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Senate Bill 350 Study

The Impacts of a Regional ISO-Operated Power Market on California

List of Report Volumes

Volume VIII.

SB 350 Study: Economic Model & Impacts

Final Report

Prepared for:

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Executive Summary

California's Senate Bill No. 350—the Clean Energy and Pollution Reduction Act of 2015—(SB 350) requires the California Independent System Operator (CAISO, Existing ISO, or ISO) to conduct one or more studies of the impacts of a regional market enabled by governance modifications that would transform the ISO into a multistate or regional entity (Regional ISO). SB 350, in part, specifically requires an evaluation of how regionalization would impact the creation or retention of jobs and other benefits to the California economy. Understanding these economic impacts is an integral part of the policy making process, and as a result Berkeley Economic Advising and Research (BEAR) has been engaged to model these impacts. This report is Volume VIII of XII of an overall study in response to SB 350's legislative requirements.

The BEAR dynamic economic forecasting model was used to evaluate California's long-term growth prospects from developing a Regional ISO. Results are generated for 3 primary scenarios and 1 sensitivity scenario across 3 time periods. Current Practice (CP) refers to business as usual renewables procurement to meet California's 50% Renewable Portfolio Standard by 2030 (50% RPS), the CAISO footprint as-is, and a 2,000 MW limit on net bilateral sales from CAISO entities. Two regionalization scenarios were compared to Current Practice. Regional 2 examines a regional market with business as usual renewables procurement and a regional ISO that includes most of U.S. WECC. Regional 3 examines a regional market with more out-of-state renewables procurement and a regional ISO that includes most of U.S. WECC. The study considers a sensitivity to the Current Practice scenario where the limit on net bilateral sales from CAISO entities is increased to 8,000 MW.

As an initial baseline we provide evidence-based support that California's higher Renewable Portfolio Standard ("RPS") (50% by 2030) will provide a wide range of benefits to California households and enterprises. Across all scenarios, including the Current Practice scenario, we project higher statewide gross product, real output, state revenue, and employment. By 2030, we estimate there will be an additional 90,000 – 110,000 statewide jobs created from the 50% RPS policy goal depending on scenario analyzed. Furthermore, we find that reduced energy rates will lead to increase household income across every scenario, ensuring that an increased RPS will provide a stream of benefits to all Californians.

While these findings offer support that a clean energy future is beneficial to the California economy, there are important differences between the scenarios that are worth noting. Most notably, we find that regionalization (scenarios Regional 2 and Regional 3) offers the most benefits to California in terms of job creation and income gains. Specifically, we find that regionalization can create 9,900 (Regional 3) to 19,300 (Regional 2) more jobs than the Current Practice scenario in 2030. Furthermore, the more affordable energy from regionalization offers further stimulus for the state economy, creating jobs that increase community real incomes by the equivalent of $290 (Regional 2) to $550 (Regional 3) per household in 2030.

Although there will be less jobs from renewable buildout created in the regionalization scenarios due to the lower renewable capacity investments within California, we find that efficiency gains and the associated ratepayer savings will spur induced jobs through increased spending on services and consumption. Consequently, the net employment impacts from regionalization are positive. This finding is significant as these jobs are often "invisible" in the sense they are not directly captured or advocated for by the renewable buildout. However, these jobs are equally as important, and arguably more so, as they allow increased discretionary spending among lower socio-economic groups, and spur job creation across the entire state. Indeed, we find that hundreds of disadvantaged communities stand to receive significant job creation and income gains. As these communities are the most at-risk and underrepresented, our findings demonstrate that a regional renewable energy market will benefit all of California. The results for disadvantaged communities are discussed in Volume X of the SB 350 study.

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I. Introduction

Comparing scenarios, we find that a regional energy market in 2030 (Regional 2 and Regional 3) can create 9,900 – 19,400 more jobs than the Current Practice (CP 1), primarily through making electricity more affordable and the associated induced job effects from these savings. Specifically, the increased affordable energy from regionalization is expected to produce a higher statewide household real disposable income of $300 - $550 per household in 2030.

Although Current Practice will see the most jobs directly linked to the large in-state renewable buildout requirements from 33% to 50%, a regional market in California can help the state balance both ratepayer savings and renewable buildout job creation. Indeed, we find that the regional market with California-focused procurement (Regional 2) offers the highest impact on statewide output and employment compared to Current Practice 1 and Regional 3[1].

The balance of this section of the SB350 report is organized as follows: Sections 2 and 3 provide background information and details the methodological approach used for this analysis; Section 4 presents our main findings of state-wide impacts across scenarios[2]; and Section 5 provides conclusions.

II. Previous Literature

A. Estimating Impacts

As explained in E3's report (Volume IV), regionalization could have a significant impact on the location and characteristics of new renewable generation resources developed by California to meet its 50% Renewable Portfolio Standard ("RPS") by 2030. Investments of this magnitude will have a material effect on the state's economy. However, estimating the economic impacts of the different investment scenarios is complicated as there are several economic drivers of income and job dynamics. In general, these drivers can be classified under one of three groups:

1. Power Capacity Investment – These are the economic impacts associated with the direct build out of new renewable generation. This includes both direct jobs working on the construction of the facility and operations, as well as indirect supply chain related jobs. There are also induced effects through increased household income from related jobs supporting the renewable generation buildout(?).
2. Infrastructure Investment – Increased renewable buildout also requires a related investment in infrastructure, such as new or upgraded transmission, to ensure the

[1] As discussed later in the section, a Current Practice sensitivity case (Scenario 1B) that assumes high bilateral exports absent a regional market produced the greatest employment impact but is very unlikely to materialize in practice due to the challenges of exporting large amounts of renewables under the current market structure.

[2] More details on disadvantaged community effects are also presented in Volume 10.

new generation reliably connects to the grid. This associated increase in infrastructure produces a variety of direct, indirect, and induced jobs.
3. Income/expenditure effects of electricity rate reductions – The implementation of the 50% RPS will affect electricity rates, resulting in a change in discretionary income. The associated expenditure effects of this change will impacts jobs across the entire economy through different spending patterns.

Adding further complexity to the estimation challenge is the fact that the income and job growth across all of these drivers will occur through a combination of effects:

1. Direct Effects – This is the increased economic activity in response to direct spending (either investment or consumption) on capacity buildout (e.g. jobs associated with the direct renewable buildout such as construction or operations).
2. Indirect Effects – This is the economic activity in enterprises linked by supply chains to directly affected sectors (e.g. suppliers of input components and raw materials)
3. Induced Effects – Demand from rising household income (e.g. spending by employed of directly and indirectly affected firms or from ratepayer savings).

Of particular interest are the induced effects as they are often the largest driver of job creation, but can be challenging to quantify. As a result, a model that does not accurately reflect these subtleties nor captures the entire supply chain of California will produce biased results.

B. Previous Studies

There have been a few previous studies that consider how renewable energy contributes to job creation in California. The majority of these studies are based on voluntary survey results and offer past assessments of existing projects within the state.

The California Advanced Energy Employment Survey is a publication-based on a survey of more than 2,000 companies in California. The survey reports some 431,800 jobs in the advanced energy economy in 2014. However, the majority of jobs (70%) are captured in the energy efficiency sector. If we strictly consider the advanced electricity generation sector, the report finds 95,000 employed in this sector, with the majority working in solar generation (~73,000). The report makes no distinction between those who work in utility-scale solar versus rooftop solar. Utility-scale wind generation was estimated to employ an additional 3,270 workers.

Two recent reports from the Donald Vial Center on Employment in the Green Economy (which is affiliated with the Berkeley Labor Center) have studied how renewable energy contributes to job growth. The first, "Environmental and Economic Benefits of Building Solar in California," by Peter Philips (2014) considers the employment effects of building 4,250 MW of utility-scale solar powered facilities over the previous five years. This report offers a useful comparison to this SB350 report as it focuses on utility-scale solar and relies on actual industry data.

Phillips (2014) finds that an estimated 10,200 construction job-years[3] were created during the rapid expansion of utility-scale solar generation facilities from 2010–2014. On average, these jobs paid $78,000 per year and offered health and pension benefits. Additionally, 136 permanent operations and maintenance job-years were created and are expected to last the lifetime of these facilities paying $69,000 a year on average with benefits. There were also an estimated 1,600 job-years created in the supply chain to perform other new business activities associated with construction. Finally, the newly-created jobs boosted consumer spending, resulting in an additional 3,700 jobs-years to meet the increased consumer demand. In total, this suggests an estimated 15,000 job-years were created from some 1,350 MW of increased solar generation capacity constructed in the timeframe of 2010–2014.

The Philips (2014) study methodology is largely based on a review of existing literature. First, he identifies the electricity generation capacity of new utility-scale solar projects that were built or under construction between 2010 and 2014. Next, using four other studies, Philips takes the average number of job-years, supply chain multipliers, income, and pension benefits per MW installed from three large PV projects in central and southern California.[4] He then multiplies the total number of estimated MW by the number of job-years (or other variable) per MW to obtain the estimates given above.

The second report from the Donald Vial Center is, "Job Impacts of California's Existing and Proposed Renewables Portfolio Standard," by Betony Jones, Peter Philips, and Carol Zabin (2015). This study considers both the historical job creation for California's renewable energy investments between 2003 and 2014 and forecasts estimates for jobs from 2015 to 2030 to meet the 50% RPS. Their study includes other sources of renewables outside of solar (such as wind), but does not include jobs created from renewable self-generation, which does not count towards the 50% RPS directly. They also do not report on jobs in operations and maintenance of these new plants as the authors argue that they are much smaller in quantity, and are unlikely to change significantly from the transition from conventional to renewable sources. Finally, the authors do not consider the jobs required for new transmission infrastructure or increased energy storage, both of which are likely needed to achieve the 50% RPS goal.

Jones et al. consider both the historical creation of jobs in the timeframe 2003 – 2014 as well as forecasting jobs creation in 2015 – 2030. Much like Philips (2014), the authors' first start with the total amount of renewable energy capacity that was built between 2003 and 2014, as well as estimates needed to achieve 50% RPS by 2030. The authors find that from

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[3] Jobs here mean job-years, or 2,080 hours of work. Construction workers are often rotated off jobs to get experience in other types of construction over the course of a year, and therefore one job year may be spread across two or more workers. In contrast, the study's estimated 136 operations and maintenance jobs each represent 25 job-years, with each job lasting the expected lifetime of a newly-built solar electrical generation facility.

[4]The reports are: Stephen F. Hamilton, Darin Smith and Tepa Banda, "Economic Impact to San Luis Obispo County of the California Valley Solar Ranch," Appendix 14B, December, 2010; Stephen F. Hamilton, Mark Berkman and Michelle Tran, "Economic and Fiscal Impacts of the Topaz Solar Farm," March, 2011; Aspen Group, "Socioeconomic and Fiscal Impacts of the California Valley Solar Ranch and Topaz Solar Farm Projects on San Luis Obispo County," January, 2011. Mark Berkman and Wesley Ahlgren, "Economic and Fiscal Impacts of the Desert Sunlight Solar Farm," The Brattle Group (private communication with the author).

2003 – 2014, California added some 7,000 MW of in-state capacity and is projected to need an additional 30,600 – 37,400 MW of additional capacity to meet the 50% RPS.

The authors use the JEDI model to then provide a historical estimate of the number of jobs created and forecast future jobs. They find that in 2003 – 2014 about 52,000 direct job-years were created due to the construction of renewable energy plants. This includes both labor-based jobs and professional services. Including both the related indirect jobs (from inputs) and induced jobs (from increased consumer spending in the service sector) this estimate stretches to 130,000 total job-years. Note that these estimates are gross, rather than net.

