ATTACHMENT A

Energy Division Staff Paper on

Draft 2016 RPS Portfolios for Generation and Transmission Planning

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1. Purpose of Staff Paper

The purpose of this paper is to provide an overview of the draft 2016 Renewable Portfolio Standard (RPS) portfolios to facilitate party review and comment. Energy Division staff will consider party comments during the development of the final 2016 RPS portfolios. The final 2016 RPS portfolios are intended for use in 2016 planning activities, such as the LTPP proceeding and the California Independent System Operator's (CAISO) Transmission Planning Process (TPP), but are not intended to be used to authorize procurement of new infrastructure. Energy Division staff anticipates that RPS portfolios to be used in any special studies conducted as part of the TPP (outside of the studies for identifying policy-driven needs) will be developed separately once the specific goals of those studies is determined by CAISO.

2. Background

The Renewable Portfolio Standard (RPS) Calculator[1] is used by the RPS proceeding to forecast the types, amounts, and locations of new renewable energy resources, and associated transmission upgrades, that may be needed in future years to meet RPS goals. The forecasted portfolios generated by the RPS Calculator (RPS portfolios[2]) are not necessarily optimal portfolios, but instead are intended to represent plausible outcomes that could reasonably be expected to result from current procurement practices. RPS portfolios produced using the RPS Calculator typically serve as inputs for at least two major state planning processes: the Commission's Long Term Procurement Planning (LTPP) proceeding[3] and the California Independent System Operator's Transmission Planning Process (TPP).[4]

In October 2014, a staff proposal[5] for overhauling the RPS Calculator was entered into the record of Rulemaking (R.) 11-05-005 by way of the Administrative Law Judge's

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[1] http://www.cpuc.ca.gov/RPS_Calculator

[2] RPS Portfolio: a set of real and hypothetical renewable energy projects that would collectively deliver sufficient energy to meet a specified target percentage of retail electricity sales in a future year.

[3] http://www.cpuc.ca.gov/PUC/energy/Procurement/LTPP/

[4] https://www.caiso.com/planning/Pages/TransmissionPlanning/Default.aspx

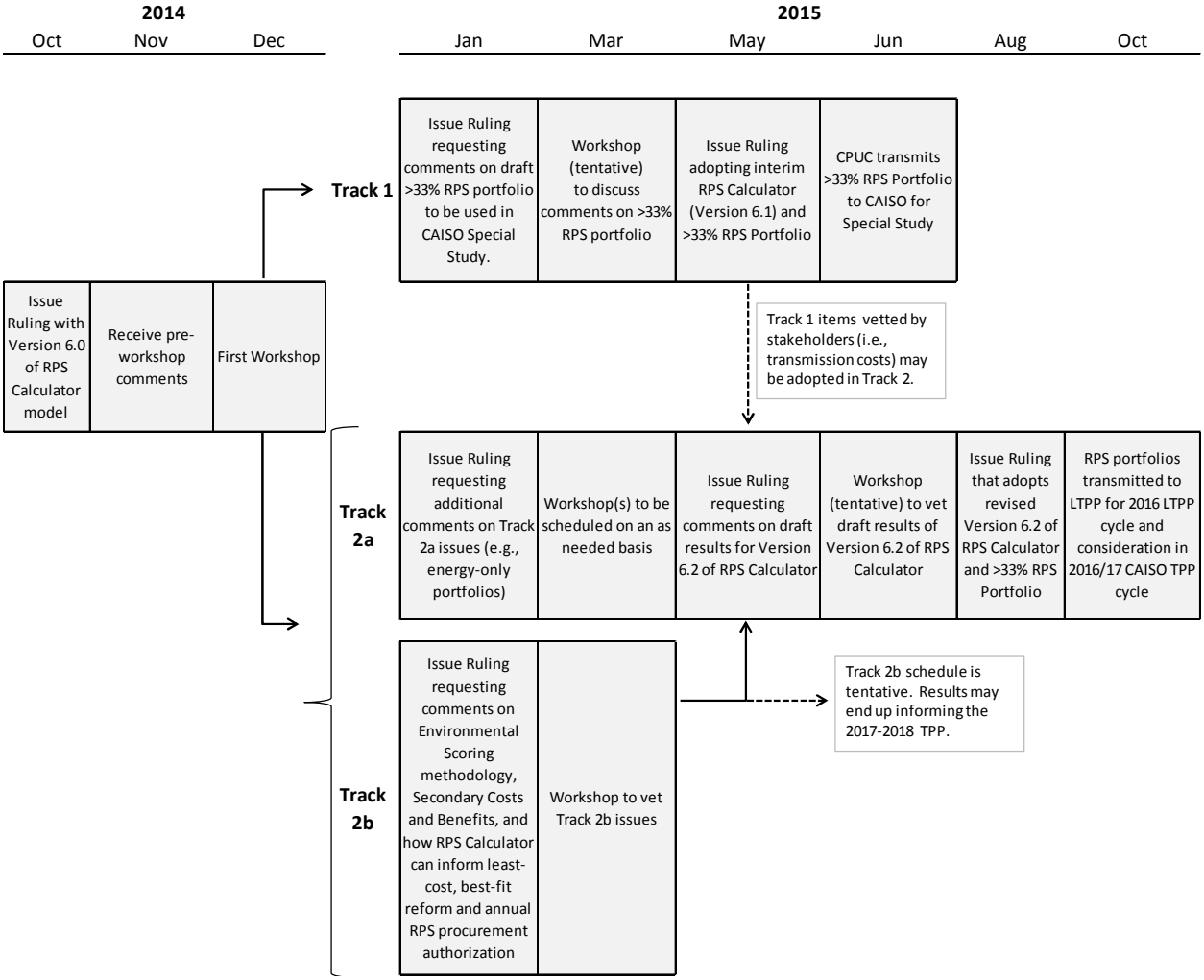
[5] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M119/K145/119145136.PDF

Ruling: (1) Issuing an Energy Division Proposal on the Renewables Portfolio Standards Calculator, (2) Entering the Proposal into the Record, and (3) Setting a Comment and Workshop Schedule (October 10,2015).[6] The staff proposal outlined three tracks, shown in Figure 1 of this paper, for vetting and further developing of the RPS Calculator: Track 1, Track 2a, and Track 2b.

The first track (Track 1) was intended to produce RPS Calculator portfolios for the purpose enabling the California Independent System Operator (CAISO) to perform a special study on >33% RPS scenarios as part of the 2015-2016 TPP. The second track (Track 2a) was intended to develop portfolios for use in the 2016 LTPP and policy-preferred portfolios for the 2016-2017 CAISO TPP. Finally, the third track (Track 2b) was intended to consider in greater detail several additional issues, including how best to incorporate environmental information into the RPS Calculator. The activities completed under each track are described in more detail below.

[6] This proceeding is the successor proceeding to R.11-05-005. The record of R.11-05-005 was transferred to this proceeding by Ordering Paragraph 17 of R.15-02-020.

Figure 1. Two Track Process for Vetting RPS Calculator 6.0, 6.1, and 6.2



a. RPS Calculator Overhaul: Track 1 Activities

The Track 1 CAISO special study was designed to develop information to facilitate the development of portfolios that include projects with energy-only deliverability status, rather than just full capacity deliverability status. Plan for the special study were detailed as part of a public workshop on the RPS Calculator Version 6.0 held by the CPUC on February 10-11, 2015;[7] in the Draft 2015-2016 RPS Calculator Work Plan attached to the Administrative Law Judge's Ruling Seeking Post-Workshop Comments filed in R.15-02-020 on April 13, 2015; [7] in CAISO's Transmission Study Plan;[8] and in a

[7] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=9366; warning: large zip file.

[8] http://www.caiso.com/Documents/2015-2016FinalStudyPlan.pdf

public teleconference held on June 29, 2015.[9] Results from the Track 1 special study were publicly released on CAISO's website on February 1, 2016.[10] The results of this study indicate that there may be up to 26,000 MW of transmission capacity available for new renewable resources assuming they interconnect as energy-only resources.[11]

The completion of the special study concludes Track 1 activity, but raises the question of whether, and how, procurement practices should be revised to reflect new information about the capacity of the existing transmission system to absorb new energy-only projects. The possibility of meeting future RPS targets using a higher proportion of projects with energy-only deliverability status than has historically been observed raises some important questions. Energy Division staff will release a staff paper in the second quarter of 2016 that will ask parties to comment on the critical market, regulatory and operational issues associated with increased energy-only procurement.

b. RPS Calculator Overhaul: Track 2a Activities

Track 2a included two phases. The first phase of Track 2a was to develop the functionality and data needed to enable the RPS Calculator to produce portfolios for 2016 LTPP and CAISO's 2016-17 TPP. The second phase of Track 2a was to produce and vet the RPS portfolios themselves.

Informed by comments received in response to the April 13 post-workshop ruling, Energy Division staff modified the RPS Calculator. The modifications were incorporated into RPS Calculator Version 6.1[12] and a summary of the modifications made[13] were published on the Commission's website on August 3, 2015. Energy Division held a public teleconference to discuss the changes included in Version 6.1 on September 9, 2015. RPS Calculator Version 6.1 included a new energy-only planning

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[9] See materials under "50% RPS Energy Only Special Study Teleconference (6/29/2015)" at http://www.cpuc.ca.gov/RPS_Calculator

[10] https://www.caiso.com/Documents/Draft2015-2016TransmissionPlan.pdf

[11] The available capacity varies significantly in different areas of the transmission system and some additional measures may be required to address future potential problems in certain areas. See the study results for more information.

[12] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=8635

[13] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5685

functionality and energy-only transmission capability data provided by CAISO. These features allowed the RPS Calculator to include energy-only projects in RPS portfolios for the first time.

Subsequently, Energy Division staff further modified the RPS Calculator to update several categories of input data and provide the ability to manually add resources to portfolios (called "setting aside"). The set-aside functionality allows the users to force in certain resources, such as specific high-quality wind or geothermal resources, and assess their impact on portfolio characteristics in a future year. The modified RPS Calculator, Version 6.2, was released at the same time as this staff paper and is available on the RPS Calculator website along with release notes documenting the changes from Version 6.1.[14] The primary inputs updated in RPS Calculator Version 6.2 were:

1. Renewable energy contract information for all known California load serving entities, including investor owned utilities, energy service providers, community choice aggregators, and publicly owned utilities;
2. Energy demand information from the California Energy Commission's 2015 Integrated Energy Policy Report;[15]
3. Land use information regarding land classified as either RETI Category 1 or RETI Category 2 from state and national permitting agencies;[16] and
4. Transmission capability estimates for both fully deliverable and energy-only resources from CAISO.

The release of RPS Calculator 6.2 concludes the first phase of Track 2a. Energy Division staff anticipate continuing to refresh the inputs used in the RPS Calculator on an annual basis to ensure the RPS portfolios continuously reflect the best available information on the future RPS need and RPS-eligible resource costs and potential.

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[14] http://www.cpuc.ca.gov/RPS_Calculator/

[15] http://www.energy.ca.gov/2015_energypolicy/

[16] RETI Category 1: land that is legally or physically impossible to develop; RETI Category 2: land with existing restrictions or conflicts; for information on the RETI category definitions and information gathered from permitting agencies, please see the staff paper attached to the August 28, 2015 ruling: http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5684. For more information on the land in each category in RPS Calculator 6.2 see the section Land Use Sensitivity Analysis later in this paper and the geographic data online: http://databasin.org/galleries/2b6b7a579f8c4df682c77ecbe3e5a346

The second phase of Track 2a was to use the RPS Calculator to produce portfolios for 2016 LTPP and the 2016-2017 TPP. The staff paper[17] attached to the Administrative Law Judge's ruling,[18] released in the RPS proceeding on August 28, 2015, addressed several issues bearing on how the RPS Calculator should be used to produce portfolios in 2016, including:

1. how to select appropriate scenarios to model;
2. how to publicly vet and/ or modify portfolios to ensure they reflect the best available information and are suitable for "least regrets" generation and transmission planning; and
3. how to align both the substance and timing of RPS Calculator modeling inputs, assumptions and portfolios with LTPP and TPP schedules.

The first and third of the Track 2a issues, how to select appropriate scenarios to model and how to align with LTPP and TPP, have largely been settled for 2016 by way of the release of the draft Assumptions and Scenarios (A&S) document in the LTPP proceeding on February 8, 2016.[19] The LTPP A&S document defines the scenarios to be modeled for LTPP and TPP and also defines a subset of assumptions to be used to generate RPS portfolios in 2016. Energy Division staff understands that the 2016 RPS portfolios will be used for informational studies only, and will not be used as the basis for authorizing any new generation or transmission infrastructure

The second Track 2a issue, how to publicly vet portfolios to ensure they provide the best available information, is directly addressed by this paper. Following review of party comments submitted in response this paper, Energy Division staff may modify the RPS portfolios, as appropriate. The final RPS portfolios, if modified from the draft RPS portfolios released in conjunction with this paper, will likely be released via ruling in the RPS proceeding at the beginning of the second quarter of 2016. This will conclude Track 2a activities. Energy Division staff anticipates that transmittal of the RPS portfolios to CAISO for use in TPP will be addressed in the LTPP proceeding, or its successor.

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[17] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5684
[18] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M154/K287/154287797.PDF
[19] http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M158/K117/158117030.PDF

Although settled for 2016, many of the Track 2a challenges described in the August 28, 2015 RPS staff paper will receive Energy Division attention throughout 2016 in preparation for planning activities at the beginning of 2017. Energy Division staff anticipates dedicated coordination activities both within Energy Division and with the California Energy Commission and CAISO to improve alignment issues, including vetting of portfolios. In addition, the Renewable Energy Transmission Initiative 2.0 (RETI 2.0)[20] and SB350-related activities, including integrated resource planning, may provide other appropriate venues for discussing and developing potential process solutions.[21]

c. RPS Calculator Overhaul Track 2b Activities

There were two primary issues to be resolved in Track 2b:

1. how best to represent land use information in the RPS Calculator and whether; and
2. how to align generation and transmission planning with renewable procurement.

The August 28, 2015 staff paper[22] solicited input from parties on land use information in the RPS Calculator. Although the LTPP A&S document described above defines many critical assumptions to be used to generate RPS portfolios, it does not define the land use assumption. As a result, this paper includes information about the influence of different land use assumptions on the 2016 RPS portfolios and solicits input from parties as to the which assumption is most appropriate for use in 2016 planning activities. Energy Division staff will consider party comments and, if appropriate, modify the RPS portfolios prior to releasing the final RPS portfolios by ruling at the beginning of the second quarter of 2016. This will conclude Track 2b activities.

The second Track 2b issue, the alignment of planning and procurement, falls within the effort to reform the least-cost, best-fit framework currently scoped into the RPS

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[20] http://www.energy.ca.gov/reti/

[21] For a recent summary of Commission-related SB350-related activities, see http://www.cpuc.ca.gov/sb350/

[22] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5684

proceeding. Energy Division staff anticipates addressing this issue in the second quarter of 2016.

3. Next Steps for the RPS Calculator

The release of the final 2016 RPS portfolios at the beginning of the second quarter of 2016 will conclude all three tracks of activity originally outlined in the October 2014 staff paper for the RPS Calculator overhaul. Energy Division staff does anticipate conducting a number of updates to inputs and assumptions, but no major changes to functionality in 2016. The inputs that Energy Division staff anticipates updating include:

1. resource cost update, with particular attention to geothermal costs
2. resource potential update, with particular attention to out-of-state (OOS) wind
3. transmission cost update, with particular attention to out-of-state transmission costs
4. transmission capability update, including both fully deliverable and energy-only capabilities
5. land use data update, with particular attention to land that has become legally prohibited from development in the past year
6. contract data update
7. minor CREZ boundary adjustments

In addition to the input updates described above, Energy Division plans to explore ways to address the challenges associated with achieving optimal portfolios through a least-cost best-fit framework (see Section 4(a)(ii) for more detailed discussion of this issue). Lastly, Energy Division staff anticipates releasing an updated version of the RPS Calculator (Version 6.3) and 2017 RPS portfolios in the first quarter of 2017 for public review and comment.

