which the busbar allocation results in exceedance of 75% of the land area estimated to be available to accommodate a resource [NEW]

3b. Available low-value land area
   a. Level 3 non-compliance threshold:
      i. Exceeds 75% of high-value land (terrestrial) within the standard radius, for four or more of the following [NEW]:
         1. Intactness
         2. Biodiversity
         3. Connectivity
         4. Rarity
         5. Native species
         6. Audubon Important Bird Areas (IBA)
         7. Important habitat
         8. Wildfire threat
   b. Level 2 non-compliance threshold:
      i. Resources for which the busbar allocation results in exceedance of 20% of the low-environmental-implication land area estimated to be available to accommodate a resource

Notes regarding available land area and available low-value land area criteria:

- Refer to the approaches described above for criterion 1, for out-of-state resources, which are also applicable for criteria 3a and 3b
- If based on review of the portfolios, these thresholds turn out to be too low (for example, if approximately half or more of the new resources get flagged at level 3 non-compliance, and this would trigger further rounds of mapping of a large portion of the portfolio, creating a major departure from the logic and optimization objective within RESOLVE), then staff may adjust these thresholds accordingly

[44] https://efiling.energy.ca.gov/getdocument.aspx?tn=214339

Alternative Option – available land and available low-value land:
The above text is based on using the exceedance thresholds of 100% and 75% for available land, and 75% and 20% of low-value land, and four or more of the underlying GIS data layers. These thresholds are based on staff's experience from prior years' mappings. Because solar has a relatively high power density (45 MW/km2)[45], available land area is not typically a binding constraint, but wind energy's lower power density (2.7 MW/km2)[46], makes it much more sensitive to land area availability. Staff has chosen thresholds numerically, and iteratively, based on data, rather than based on any theoretical limit.

An alternative is to set land area utilization limits based on desired resource diversity or geographic diversity targets, or to change the land area utilization thresholds as new information becomes available. For example, the decreasing specific power of wind energy as more low-wind-speed turbines with higher rotor diameters become commercially available may drive higher land area requirements.[47]

Staff proposes to use the thresholds identified in the main text above based on experience, to balance accuracy with the practicalities of implementing a manual process.

4. Commercial interest
   a. Level 3 non-compliance threshold:
      i. Selected resource (any amount) in transmission zone without any commercial interest; or
      ii. Commercial interest in transmission zone is evident, yet selected resource amount is higher or lower by more than 3,000 MW
   b. Level 2 non-compliance threshold:
      i. Commercial interest in transmission zone is evident, yet selected resource amount is higher or lower by more than 2,000 MW
5. Consistency with prior year's mapping
   a. Level 3 non-compliance threshold:
      i. 1,000 MW or greater difference from prior year (to identify material absolute changes from prior year's mapping)
   b. Level 2 non-compliance threshold:
      i. 60% or greater difference from prior year (to identify changes that may be smaller in absolute terms yet are still significant in percentage terms)

Note: If based on review of the portfolios, these thresholds turn out to be too low (for example, if approximately half or more of the new resources get flagged at level 3 non-compliance, and this would trigger further rounds of mapping of a large portion of the

[45] Source: Carr, N.B., Fancher, T.S., Freeman, A.T., Battles Manley, H.M.,. "Surface Area of Solar Arrays in the Conterminous United States." *U.S. Geological Survey*, June 2016, doi: http://dx.doi.org/10.5066/F79S1P57 .
[46] Hoen, B.D., Diffendorfer, J.E., Rand, J.T., Kramer, L.A., Garrity, C.P., and Hunt, H.E. *United States Wind Turbine Database (Ver. 3.1, July 2020)*. 2018, doi: https://doi.org/10.5066/F7TX3DN0 .
[47] Mark Bolinger, Eric Lantz, Ryan H Wiser, Ben Hoen, Joseph Rand, Robert Hammond. "Opportunities for and Challenges to Further Reductions in the 'Specific Power' Rating of Wind Turbines Installed in the United States." *Wind Engineering*, Jan. 2020, doi: 10.1177/0309524X19901012.

portfolio, creating a major departure from the logic and optimization objective within RESOLVE), then staff may adjust these thresholds accordingly.

Alternative Option – commercial interest:
The above text is based on using exceedance thresholds which have been chosen numerically, and iteratively, based on staff's experience of prior years' mappings, rather than based on any theoretical limit.

An alternative is to set thresholds based on desired commercial interest consistency targets, or to change the thresholds as new information becomes available.

Staff proposes to use the thresholds identified in the main text above based on experience, to balance accuracy with the practicalities of implementing a manual process.