For the period from 2015 – 2030, the authors find that increasing the RPS to 50% by 2030 would create an additional 354,000 (low scenario) to 429,000 (high scenario) direct construction job-years. Including both indirect and induced jobs, this number becomes an estimated 879,000 to 1,067,000 job-years by 2030. In terms of permanent jobs instead of job years, these numbers represent some 23,600 to 28,600 direct full-time construction jobs and about 58,600 to 71,100 *total* full-time jobs from 2015 – 2030. It should be noted that these numbers represent "cumulative jobs" across the 2015 – 2030 period, a somewhat ambiguous aggregation of differences form reference employment levels over 15 years. In more concrete terms, annual average job creation and the increase in the standing labor force by 2030 are less than 10% of these cumulative numbers.

The authors concede that their estimates likely overstate the amount of jobs created. They compare their results to their co-author Philips' study from 2014 and find that JEDI overestimates direct jobs per MW, especially for solar which Philips (2014) has industry data for. For example, Philips (2014) estimates approximately 2.4 direct jobs per MW, while Jones et al. (2015) estimate 5.8 direct jobs per MW. Therefore, they conclude that the JEDI model is best used for comparisons between alternative scenarios and technology mixes than for absolute job numbers.

III. Model and Methodology

A. BEAR Model Description

The BEAR model is a dynamic economic forecasting model for evaluating long-term growth prospects for California (Roland-Holst, 2015). The model is an advanced policy simulation tool that models demand, supply, and resource allocation across the California economy, estimating economic outcomes annually over the period 2015–2030. This kind of Computable General Equilibrium ("CGE") model is a state-of-the-art economic forecasting tool, using a system of equations and detailed economic data that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also included, with varying degrees of detail, to close the model and account for economy-wide resource allocation, production, and income determination.

BEAR is calibrated to a 2013 dataset of the California economy and it includes highly disaggregated representation of firm, household, employment, government, and trade behavior (Table 1). The model's 2015 - 2030 baseline is calibrated to the California Department of Finance economic and demographic projections. The model's baseline is recalibrated to incorporate the new data whenever new projections are released.

Table 1: BEAR 2013 - Current Structure

1.	195 production activities
2.	195 commodities (includes trade and transport margins)
3.	15 factors of production
4.	22 labor categories
5.	Capital
6.	Land
7.	Natural capital
8.	10 Household types, defined by income decile
9.	Enterprises
10.	Federal Government (7 fiscal accounts)
11.	State Government (27 fiscal accounts)
12.	Local Government (11 fiscal accounts)
13.	Consolidated capital account
14.	External Trade Account

For the SB 350 study the BEAR model was aggregated to 60 economic sectors (Table 2). The electric power sector was disaggregated by 8 generation types in order to be consistent with the portfolios generated by the RESOLVE and PSO models.

Table 2: 60 Sector BEAR Model Aggregation

Label	Description	Label	Description
A01Agric	Agriculture	A31Aluminm	Aluminum production and related manufacturing
A02Cattle	Livestock	A32Machnry	Machinery manufacturing
A03Dairy	Dairy cattle and milk production	A33AirCon	Major appliance manufacturing
A04Forest	Forestry, forest products, and timber tract production	A34MfgComp	Computer and related component manufacturing
A05OilGas	Oil and gas extraction	A35SemiCon	Semiconductor and related component manufacturing
A06OthPrim	Other mining activities	A36ElecApp	Electrical appliance manufacturing
A07EleHyd	Electric power generation- Hydro	A37Autos	Automobile manufacturing
A08EleFF	Electric power generation- Fossil	A38OthVeh	Other vehicle and component manufacturing
A09EleNuc	Electric power generation- Nuclear	A39AeroMfg	Aerospace, railroad, ship, and related component manufacturing
A10EleSol	Electric power generation- Solar	A40OthInd	Other manufacturings
A11EleWind	Electric power generation- Wind	A41WhlTrad	Wholesale trade
A12EleGeo	Electric power generation- Geothermal	A42RetVeh	Retail- vehicles
A13EleBio	Electric power generation- Biomass	A43AirTrns	Air transportation
A14EleOth	Electric power generation- All other	A44GndTrns	Rail and pipeline transportation
A15DistElec	Electric power transmission and distribution	A45WatTrns	Water transportation
A16DistGas	Natural gas distribution	A46TrkTrns	Truck transportation
A17DistOth	Other utilities	A47PubTrns	Transit and ground passenger transportation
A18ConRes	Construction- Residential	A48RetAppl	Apparel and other related retail
A19ConNRes	Construction- NonResidential	A49RetGen	Other retail
A20ConPow	Construction- Power and communications	A50InfCom	Information and communication services
A21ConRd	Construction- Highways and roads	A51FinServ	Financial services
A22FoodPrc	Food processing	A52OthProf	Other professional services
A23TxtAprl	Textile and apparel manufacturing	A53BusServ	Business services
A24WoodPlp	Wood product manufacturing	A54WstServ	Waste services
A25PapPrnt	Paper manufacturing and printing	A55Educatn	Education services
A26OilRef	Petroleum products manufacturing	A56Medicin	Medical services
A27Chemicl	Chemical manufacturing	A57Recratn	Recreation services
A28Pharma	Pharmaceutical and medicine manufacturing	A58HotRest	Hotels and restaurants
A29Cement	Cement and concrete product manufacturing	A59OthPrSv	Other private services
A30Metal	Ferrous and nonferrous metal production and metal fabrication	A60GovtSv	Government services

B. Scenarios

The BEAR model produces results at the state level. Results are generated for 3 primary scenarios and 1 sensitivity scenario across 3 time periods. The scenarios are:

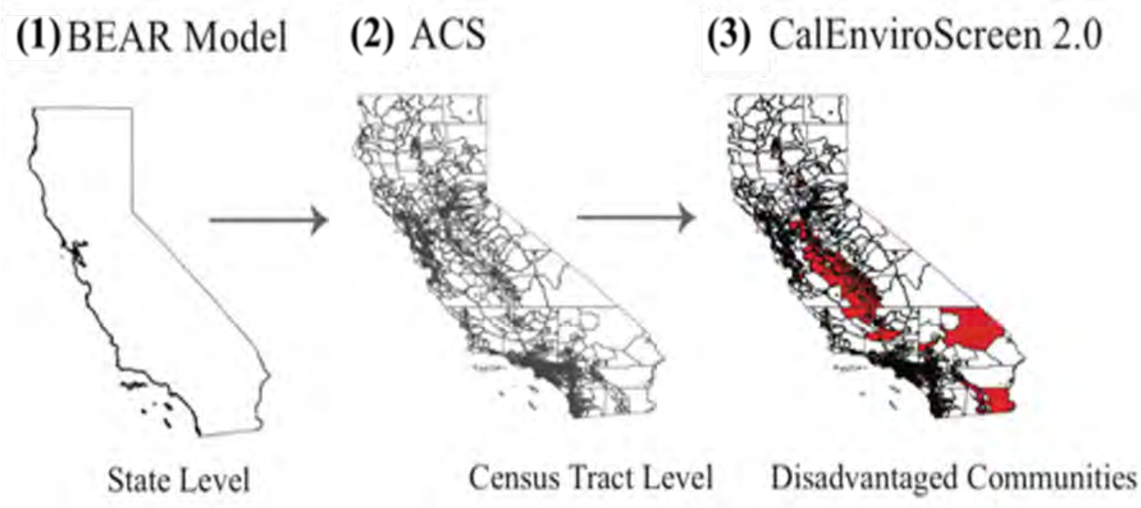
- Current Practice 1: Current Practice Procurement, CAISO operations, 2,000MW export limit
- Regional 2: Current Practice Procurement, WECC-wide operations, 8,000 MW export limit
- Regional 3: WECC-wide Procurement, WECC-wide operations, 8,000 MW export limit
- Sensitivity 1b: Current Practice Procurement, CAISO operations, 8,000MW export limit

The reporting years for the economic study are: 2020, 2025, and 2030.

C. Disaggregation

The process of estimating economic impacts on disadvantaged communities is carried out in several steps. This assessment technique leverages available data to downscale state level estimates to the census tract level conforming to disadvantaged community definitions. Detailed descriptions of each step are presented below.

Figure 1: Downscaling Results to Identify Impacts of Disadvantaged Communities



1. Step 1 – Census Tracts

State-wide results produced by the BEAR model are first disaggregated to individual census tracts. Complete data on economic activities are not available at the census tract level, so it is not possible to build Social Accounting Matrices (SAMs) for individual census tracts. Instead, we construct census tract shares of state level economic activity for select variables of interest, i.e. income by decile, sector of employment, and occupation. Census tract estimates of these values are derived from the American Communities Survey ("ACS")[5] using the 5-year averages covering the period 2008-2013.

Income

The ACS reports income by tax bracket, however, the BEAR model estimates impacts on income by decile. Consequently, tax brackets were converted to income decile according to the share of overlap in each category. The number of households in each income decile was calculated for each census tract. State level income estimates were then shared out across census tracts according to the number of households in each income decile in each census tract.

The income estimates are presented as community income per household in 2030. In order to estimate the *number of households* in each census tract in 2030 we use Department of Finance estimates of population growth by county. We assume that population growth within counties is constant across census tracts and that household size remains constant so population growth is equivalent to growth in households. Relying on these assumptions, we calculate household growth rates for each census tract and apply them to the current number of households in order to forecast the number of households in each census tract in 2030.

[5] http://factfinder.census.gov/

Jobs

Job estimates from the BEAR model measure total jobs by occupation. Jobs due to ratepayer impacts at the state level are calculated by netting out statewide total estimated direct jobs. Jobs by occupation resulting from ratepayer savings are then downscaled from state to census tract level according to the number of employees in each occupation in each census tract. Direct jobs are downscaled from the county to census tract level according to the number of employees in construction-based occupations in each census tract. Renewable buildout and ratepayer savings jobs are then summed to estimate total jobs in each census tract.

2. Step 2 – Disadvantaged Community Level

In the final step, we use CalEnviroScreen 2.0 ("CES")[6] to identify census tracts designated as disadvantaged communities. We define disadvantaged communities as census tracts in the top 25th percentile of CES scores. By this definition, there are 2,009 disadvantaged communities (census tracts) in California. Income and job estimates for the subset of census tracts meeting this condition are presented in Volume X of the SB 350 study.

IV. Results

Study results are presented below in two formats. Section 4.1 presents results comparing all scenarios to a hypothetical reference point that maintains the state's current 33% RPS. Section 4.2 fulfills the direct requirements of SB350 by isolating the specific impacts of regionalization.

A. Baseline Effects of Investment in 50% RPS

To better understand how California's future renewables investments could affect the state's economy and job creation we simulated a hypothetical reference point in which the state maintains its 33% RPS and does not expand to 50% by 2030. By first doing this we find strong evidence that regional electric power trading can benefit the California economy across a variety of indicators. Table 3 shows the percentage change from the reference scenario in 2030 for gross state product, real output, employment, state revenue, and real wage. The differences reported are estimated with respect to a reference scenario assuming no additional RPS investment from 2020. For Current Practice 1, we find increases ranging from 0.21% (state revenue) to 0.48% (real income).

[6] http://oehha.ca.gov/ej/pdf/CES2_0SHP.zip

Table 3: Baseline Impacts of Moving from 33% RPS to 50% RPS (Percent Change from Reference in 2030)

	Current Practice 1	Regional 2	Regional 3
Gross State Product	**0.32%**	**0.37%**	**0.35%**
Real Output	**0.35%**	**0.40%**	**0.39%**
Employment	**0.29%**	**0.35%**	**0.32%**
Real Income	**0.48%**	**0.53%**	**0.61%**
State Revenue	**0.21%**	**0.33%**	**0.34%**

Percent changes are useful in comparing the relative impacts between different scenarios, but do not give a clear idea to the size of these effects. To counter this, we also report our findings in terms of raw number in Table 4. These results illustrate the size of the impacts with Gross State Product increasing some $11.3 – $13 billion depending on the scenario. Real income is projected to increase the largest, ranging between $26.9 billion - $34.7 billion depending on scenario. In regards to jobs, we find an estimated increase of 90,000 new jobs in 2030 under Current Practice 1 to 110,000 new jobs under Regional 2.