4. Summary of Draft 2016 RPS Portfolios

The draft LTPP A&S document specifies four types of RPS portfolios for use in various scenarios. After reviewing comments from parties regarding the draft LTPP A&S

document, Energy Division staff determined four additional RPS portfolios would be useful for planning activities. The seven draft 2016 RPS portfolios are as follows:

1. **33% RPS**: the 33% RPS portfolio used in the 2015-16 TPP
2. **Default**: a 50% by 2030 portfolio that is fully deliverable; new, generic resources may be selected only from within California[23]
3. **Energy-Only:** same as default, but incorporates energy-only projects to reach the RPS target
4. **Out-Of-State**: same as default, but incorporates 3,000 MW of Wyoming wind
5. **WECC-Wide**: same as default except that new generic resources may be selected from throughout the WECC region
6. **Energy-Only & WECC-Wide**: same as default, but incorporates energy-only projects to reach the RPS target and new generic resources may be selected from throughout the WECC region
7. **Lower Efficiency**: same as default, but assumes energy efficiency achievements equal to those in the 2015 IEPR mid AAEE case

The 33% portfolio specified in the LTTP A&S document is the 33% portfolio used in last year's TPP (2015-16) and was generated with a prior version of RPS Calculator (<6.0) rather than RPS Calculator 6.2. Consequently, this paper does not address the 2015 33% portfolio further. For the other six portfolios, the assumptions used to generate the portfolios are presented in Appendix A. A summary of the portfolios is included in Appendix B, with detailed results in Appendix C. The raw portfolio data is available for download from the RPS Calculator website.[24]

a. Considerations When Reviewing and Using the Draft 2016 RPS Portfolios

There are several important considerations for reviewing and using the 2016 RPS portfolios in planning or other modeling activities. In addition, please review the RPS

[23] The assumption to select generic resources only from in-state locations does not reflect RPS program rules and was used for modeling simplicity only
[24] http://www.cpuc.ca.gov/RPS_Calculator/

Calculator 6.2 User Guide for more information on how the RPS Calculator works, and the sources of its inputs and assumptions.[25]

i. Out of State Resource and Transmission Information is Less Detailed Than In-State Information

The RPS Calculator 6.2 does not have sufficiently detailed information on the variety of out of state wind resources and transmission solutions to clearly distinguish between alternative OOS resources on an economic basis. Energy Division staff intends to work with parties and sister agencies to improve the quality of out-of-state resources and transmission projects in 2016 for incorporation into the next version of the RPS Calculator (6.3).

ii. RPS Calculator Produces Plausible Portfolios, Not Necessarily Optimal Portfolios

The RPS Calculator 6.2 is not designed to produce an optimal portfolio in any given future year. Rather, it is designed to mimic the annual least-cost, best-fit procurement framework currently used by Commission-jurisdictional load-serving entities for procuring RPS resources. In other words, while the RPS Calculator does account for the future value of prospective resources in the context of the portfolio that exists in the year that projects are being selected, it does not account for how future procurement of other resources could affect those values. The reason the RPS Calculator does not account for the impact of future procurement is that it does not currently have a way of anticipating what will be procured in the future, nor does it have the ability to search through a range of possibilities to determine what would result in the lowest total revenue requirement.

For example, in evaluating whether to pick a wind, a geothermal, or a solar PV resource in a particular part of the state, the RPS Calculator does account for future curtailment of the prospective resources resulting from adding those resources to the current portfolio. It does not, however, account for the possibility that a large amount of future solar PV procurement could drive curtailment higher than it would be with the current mix of resources. Eventually, the higher curtailment does cause the RPS Calculator to

[25] http://www.cpuc.ca.gov/RPS_Calculator/

begin selecting a higher proportion of non-solar PV resources, but in some cases the available in-state transmission capacity has become fully subscribed by that point in time. As a result, it is possible for the RPS Calculator to pick a resource that has the greatest net market value in the year that the selection is made, but does not result in the lowest possible revenue requirement or average rate in a future year.

A resource's ability to reduce the overall revenue requirement or average rate in a specific future year can be explored by using the RPS Calculator's "set-aside" functionality to force in that resource and then evaluating costs in the future year of interest. This approach is taken in the geothermal and in-state wind sensitivity analyses presented later in this paper.

iii. Transmission Upgrades Triggered by RPS Calculator Are Not Necessarily Studied in CAISO's Transmission Planning Process

Transmission upgrades that RPS Calculator 6.2 reports as being triggered will not necessarily be explicitly studied by CAISO in the 2016 TPP.[26] While some of upgrades in the RPS Calculator correspond to projects previously studied by CAISO, some upgrades are conceptual in nature. When CAISO conducts studies to determine which transmission projects, if any, are justified by the RPS portfolio, it uses the portfolio of generation projects produced by the RPS Calculator and not the list of transmission upgrades that were triggered. In this respect, the RPS Calculator identifies broad areas where transmission projects may be justified by the need to meet the RPS target, but should not be construed as determining the nature or location of specific transmission upgrades that CAISO hasn't already studied.

iv. Generic Resource Locations Selected by the RPS Calculator Are Subject to the "Knife Edge" Effect

The individual CREZs selected for generic resource development by the RPS Calculator are plausible based on the resource potential and costs, transmission capability and costs, and land use information used as inputs. Each of these inputs has uncertainties. Variation within a reasonable range of input values can shift generic resource

[26] In fact, in 2016, it is not anticipated that any new transmission infrastructure will be approved as policy-driven upgrades, whether indicated by the RPS Calculator 6.2 or in CAISO's own studies.

development from one CREZ to another within a set of reasonably competitive CREZs. The ability of small variations of inputs to shift generic resources from one CREZ to another is referred to in this paper as the "knife edge" effect.

The resource potential and costs, with the exception of out-of-state wind and geothermal resources, are the most vetted and least uncertain of these inputs. The quality and granularity of the transmission capability and costs are anticipated to improve each year as CAISO conducts studies in TPP and provides updated information to Energy Division.

Land use information was provided in 2016 by state and federal renewable energy permitting agencies. More limited data was available from counties. Consequently, there may be land use-related constraints arising from County planning processes, or other state conservation activities, that are not yet represented in RPS Calculator 6.2. These constraints could influence the viability of generic resources appearing in the 2016 RPS portfolios, potentially shifting resources within and between CREZs. Similar

Due to the uncertainties described above, generic resource locations, like transmission projects, should be treated as high level output suitable for planning purposes rather than a definitive identification of the specific locations where future development will inevitably occur.

v. Draft RPS Calculator Portfolios Assume Minimum Land Use Restrictions

Although the draft LTPP A&S document specified many of the assumptions to be used to generate RPS portfolios with the RPS Calculator, it did not indicate which land use assumptions should be used. In the absence of a specification, the "Base" assumption was used in the draft portfolios rather than the "Environmental Baseline."

In other words, only resources on land where legal or technological limitations preclude development were excluded from being considered for selection in the RPS Calculator. A specific goal of this staff paper is to solicit party feedback on whether this assumption is appropriate.

Additional information on the difference between the land associated with the "Base" and "Environmental Baseline" assumptions is provided below the section 5(a) of this paper and in online maps.[27]

b. Comparison of Draft 2016 RPS Portfolios

To facilitate comparison of portfolios, staff have identified five metrics. Table 1 lists these metrics, along with a brief explanation of each. A high-level comparison of the seven 2016 RPS portfolios using the metrics described in Table 1 is presented in Table 2. Overall, the portfolios are relatively similar due to the magnitude of the assumed energy efficiency achievements and the small increment between current RPS achievements and the 2026 target of 43.3%.

[27] http://databasin.org/galleries/2b6b7a579f8c4df682c77ecbe3e5a346

Table 1. Metrics Used to Compare RPS Portfolios

Metric	Unit	Explanation
Total Generic RPS Resources	MW	the total generic RPS resources selected by the RPS Calculator least-cost, best-fit algorithm for inclusion in the portfolio; excludes all projects with contracts authorized by the Commission
Total Transmission Upgrades	MW	the total capacity of transmission upgrades triggered within the RPS Calculator (may include combination of CAISO-studied projects and conceptual, generic projects)
PV Ratio	GWh PV energy/ GWh renewable energy	the proportion of energy generated by solar PV, including behind-the-meter PV, to the total amount of renewable energy generation
Curtailment	%	the percentage of RPS-eligible generation that is curtailed due to oversupply
Revenue Requirement	$MM (millions of dollars)	the aggregate total revenue required to generate and deliver electricity to load across the three investor-owned electric utilities
Average Rate	¢/kWh	the average rate associated with the revenue requirement across the three investor-owned electric utilities

Table 2. Comparison of RPS Portfolios Generated with RPS Calculator 6.2 for the Years 2026

Portfolio	Total Generic RPS Resrcs (MW)	Total Tx Upgrades (MW)	PV Ratio (PV GWh / Ren GWh)	Curtail (% RPS Energy)	Rev Reqrmt ($MM)	Avg Rate (¢/kWh)
Default	3,428	1,500	0.48	2.5%	37,283	26.2
Energy-Only	3,408	0	0.46	2.2%	37,266	26.2
Out-Of-State	4,875	4,500	0.42	2.5%	37,553	26.4
WECC-Wide	3,428	1,500	0.48	2.5%	37,283	26.2
Energy-Only & WECC-Wide	3,203	0	0.46	2.1%	37,226	26.2
Lower Efficiency	5,182	2,500	0.50	2.2%	38,317	25.0

5. Sensitivity Analyses

In order to explore the impact of certain assumptions on the RPS portfolios, several sensitivity analyses were conducted. In each of these sensitivity analyses, an alternate portfolio was generated by modifying one or more of the assumptions used to generate the default portfolio defined by the LTPP A&S document (in-state resources only, all resources fully deliverable). The impact of the assumption on the portfolio was assessed by calculating the difference between the sensitivity portfolio and the default portfolio for each of the portfolio metrics described in Table 1. For all sensitivity analyses, the metrics were evaluated in 2030 rather than 2026 because portfolios diverge more clearly by 2030 and thus provide a greater contrast.

a. Land Use Sensitivity Analysis

There are three different possible land use assumptions in the RPS Calculator 6.2, each of which alters the amount, quantity, and location of resources available throughout the state to meet the specified RPS target. A short description of each assumption is provided in Table 3. The land use assumption to be used when generating RPS portfolios was not specified in the 2016 A&S Document, so the "Base" assumption was used to produce the draft portfolios summarized in Table 2. To explore the potential impacts of other land use assumptions, two additional portfolios were generated: one with an "Environmental Baseline" assumption and one with a "DRECP & SJVP" assumption.

The Desert Renewable Energy Conservation Plan (DRECP) information was provided by the Bureau of Land Management. The San Joaquin Valley Solar Project (SJVP) information was developed through a collaborative, stakeholder-driven planning process at the request of the Governor's Office and Office of Planning and Research. The process was intended to identify and recommend least-conflict areas in the San Joaquin where solar PV development could reduce siting conflicts and facilitate timely project construction. The collaborative planning process was non-regulatory and informational only; it does not legally restrict PV project development to specific areas in the San Joaquin Valley. The study area used in the RPS Calculator 6.2 is an approximation based on information available from the project gateway: http://sjvp.databasin.org/.

Table 3. Description of Land Use Assumptions in RPS Calculator 6.2

Land Use Assumption	Description of Resources Considered for Selection by RPS Calculator*
Base	Resources that are not on land where development is prohibited legally or by virtue of technological limitations (e.g., slope)
Environmental Baseline	Resources that are not on RETI Category 1 Land AND are not on land where additional restrictions or conflicts that have been identified by state or federal permitting agencies
DRECP & SJVP**	• Within the DRECP, only resources in development focus areas proposed by the Bureau of Land Management are considered for selection • Within the San Joaquin Valley Solar Project study area, only resources in the composite least conflict areas are considered for selection • Everywhere else in the state, only resources not on RETI Category 2 or RETI Category 1 land are considered for selection

*More detailed description available in the RPS Calculator 6.2 User Guide available on the RPS Calculator website: http://www.cpuc.ca.gov/RPS_Calculator/

**DRECP = "Desert Renewable Energy Conservation Plan"; SVJP: San Joaquin Valley Solar Project

The impact of the "Environmental Baseline" and "DRECP & SJVP" assumptions are shown in Table 3. In general, the use of alternative land use assumptions increases the implied revenue requirement and average rate of the portfolio, although for slightly different reasons. In the Environmental Baseline portfolio, the increased costs are primarily caused by an increase in the relative proportion of solar PV generation compared to the default portfolio due to the exclusion of high quality in-state wind resources. The additional proportion of solar PV increases renewable curtailment and curtailment-related costs. In contrast, in the DRECP & SJVP portfolio, the increased revenue requirement and average rate are primarily the result of the need for additional transmission infrastructure to access the available resources.

Table 4. Impact of Different Land Use Assumptions Compared to Default In-State, Fully Deliverable RPS Portfolio in 2030

Portfolio	Change in Total Generic RPS Resrcs (MW)	Change in Total Tx Upgrades (MW)	Change in PV Ratio (PV GWh / Ren GWh)	Change in Curtail (% RPS Energy)	Change in Rev Reqrmt ($MM)	Change in Avg Rate (¢/kWh)
Env Baseline	+194	+740	+0.01	+1.0%	+156	+0.13
DRECP & SJVP	+85	+1,240	0.00	+0.3%	+215	+0.18

b. In-State Wind Sensitivity Analysis

As described in Section 4(a)(ii) of this paper, prior party comments and staff experience indicated that some of the highest quality in-state wind resources were typically not selected by 2030 in 50% RPS portfolio. This appeared to be a result of the fact that the relative net value of solar PV was higher than even the highest quality wind in the earlier years of the simulation (e.g., 2016-2020). As a result, solar PV claimed the available transmission capacity in the high-quality wind areas in those years. In later years, because the available transmission capacity was used by solar PV, high quality wind was burdened with the additional cost of a transmission upgrade and continued to not be selected.

In order to test the possibility that in-state wind resources could lower overall portfolio costs by 2030 if it had not been displaced by solar PV in earlier years, a sensitivity portfolio was developed. To create the in-state wind sensitivity portfolio, 1,294 MW of the highest-quality resources in the state were forced into the portfolio as energy-only resources in 2018. The impact of setting aside in-state wind resources relative to the default portfolio is shown in Table 5.

Table 5. Impact of Forcing Energy-Only In-State Wind into the RPS Portfolio Compared to the Default In-State, Fully Deliverable Portfolio in 2030

Portfolio	Change in Total Generic RPS Resrcs (MW)	Change in Total Tx Upgrades (MW)	Change in PV Ratio (PV GWh / Ren GWh)	Change in Curtail (% RPS Energy)	Change in Rev Reqrmt ($MM)	Change in Avg Rate (¢/kWh)
In-State Wind	-1,147	-1,760	-0.01	-1.8%	-227*	-0.19*

*Several factors may influence cost results; cannot be attributed solely to resource value

Forcing energy-only California wind resources into the RPS portfolio reduces the quantity of generic resources selected and the total transmission upgrade needs relative to the default in-state, fully deliverable portfolio. The effect on generic resources and transmission upgrades is likely due to the displacement of fully deliverable solar PV resources by in-state wind. This portfolio also has a lower revenue requirement and average rate relative to the default portfolio. There are several possible explanations for the cost results, which are not mutually exclusive:

1. the difference in resource value between the displaced, fully deliverable solar PV resources, along with associated transmission, and the in-state wind
2. the capture of production tax credits
3. the use of results from a single snapshot year

The first explanation relates to the resource value that in-state wind provides. It is possible that wind may be serving load more cost-effectively in 2030 than solar PV would have because of its production shape and capacity factor. The second explanation relates to the expiration of the production tax credit in 2020. The sooner wind is selected, the greater the tax credits available to reduce wind costs.