Example Application of Battery Mapping Steps (For Illustrative Purposes Only)

This section walks through the example in Figure 2 below. The data for the substations contained in Figure 2 will be reviewed and potentially revised for the final mapping. Figure 2 contains a list of substations. Attributes for each substation are presented in columns 2-10. Using the first row in Figure 2 as an example:

- Vincent is the substation (column 1)
- This substation is located in the Tehachapi transmission zone (column 2)
- The Tehachapi zone has a transmission limit of 3,221 MW (column 3)
- The Vincent substation has 0 MW of solar mapped here (column 4)
- It has 1,861 MW of commercial interest in storage per the CAISO queue (column 5)
- It is located in the Big Creek/Ventura LCR area (column 6)
- It can accommodate up to 90 MW of 4-hr batteries for local and system RA (column 7), per the CAISO TPP presentation dated September 24, 2020[48] (pg. 167)
- This substation not in a Disadvantaged Community (column 8)
- It is in an ozone air-quality standard nonattainment area (column 9)
- It is not in an air quality non-attainment area for particulate matter (2.5 microns) (column 10)

The paragraphs below describe the process for assigning batteries to this substation (populating columns 11-14).

[48] http://www.caiso.com/Documents/Presentation-2020-2021TransmissionPlanningProcess-Sep242020.pdf

Beginning with the first substation in the list (Vincent), we assess the first three criteria: transmission headroom, commercial interest, and solar mappings.

- This Vincent substation is in the Tehachapi transmission zone which has 3,221 MW transmission headroom (it originally had 4,300 MW per the CAISO transmission capability whitepaper, and the total solar busbar mappings in the Tehachapi zone included in the base case portfolio transmitted for the 2020-2021 TPP have been subtracted from this to arrive at 3,221 MW remaining headroom).
- This substation has 1,861 MW commercial interest per the CAISO queue, but no solar resource has been mapped to this particular substation.
- Because there is no solar resource mapped to this substation, we cannot assign battery storage and assume it to be co-located with solar, so the value in column 11 (battery mapping – co-located) is zero. Next we check whether the substation is located in an LCR area (column 6) and it is – the Big Creek/Ventura area. We know from CAISO TPP analysis (released September 24, 2020) that the Big Creek/Ventura LCR area can accommodate up to 90 MW battery energy storage (up to 4-hr duration) to meet local and system RA needs. Thus, the value in column 12 "Battery mapping – Standalone LCR + System" – becomes 90 MW.
- The value in in column 13 "Battery Mapping – Standalone – System Only" is 240 MW, because this substation is in an LCR area and while only 90 MW of batteries can be assigned here to meet local and system need, there is the possibility of adding more batteries to meet system-only need, up to 330 MW in the Big Creek/Ventura area. Therefore the value in column 13 is 240 MW (330 minus 90).

Alternative Option – treatment of batteries in LCR Areas:

The above text is based on the assumption that the overall (non-4hr) LCR Area battery limits specified in the September 24, 2020 TPP presentation are applicable for system-only RA. CPUC staff believes this is appropriate based on discussion with CAISO staff.

An alternative option is to skip this step, and to consider the (lower) charging limit for 4-hr batteries for local + system RA to be the binding constraint.

Staff proposes to use the higher limit for system-only RA. Staff believes this is more likely to enable the mapping of a large amount of battery resources included in recent IRP portfolios. If in practice staff finds that this is more than necessary to map the portfolio, then the portfolio can be trimmed down accordingly.

Proceeding to the next substation, Midway, we assess transmission headroom, commercial interest, and solar mappings.

- Midway is the substation (column 1)
- This substation is located in the Kern and Greater Carrizo transmission zone (column 2)
- The Kern and Greater Carrizo zone has a transmission limit of 1,000 MW (column 3)
- The Midway substation has 0 MW of solar mapped here (column 4)

- It has 1,431 MW commercial interest in storage per the CAISO queue (column 5)
- It is located in the Big Creek/Ventura LCR area, which can accommodate up to 90 MW of 4-hr batteries for local and system RA, and up to 330 MW of battery energy storage for system-only RA per the CAISO TPP presentation dated September 24, 2020 (pg. 167)
- This substation is in an ozone air-quality standard nonattainment area (column 9). It is also in an air quality non-attainment area for particulate matter (2.5 microns) (column 10).
- It is in a Disadvantaged Community (column 8)
- This substation is in the Kern and Greater Carrizo transmission zone, which has 1,000 MW of remaining transmission headroom. It has commercial interest (1,431 MW) per the CAISO queue, and it has 0 MW of solar mapped here.
- For column 11, "Battery Mapping – Co-located," we take the minimum of the amount prescribed by the binding criteria: 90% of transmission headroom, OR 60% of the amount of solar mapped here. In this case, the amount of solar is binding, and so the value in column 11 is 0 MW, 60% of the solar nameplate capacity mapped here.
- Next, we evaluate whether there can be additional standalone storage mapped here. The substation is in the same LCR area as the prior substation – the Big Creek/Ventura LCR area. This area can accommodate up to 90 MW battery energy storage (up to 4-hr duration) to meet local and system RA needs, and up to 330 MW to meet system need only. The 330 MW have been assigned to the Vincent substation. No more batteries can be charged and used for local and system RA here. For this reason the value in column 12 "Battery Mapping - Stand-alone LCR + System (MW)" is zero.
- Similarly to the prior substation, the substation is in the Big Creek/Ventura LCR area, so the value in column 13 "Battery Mapping - Stand-alone System Only" is zero

The next two substations (Windhub and Antelope) are also in the Big Creek/Ventura LCR area.