Table 4: Baseline Impacts of Moving from 33% RPS to 50% RPS (Difference from Reference in 2030; 2015 $ Billions Unless Noted)

	Current Practice 1	Regional 2	Regional 3
Gross State Product	**11.298**	**12.987**	**12.467**
Real Output	**18.289**	**21.027**	**20.564**
Employment (,000 FTE)	**90.330**	**109.678**	**100.247**
Real Income	**26.853**	**30.970**	**34.747**
State Revenue	**6.082**	**6.669**	**7.663**

B. Impact of Regionalization

While these numbers are supportive that increasing to a 50% RPS is beneficial for the California economy, we are more interested in how this scenario compares to Regional 2 and Regional 3, which introduce WECC procurement and operations. In general, we find that some form of regionalization is more beneficial to the California economy, with more growth across every single indicator compared to Current Practice. Of the two regionalization scenarios, we find the most gains in Regional 2, due to both the lower electricity rates associated with regional operations as well as the comparatively larger build out in California compared to Regional 3.

1. Employment Impacts by Occupation

One of the salient features of the BEAR model is the ability to forecast employment impacts by occupation. In Figure 2 we present the employment impacts (relative to the 33% RPS reference scenario) by occupation across the different scenarios. Significant gains in employment span a variety of diverse sectors, signaling the large scope of indirect and induced effects from increasing the RPS. For example, while we find large increases in employment sectors readily associated with a large renewable build out such as construction, there are also large projected increases in sectors that are much less direct such as office support, sales and marketing, and food processing and preparation. In Figure 3 we compare how Current Practice 1 compares to the two different regionalization scenarios, Regional 2 and Regional 3. Here we find that job creation increases universally across all categories for Regional 2 compared to Current Practice 1, while Regional 3 shows some categories with less jobs created than Current Practice 1. This finding is important as although all scenarios stimulate job creation in California (as seen in Figure 2), there are some large differences between the regionalization scenarios in which occupations are affected.

Figure 2: Employment Impacts by Occupation (FTE Change from Reference in 2030)

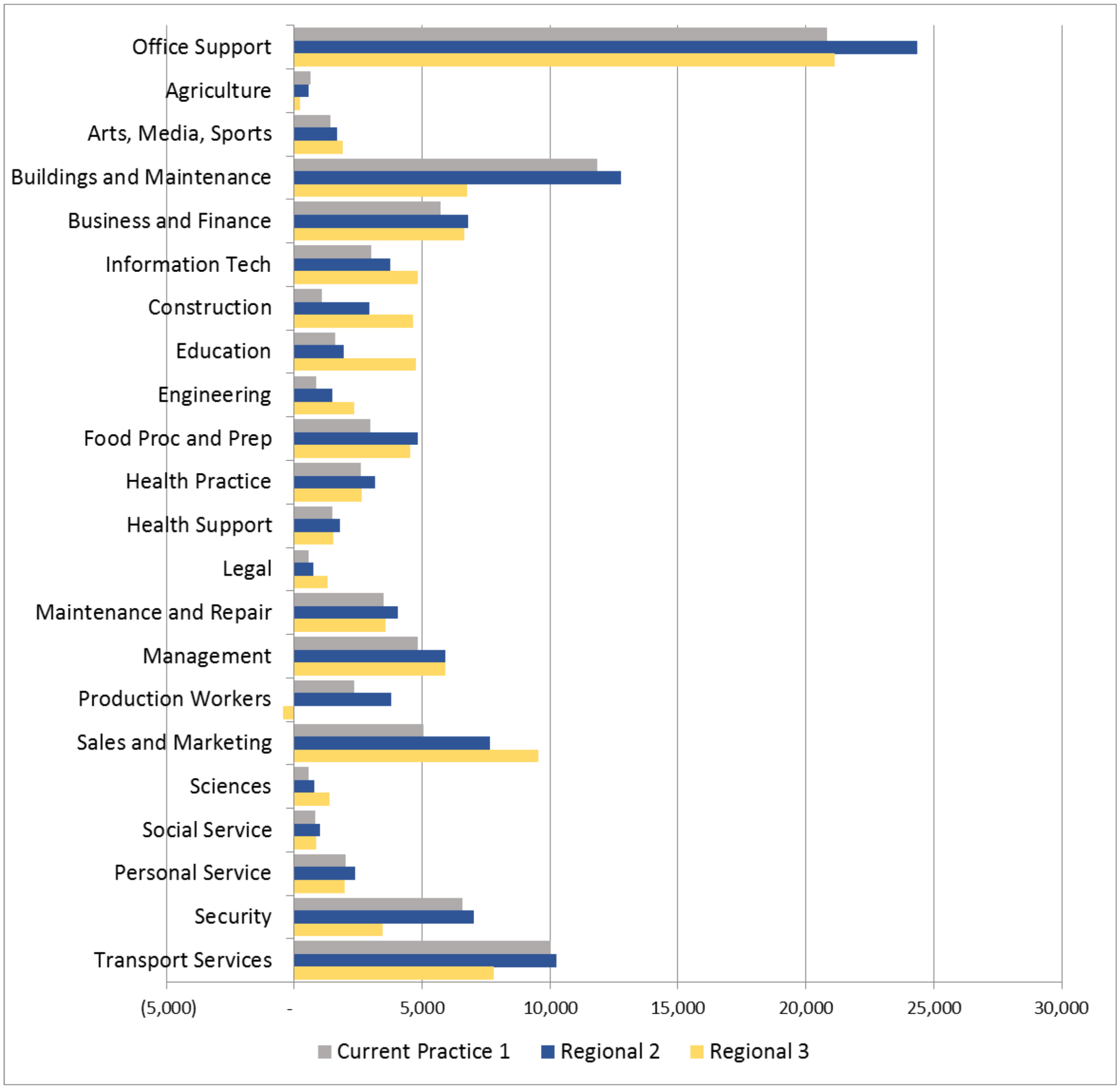
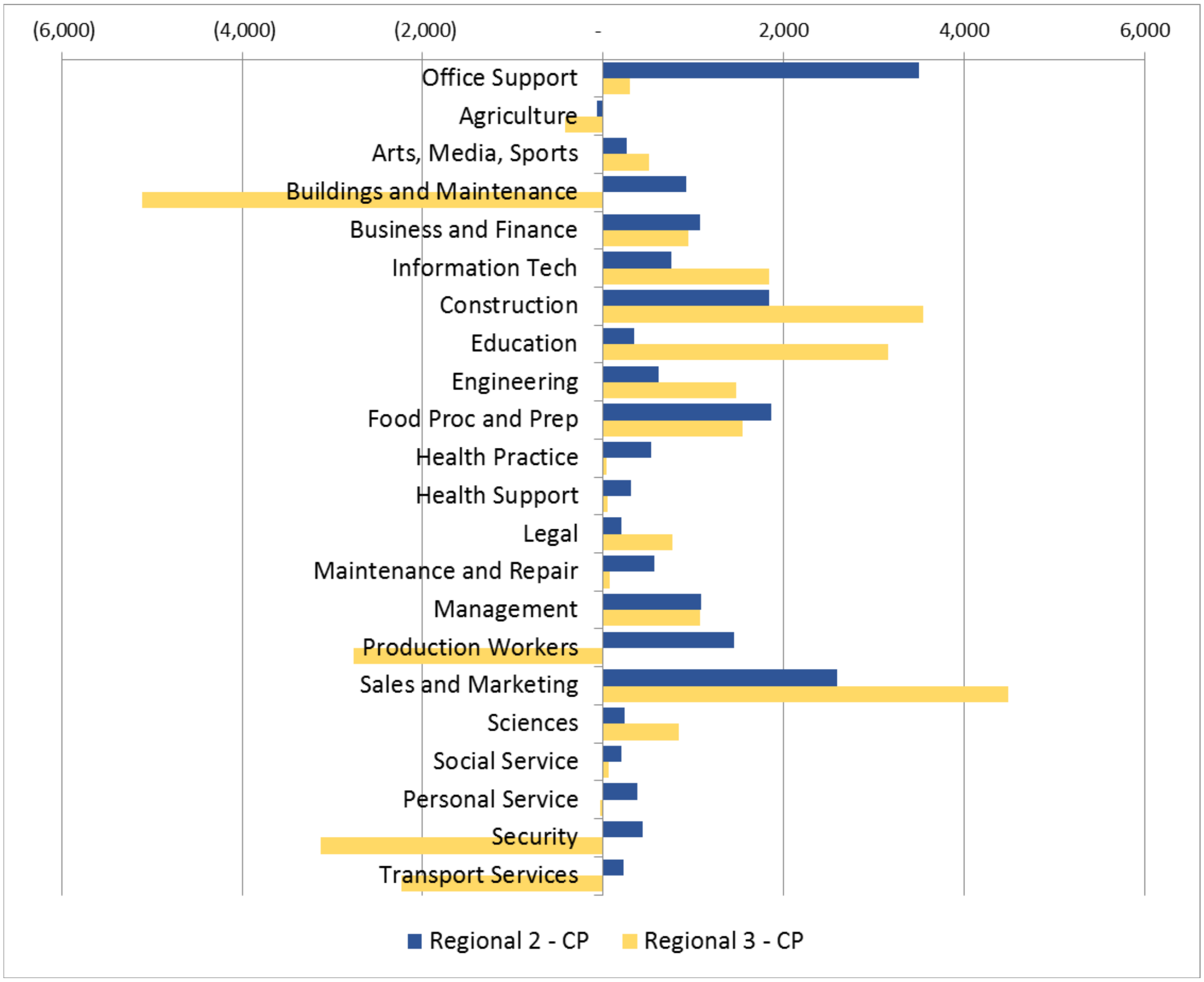


Figure 3: Employment Impacts by Occupation – Regionalization Comparison (FTE Change from Baseline in 2030)



For each of the occupation classes previously listed, job creation either occurs as a result of the renewable buildout or from ratepayer savings effects. In Figure 4 and Figure 5, we show the different job creation between scenarios for ratepayer savings induced jobs and jobs from the renewable buildout. Regional 2 produces the most jobs overall, with an increase of over 19,000 jobs compared to Current Practice 1. This large growth is led primarily from ratepayer savings induced jobs and increased renewable build in California. Comparing Current Practice 1 and Regional 3 we find that Regional 3 has an even larger increase in jobs generated by the ratepayer savings from reduced energy rates, but has less jobs overall compared to Regional 2 due to less renewable buildout job creation in solar from more out-of-state renewables procurement.