The first and second explanations reflect true benefits that selecting in-state wind to utilize scarce available transmission capacity in earlier years could provide. The third explanation reflects an artifact of the analytical approach. The approach taken in this paper relies on comparing the real costs associated with two portfolios in a single snapshot year (2030).

In the default portfolio, the quantity of resources selected each year is based on the need to satisfy the RPS target in that year. In the in-state wind portfolio, a large quantity of wind is injected into the portfolio in 2018 without regard to need. When the cost associated with each portfolio is calculated only for the snapshot year, the in-state wind portfolio benefits by virtue of the fact that the Calculator adjusts nominal resource costs each year to account for inflation. Since the in-state wind portfolio includes a large injection in 2018, the costs associated with that portion of the portfolio have declined in real terms by much more than any equivalent quantity of generation in the default portfolio. As a result, any portfolio in which resources are forced-in in excess of need relatively early in the modeling time horizon would be expected to appear to have a lower cost when compared to a default portfolio in a single snapshot year.

One potential remedy to the problem of using a single snapshot year approach to evaluate the effect of forcing in a resource is to ensure that the same amount of generation is added in the same years in the sensitivity portfolio as in the default portfolio to which it is being compared. Another potential remedy is to use a net present value approach that would appropriately incorporate the time value associated with "pre-purchasing" the forced-in quantity of the resource being examined. Energy Division staff intends to further investigate these and other approaches for improving portfolio comparisons.

c. Geothermal Resources Sensitivity Analysis

In response to party comments, the RPS Calculator released in 2015 (version 6.1) included an update to geothermal costs. Based on a survey of recent studies, the update uniformly increased geothermal costs above what they had been in the RPS Calculator released in 2014 (version 6.0). The increase was largely driven by the costs associated with development in the Salton Sea area, but geothermal costs are highly location-specific. Therefore, it is possible that the capital costs associated with geothermal resources in other locations may be lower than what is currently represented in RPS Calculator 6.2, which was used to generate the 2016 RPS portfolios.

In order to better understand how different assumptions about geothermal resources might affect the 2016 RPS portfolios, three sensitivity portfolios were developed. In the first, the costs of geothermal resources were reduced to approximately the level they were in RPS Calculator version 6.0. In the second portfolio, a selection of the highest

quality geothermal resources from within and outside of California, totaling 1,664 MW, was forced into the portfolio (or "set aside") without changing the costs relative to the default portfolio. In the third portfolio, the costs of geothermal resources were reduced and geothermal resources were set-aside. In both cases where geothermal capital costs were reduced, for simplicity of modeling, the cost reductions were applied to the Salton Sea resources as well as other resources. The impacts of these three portfolios, relative to the default in-state, fully deliverable portfolio, are presented in Table 6.

Table 6. Impact of Different Geothermal Resource Assumptions Compared to Default In-State, Fully Deliverable Portfolio in 2030

Portfolio	Change in Total Generic RPS Resrcs (MW)	Change in Total Tx Upgrades (MW)	Change in PV Ratio (PV GWh / Ren GWh)	Change in Curtail (% RPS Energy)	Change in Rev Reqrmt ($MM)	Change in Avg Rate (¢/kWh)
Geothermal 1 (cost reduction only)	0	0	0.00	0.0%	-1	0.00
Geothermal 2 (force-in)	-2,710	+4,240	-0.08	-2.5%	+102	+0.08
Geothermal 3 (cost reduction & force-in)	-2,710	+4,240	-0.08	-2.5%	-61	-0.05

Reducing geothermal costs (Geothermal 1 portfolio) has very little impact relative to the default portfolio because even lower cost geothermal has a lower net market value than other available resources. Forcing in high-quality geothermal resources (Geothermal 2 portfolio) decreases the total generic resources needed by 2026 due to the high capacity factor of geothermal plants relative to solar PV and wind plants. Forcing in geothermal resources also decreases the PV ratio and decreases curtailment, but increases the transmission infrastructure needed for full deliverability. Consequently, forcing in geothermal resources without changing the cost assumption increases the revenue requirement and average rate.

Reducing geothermal costs and forcing in geothermal resources at the same time (Geothermal 3 portfolio) has the same impact on total generic resources, transmission needs, PV ratio, and curtailment as simply setting aside geothermal resources. The lower geothermal cost assumption, however, reduces the revenue requirement and rate impact relative to the default portfolio, even after accounting for increased transmission infrastructure.

It should be noted that the revenue requirement and rate impact of the third geothermal portfolio is probably heavily dependent on the lower costs assigned to Salton Sea geothermal resource. More work is required to validate the appropriate geothermal costs to use for each resource represented in the RPS Calculator, included Salton Sea resources, for future portfolios that may be used to justify infrastructure investment. (As discussed section 1 of this paper, the 2016 RPS portfolios are not intended to justify any procurement tin 2016.) Energy Division staff plans to work with parties and industry representatives in the second quarter of 2016 to further refine capital cost assumptions for each potential geothermal resource represented in the RPS Calculator for inclusion in the next version of the RPS Calculator (6.3).

d. Other Sensitivity Analyses

Three additional sensitivity portfolios were produced to explore the impacts of different possible future policies in 2030: electric vehicles, exports, and storage. In the electric vehicle portfolio, the default in-state, fully deliverable portfolio load shape was modified to approximate the effect of the "High BEV" scenario included in the California's PATHWAYS modeling initiative.[28] This involves increasing the load and altering the load shape to account for electric vehicle charging. Costs associated with the electric vehicles and charging infrastructure were not included.

In the exports portfolio, it was assumed that up to 5,000 MW of power could be exported from CAISO. In contrast, the default portfolio assumes no power can be exported. In the storage portfolio, 3,000 MW of six hour storage was forced into the portfolio in 2020. The results of all three sensitivities relative to the default in-state, fully deliverable portfolio in 2030 is shown in Table 7.

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[28] https://ethree.com/public_projects/energy_principals_study.php

Table 7. Impact of Battery Electric Vehicle and Export Assumptions Compared to Default In-State, Fully Deliverable Portfolio in 2030

Portfolio	Change in Total Generic RPS Resrcs (MW)	Change in Total Tx Upgrades (MW)	Change in PV Ratio (PV GWh / Ren GWh)	Change in Curtail (% RPS Energy)	Change in Rev Reqrmt ($MM)	Change in Avg Rate (¢/kWh)
BEV Vehicles	+1,458	+1,000	+0.03	-2.0%	+163	-2.11
Exports	-1,974	-1,760	+0.00	-7.4%	-129	-0.11
Storage	-1,344	-760	-0.01	-5.3%	1,258	1.03

The battery electric vehicles portfolio creates a larger demand for generic resources, an increase in transmission upgrades, and an increase in the proportion of RPS energy derived from solar PV relative to the default portfolio. The ability of electric vehicles to absorb supply reduces curtailment relative to the default portfolio. While the battery electric vehicles portfolio entails a larger overall revenue requirement, the average rate is lower than in the default portfolio due to the distribution of the revenue requirement across a larger overall load.

The exports portfolio includes a greatly reduced demand for generic resources and transmission upgrades compared to the default portfolio. This outcome is the result of the fact that there is much less curtailment than in the default portfolio, which reduces the need to overbuild the RPS-eligible fleet. The overall reduction in generic renewable resource selection reduces both the revenue requirement and average rate.

The storage portfolio is similar to the exports portfolio in that it involves few total generic resources, a lower level of transmission upgrades, and less curtailment by 2030 than the default in-state, fully deliverable portfolio. The primary difference between the storage and the exports portfolio is that the storage portfolio involves much higher revenue requirements and a higher average rate than both the exports and the default portfolios.

e. Summary of the Impact of Tested Assumptions on RPS Portfolios

Table 7 presents a qualitative summary of the results of the sensitivity analyses described in this paper, as well as addition analyses conducted by Energy Division staff. The results are presented in terms of the relative direction and magnitude of the impact of each assumption on each portfolio metric relative to the default portfolio as defined by the LTPP A&S document. Where the overall magnitude is small or ambiguous, no impact is depicted.

The load assumption has one of the largest overall impacts of all tested assumptions. Larger loads require larger total generic resources, more transmission upgrades, and more revenue. Conversely, larger loads dilute revenue requirements, reducing the average rate. Since the default portfolio is defined as an in-state portfolio, larger load is also associated with larger PV ratios because of the much larger PV resource in California and the least-cost best-fit selection algorithm (see also Section 4(a)(ii)).

The BTM PV assumption has a small or ambiguous impact on the total generic resource needs within the tested range (from a 15% decrease to a 15% increase relative to the BTM PV levels in the 2015 IEPR). The reason a higher BTM PV assumption does not clearly reduce generic resource requirements is probably due to the increased oversupply-related curtailment, which forces overbuilding of RPS resources. The higher BTM PV assumption does have a large impact on the average rate, because it both increases curtailment costs and reduces the load over which revenue is distributed. In other words, an increase in BTM PV exacerbates the oversupply-related curtailment of RPS-eligible central station PV, which imposes additional revenue requirements associated with replacing the curtailed RPS-eligible PV. Simultaneously, BTM PV reduces load, so the additional costs incurred as a result of increased curtailment are spread over fewer kilowatt hours of energy consumption.

Allowing energy-only resources reduces the total transmission upgrade requirements, the PV ratio, curtailment, revenue requirement, and the average rate. As mentioned in section 2(a), the potential benefits from energy-only resources raise market, regulatory, and operational questions that Energy Division staff plan to explore in a staff paper in the second quarter of 2016.

Both in-state and out-of-state wind resources tend to reduce the PV ratio, curtailment, the revenue requirement, and the average rate. To better account for the ability of

specific resources to contribute to a portfolio that has a lower revenue requirement and lower average rate, Energy Division staff plans to explore ways to reform the least-cost, best-fit selection framework used in the RPS Calculator and RPS procurement. Energy Division staff anticipates that least-cost best-fit reform activity will also help inform the Commission's response to the requirement imposed by SB350 to develop optimal portfolios for integrated resource planning.

Geothermal resources tend to decrease the total generic renewable resource requirement and reduce curtailment, but increase the transmission infrastructure needed. The impact of geothermal resources on the revenue requirement and average rate is ambiguous, depending heavily on the capital cost assumptions. Energy Division staff plans to work with parties and industry representatives in the second quarter of 2016 to develop appropriate capital cost assumptions for each potential geothermal resource represented in the RPS Calculator.

The land use assumptions tested tend to put pressure on in-state wind resources, increase the PV ratio and curtailment, and raise the revenue requirement and average rate. The DRECP/SJVP assumption appears to slightly increase transmission upgrade requirements by concentrating development in certain areas, but this impact could be mitigated if resources were energy-only rather than fully deliverable.

Battery electric vehicles represent a source of additional load. As a result, like load, battery electric vehicles tend to increase the revenue requirement while reducing the average rate by spreading costs across a broader base. Battery electric vehicles also increase the proportion of RPS generation that is provided by solar PV. In this analysis, the effect of battery electric vehicles is probably driven more by the increase in the load and corresponding increase in the value of energy provided by solar PV outside of times of curtailment rather than by the reduction in curtailment itself.

The largest impact of being able to export from CAISO is to reduce curtailment. The reduced curtailment contributes to a relatively small reduction in revenue requirement and average rate, and does not have a large impact on the proportion of solar PV selected to serve load by 2030 relative to the default in-state, fully deliverable portfolio. This is most likely a result of the fact that the overbuilding in the default portfolio relies primarily on solar PV resources due to transmission constraints (see section 4(a)(ii)).

Like exports, the largest impact of storage is to reduce curtailment. Also similar to the exports, storage does not have a large impact on the proportion of selected resources that are solar PV resources. Unlike exports, storage is associated with a large impact on both the revenue requirement and average rate due to current assumptions about storage costs.

Table 8. Summary of Relative Influence of Tested Assumptions on RPS Portfolios*

Portfolio	Change in Total Generic RPS Resrcs (MW)	Change in Total Tx Upgrades (MW)	Change in PV Ratio (PV GWh / Ren GWh)	Change in Curtail (% RPS Energy)	Change in Rev Reqrmt ($MM)	Change in Avg Rate (¢/kWh)
Load	+++	+++	+++		+++	---
BTM PV		+		+++	++	+++
Energy-Only		--	--	-	-	-
OOS Wind		+	---	--	-	-
In-State Wind	-	-	-	-		
Geothermal	-	++	---	--		
Env Baseline			+	+	++	++
DRECP-SJVP		+			++	++
Exports	+	+	++	-	++	---
BEV Vehicles	-	-		---	-	-
Storage	-			---	+++	++

*Sign indicates direction of impact; number of characters reflects relative magnitude of impact relative to each other when comparing to a default in-state, fully deliverable portfolio. Where the overall magnitude is small or ambiguous, no impact is depicted.

Appendix A.

Assumptions Used To Generate the Draft 2016 RPS Calculator Portfolios

1. **33% RPS**: the 33% RPS portfolio used in the 2015-16 TPP

This portfolio was not generated with RPS Calculator 6.2.

2. **Default**: a 50% by 2030 portfolio that is fully deliverable; new, generic resources may be selected only from within California[1]

RPS Policy	**50% by 2030**
Deliverability Type	**FCDS Only**
Geography	**In-State**
Land Use Exclusions	**Base**
Dist Gen Set-Aside	**None**
Load Forecast	**Mid Demand - SB350**
BTM PV Forecast	**IEPR (2015)**
PATHWAYS Load Modifiers	**None**
Analysis Horizon	
First Year	**2014**
Final Year	**2030**

[1] The assumption to select generic resources only from in-state locations does not reflect RPS program rules and was used for modeling simplicity only

3. **Energy-Only:** same as default, but incorporates energy-only projects to reach the RPS target

RPS Policy	**50% by 2030**
Deliverability Type	**FCDS & EO**
Geography	**In-State**
Land Use Exclusions	**Base**
Dist Gen Set-Aside	**None**
Load Forecast	**Mid Demand - SB350**
BTM PV Forecast	**IEPR (2015)**
PATHWAYS Load Modifiers	**None**
Analysis Horizon	
First Year	**2014**
Final Year	**2030**

4. **Out-Of-State**: same as default, but incorporates 3,000 MW of Wyoming wind

RPS Policy	**50% by 2030**
Deliverability Type	**FCDS Only**
Geography	**WECC-Wide**
Land Use Exclusions	**Base**
Dist Gen Set-Aside	**None**
Load Forecast	**Mid Demand - SB350**
BTM PV Forecast	**IEPR (2015)**
PATHWAYS Load Modifiers	**None**
Analysis Horizon	
First Year	**2014**
Final Year	**2030**

Set-Aside (Force-In) Assumptions:

Resource Type	**Wind**
Electrical Area (CREZ)	**WY_EA**
Transmission Area	*WY_EA*
Energy-Only Zone	*Mountain Pass & El Dorado*
Contract Start Year	**2018**
Deliverability Type	**FCDS**
MW of Resource	**3,000**

5. **WECC-Wide**: same as default except that new generic resources may be selected from throughout the WECC region

RPS Policy	**50% by 2030**
Deliverability Type	**FCDS Only**
Geography	**WECC-Wide**
Land Use Exclusions	**Base**
Dist Gen Set-Aside	**None**
Load Forecast	**Mid Demand - SB350**
BTM PV Forecast	**IEPR (2015)**
PATHWAYS Load Modifiers	**None**
Analysis Horizon	
First Year	**2014**
Final Year	**2030**

Set-Aside (Force-In) Assumptions: None

6. **Energy-Only & WECC-Wide**: same as default, but incorporates energy-only projects to reach the RPS target and new generic resources may be selected from throughout the WECC region

RPS Policy	**50% by 2030**
Deliverability Type	**FCDS & EO**
Geography	**WECC-Wide**
Land Use Exclusions	**Base**
Dist Gen Set-Aside	**None**
Load Forecast	**Mid Demand - SB350**
BTM PV Forecast	**IEPR (2015)**
PATHWAYS Load Modifiers	**None**
Analysis Horizon	
First Year	**2014**
Final Year	**2030**

7. **Lower Efficiency**: same as default, but assumes energy efficiency achievements equal to those in the 2015 IEPR mid AAEE case

RPS Policy	**50% by 2030**
Deliverability Type	**FCDS Only**
Geography	**In-State**
Land Use Exclusions	**Base**
Dist Gen Set-Aside	**None**
Load Forecast	**Mid Demand - Mid AAEE**
BTM PV Forecast	**IEPR (2015)**
PATHWAYS Load Modifiers	**None**
Analysis Horizon	
First Year	**2014**
Final Year	**2030**

Appendix B.