- Windhub and Antelope are the substations (column 1)
- These substations are located in the Tehachapi transmission zone (column 2)
- The Tehachapi transmission zone has a starting transmission limit of 2,891 MW (column 3). (Note that the transmission headroom limit for the Tehachapi zone has been reduced by 330 MW, due to the batteries assigned to Vincent substation in prior steps. This amount is reduced for Antelope after storage is assigned to Windhub in the steps below).
- The Windhub and Antelope substations have 277 MW and 300 MW of solar mapped here respectively (column 4)
- They have 3,560 and 575 MW commercial interest in storage per the CAISO queue (column 5)

- They are located in the Big Creek/Ventura LCR area, which can accommodate up to 90 MW of 4-hr batteries for local and system RA, and up to 330 MW of battery energy storage for system-only RA
- These substations are in an ozone air-quality standard nonattainment area (column 9). They are not in an air quality non-attainment area for particulate matter (2.5 microns) (column 10).
- They are not in a Disadvantaged Community (column 8)
- There is a significant amount of solar mapped here, and so there can be co-located batteries assigned up to 60% of the solar nameplate capacity (60% x 277 MW solar at Windhub) or up to the transmission headroom limit (2,891 MW), whichever is lower.
- The result is that Windhub is assigned 166 MW and Antelope is assigned 180 MW co-located batteries (column 11)
- They do not have any more battery energy storage assigned for local and system RA, since the maximum amount has been assigned for this area already. The values in columns 12 and 13 "Battery Mapping - Stand-alone LCR + System (MW)" are zero for both Windhub and Antelope.

Proceeding to the Mohave substation, values in columns 2, 3, and 4 indicate no full deliverability (FD) transmission headroom, substantial commercial interest, and no solar mapped here on a fully deliverable basis.

- Mohave is the substations (column 1)
- This substation located in the Southern California Desert and Southern Nevada transmission zone (column 2)
- The Southern California Desert and Southern Nevada transmission zone has remaining transmission headroom of 0 MW (column 3). (Note that the Fully Deliverable transmission headroom for this zone has been fully utilized with solar in the 2020-2021 TPP Base portfolio, in the nested zones – Mountain Pass and El Dorado, Riverside East and Palm Springs, and Southern Nevada).
- The Mohave substation has 0 MW of FD solar mapped here (column 4)
- It has 1,520 MW commercial interest in storage per the CAISO queue (column 5)
- It is not located in an LCR area
- This substation is not in an ozone air-quality standard nonattainment area (column 9). It is not in an air quality non-attainment area for particulate matter (2.5 microns) (column 10).
- It is not in a Disadvantaged Community (column 8)
- This substation can have 0 MW assigned in column 11 "Battery Mapping – Co-located" due to the absence of any FD solar mapped here
- It is not in an LCR area, so 0 MW are assigned in column 12 "Battery Mapping - Stand-alone LCR + System"

- It is outside an LCR area, and it is in a transmission zone with no available headroom "SCADSNV_Z5_SCADSNV"
- It is possible to assign 0 MW in column 13 "Battery Mapping - Stand-alone System Only." This standalone storage is assigned up to 90% of the transmission headroom limit (which is zero).

The remaining substations can be assessed in the same way. There are about 400 substations in the overall list. In this example we have been able to assign approximately 3,200 MW of battery energy storage to busbars, using only 10 substations. This makes us reasonably confident that we will be able to find appropriate locations for the amount of battery energy storage in recent IRP portfolios – up to 12,000 MW battery energy storage.

Furthermore, this method is anticipated to assign locations for more than the desired IRP portfolio amount of battery energy storage. This means that there is room for adjustment to prioritize battery energy storage in DACs, and in locations with unhealthy air quality. The method is as follows: After the maximum possible amount of battery energy storage is assigned to locations using the steps above, the total amount of battery energy storage, exceeding the desired IRP portfolio amount, can be "trimmed" down to the portfolio size, by removing batteries from substations with zeroes in all three of columns 8, 9 and 10 (DAC status, Ozone Non-Attainment Status, and Particulate matter 2.5 Non-Attainment Status). The result will be that the majority of the remaining battery energy storage will be located in disadvantaged communities with unhealthy air quality (substations with ones in columns 8-10). This outcome is desired to achieve the policy objective of reducing criteria air quality pollutants in disadvantaged communities.