Figure 4: Statewide Jobs Created by 2030

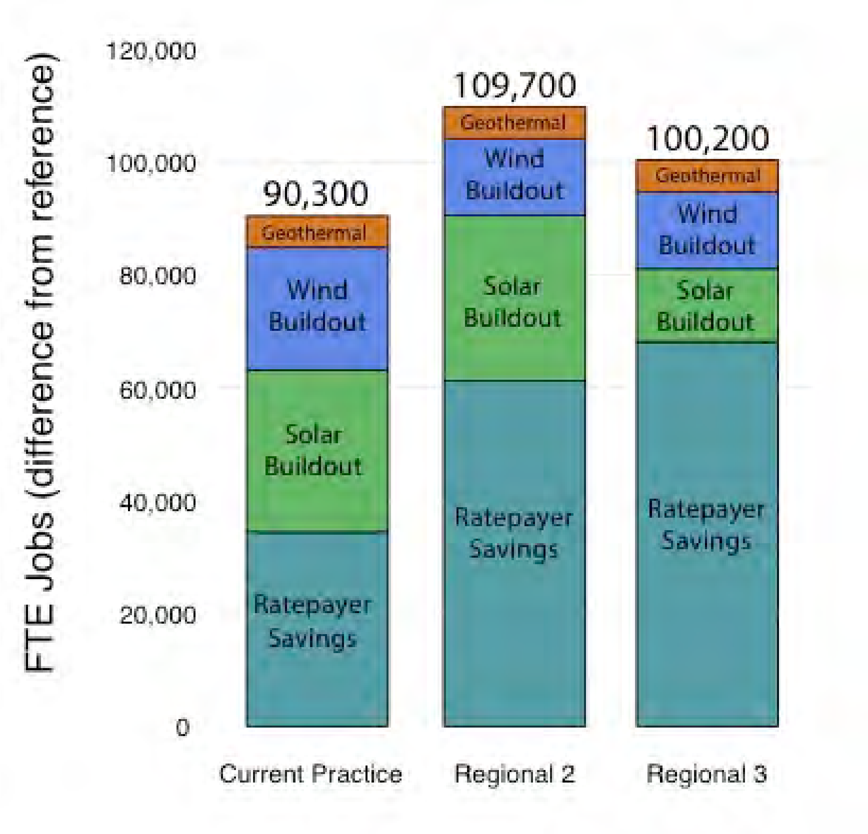
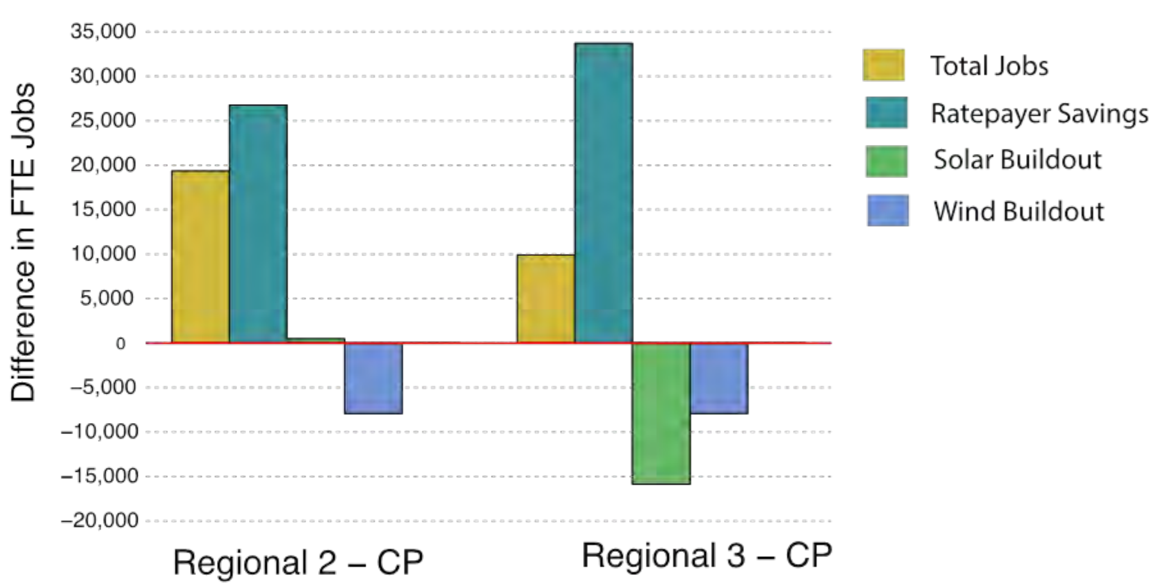


Figure 5: Difference in Statewide Jobs Created by 2030



2. Impacts by Income Decile

Another notable feature of the BEAR model is the ability to forecast results across income deciles. Given that the benefits from an increased renewable buildout will not be uniformly disturbed across the population, this feature of the model is particularly relevant for this study. The results for income impacts by decile are listed in Figure 6. In general, we find that the largest share of increases across income deciles occur in the middle and upper income deciles, with the largest projected increases occurring in decile 7, 8, and 9 under Regional 3. Consistent with our other results, we find the largest increases across all income groups in Regional 3. These results are reflective of the fact that more out-of-state procurement and Regional ISO operations in Regional 3 will produce the lowest energy rates among all scenarios, resulting in higher household income across all deciles.

The difference in statewide income across all deciles can be seen more clearly in Figure 7, which reports the difference in statewide income between Scenario 1 and Regional 2 and Regional 3. As seen in the figure, Regional 3 results in the largest income effect owing to the lower rates from full regionalization. Note however that these figures should not be interpreted as how much additional income each household in California will enjoy as a result of regionalization. Instead, those households that receive new jobs will receive the vast amount of new benefits, while other households will only see a small increase from ratepayer savings. Therefore, this figure is somewhat misleading as it averages out the benefits across all households, when in reality only a few will receive the majority of benefits. However as each utility has different rate classes and rate allocations, it is not feasible to do a rate allocation study for this detail of a study.

Figure 6: Household Real Income Impact by Decile (Percent Change from Reference in 2030)

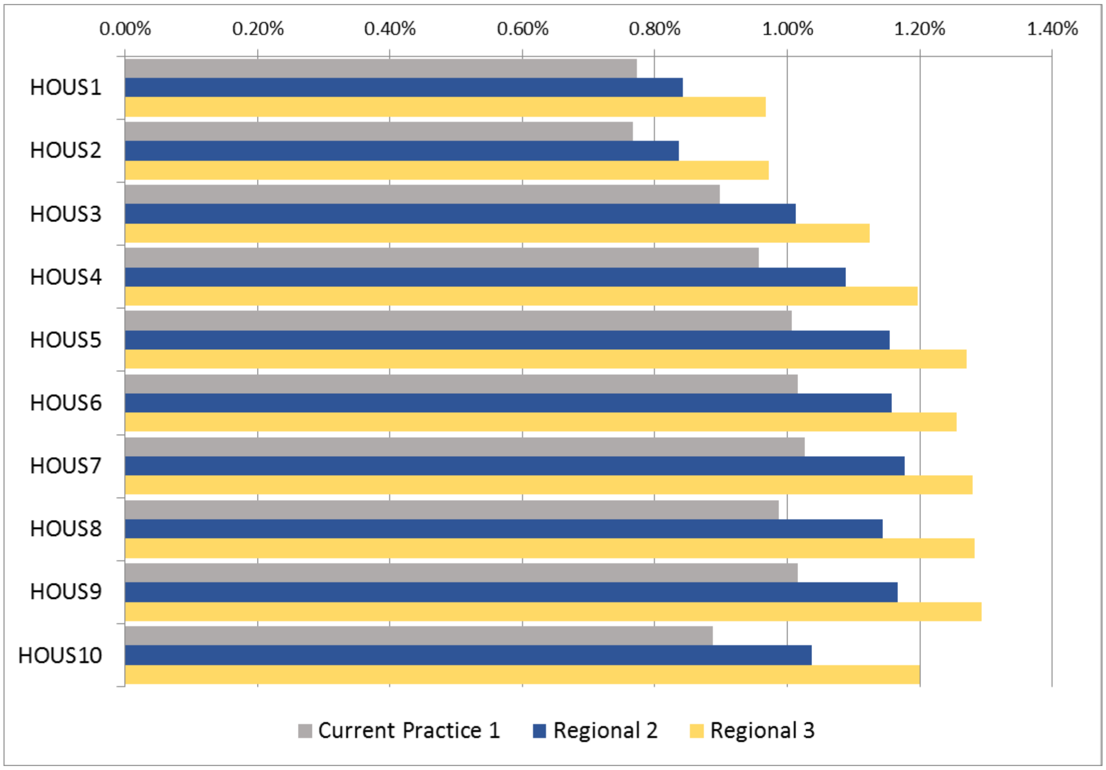
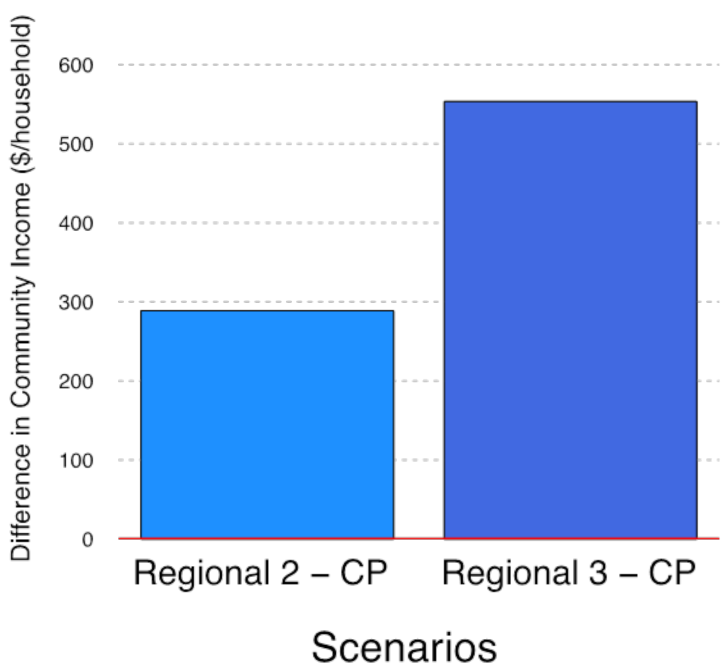


Figure 7: Difference in Statewide Income in Year 2030



3. Sensitivity Analysis

The economic analysis includes one sensitivity analysis that is identical to the Current Practice 1 scenario except with a higher limit on net bilateral sales from CAISO entities (8000MW vs. 2000MW). The statewide macroeconomic impacts for sensitivity 1B are shown in Table 5. The positive economic impacts compared to Current Practice 1 are due to the higher levels of investments in in-state wind and solar resources, combined with greater ratepayer savings due to the higher export capacity. The two regionalization scenarios result in moderately lower levels of employment growth compared to the sensitivity 1B scenario. Regional 2 results in 1,212 fewer jobs created and Regional 3 results in 9,432 fewer jobs created. Similar results are observed for gross state product and real output. Despite slightly lower ratepayer savings than the two regionalization scenarios, the greater in-state investments due to the renewable buildout generate more jobs and in-state economic activity. It is important to note that this sensitivity is an extreme bookend to isolate the benefits of a regional market holding the level of export capability constant. Achieving this level of export capability under the current market structure is extremely unlikely given the operational and market barriers that exist in the West. Nonetheless, the statewide macroeconomic impacts of this sensitivity are presented here for completeness.

Table 5: Macroeconomic Impacts for Sensitivity 1B in 2030 (2015 $ billions unless noted)

	1B – CP1	Regional 2 – 1B	Regional 3 – 1B
Gross State Product	**2.284**	**-0.595**	**-1.115**
Real Output	**3.607**	**-0.869**	**-1.332**
Employment (,000 FTE)	**20.560**	**-1.212**	**-9.432**
Real Income	**4.285**	**-0.168**	**3.609**
State Revenue	**0.792**	**-0.205**	**0.788**

V. Conclusion

Although we find that all renewables investment scenarios offer tremendous benefits to a wide group of occupations and income groups, regionalization offers benefits to the widest group of Californians. While this is an important finding on its own, the benefits of a regional market undoubtedly extend beyond California. Regionalization offers other states an opportunity to increase their own RPS providing both job creation and income benefits through ratepayer savings.

The foundation developed in this study could be used by others to assess what would demonstrate the scope of ratepayer benefits beyond California, and especially with respect to states who might opt in or out of a given regional framework. Our current findings are based on a variety of assumptions regarding the coordination and renewable buildout of other states, but they do not elucidate potential benefits that might recruit other states to the regional initiative. Such an exercise would be valuable for political sustainability, but also to facilitate more optimal regional trading and transmission integration for states considering joining the Regional ISO.