Overview of Draft 2016 RPS Calculator Portfolios

DRAFT 2016 RPS Portfolios

3/9/2016

2016 RPS Portfolios Defined by LTPP

Draft 2016 LTPP Assumptions and Scenarios (A&S) document* specifies four RPS portfolios:

1. Default (Fully Deliverable, CA-Only)
2. Infrastructure Investment (33% RPS from 2014 LTPP)
3. Energy-Only Allowed
4. Out-of-State Wind (3,000 MW WY Wind)

Staff also produced three additional RPS portfolios:

1. WECC-Wide (default + OOS resources allowed)
2. Energy-Only & WECC-Wide
3. Lower Efficiency (2015 AAEE rather than SB350 AAEE)

*http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M158/K117/158117030.PDF

RPS Portfolios Specified in Draft LTPP A&S

Assumption	Default	Energy-Only	Out-of-State	Infrastructure Investment
Year	2026	2026	2026	2016 LTPP A&S specifies using old 33% RPS portfolio from 2014 LTPP
RPS	50%	50%	50%	
RPS in Year	43%	43%	43%	
Load	2015 IEPR Mid	2015 IEPR Mid	2015 IEPR Mid	
Efficiency	SB350-Friendly[1]	SB350-Friendly[1]	SB350-Friendly[1]	
BTM PV	2015 IEPR Mid	2015 IEPR Mid	2015 IEPR Mid	
Diablo Canyon	Retired in 2024	Retired in 2024	Retired in 2024	
Deliverability	FCDS	EO+FCDS[2]	FCDS	
Geography	CA Only	CA Only	3,000 MW WY Wind	
Land Use	*Not specified*	*Not specified*	*Not specified*	

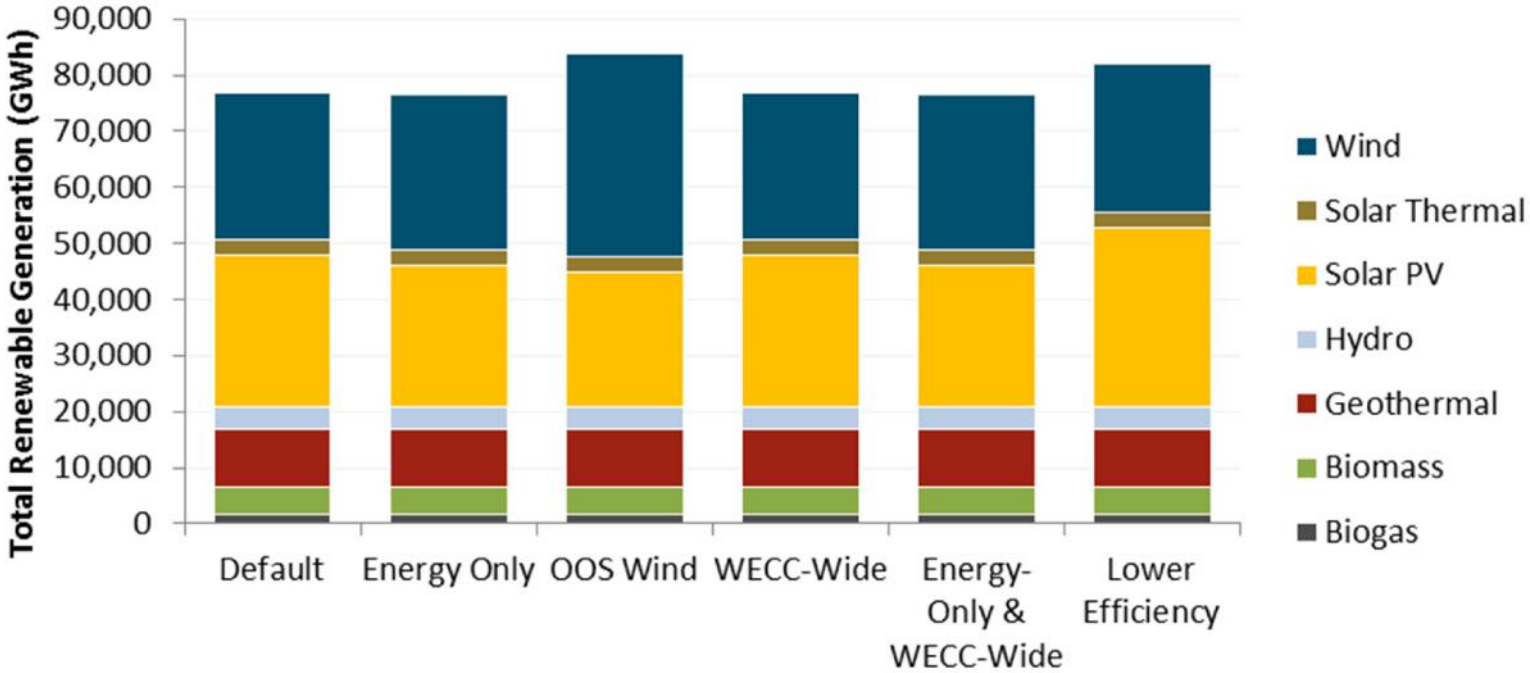
[1]interim approach that ramps up to 2X2014 IEPR Mid AAEE by 2030
[2]energy-only and fully deliverable projects are both allowed; resulting portfolio is a combination of energy-only and fully deliverable resources

Additional 2016 RPS Portfolios

Assumption	WECC-Wide	Energy-Only & WECC-Wide	Lower Efficiency
Year	2026	2026	2026
RPS	50%	50%	50%
RPS in Year	43%	43%	43%
Load	2015 IEPR Mid	2015 IEPR Mid	2015 IEPR Mid
Efficiency	SB350-Friendly[1]	SB350-Friendly[1]	2015 AAEE
BTM PV	2015 IEPR Mid	2015 IEPR Mid	2015 IEPR Mid
Diablo Canyon	Retired in 2024	Retired in 2024	Retired in 2024
Deliverability	FCDS	EO+FCDS[2]	FCDS
Geography	WECC-Wide	WECC-Wide	CA Only
Land Use	*Not specified*	*Not specified*	*Not specified*

[1]interim approach that ramps up to 2X2014 IEPR Mid AAEE by 2030
[2]energy-only and fully deliverable projects are both allowed; resulting portfolio is a combination of energy-only and fully deliverable resources

2016 RPS Portfolios Comparison (Total Generation in Year 2026)



Additional RPS generation in OOS Wind portfolio results from setting aside 3,000 MW of WY wind, which causes the overall RPS achieved in 2026 to reach 46% rather than 43% as in other portfolios.

Key RPS Portfolio Metrics

- **Total new generic generation** (MW)
- **Total transmission network upgrades (DNU)** (MW)
- **PV Ratio (PVR)** (PV GWh as % of total renewable GWh)*
- **Curtailment** (% of RPS generation)
- **Revenue Requirement** ($)
- **Average Rate** (¢/kWh)

*PV GWh = RPS-eligible PV energy + behind the meter (BTM) PV energy;
total renewable energy (RN) = all RPS-eligible energy + BTM rooftop PV eenergy

2016 RPS Portfolio Results for 2026

Portfolio	Total Generic Buildout (MW)	Total DNU (MW)	PV Ratio (PV GWh/ RN GWh)	Curtailmt (% RPS energy)	Rev Reqmt ($MM)	Avg Rate (¢/kWh)
Default	3,428	1,500	0.48	2.5%	37,283	26.2
Energy-Only[1]	3,408	0	0.46	2.2%	37,266	26.2
Out-of-State[2]	4,875	4,500	0.42	2.5%	37,553	26.4

[1]In Energy-Only (EO) portfolio, fully deliverable projects and energy-only projects are both allowed; resulting portfolio is a combination of energy-only and fully deliverable resources

[2]Out-of-State (OOS) portfolio includes a "set aside" of 3,000 MW of WY Wind; RPS is 46% in 2026

[3]EO & OOS portfolio, not specified in draft LTPP A&S; includes ~1,400 MW of WY Wind selected economically; RPs is 43% in 2026

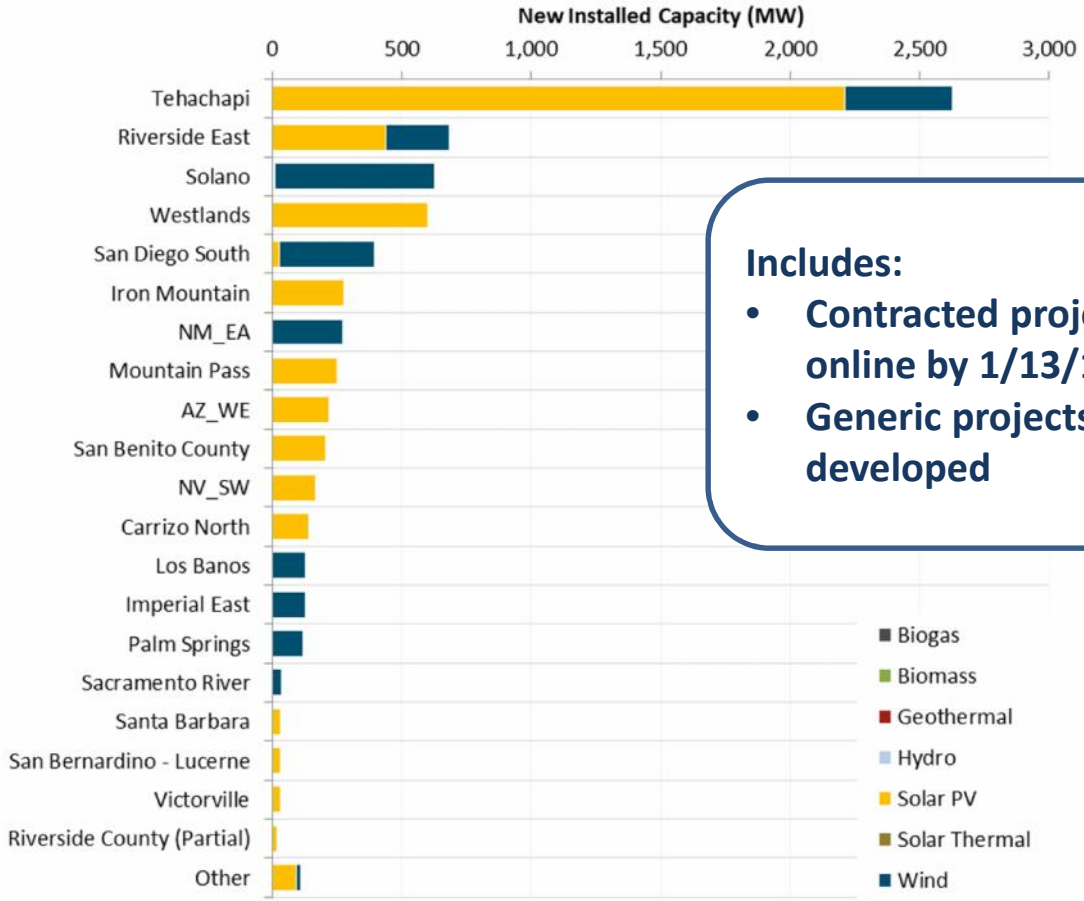
2016 RPS Portfolio Results for 2026

Portfolio	Total Generic Buildout (MW)	Total DNU (MW)	PV Ratio (PV GWh/ RN GWh)	Curtailmt (% RPS energy)	Rev Reqmt ($MM)	Avg Rate (¢/kWh)
WECC-Wide[1,2]	3,428	1,500	0.48	2.5%	37,283	26.2
EO & WECC-Wide[1,2]	3,203	0	0.46	2.1%	37,226	26.2
Lower Efficiency	5,182	2,500	0.50	2.2%	38,317	25.0

[1]Renewable resources from across the WECC region are selected economically

[2]Fully deliverable projects and energy-only projects are both allowed; resulting portfolio is a combination of energy-only and fully deliverable resources

2016 RPS Portfolio: Default (New Capacity By Year 2026)

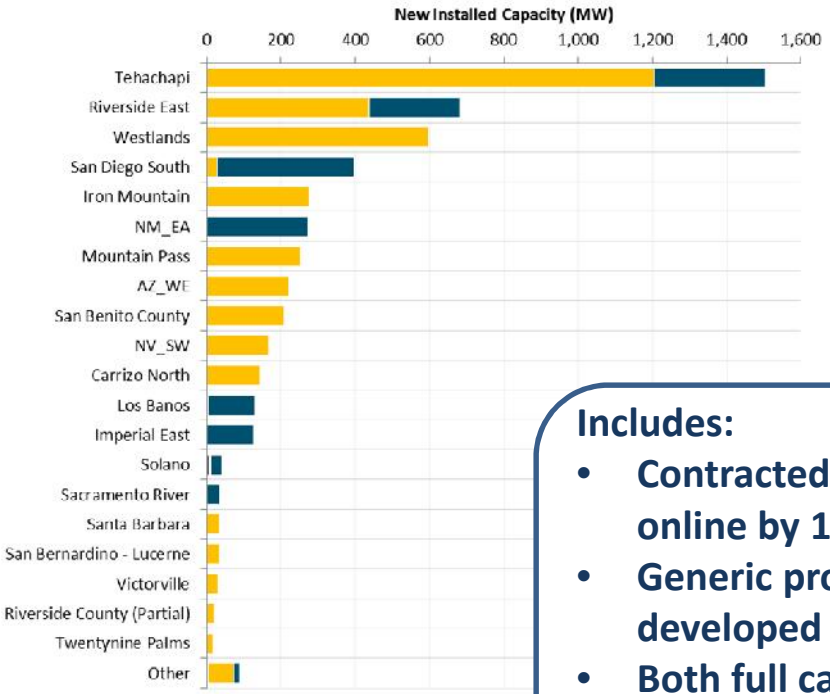


Includes:

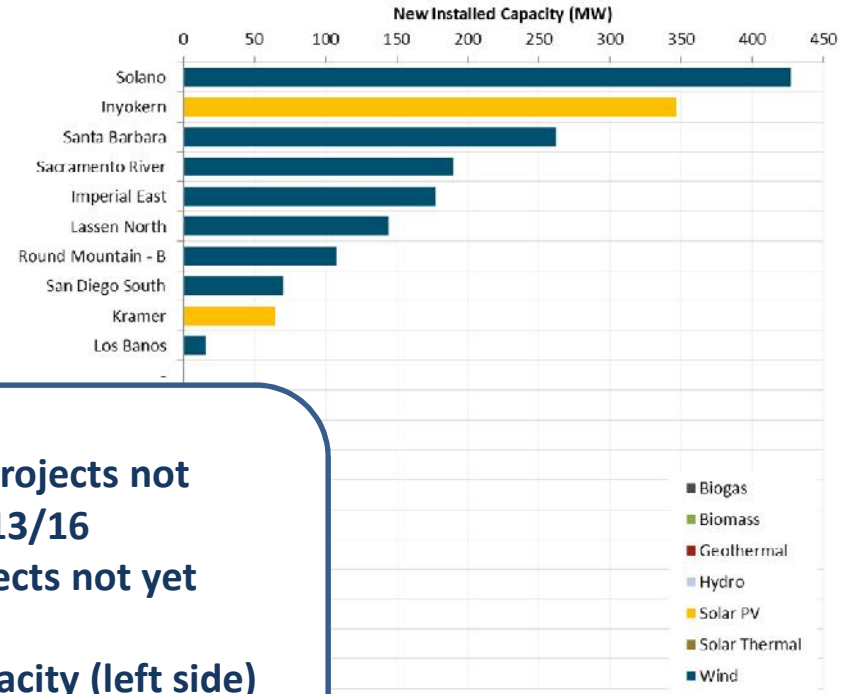
- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