Figure 2. Example Battery Mapping

Sub-station Name	Tx Deliv. Zone	Tx Limit (MW)	FD Solar PV Mapped (MW)	Comm. Int (MW)	LCR Name	LCR Battery Limit (4-hr duration) (MW)	DACs Status (1/0)	Ozone NA Status (1/0)	PM 2.5 NA Status (1/0)	Battery Mapping – Co-located (MW)	Battery Mapping - Stand-alone LCR + System (MW)	Battery Mapping - Stand-alone System Only (MW)	Total Battery Mapping (MW)	Total Battery Mapping (MWh)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
VINCENT	Tehachapi	3,221	0	1,861	Big Creek/Ventura area	90	0	1	0	-	90	240	330	1,320
MIDWAY	SPGE_Z2_KernAndGreater Carrizo	1,000	0	1,431	Big Creek/Ventura area	90	1	1	1	0	-	-	0	0
WINDHUB	Tehachapi	2,891	277	3,560	Big Creek/Ventura area	90	0	1	0	166	-	-	- 166	664
ANTELOPE	Tehachapi	2,625	300	575	Big Creek/Ventura area	90	0	1	0	180	-	-	- 180	720
MOHAVE	SCADSNV_Z5_SCADSNV	0	0	1,520	none	-	0	0	0	0	-	0	0	0
RED BLUFF	SCADSNV_Z4_RiversideAnd	2,463	192	3,247	none	-	0	0	0	115	-	2,113	2,228	8,912

Sub-station Name	Tx Deliv. Zone	Tx Limit (MW)	FD Solar PV Mapped (MW)	Comm. Int (MW)	LCR Name	LCR Battery Limit (4-hr duration) (MW)	DACs Status (1/0)	Ozone NA Status (1/0)	PM 2.5 NA Status (1/0)	Battery Mapping – Co-located (MW)	Battery Mapping - Stand-alone LCR + System (MW)	Battery Mapping - Stand-alone System Only (MW)	Total Battery Mapping (MW)	Total Battery Mapping (MWh)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	PalmSprings													
KRAMER	GK_Z2_InyokernAndNorthOfKramer	0	100	1,012	none	-	0	1	0	0	-	0	0	0
VICTOR	GK_Z3_NorthOfVictor	300	0	50	none	-	0	1	0	77	-	- 0	270	980
BRIDGEVILLE	Norcal_Z2_Humboldt	0	0	61	Humboldt Area	39	0	0	0	0	43	-	43	172
WHIRLWIND	Tehachapi	2,445	307	1,645	Big Creek/Ventura area	90	0	1	0	- 0	- 0	- 0	- 0	-

10. Other TPP Assumptions

Thermal Generator Retirement Assumptions

RESOLVE reports the aggregate amount of thermal generation not retained by resource category. Unit-specific information is not modeled. Because the TPP studies require modeling of specific units and locations, CPUC staff will apply the following steps to RESOLVE's aggregate data on thermal generation not retained in order to specify in the transmitted portfolios which units should be assumed as retired for transmission planning purposes:

1. Rank all existing thermal generation units by age in the categories of combined cycle (CCGT), combustion turbine (Peaker), Biomass, reciprocating engine (ICE) and combined heat and power (CHP). Staff recognizes there are additional economic considerations on CHP operations.
2. Model offline the oldest units, up to but not exceeding the total amount selected in RESOLVE, broken down by resource category up to the limits below. While CHP is not specifically modeled in RESOLVE and therefore cannot be one of the thermal generator types not selected for retention, CHP often operates similarly to a CCGT unit, so CPUC staff will retire CHP and CCGT up to the limit for the CCGT category in the table below.
3. CPUC staff will share the specific list of retired units with CAISO, and through consultation, CPUC staff will assemble a list that does not create additional transmission needs. This will include in the following order:
    a. Maintaining the retirement of the thermal generation unit in the area with identified transmission needs but adequately replacing the capacity with generation and/or battery storage resources; and/or
    b. Restoring the thermal generation units in areas with identified transmission needs in reverse order of the list developed in steps 1 and 2.
4. If specific local units are turned back on in step 3.b. then an equal amount of additional system generation capacity will be modeled off-line following steps 1 and 2.

The above steps aim to minimize any post-processing work by the CAISO. Once the IRP portfolios are transmitted to the CAISO, if within the TPP it is identified that known local area requirements are not met, then CAISO staff may reallocate mapped battery storage from a general CAISO System area to a particular local area to meet the local area requirement up to known battery storage charging limits. Refer to Section 8: Battery Storage Mapping Steps for related guidance. If known local area requirements are still not met, then local thermal generation will be restored in reverse order of the list developed in steps 1 and 2.

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