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Senate Bill 350 Study

Volume IX: Environmental Study

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Senate Bill 350 Study

The Impacts of a Regional ISO-Operated Power Market on California

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Environmental Study

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Executive Summary and Key Findings

California's Senate Bill No. 350—the Clean Energy and Pollution Reduction Act of 2015 — (SB 350) requires the California Independent System Operator (CAISO, Existing ISO, or ISO) to conduct one or more studies of the impacts of a regional market enabled by governance modifications that would transform the ISO into a multistate or regional entity (Regional ISO). SB 350, in part, specifically requires an evaluation of "the environmental impacts in California and elsewhere." Aspen Environmental Group has been engaged to study these environmental impacts. This report is Volume IX of XII of an overall study in response to SB 350's legislative requirements.

A foundational assumption to our study is how regionalization could affect California's procurement of incremental future renewable resources to satisfy the state's 50% Renewable Portfolio Standard (RPS) by 2030. With a regional ISO, renewables would be better integrated into the regional system and California's investments would be more efficient. In other words, regionalization would allow California to build less renewable generation capacity to meet its 50% RPS. Additionally, regional operations and markets would give California better access to lower-cost out-of-state resources in wind- or solar-rich areas of the west. In particular, generating plants in the more wind-rich areas of the west use land more efficiently by producing more renewable energy per acre of land. California's renewable development footprint, therefore, could be shifted more out of state. The combination of less capacity built and the shift towards out-of-state development is a major driver of our key findings. We also consider expected changes in the operations of existing power plants both in state and out of state, and the resulting expected changes in water use, fuel burn, and emissions. Our findings, along with the findings in the SB 350 study's economic impact analysis (Volume VIII) and the analysis of the impact on California's disadvantaged communities (Volume X) reflect inherent tradeoffs to in-state versus out-of-state renewable development.

In 2020, we assume no incremental buildout of renewable resources or transmission beyond what is already planned to meet the state's 33% RPS by 2020. With limited regionalization in 2020, we also assume no incremental renewable energy development and no associated ground disturbance. Therefore, there would be no effects to land use or biological resources from the implementation of the limited regional market. However, there would be changes associated with how the wholesale electric system might respond to the limited regional market in 2020 (CAISO + PAC), in terms of changes to the operations of existing resources. These operational changes would have effects on water use and air emissions.

The 2020 results for water use and emissions are summarized as follows:

- By achieving a small decrease in fossil fuel use for electricity production in California, limited regionalization in 2020 results in a small but beneficial decrease in the electric power sector's use of water resources (water used by electricity generation decreases by 1.5% statewide).
- Limited regionalization in 2020 reduces air pollutant emissions from natural gas-fired electricity generation in California on average (decrease 0.5% to 1.2% statewide, depending on pollutant), depending on the dispatch of the fleet of natural gas–fired power plants. Certain air basins would experience slight increases in PM2.5 and SO_2 emissions (increase 0.4% in San Joaquin Valley and South Coast air basins and increase 0.7% in Mojave Desert air basin), but the San Joaquin Valley and South Coast air basins would experience greater benefits through decreases in NOx, which is a precursor to both ozone and PM2.5.

By 2030, a significant incremental renewable generation buildout would be required to satisfy California's 50% RPS under any scenario. This buildout would require developing land, which is associated with ground disturbance and environmental effects. Changes associated with how the wholesale electric system might respond to regionalization would also be a part of the 2030 scenarios. The potential changes in land use and potential impacts to biological resources depend on the geographic distribution of the portfolios modeled in the 2030 scenarios. With regionalization, we find that land use and the acreage required decreases in California by 42,600 acres in the Regional 2 scenario and by 73,100 acres in the Regional 3 scenario. Outside of California, land use decreases by 31,900 acres in Regional 2, and increases by at least 69,300 acres in Regional 3, largely due to assumed wind resource development. While the development footprint associated with wind resources is larger, the actual ground disturbance would be much smaller; wind resources normally require only a portion of the acreage to be disturbed by the access roads and foundations for wind turbines while the remainder of the site may remain undisturbed and available for other uses. Under Scenario 3, additional land and acreage would be devoted to out-of-state transmission right-of-way to integrate the high-quality out-of-state renewable generation into the regional power system. Results for Regional 2 versus Regional 3 illustrate an inherent tradeoff of building renewables for RPS in state versus out of state.

The 2030 results for water use and emissions are summarized as follows:

- Scenarios Regional 2 and Regional 3 decrease the amount of water used by power plants statewide, when compared with Current Practice Scenario 1. By decreasing fossil fuel use for electricity production in California, regionalization results in a beneficial decrease in the electric power sector's use of California water resources (decrease by 4.0% to 9.7% statewide).
- Scenarios Regional 2 and Regional 3 decrease the emissions of NOx, PM2.5, and SO_2 from power plants statewide and also decrease these emissions in several air basins with nonattainment designations, because of the changed dispatch of the fleet of natural gas-fired power plants. In particular, the San Joaquin Valley, South Coast, Mojave Desert, and Salton Sea air basins experience decreased emissions of all pollutants when compared with Current Practice Scenario 1. Modeling for 2030 shows very small increases in PM2.5 and SO_2 emissions in certain other locations, namely the San Francisco Bay and North Central Coast air basins, although these other locations would experience greater benefits through decreases in NOx. Statewide, combustion-fired electric generation comprises a small portion or roughly 1% to 2% of California's average daily inventories of NOx and PM2.5; this means that the transformation into regional wholesale electricity market is likely to have a negligible impact on California's overall criteria air pollutant inventories.

The differences due to an expanded regional power market and the modeled portfolio and operational changes are summarized in Table ES-1.

Table ES-1. Summary of Environmental Study Key Findings

Study Topic	2020 CAISO + PAC Relative to Current Practice	2030 Regional 2 Relative to Current Practice Scenario 1	2030 Regional 3 Relative to Current Practice Scenario 1
Land Use and Acreage Required in California	No change	▪ Comparable impacts for solar ▪ More solar acreage (+1,400 ac) ▪ Fewer impacts for wind ▪ Less wind acreage (–44,000 ac)	▪ Fewest impacts for solar ▪ Lowest solar acreage (–29,000 ac) ▪ Fewer impacts for wind ▪ Less wind acreage (–44,000 ac)
Land Use and Acreage Required Outside California	No change	▪ More solar acreage (+3,500 ac) ▪ Impacts substantially similar except fewer impacts in Northwest (wind) ▪ Lowest wind acreage for RPS (–35,400 ac) ▪ Facilitates development beyond RPS (+200,000 ac, wind)	▪ More solar acreage (+3,500 ac) ▪ Impacts increase in Wyoming, New Mexico ▪ Fewest impacts in Northwest and Utah (wind) ▪ Most wind acreage for RPS (+65,800 ac) ▪ Adds acreage for out-of-state transmission for California RPS ▪ Facilitates development beyond RPS (+200,000 ac, wind)
Biological Resources in California	No change	▪ Impacts slightly increased from solar ▪ Fewer impacts from wind	▪ Fewest impacts from solar ▪ Fewer impacts from wind
Biological Resources Outside California	No change	▪ Increased avian mortality due to wind beyond RPS	▪ Fewest impacts in Northwest and Utah (wind) ▪ Most avian mortality for wind beyond RPS plus RPS portfolio wind ▪ Adds impacts of out-of-state transmission for California RPS
Water in California	▪ Slight decrease in water used for operation of generators	▪ Less water used during construction in high risk water areas ▪ Less water used for operation of generators	▪ Least water used during construction in high risk water areas ▪ Least water used for operation of generators
Water Outside California	▪ Slight increase in water used for operation of generators	▪ More water used during construction in high risk water areas ▪ Least water used for operation of generators	▪ Most water used during construction in high risk water areas ▪ Less water used for operation of generators
Air Emissions Changes in California	▪ Slight decrease in emissions	▪ Lower emissions of NOx (–6.5%) ▪ Lower emissions of PM2.5 and SO_2 (–4.0%)	▪ Lowest emissions of NOx (–10.2%) ▪ Lowest emissions of PM2.5 and SO_2 (–6.8%)
Air Emissions Changes Outside California	▪ Slight increase in emissions	▪ Lowest emissions of NOx (–1.9%) ▪ Lowest emissions of SO_2 (–0.9%)	▪ Lower emissions of NOx (–1.3%) ▪ Lower emissions of SO_2 (–0.2%)

Notes:
Solar acreage shown for site control and potential ground disturbance.
Wind acreage shown for site control; ground disturbance is less than 10% of acreage.

1. Introduction to Environmental Study

1.1 Background and Scope

California's Senate Bill No. 350 — the Clean Energy and Pollution Reduction Act of 2015 — (SB 350) requires the California Independent System Operator (ISO) to conduct one or more studies of the impacts of a regional market enabled by governance modifications that would transform the ISO into a multistate or regional entity. Further, SB 350 requires the ISO to evaluation the environmental impacts in California and elsewhere due to regionalization. This environmental study depends on the scenario modeling and portfolio development efforts within the overall SB 350 study process, described below.

This environmental study does not consider all of the environmental resources or topics that could be impacted by regionalization and the associated renewable buildout, as might be within an environmental impact report, but rather it focuses on some of the most sensitive resources and where the changes resulting from regionalization would be most important. Some of these resources are addressed qualitatively, like land use and biological resources, and some are addressed quantitatively, like acreage, water use, and air emissions, depending on the type of data available. Electric sector greenhouse gas (GHG) emissions results are presented and discussed in Volume I and Volume V (Production Cost Analysis) of the SB 350 study.

The environmental study's treatment of renewable portfolios to meet California's 50% Renewable Portfolio Standard by 2030 (50% RPS), and the treatment of renewable study areas, recognizes that siting decisions are not made by the ISO. As such, the renewable portfolios themselves and the geographic definitions of the renewable study areas are not binding or reflective of any specific generation proposals.

1.2 Role of Environmental Study in SB 350 Study Process

This environmental study depends on the defined renewable portfolios and production cost simulations developed elsewhere within the overall SB 350 study process. Accordingly, the environmental study methodology and the analysis of environmental topics rely upon these two separate modeling efforts.

Renewable Portfolios. The SB 350 study process includes a Renewable Energy Portfolio Analysis (Volume IV) that identifies optimal renewable capacity additions to meet California's 50% RPS using the Renewable Energy Solutions (RESOLVE) model and a number of modeling assumptions discussed in Volume IV. The model defines renewable portfolios and identifies needs for new system infrastructure, such as regional transmission and flexible generating capacity. The environmental study uses the following information from the RESOLVE model:

- Locations of incremental new resources for California to achieve RPS goals by 2030, identifiable in terms of Competitive Renewable Energy Zone (CREZ) and selected development regions (outside of California) and renewable technology.
- Megawatt (MW) capacity and type of new added generation resources, including storage.
- New high-voltage transmission system additions to access and integrate out-of-state resources that would help meet California's 50% RPS.

Production Cost Simulation. The SB 350 study process also includes a Production Cost Analysis (Volume V) that identifies potential changes in the operation of existing generation facilities including retirements. The environmental study uses the following information from the production cost simulation in the analysis of scenarios:

- Locations of megawatt hours (MWh) produced and fuel consumed in million British Thermal Units (MMBtu) by generating unit, aggregated by California air basin.
- MWh produced and/or displaced by generation or transmission additions.
- Changes in fuel type(s) used and type of generating unit dispatched.
- Emissions of carbon dioxide (CO_2) and key criteria air pollutants (NOx and SO_2); although the analysis of electric sector greenhouse gas emissions is presented in the Production Cost Analysis (Volume V) since it is a direct output of the production cost simulations.

Environmental Study Process as Downstream from Sector Modeling. Table 1-1 illustrates the various inputs to the environmental study as they are derived from the wider SB 350 study process.