2016 RPS Portfolio: Energy-Only (New Capacity By Year 2026)

Full Capacity Resources



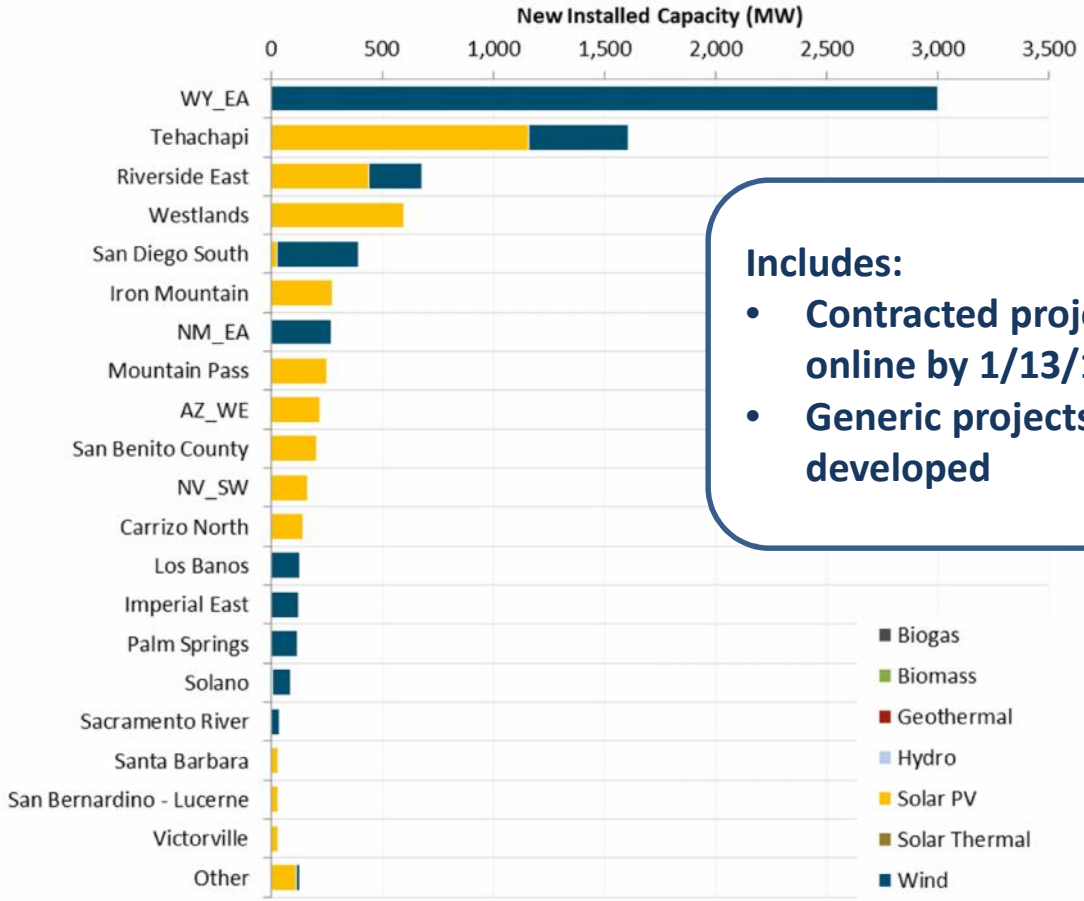
Energy-Only Resources



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**
- **Both full capacity (left side) and energy-only resources (right side)**

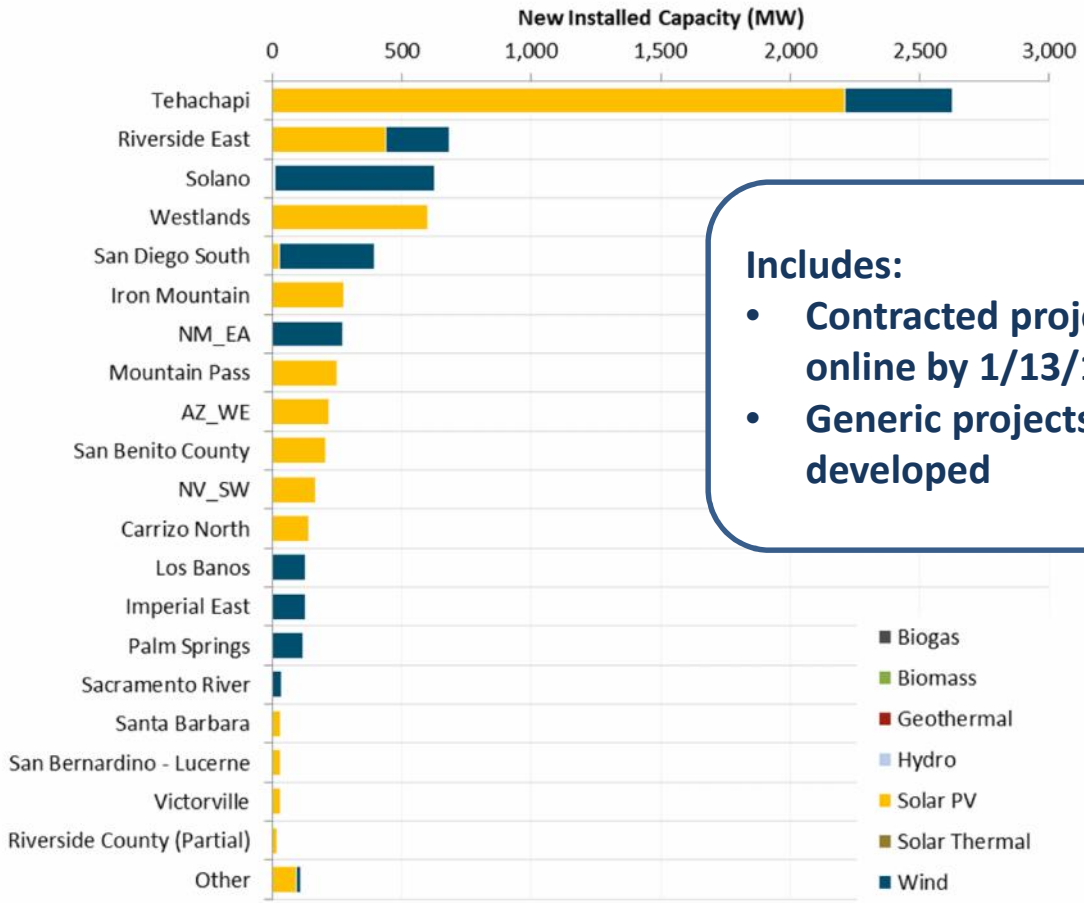
2016 RPS Portfolio: Out-of-State Wind (New Capacity By Year 2026)



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

2016 RPS Portfolio: WECC-Wide (New Capacity Year 2026)

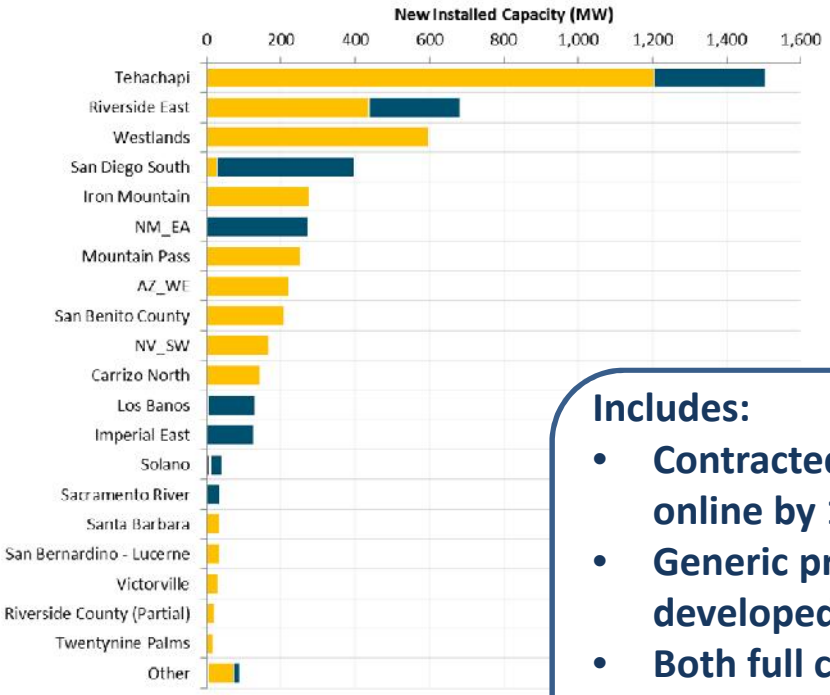


Includes:

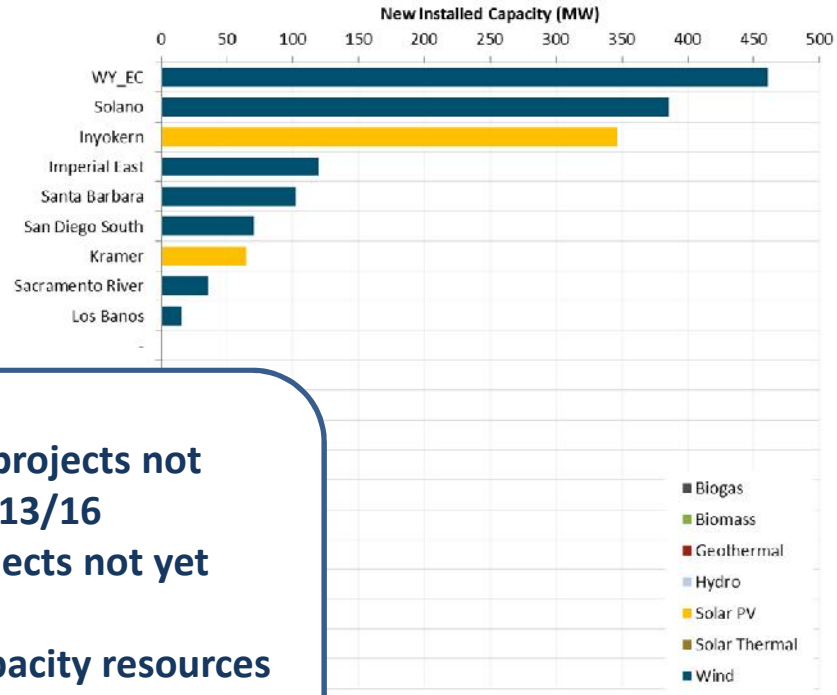
- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

2016 RPS Portfolio: Energy-Only & WECC-Wide (New Capacity By Year 2026)

Full Capacity Resources



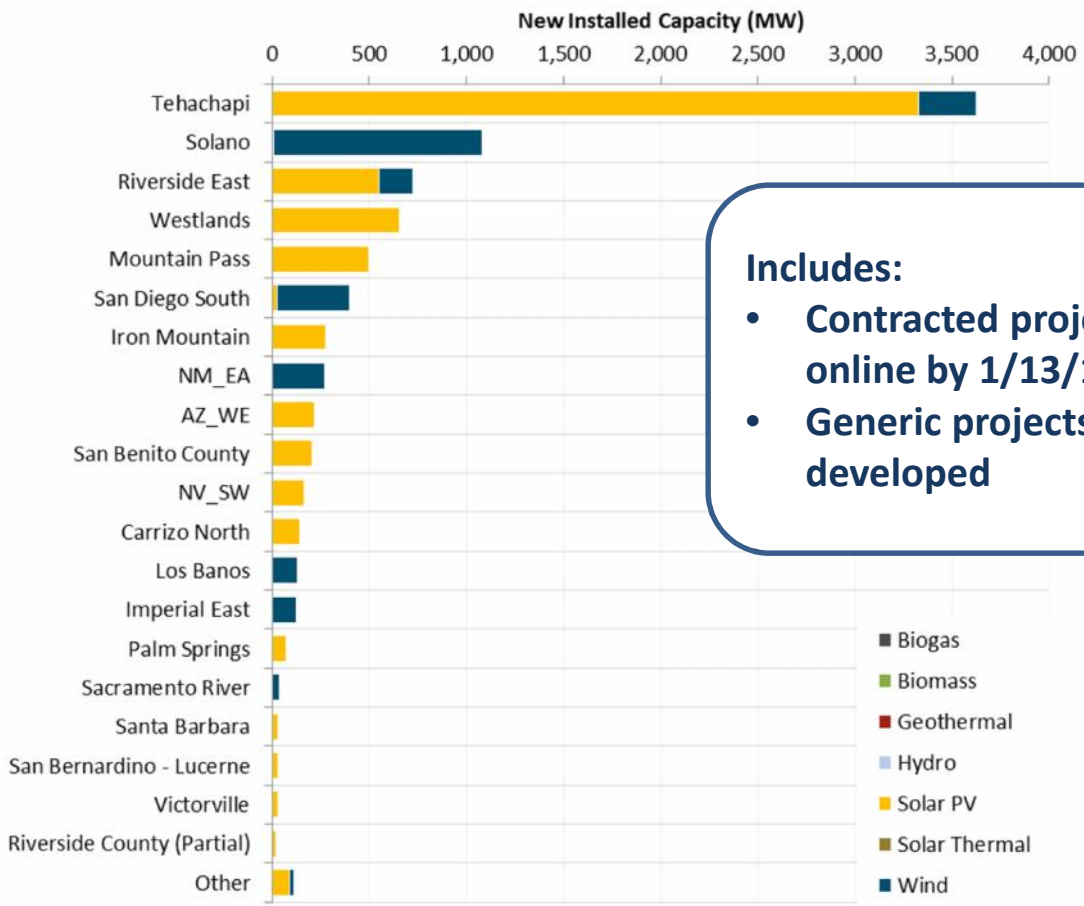
Energy-Only Resources



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**
- **Both full capacity resources (left side) and energy-only resources (right side)**

2016 RPS Portfolio: Lower Efficiency (New Capacity By Year 2026)



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

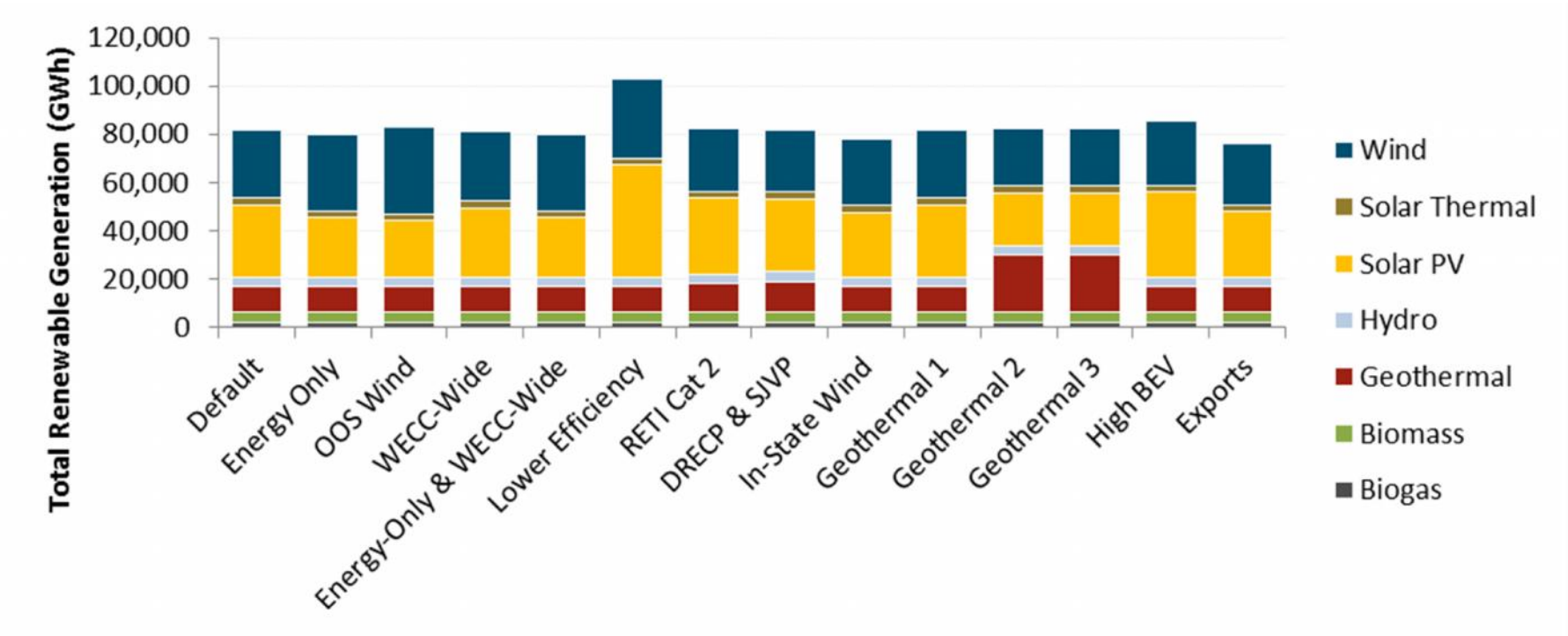
Sensitivity Analysis: Case Descriptions

- Land Use
  - Restrictions or conflicts on land classified as RETI Category 2 tends to put pressure on high quality in-state wind resources:
  - RETI Category 2 may represent the most realistic perspective on in-state wind potential
  - "Environmental Baseline" assumption in RPS Calculator reflects updated RETI Category 1 and Category 2 information
- In-State Wind
  - Wind gets outcompeted for scarce transmission in early 2020, but could offer a benefit by 2030
- Geothermal
  - Geothermal costs are very location specific and uncertain - lower cost assumption might increase selection
- High BEV
  - Could offer a sink for solar PV, avoiding curtailment costs
- Exports
  - Could offer a sink for solar PV, avoiding curtailment costs

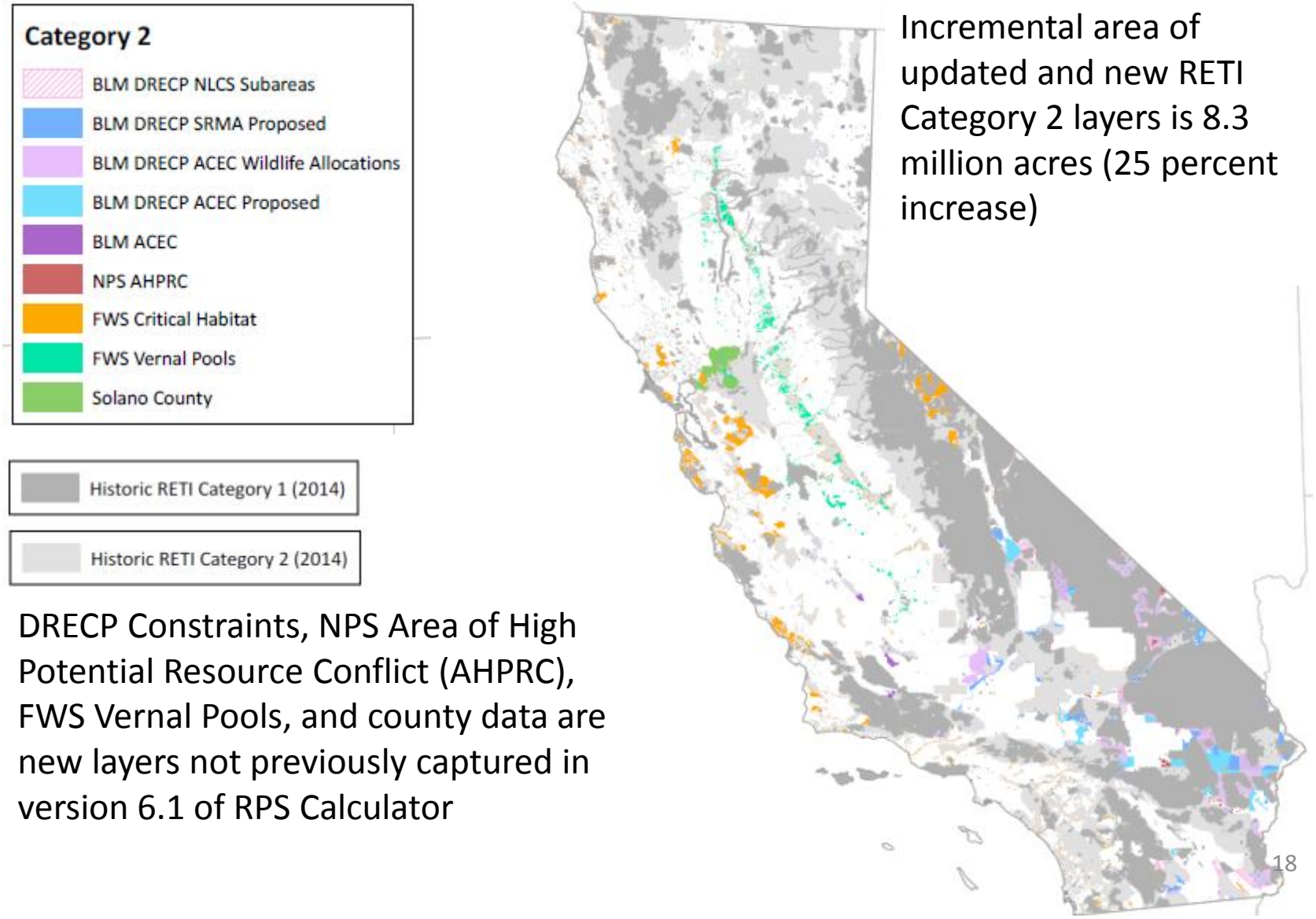
Quantifying Sensitivity Impacts

- All portfolios were developed for the year 2030 (including default)
  - More divergence between portfolios occurs by 2030 than by 2026
  - Allows clearer examination of difference between sensitivity and default
- Impact on each of the five key portfolio metrics was calculated
- Impact was calculated by subtracting default portfolio metric from sensitivity portfolio metric in 2030: sensitivity – default

2016 RPS Portfolio Sensitivities Comparison (Total Generation in Year 2030)



Land Use Sensitivity #1: RETI Category 2 Updates/Additions



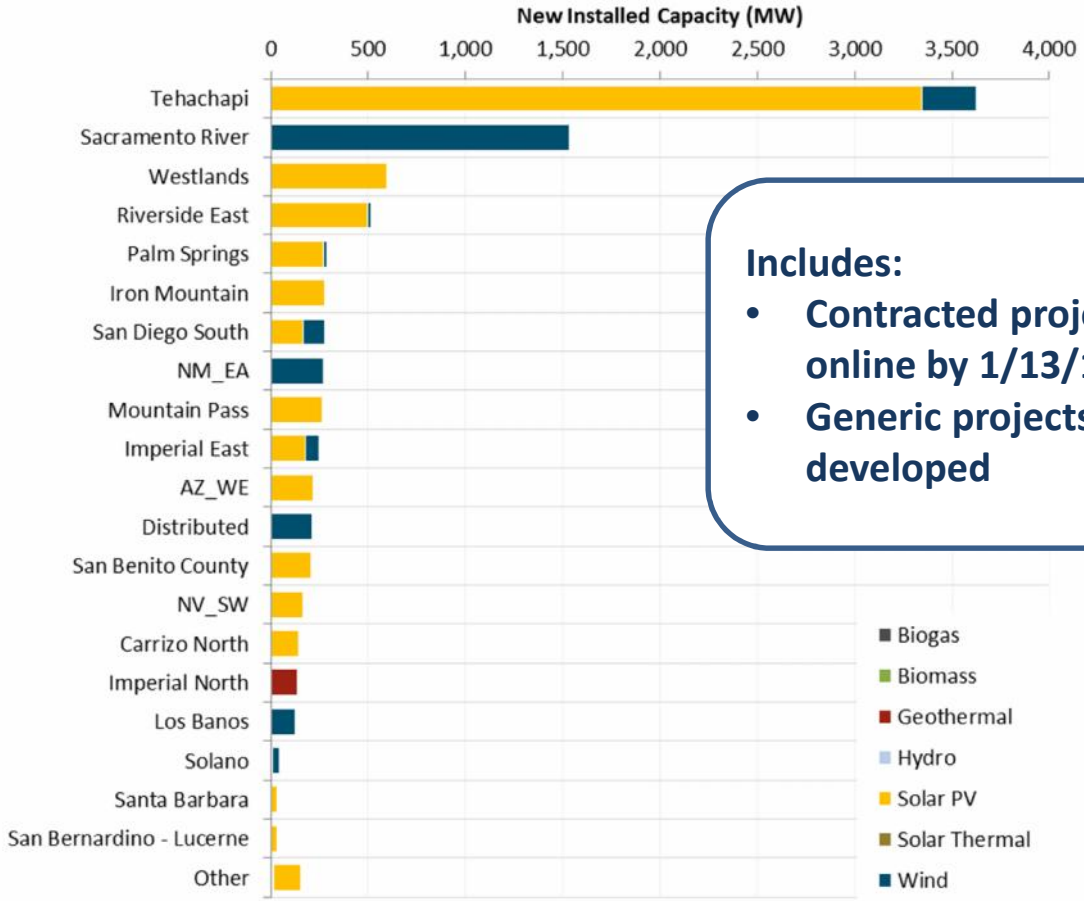
Incremental area of updated and new RETI Category 2 layers is 8.3 million acres (25 percent increase)

DRECP Constraints, NPS Area of High Potential Resource Conflict (AHPRC), FWS Vernal Pools, and county data are new layers not previously captured in version 6.1 of RPS Calculator

Land Use Sensitivity #1: County-Level Data Updates/Additions

- Outreach to county staff confirmed practical barriers or conflicts involved in wind development in Solano and San Diego counties that fell short of legal prohibitions
- Wind resources are eliminated in these two counties under the Environmental Baseline assumption

Land Use Sensitivity #1: Environmental Baseline (New Capacity By Year 2030)



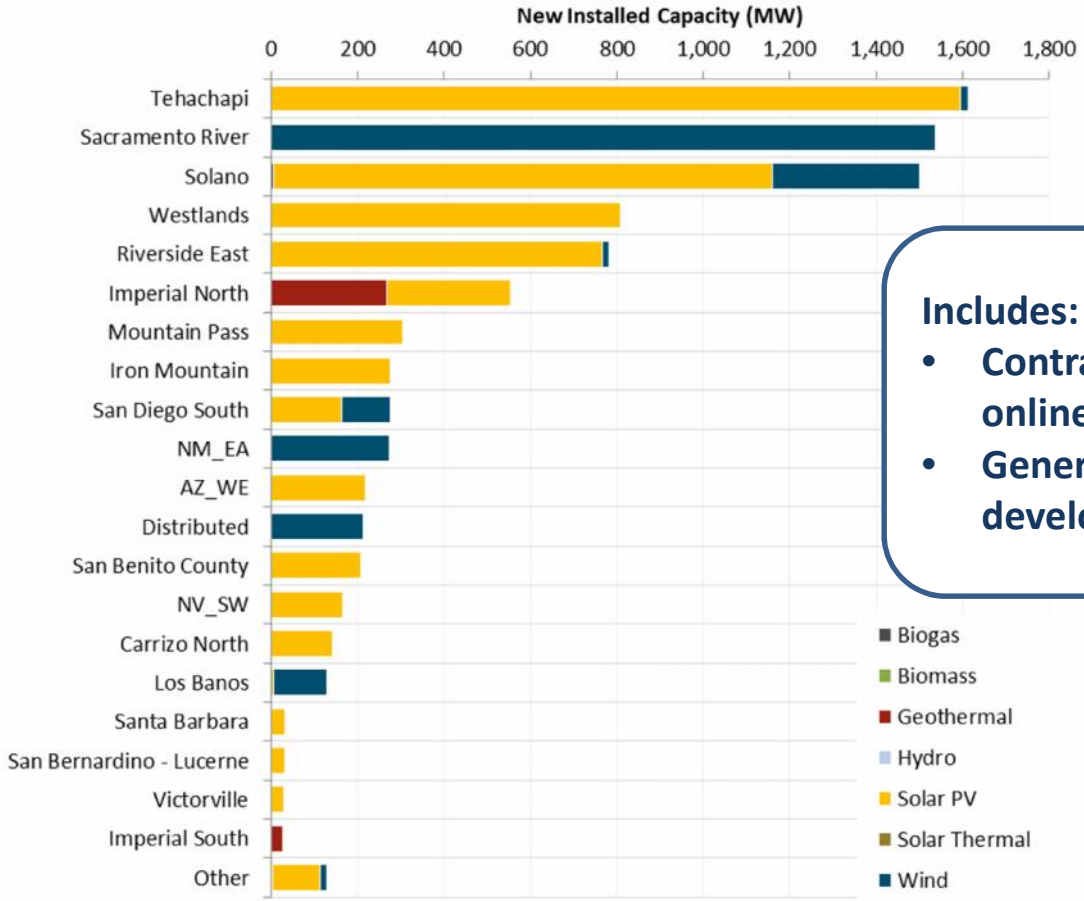
Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

Land Use Sensitivity #2:
DRECP & San Joaquin Valley Solar Project Data

- Third supply curve developed that used Category 1 and 2 restrictions, PLUS only allowed development in preferred locations identified by the DRECP (DFA) and Data Basin San Joaquin Valley Stakeholder Group (SJV, grey shaded)
- SJV "developable areas" include 3 categories: priority least conflict, least conflict, potential least conflict
- Note: SJVP developable areas do not reflect a consensus outcome of all parties involved and are included here as a "thought experiment" only
- DRECP "developable areas" include DFAs only

Land Use Sensitivity #2: DRECP & San Joaquin Valley Solar Project (New Capacity By Year 2030)



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

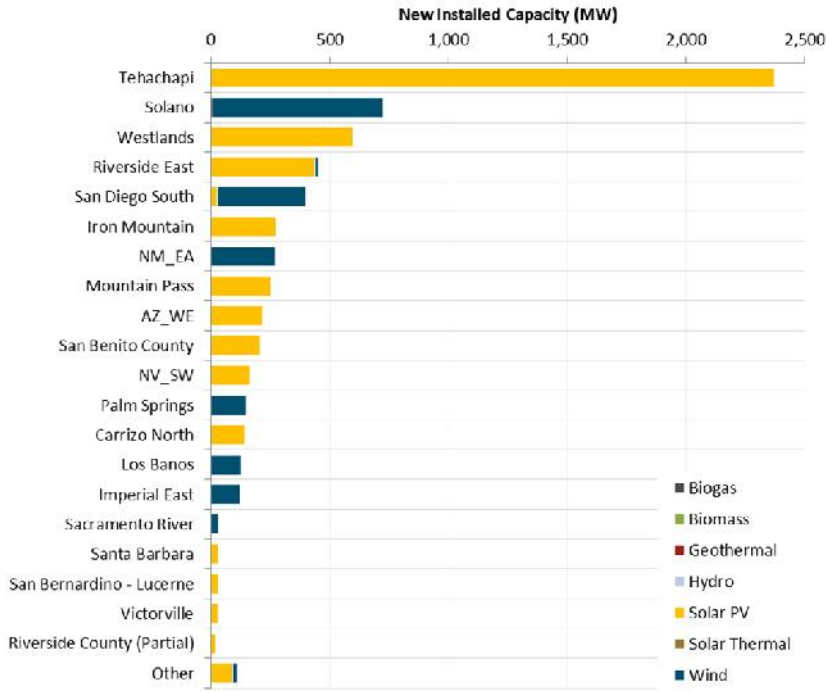
In-State Wind Sensitivity Design

A wind sensitivity was developed as follows:

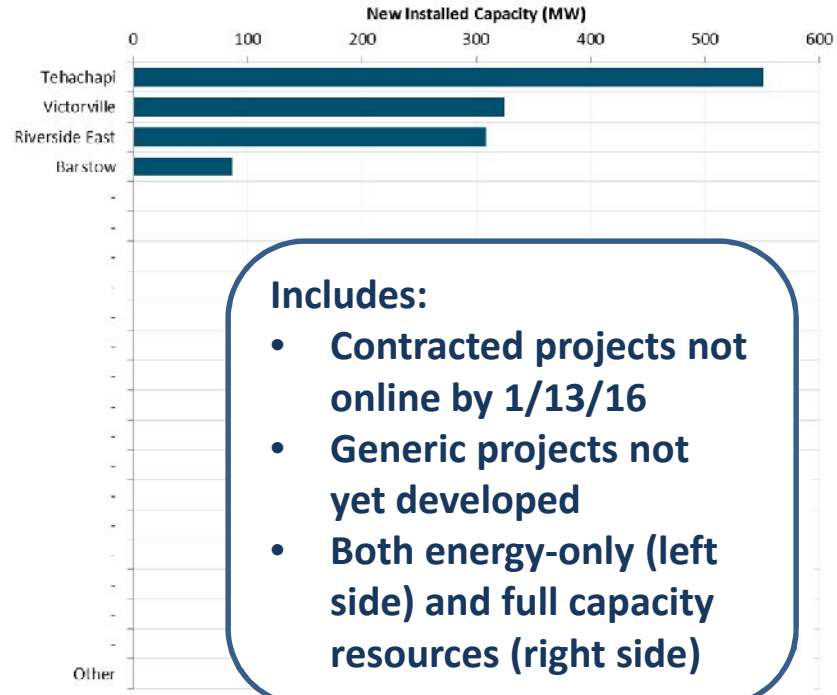
- Forced in ("set aside") a selection of the highest quality in-state wind resources as follows:
  - Victorville: 325 MW
  - Barstow: 109 MW
  - Tehachapi: 551 MW
  - Riverside East: 309 MW
- Total in-state wind set aside: 1,294 MW
- Set aside resources were all Energy-Only resources
- All other assumptions remained the same as the default portfolio

In-State Wind Sensitivity (New Capacity By Year 2030)

Full Capacity Resources



Energy-Only Resources



Includes:

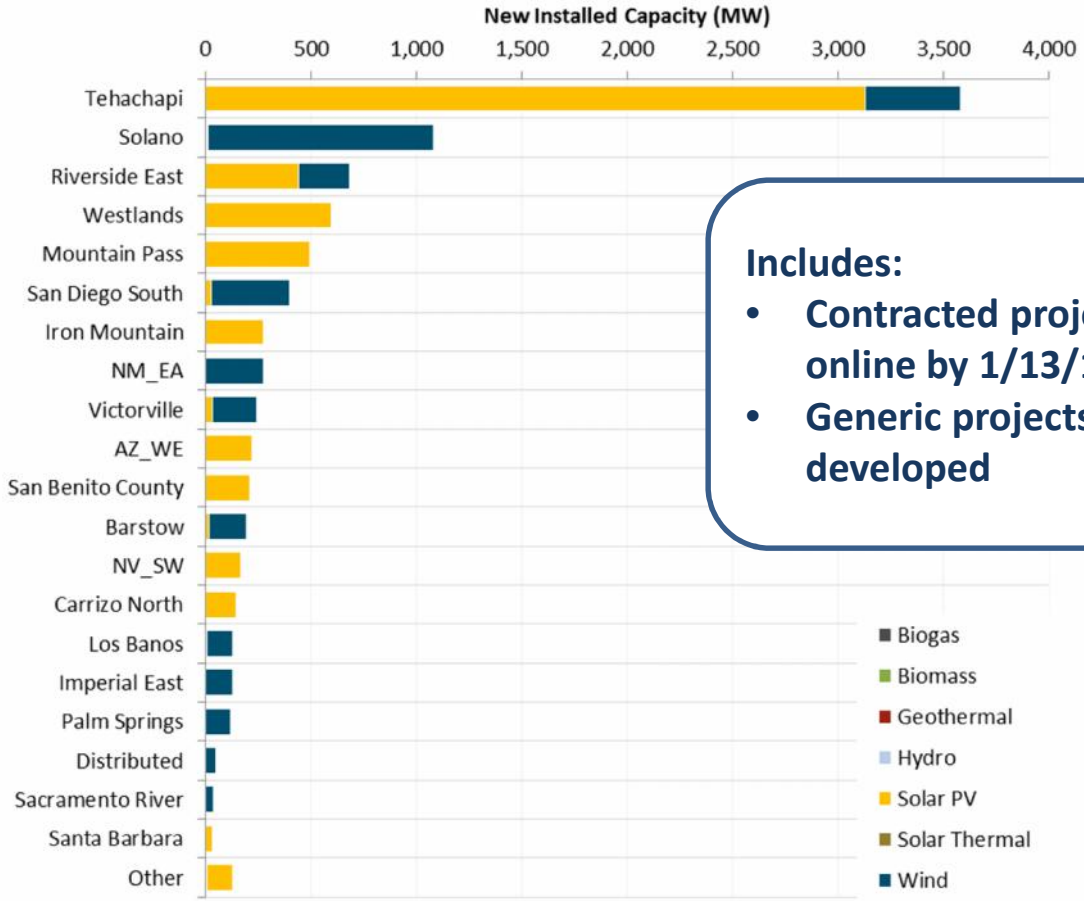
- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**
- **Both energy-only (left side) and full capacity resources (right side)**

Geothermal Sensitivity Design

A geothermal sensitivity was developed as follows:

- Reduced geothermal costs uniformly by 25%
  - Brings weighted CA average just below value used in RPS Calculator 6.1 ($5,063)
  - Energy Division survey of other studies indicates Salton Sea costs are likely to be significantly higher
  - For modeling simplicity, cost was reduced across all generic geothermal resources, including Salton Sea
- Forced in ("set aside") ~1,600 MW highest quality geothermal resources from variety of areas
  - NV_NO (203 MW)
  - UT_WE (81 MW)
  - Sonoma County (135 MW)
  - Siskiyou County (Partial) (45 MW)
  - Imperial North/Salton Sea (1,200 MW)

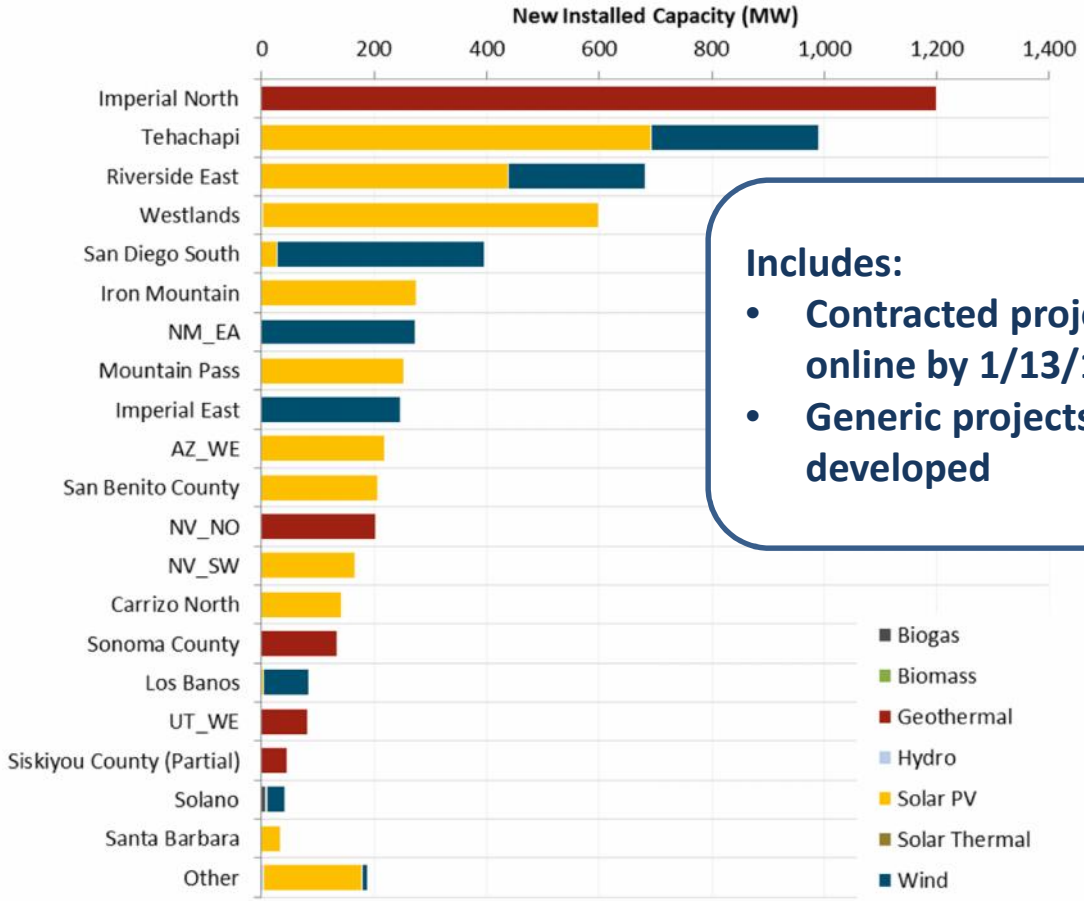
Geothermal Sensitivity #1: Reduced Cost Only (New Capacity By Year 2030)



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

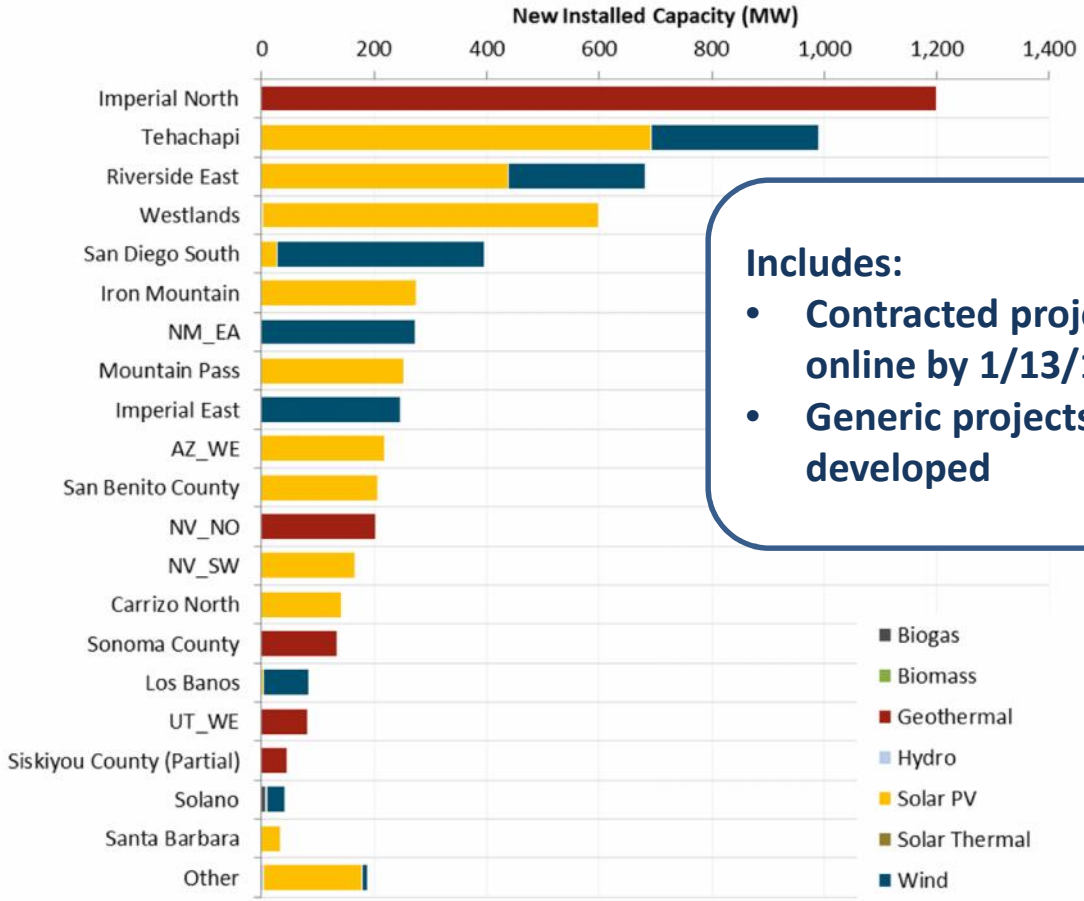
Geothermal Sensitivity #2: Forced-In Only, Costs Unchanged (New Capacity By Year 2030)



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

Geothermal Sensitivity #3: Reduced Cost & Forced In (New Capacity By Year 2030)



Includes:

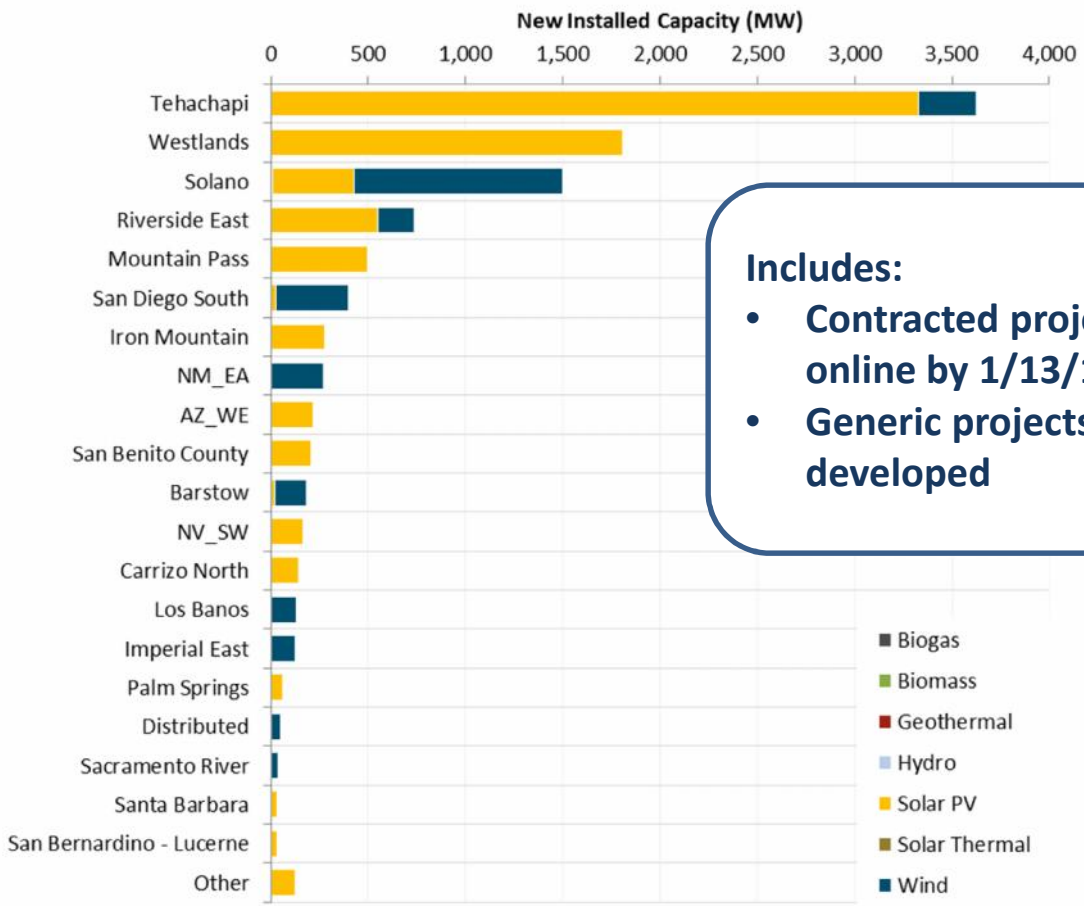
- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