Table 1-1. Sector Modeling as Input to Environmental Study

Key Inputs	2020 Current Practice	2020 CAISO + PAC	2030 Current Practice Scenario 1	2030 Regional 2	2030 Regional 3
Renewable Portfolios ■ Incremental MW buildout for California by 2030	Already contracted	No change from 2020 CP	Portfolio 1 Incremental Buildout by 2030	Compare Buildout of Portfolio 2 to Current Practice 1	Compare Buildout of Portfolio 3 to Current Practice 1
Production Cost Simulations ■ Dispatch of generation in 2020 and 2030 ■ MWh, Unit starts ■ WECC-Wide emissions	2020 Environmental Baseline	Difference in 2020 CAISO + PAC relative to CP	2030 Environmental Baseline	Difference in 2030 Regional 2 relative to Current Practice 1	Difference in 2030 Regional 3 relative to Current Practice 1
Major Out-of-State Transmission Additions for California RPS	None	No change from 2020 CP	2030 Future Buildout	No change from 2030 Current Practice 1	Incremental transmission to deliver from Wyoming, New Mexico
Renewables Beyond RPS, Out-of-State	None	No change from 2020 CP	None	5,000 MW added	5,000 MW added

1.3 Environmental Study Approach

The geographic scope of the environmental study is set by SB 350 to include "environmental impacts in California and elsewhere," and for this environmental study, we take "elsewhere" to mean the area of the Western Interconnection. Within this extremely broad and environmentally diverse region, this study aims to narrow the focus to key zones or areas where possible.

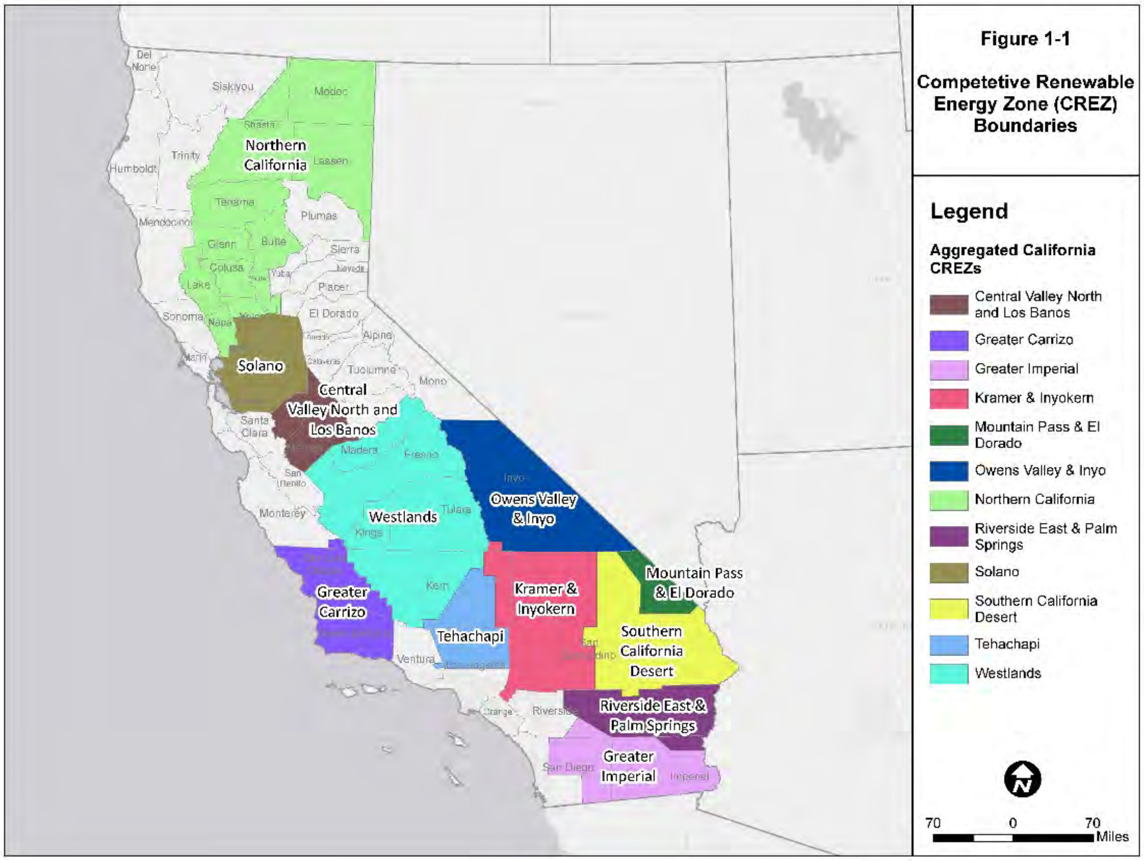
The environmental study process requires defining geographic areas to focus the analysis to areas that could reasonably accommodate the new buildout, establishing an understanding of the baseline conditions, and analyzing the potential environmental effects of regionalization including the renewable buildouts. The three steps used in the approach are described further as follows.

Step 1: Define Renewable Resource Study Areas

The environmental study authors have defined physical boundaries of "study areas" in order to limit the impact analysis presented in this study (as described in detail in Section 3). The areas represent the geographic areas that could reasonably supply the range of resources selected in the portfolios from RESOLVE. The analysis considers and identifies more than 20 study area locations across California and the rest of the west for new renewable resources, as selected by RESOLVE for the incremental buildout by 2030. The geographic scope for the buildout includes approximately 12 different CREZs in California, and renewable energy resources in the Southwest (Arizona), the Northwest (Oregon or Washington), Utah, Wyoming, and New Mexico.

The CREZ boundaries for California's renewable energy resources within the scope of the RESOLVE model and this environmental study are shown in Figure 1-1.

Figure 1-1. Competitive Renewable Energy Zone (CREZ) Boundaries



Step 2: Describe Baseline Conditions

For each environmental discipline, each renewable resource study area has been assessed to determine its existing natural resources and conditions. These conditions help define the potential level of concern or conflict for various environmental factors. The baseline conditions are quantified or categorized for relative sensitivity, where possible and where impaired conditions are known to occur. This allows the study to focus on specific sensitive environmental resources or locations of concern for each environmental topic.

Step 3: Analyze Potential Impacts of Regionalization

The environmental analysis considers regionalization including each renewable buildout as a potential expansion of today's infrastructure, which is projected to achieve the 33% RPS by 2020. The activities necessary to construct, install, and operate the different buildouts between 2020 and 2030 are described briefly in Section 2. However, the focus of this environmental study is to highlight the potential environmental differences that result from implementation of the “current practice” or Scenario 1 and potential “regionalization” scenarios.

This means that this study focuses on the changes between regionalization scenarios and the different portfolios to the extent that they would have different physical effects on the environment. Because the various portfolios rely on construction of generators in different locations and using different generation resources, the study identifies how regionalization changes the renewable buildout such that it would place or avoid development in locations known to be environmentally sensitive. Adverse effects may occur where the potential for collocation of the buildout and environmentally sensitive locations is highest.

New transmission outside of California is presented separately for the Regional 3 scenario. The environmental impacts of potential major transmission additions for California to achieve the 50% RPS are summarized (in Section 5) based on a review of several proposed transmission projects that have been the subject of previous environmental analysis by siting authorities and are similar to the transmission facilities that would be needed to implement the portfolio of the Regional 3 scenario.

2. Summary of Scenarios

2.1 Current Practice and Regional ISO Scenarios in 2020

The near-term 2020 scenarios include no incremental buildout of renewable energy beyond what is already planned to meet California's 33% RPS by 2020. Accordingly, limited regionalization in 2020 involves no incremental renewable energy development. There would be no incremental construction activities and no construction-related impacts to the environment. The limited regionalization in the 2020 scenario (CAISO + PAC) would cause changes in the operation of the existing system of generation.

2.2 Incremental Buildout by 2030

The scenarios for regionalization in 2030 include the following assumptions carried forward into the environmental analysis:

- No additional major transmission inside California would be needed to interconnect the incremental 50% RPS renewable energy buildout inside California.
- Incremental additions include geothermal (500 MW) and energy storage (at least 500 MW), which are common to all 2030 scenarios in California.
- Regional scenarios include renewable development beyond RPS facilitated by regional market (5,000 MW of wind) distributed as 3,000 MW in Wyoming and 2,000 MW in New Mexico. It is assumed that no additional transmission would be needed to facilitate these renewables beyond RPS. The environmental effects related to construction activities for these renewables are not considered in the analysis.
- Regional 3 includes additional transmission for California to access and integrate new wind resources in Wyoming and New Mexico.

The environmental analysis of 2030 scenarios starts by presuming construction of the renewable portfolios defined with the RESOLVE model. Where the RESOLVE model selects Renewable Energy Certificates (RECs) for procurement, this environmental study presumes incremental construction would occur. The incremental renewable buildout between 2020 and 2030 is presented in Table 2-1 for inside and outside California. Notable differences between the scenarios are described in subsequent text.

Table 2-1. Incremental Renewable Buildout for California by 2030 (MW)

Portfolio Composition	Current Practice Scenario 1	Regional 2	Regional 3
California Solar	7,601	7,804	3,440
California Wind	3,000	1,900	1,900
California Geothermal	500	500	500
Out-of-State Solar	1,000	1,500	1,500
Out-of-State Wind	4,551	3,666	6,194
Total California New Capacity	11,101	10,204	5,840
Total Out-of-State New Capacity	5,551	5,166	7,694
Total New Renewable Capacity	16,652	15,370	13,534
Major Out-of-State Transmission Additions for California RPS?	No	No	Yes
Renewables Beyond RPS, Out of State	No	5,000	5,000

Source: Results from the RESOLVE model; adding renewable development beyond RPS facilitated by regional market.

Notes:
- All portfolios also include energy storage (batteries and/or pumped hydro);
- Incremental California geothermal located in Greater Imperial.

Incremental Buildout Inside California

The renewable portfolios as developed through the RESOLVE model reflect MW of renewable buildout by CREZ and technology for the entire state of California including both CAISO and non-CAISO utilities. The buildout for solar is presented in Table 2-2 and for wind is presented in Table 2-3.

Table 2-2. California Solar, Incremental Buildout Details (MW)

California Solar Portfolio	Current Practice Scenario 1	Regional 2	Regional 3
Greater Carrizo Solar	570	570	0
Greater Imperial Solar	923	923	512
Kramer and Inyokern Solar	375	375	375
Owens Valley Solar	578	578	305
Riverside East and Palm Springs Solar	331	1,984	0
Tehachapi Solar	2,500	2,500	1,761
Westlands Solar	2,323	873	486
Total California New Solar Capacity	7,601	7,804	3,440

Source: Results from the RESOLVE model.

Table 2-3. California Wind, Incremental Buildout Details (MW)

California Wind Portfolio	Current Practice Scenario 1	Regional 2	Regional 3
Central Valley North and Los Banos Wind	150	150	150
Greater Carrizo Wind	500	500	500
Greater Imperial Wind	400	400	400
Riverside East and Palm Springs Wind	500	0	0
Solano Wind	600	0	0
Tehachapi Wind	850	850	850
Total California New Wind Capacity	3,000	1,900	1,900

Source: Results from the RESOLVE model.

Current Practice (Scenario 1) emphasizes solar in Tehachapi, Westlands, and Imperial and distributes wind across six resource areas (3,000 MW), emphasizing Tehachapi and Solano. The Regional 2 buildout emphasizes solar in Riverside East & Palm Springs, Tehachapi, and Imperial and distributes wind across four resource areas (1,900 MW); there would be no incremental wind in the Riverside East and Solano CREZs. The Regional 3 buildout distributes solar across five resource areas with no incremental solar in Greater Carrizo and Riverside East; it also distributes wind across four resource areas (1,900 MW) and eliminates incremental wind in the Riverside East and Solano CREZs.

Incremental Buildout Out of State

The renewable portfolios also include the MW of renewable buildout outside California. The buildout for solar and wind is presented in Table 2-4.

Table 2-4. Out-of-State Solar and Wind, Incremental Buildout Details (MW)

Out-of-State Portfolio for California	Current Practice Scenario 1	Regional 2	Regional 3
Southwest Solar (Arizona)	1,000	1,500	1,500
Northwest Wind (Oregon)	2,447	1,562	318
Utah Wind	604	604	420
Wyoming Wind	500	500	2,495
New Mexico Wind	1,000	1,000	2,962
Total Out-of-State New Capacity	5,551	5,166	7,694
Major Out-of-State Transmission Additions for California RPS?	No	No	Yes
Renewables Beyond RPS, Out-of-State	No	5,000	5,000

Source: Results from the RESOLVE model; adding renewable development beyond RPS facilitated by regional market.

Outside of California, Current Practice (Scenario 1) emphasizes Northwest wind and uses existing transmission for Southwest solar and wind in Utah, Wyoming, and New Mexico. The Regional 2 buildout increases solar development in the Southwest and decreases Northwest wind. It uses existing transmission for Southwest solar and wind in Northwest, Utah, Wyoming, and New Mexico. The Regional 3 buildout has the greatest level of out-of-state resources overall emphasizing wind in Wyoming and New Mexico. It includes additional transmission for California to access this wind. Both regional scenarios create a market that facilitates renewable energy development beyond RPS (5,000 MW wind) distributed in Wyoming and New Mexico.

Differences between the Buildouts for 2030

The environmental analysis focuses on the environmental effects of regionalization rather than the effects of building out the portfolios themselves. Therefore, the relative construction-related environmental effects of the scenarios depend on the differences between the renewable buildout rather than the totals. These differences are presented in Table 2-5 for solar buildout in California, Table 2-6 for wind buildout in California, and Table 2-7 for renewable buildout out of state.

Table 2-5. California Solar, Differences Between Scenarios (MW)

California Solar Portfolio	Regional 2 minus Current Practice Scenario 1	Regional 3 minus Current Practice Scenario 1
Greater Carrizo Solar	0	–570
Greater Imperial Solar	0	–411
Kramer and Inyokern Solar	0	0
Owens Valley Solar	0	–273
Riverside East and Palm Springs Solar	1,653	–331
Tehachapi Solar	0	–739
Westlands Solar	–1,450	–1,837
Difference in California New Solar	203	–4,161

Source: Results from the RESOLVE model.

Table 2-6. California Wind, Differences Between Scenarios (MW)

California Wind Portfolio	Regional 2 minus Current Practice Scenario 1	Regional 3 minus Current Practice Scenario 1
Central Valley North and Los Banos Wind	0	0
Greater Carrizo Wind	0	0
Greater Imperial Wind	0	0
Riverside East and Palm Springs Wind	–500	–500
Solano Wind	–600	–600
Tehachapi Wind	0	0
Difference in California New Wind	–1,100	–1,100

Source: Results from the RESOLVE model.

Table 2-7. Out-of-State Solar and Wind, Differences Between Scenarios (MW)

Out-of-State Portfolio for California	Regional 2 minus Current Practice Scenario 1	Regional 3 minus Current Practice Scenario 1
Southwest Solar (Arizona)	500	500
Northwest Wind (Oregon)	–885	–2,129
Utah Wind	0	–184
Wyoming Wind	0	1,995
New Mexico Wind	0	1,962
Difference Out-of-State	–385	2,143
Major Out-of-State Transmission Additions for California RPS?	No	Yes
Renewables Beyond RPS, Out-of-State	5,000	5,000

Source: Results from the RESOLVE model; adding renewable development beyond RPS facilitated by regional market.

Major Out-of-State Transmission Additions for Regional 3

One regionalization scenario (Regional 3) adds incremental new transmission to access and integrate out-of-state resources to satisfy California's 50% RPS goals. To assess the environmental impacts of the new transmission, this environmental study describes the physical features and potential locations of representative transmission projects that could carry the Wyoming and New Mexico generation to the regional load. The projects that are analyzed in this environmental study were chosen for convenience as a significant amount of public information regarding potential impacts and costs is available. These projects are intended to merely represent a transmission solution that would be included with the Regional 3 scenario. The choice of the projects used in this analysis is for the sole purpose of assessing the benefits of a regional market over a range of plausible scenarios. This study is not promoting or advocating for a particular project.

The relevant transmission line proposals that are pending review or under review by siting authorities are listed in Table 2-8. The environmental impacts of these proposals are summarized in Section 5.

Table 2-8. Major Out-of-State Potential Transmission

Project	Voltage/ Configuration	Length	Permitting Status
PacifiCorp Gateway West (Segment D: Windstar to Populus Substation) for access to Wyoming wind at Hemingway in Idaho	230, 345 & 500 kV (1,500 MW capacity)	488 miles	BLM issued Record of Decision (ROD) on 11/14/13, except deferred decision in southwestern Idaho to perform additional environmental analysis of Morley Nelson Snake River Birds of Prey Conservation Area. Targeted online in 2019-2024.
PacifiCorp Energy Gateway South (Segment F) for access to Wyoming wind at Clover Substation in Mona, Utah	500 kV HVAC	~400 miles	BLM issued Draft EIS in February 2014 and announced Agency Preferred Alternative in December 2014, stating that it was moving forward with its analysis in the Final EIS. Targeted online in 2020-2024.
Anschutz Corporation TransWest Express for access to Wyoming wind at southern Nevada	600 kV HVDC (~3,000 MW capacity)	730 miles	BLM and Western Area Power Administration published Final EIS on 5/1/15.
Duke-American Transmission Company Zephyr Power for access to Wyoming wind at compressor air energy storage facility near Delta, Utah	500 kV HVDC (~2,100 to 3,000 MW capacity)	~500 to 800 miles (525 miles to energy storage, plus 490 miles of existing transmission to Los Angeles area)	Preliminary routing and pre-NEPA work by applicant. Applicant may submit a proposal to the Southern California Public Power Authority to supply the Los Angeles area with renewable energy and electricity storage. Targeted online by 2023.
SunZia Southwest Transmission Project for access to New Mexico wind from SunZia East to Pinal Central in Arizona	Two single-circuit 500 kV HVAC lines; or One single-circuit 500 kV HVAC and one single-circuit 500 kV HVDC line (~3,000 to 4,500 MW capacity)	515 miles	BLM issued ROD on 1/23/15. Targeted online by 2021.
Western Spirit Clean Line for access to New Mexico wind at northern Arizona	345 kV HVAC (~1,500 MW capacity)	~140 to 200 miles	Preferred and alternative routes being identified by Clean Line Energy Partners, LLC, and the New Mexico Renewable Energy Transmission Authority based on stakeholder input.

Source: BLM, 2014; BLM, 2013; BLM and USFS, 2013; BLM and Western, 2015; Clean Line Energy, 2013; DATC, 2014; Linares, 2015.

3. Renewable Resource Study Areas

This section describes the assumptions regarding the physical features of the portfolios and how the portfolios are treated by the environmental study. The primary effort is to define “study areas” or proxy locations for each renewable energy resource type within the incremental buildouts.

The purpose of defining study areas is to allow a focused look at the potential environmental effects of the buildouts. This study separately considers:

- In-State Renewable Resources (see Appendix 1)
- Out-of-State Renewable Resources (see Appendix 2)

It is important to note that despite use of study areas to allow focusing of the impact analysis, this environmental study is not site-specific, and it does not reflect or represent a siting study for any particular planned or conceptual construction project. Siting decisions are not made by the ISO. The boundaries of study areas are representative and are intended to include land areas large enough to accommodate the build-out of each plausible portfolio. The boundaries are tailored to avoid “no go” areas and to reflect location-specific constraints and previous planning processes, where known. The geographic definitions of the study areas are not binding or reflective of any specific generation proposals.

Additionally, California’s renewable energy goals may be achieved by following many different paths. The SB 350 study presents plausible portfolios as possible renewable energy buildouts to demonstrate the impact of regionalization, but any future or actual buildout may or may not resemble these portfolios.

3.1 Defining Boundaries for Study Areas

This study uses physical boundaries to define study areas that represent geographic locations that could reasonably supply the resources that are selected by the RESOLVE model for the incremental buildout by 2030 for this SB 350 study.

3.1.1 Portfolios Output

Each portfolio from RESOLVE draws renewable energy resources for California and elsewhere from a range of locations and across a range of generation technologies. Portfolios represent different potential buildouts that may be completed before 2030 for California to achieve the 50% Renewable Portfolio Standard (RPS).

In California, RESOLVE builds the portfolios with a locational specificity within individual competitive renewable energy zones (CREZs). The geographic scope of the portfolios within California and the CREZ boundaries appear in Figure 1-1.

The term “CREZ” comes from the Renewable Energy Transmission Initiative (RETI) process, as originally presented in 2008, and the term remains in use by California’s energy agencies. However, the boundaries of CREZs have changed over time as the scope and breadth of California’s renewable energy planning efforts have changed and as developers have built capacity. In general, CREZs define boundaries of areas within which renewable resources and development potential is expected to be somewhat similar. CREZs have been defined for areas where renewable development is generally not prohibited and where generation resources exist. The RESOLVE model builds portfolios in terms of the Aggregated CREZ, which is a more coarsely-defined geographic area than the original CREZs. An

Aggregated CREZ may span multiple counties or substantial portions of counties. This environmental study uses the terms Aggregated CREZ and CREZ interchangeably.

For out-of-state resources available across the U.S. portion of the Western Interconnection, the RESOLVE model builds portfolios with a locational specificity in terms of the highest-quality wind or solar resources predominately based on availability and capacity factor, and relatively near transmission within the particular state.

Some stakeholders expressed a concern that portfolios may include "overbuilding" California resources. This concern is addressed in Volume IV (Renewable Energy Portfolio Analysis), which indicates that the RESOLVE model may produce renewable energy portfolios that include some overbuilding as necessary to overcome curtailed energy loss and still produce enough to meet the RPS target. This environmental study considers the buildout for each scenario as it is derived from the portfolio modeling effort. Accordingly, the impacts of overbuilding renewable capacity are included in the environmental study of each buildout.

3.2.2 Study Area Boundaries

The analysis started with definition of "study areas" within the larger regions drawn upon by RESOLVE. The study areas serve as proxy locations to focus the environmental review. At least one study area has been defined for each generation technology type per CREZ or resource zone selected by the portfolio analysis, in Volume IV (Renewable Energy Portfolio Analysis). These study areas are used to characterize the environmental setting and potential indicators of impacts within and adjacent to the study area boundaries.

Most study areas align with areas where siting generation has been historically successful, or within larger regions previously defined or considered viable for future siting. Boundaries of each study area have been tailored for this study so that the areas largely avoid areas of high environmental conflict and areas with greater development risk, because this environmental study need not consider the effects of developing in areas where siting of generation facilities is unlikely or not permitted.

Inside California, the starting point for definition of study areas was the CPUC's RPS Calculator solar and wind potential areas as posted on DataBasin.[1] The RPS Calculator contains generic proxy polygons representing the best solar and wind resource areas for the state of California. The RPS wind potential areas were updated to eliminate any areas that are not currently available to wind development due to local or regional zoning or other planning restrictions. Within the RPS solar potential areas, study areas focused where solar projects would be technically viable (i.e., the slope and the insolation were adequate). Because the RPS Calculator solar potential areas are finely drawn, these areas were aggregated into larger, more uniform areas. The solar study areas were also defined to eliminate areas defined as incompatible with solar by existing renewable energy planning documents. The study areas were drawn to be of sufficient size and shape to provide flexibility for location of resources selected by RESOLVE. They also included diverse areas whenever possible to provide for a more comprehensive look at potential environmental effects of the portfolio buildout. Additional details on the methodology used in selecting the study area boundaries in California is presented in Appendix 1 to this environmental study.