Electric Vehicles Sensitivity Design

An electric vehicles sensitivity was developed by:

- Modifying the load and load shape of the default scenario to be consistent with expectations of the E3 PATHWAYS “High BEV” scenario
- All other assumptions remained the same as the default portfolio

Electric Vehicles Sensitivity (New Capacity By Year 2030)



Includes:

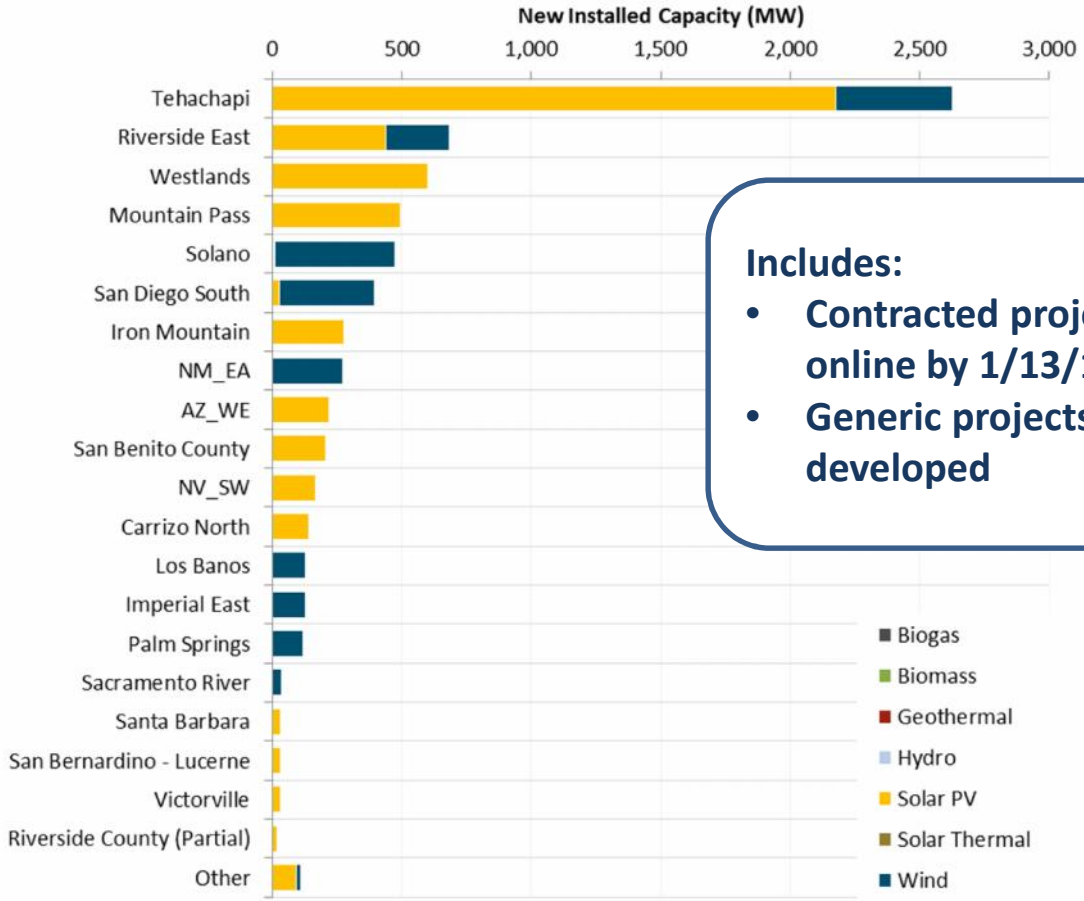
- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

Exports Sensitivity Design

An exports sensitivity was developed by:

- Allowing export of up 5,000 MW
- All other assumptions remained the same as the default portfolio

Exports Sensitivity: 5,000 MW (New Capacity By Year 2030)



Includes:

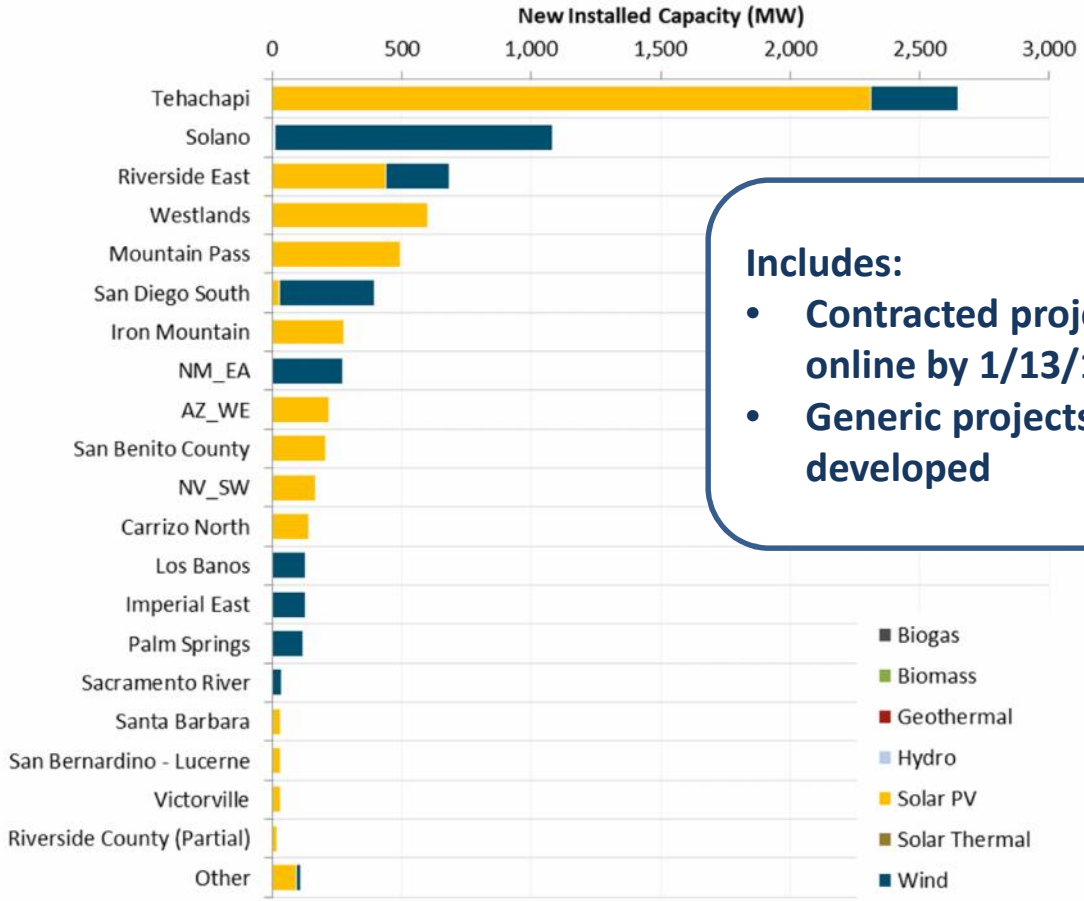
- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

Storage Sensitivity Design

A storage sensitivity was developed by:

- Forcing in 3,000 MW of 6 hour storage in 2020
- All other assumptions remained the same as the default portfolio

Storage Sensitivity: 3,000 MW (New Capacity By Year 2030)



Includes:

- **Contracted projects not online by 1/13/16**
- **Generic projects not yet developed**

2016 RPS Portfolio Sensitivities Impacts

(Sensitivity – Default in Year 2030)

Sensitivity	Total Generic Buildout (MW)	Total DNU (MW)	PV Ratio (PV GWh/ RN GWh)	Curtailmt (% RPS energy)	Rev Reqmt ($MM)	Avg Rate (¢/kWh)
Env Baseline	+194	0	+0.01	+1.0%	+156	+0.13
DRECP/SJVP	+85	+4,240	0.00	+0.3%	+215	+0.18
In-State Wind	-1,147	-3,260	-0.01	-1.8%	-227	-0.19
Geotherm. 2	-2,710	4,240	-0.08	-2.5%	-61*	-0.05**
BEV Vehicles	1,458	-1,760	+0.03	-2.0%	+163	-2.11
Exports	-1,974	-760	0.00	-7.4%	-129	-0.11
Storage	-1,344	0	-0.01	-5.3%	1,258	+1.03

*without assuming lower geothermal capital costs, revenue requirement impact is +$102 MM
**without assuming lower geothermal capital costs, average rate impact is +0.08 ¢/kWh

Conclusions from Sensitivities

- Land Use:
  - More restrictive land use assumptions increase curtailment by eliminating high quality in-state wind
- In-State Wind:
  - In-state wind connecting as energy-only resources an reduce overall portfolio costs if prioritized for available transmission capacity
- Geothermal:
  - Significantly lower geothermal cost assumption, including in the Salton Sea area, reduces the amount of PV on the system by 2026
- Electric Vehicles
  - Battery electric vehicle adoption tends to increase solar PV selection and reduce curtailment
- Exports
  - Exports can greatly reduce solar PV curtailment
- Storage
  - Storage can greatly reduce solar PV curtailment, but at a higher cost than exports

Summary of Assumptions that Have Large Influence Within Tested Ranges

Sensitivity	Total Generic Buildout (MW)	Total DNU (MW)	PV Ratio (PV GWh/ RN GWh)	Curtailment (% RPS energy)	Rev Reqmt ($MM)	Avg Rate (¢/kWh)
Load	+++	+++	+++		+++	---
BTM PV		+		+++	++	+++
Energy-Only		--	--	-	-	-
OOS Wind		+	---	--	-	-
In-State Wind	-	-	-	-		
Geothermal	-	++	---	--		
Env Baseline			+	+	++	++
DRECP/SJVP		+			++	++
BEV Vehicles	+	+	++	-	++	---
Exports	-	-		---	-	-
Storage	-			---	+++	++

Assumptions That Do Not Have A Large Influence Within Tested Ranges

Does not affect any key portfolio metric:

- Diablo Canyon retirement (2024 vs. 2099)
- Generic lag* (1-3 years)
- Integration adder ($3/$4 for solar/wind)
- Future solar cost decline (~75% to ~95% of 2015 costs by 2030)

Affects revenue requirement but not infrastructure buildout, portfolio composition, or curtailment:

- Gas price (0.3 – 3X default assumption)

*time before generic projects can be selected by RPS Calculator

Appendix C.

Detailed Results for Draft 2016 RPS Calculator Portfolios

Table C1 presents the generic renewable resources (MW), aggregated by electrical area, that were selected by the RPS Calculator 6.2 through the year 2026 to achieve a 50% RPS target in the year 2030. Resources that have not yet been fully developed but are associated with a power purchase agreement approved by the Commission ("commercial" projects) are not included in Table 1.

Table C2 presents the total renewable generation (GWh) in the year 2026, including RPS-eligible resources and behind-the-meter solar PV (BTM PV) that is not RPS-eligible.

The RPS Calculator 6.2 spreadsheet model, user guide, and complete draft 2016 RPS portfolios can be downloaded from the RPS Calculator website:

http://www.cpuc.ca.gov/RPS_Calculator/

By loading the draft portfolios into the spreadsheet model (see user guide for instructions), it is possible to reproduce and review the results presented in this appendix. Within the spreadsheet model, the Dashboard and Portfolio_Analytics worksheets provide additional analytical information about the portfolios.

DRAFT 2016 RPS Portfolio Results

Table C1: Generic Renewable Resources Selected by 2026 (MW)

	Default			Energy-Only			Out-of-State			WECC-Wide			Energy-Only & WECC-Wide			Lower Efficiency		
CREZ/WREZ	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind
Alameda County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpine County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amador County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barstow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calaveras County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carrizo North	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carrizo South	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Central Valley North	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cuyama	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Del Norte County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Humboldt County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial East	-	-	126	-	-	304	-	-	126	-	-	126	-	-	246	-	-	126
Imperial North	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial South	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inyo County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inyokern	-	-	-	-	347	-	-	-	-	-	-	-	-	347	-	-	-	-
Iron Mountain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kramer	-	-	-	-	65	-	-	-	-	-	-	-	-	65	-	-	-	-
Lassen North	-	-	-	-	-	144	-	-	-	-	-	-	-	-	-	-	-	-
Los Angeles County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Los Banos	-	-	127	-	-	143	-	-	127	-	-	127	-	-	143	-	-	127
Marin County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mariposa County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mendocino County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mono County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monterey County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mountain Pass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	243	-
Nevada County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Owens Valley	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Palm Springs	-	-	118	-	-	-	-	-	118	-	-	118	-	-	-	-	74	-
Pisgah	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Placer County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plumas County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside East	-	-	228	-	-	228	-	-	228	-	-	228	-	-	228	-	113	159
Round Mountain - A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Round Mountain - B	-	-	-	-	-	108	-	-	-	-	-	-	-	-	-	-	-	-
Sacramento River	-	-	35	-	-	225	-	-	35	-	-	35	-	-	71	-	-	35
San Benito County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Bernardino - Baker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Bernardino - Lucerne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Diego County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Diego North Central	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Diego South	-	-	258	-	-	328	-	-	258	-	-	258	-	-	328	-	-	258
San Francisco County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Mateo County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Santa Barbara	-	-	-	-	-	263	-	-	-	-	-	-	-	-	102	-	-	-
Santa Clara County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Santa Cruz County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sierra County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siskiyou County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solano	-	-	585	-	-	428	-	-	48	-	-	585	-	-	386	-	-	1,040
Sonoma County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stanislaus County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tehachapi	-	1,520	413	-	514	297	-	467	449	-	1,520	413	-	514	297	-	2,636	297
Trinity County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tuolumne County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Twentynine Palms	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ventura County (Partial)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Victorville	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Westlands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56	-
Yuba County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

DRAFT 2016 RPS Portfolio Results

Table C1: Generic Renewable Resources Selected by 2026 (MW)

CREZ/WREZ	Default			Energy-Only			Out-of-State			WECC-Wide			Energy-Only & WECC-Wide			Lower Efficiency		
	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind	Geothermal	Solar PV	Wind
AZ_NE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AZ_NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AZ_SO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AZ_WE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_CT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_EA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_NE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_NW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_SO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_SW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_WC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BC_WE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BJ_NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BJ_SO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ID_EA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ID_SW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NM_EA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NM_SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NV_EA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NV_NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NV_SW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NV_WE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OR_NE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OR_SO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OR_WE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UT_WE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WA_SO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WY_EA	-	-	-	-	-	-	-	-	3,000	-	-	-	-	-	-	-	-	-
WY_EC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	461	-	-	-
WY_NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WY_SO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Distributed	-	-	19	-	-	15	-	-	19	-	-	19	-	-	15	-	-	19
NonCREZ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**-**	**1,520**	**1,908**	**-**	**925**	**2,483**	**-**	**467**	**4,408**	**-**	**1,520**	**1,908**	**-**	**925**	**2,277**	**-**	**3,121**	**2,061**

DRAFT 2016 RPS Portfolio Results
Table C2: Total Renewable Generation in 2026 (GWh)

Portfolio	Biogas	Biomass	Geothermal	Hydro	Solar PV	Solar Thermal	Wind	Total	BTM PV	Total
Default	1,802	4,649	10,419	4,000	27,062	2,751	26,140	76,823	19,105	95,928
Energy Only	1,802	4,649	10,419	4,000	25,282	2,751	27,737	76,641	19,105	95,746
OOS Wind	1,802	4,649	10,419	4,000	23,904	2,751	36,167	83,693	19,105	102,798
WECC-Wide	1,802	4,649	10,419	4,000	27,062	2,751	26,140	76,823	19,105	95,928
Energy-Only & WECC-Wide	1,802	4,649	10,419	4,000	25,282	2,751	27,730	76,633	19,105	95,738
Lower Efficiency	1,802	4,649	10,419	4,000	31,857	2,751	26,427	81,905	19,105	101,010