Outside of California, the treatment of the study areas began with a review of the renewable resources as identified by the National Renewable Energy Laboratory. After identifying available resources, the

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[1] CPUC RPS Calculator solar and wind potential areas can be found at: https://databasin.org/datasets/c4ddcb27f7d74e68b7dcdb19cc8dfe02 and https://databasin.org/datasets/64b8dab6dad34680baa6355851e1d9e0.

team identified study areas based on a review of existing operating projects, previous energy planning documents, proposed transmission interconnection options, and land availability. The areas were then tailored to avoid areas of high environmental impact and development risk. The treatment of each state's resource areas varied depending on information available. For example, in Utah, state-defined renewable energy zones were used, and in New Mexico large areas with good wind resources were identified based on locations of potential transmission projects. The methodology for selecting the study area boundaries for each state is presented in Appendix 2 to this environmental study.

Again, the treatment of portfolio components and the study areas in the environmental study recognizes that siting decisions are not made by the ISO, and that the geographic definitions of the study areas are not binding or reflective of any specific generation proposals. The study areas are merely plausible siting options selected solely for the purpose of this regional impact study.

3.2.3 Capturing Earlier Foundational Studies

The boundaries of the study areas have been drawn to incorporate results of previous regional and foundational studies, including the Desert Renewable Energy Conservation Plan (DRECP), County-level, and WECC efforts to identify the locations where siting could be expected to avoid or minimize environmental land use conflicts. The buildouts are assumed to generally adhere to these previously-documented zones and the mitigation practices defined in earlier studies, or enforced by siting authorities that have historically reviewed specific development proposals.

These previous and foundational studies include:

- Programmatic Environmental Impact Statement (EIS) for Solar Energy Development in Six Southwestern States (BLM, 2012)
- Draft DRECP and EIR/EIS (CEC [California Energy Commission], BLM, CDFW, USFWS 2014) and BLM Proposed LUPA and Final EIS (BLM, 2015)
- Renewable Energy Transmission Initiative (and RETI 2.0, ongoing)
- Solar and the San Joaquin Valley: Identification of Least Conflict Lands
- WECC Environmental Data Task Force data sets
- County renewable energy plans and ordinances
- Utah Renewable Energy Zones Task Force

Information on typical environmental impacts from renewable energy development and presented throughout this study was obtained from several sources, including:

- Programmatic EIS for Solar Energy Development in Six Southwestern States (BLM, 2012)
- Programmatic EIS on Wind Energy Development on BLM-Administered Lands in the Western United States (BLM, 2005)
- Programmatic EIS for Geothermal Leasing in the Western United States (BLM, 2008)
- Geothermal Power Plants – Minimizing Land Use and Impact (DOE, 2016)
- Draft DRECP and EIR/EIS (CEC [California Energy Commission], BLM, CDFW, USFWS 2014) and BLM Proposed LUPA and Final EIS (BLM, 2015)

3.2 Acreage Required by Buildouts

The limited regionalization of the 2020 CAISO + PAC scenario includes no incremental renewable energy development. No incremental acreage would be required, and no changes to construction-related activity would occur inside or outside of California.

Each 2030 portfolio to expand California's RPS from 33% to 50% requires new solar, wind, geothermal, and other resource development, and this would require land use conversion in each study zone. A portion of this land would have disturbance during construction.

The approximate area of land that would need to be dedicated to buildout of the renewable energy is estimated using acreage conversion factors (acres/MW). This study uses factors from the DRECP, which developed a set of fixed input assumptions regarding renewable energy development in the desert. During the DRECP process, the public was provided an opportunity to comment on acreages per MW for renewable development. The acreage conversion factor for wind falls within the range given in the NREL study, *Land-Use Requirements of Modern Wind Power Plants in the US* (2009). The factor for solar development is similar to those reflected by current trade publications and by the NREL study, *Land-Use Requirements for Solar Power Plants in the US* (2013). These factors were developed through the DRECP process (BLM, 2015) for renewable energy development in the California desert:

- Solar (PV): 7 acres/MW
- Wind: 40 acres/MW; 3 acres/MW of ground disturbance
- Geothermal: 6 acres/MW

Table 3-1 shows the acres required for each buildout under these assumptions.

Table 3-1. Approximate Acres Required for Incremental Buildout by 2030 (acres)

Resource Type	Current Practice Scenario 1	Regional 2	Regional 3	Difference: Regional 2 Relative to Current Practice Scenario 1	Difference: Regional 3 Relative to Current Practice Scenario 1
California Solar	53,200	54,600	24,100	1,400	–29,100
California Wind	120,000	76,000	76,000	–44,000	–44,000
California Geothermal	3,000	3,000	3,000	No change	No change
Out-of-State Solar	7,000	10,500	10,500	3,500	3,500
Out-of-State Wind	182,000	146,600	247,800	–35,400	65,800
Total Acreage in California	176,200	133,600	103,100	–42,600	–73,100
Total Acreage Out-of-State	189,000	157,100	258,300	–31,900	69,300
Major Out-of-State Transmission Additions for California RPS?	No	No	Yes	No change	Added
Renewables Beyond RPS, Out of State	No	200,000	200,000	200,000	200,000

Notes:
Solar acreage shown for site control and potential ground disturbance.
Wind acreage shown for site control; ground disturbance is less than 10% of acreage.
Common to all 2030 scenarios in California: Geothermal (500 MW); energy storage (min. 500 MW)
Regional scenarios include renewable development beyond RPS facilitated by regional market (5,000 MW wind) distributed in WY and NM.

To achieve the buildout capacity under Current Practice Scenario 1, approximately 176,200 acres in California and 189,000 acres outside of California are the total land and acreage required (Table 3-1). Less renewable generation capacity would have to be built with regionalization. This is because regionalization shifts development towards relatively higher-performing and lower-cost out-of-state resources. With renewables being better integrated into the system, the investments to satisfy the RPS would be more efficient; this tends to reduce the overall land use and acreage required.

Both scenarios of regionalization reduce the amount of land in California for wind (–44,000 acres), and scenario Regional 2 achieves the lowest amount of out-of-state acreage for wind (–35,400 acres for wind outside California compared with Current Practice Scenario 1). While Regional 3 involves a larger footprint of out-of-state acreage for wind (+65,800 acres compared with Current Practice Scenario 1), and the additional land devoted to out-of-state transmission right-of-way, only a modest portion of the acreage, usually less than 10 % would be disturbed by the access roads and foundations needed for installing the wind capacity. The remainder of the land within a typical wind site would remain undisturbed and available for other uses. Overall, with regionalization the land use and acreage required decreases in California by 42,600 acres in the Regional 2 scenario and by 73,100 acres in the Regional 3 scenario. Outside of California, a tradeoff between regional scenarios is more apparent; land use and acreage decreases by 31,900 acres in Regional 2 and increases by at least 69,300 acres in Regional 3 due to the emphasis on out-of-state wind in Regional 3.

4. Environmental Analysis by Discipline

This section presents discussions of impacts for land use, biological resources, water, and air emissions. Separately, Section 5 presents the impacts of out-of-state transmission that may be required for the Regional 3 scenario.

4.1 Land Use

This section describes potential land use impacts for the incremental renewable energy buildouts and the potential land use impacts of regionalization as compared with the current practice. The approach to the analysis relies upon a narrow set of baseline conditions that are treated as potential indicators or predictors of impacts, as listed in Table 4.1-1.

Table 4.1-1. Baseline Conditions and Indicators of Impacts, Land Use

Baseline condition of a study area	How are scenarios analyzed relative to the baseline?	Potential indicator of land use impact
Land Use		
Population density	Coincidence of incremental renewable energy buildout with areas of high population density	Land use compatibility
Existing land uses	Coincidence of incremental renewable energy buildout with areas of high-value agricultural uses	Land use compatibility
Proximity to excluded or protected land uses	Proximity of incremental renewable energy buildout to lands with excluded or protected uses, including natural or recreational areas and military installations	Land use compatibility and visual resources

Assumptions and Methodology for Land Use Analysis

This analysis reviews the relative compatibility of renewable energy development in light of existing land uses in the different study areas and the acreage required by the buildouts (Section 3), and then compares the scenarios. Population density, existing land uses, and proximity to protected lands are used to identify whether the renewable energy buildouts in a given study area may create a low, medium, or high degree of land use conflict.

The topic of cultural resources is addressed within this land use analysis; however, this study does not include an analysis of potential impacts to cultural resources. Establishing a definitive level of risk for impacts to cultural resources requires spatial datasets or area surveys for each area, and an analysis of data gaps, which are unavailable at the scale of this study.

Land Use Conversion and Incompatibilities

Population Density. It is assumed that a large-scale renewable energy development would be located on land that is vacant or largely undeveloped land, such as agricultural or open land. Open land may be previously disturbed. Development locations may include brownfield sites, where previous practices limit the development options. The study area boundaries exclude some areas to ensure that potential land use conflicts are not overstated; however, such conflicts can still occur within the study areas, and the potential for them to occur varies between study areas.

Population density indicates the number of people in a given geographic area, and population density is used as an indicator of relatively open or unoccupied lands. Higher density (greater number of persons per square mile or per acre) suggest that an area has less vacant or open land and a greater number of potentially affected people, while lower densities suggest the opposite. Density data were from 2012 (ArcGIS 2016). To characterize population density data, a density of 3.2 persons per square mile is equal to 1 person per 200 acres; 32 persons per square mile is equal to 1 person per 20 acres; and 640 persons per square mile is equal to a density of 1 person per acre. U.S. Census data apply uniformly across a census tract, however, population is not uniformly distributed across an area. Therefore, there are always areas within a census tract where the population is higher than the tract-wide average and areas where the density is lower than the average.

A low number of residents in an area indicates two things: there is likely to be more vacant or open land; and there are relatively fewer people to be potentially affected by development. Census tracts wholly or partially within a study area were identified and the population density per square mile of the tracts was determined using U.S. Census data. Three density ranges were identified to indicate a low, medium, or high potential for conflict. The ranges were based on persons per square mile, with density thresholds set at 5 persons or less (low), between 5 and 15 persons (medium), and more than 15 (high). To be able to qualitatively describe other potential population-related concerns, population centers in and near the study areas were identified based on visual inspection of online satellite photos and maps.

Existing Land Uses. The existing uses of land within the study areas were qualitatively assessed by examining satellite photos, to generally characterize if the land within a study area is substantially built out or is primarily open space (vacant or in agriculture). It is possible that brownfield areas exist within study areas and could be suitable sites for renewable projects, but this was not quantified or determined in the analysis of satellite photos.

The presence of active agriculture is a consideration because while it creates large areas with fewer biological concerns, it has become a land use type that may be attractive to large scale renewable energy development. In many areas where renewable energy facilities may locate, agriculture use could be absent, inactive, or could occur at a low intensity; common low-intensity uses include rangeland or land used for hay production. Other areas may have high-value crops, including agricultural uses that is actively irrigated. The agricultural uses of the study areas were determined by inspecting Google Earth aerial photography.

If an area is in agricultural use, this study considers whether the agricultural use is intensive (such as in orchards or cropland) or not intensive (such as pasture or rangeland). Rangeland is more likely to be compatible with the buildout than more intensively used agricultural areas. Rangeland generally creates a low degree of land use conflict (but has potential for greater impacts on biological resources), while more intensively use agricultural lands are likely to create a medium degree of conflict or incompatibility. Areas that are not agricultural but built-upon with urban/suburban development are likely to be incompatible with large-scale renewable generation.

Proximity to Excluded or Protected Areas. Excluded or protected land uses include areas valued for their natural or scenic conditions or for their particular uses or characteristics that may require isolation or separation from other uses. Protected land uses that occur in proximity to a study area are considered in two ways. Visual impacts are considered because renewable energy development, particularly wind development, may be visible over long distances. Energy facilities developed in proximity to protected land uses (e.g., wilderness areas, national and state parks, historic trails, scenic highways) may be visible from high-value natural or scenic areas, altering the view and adversely affecting a visitor's experience. Protected land uses were identified using mapped data from multiple BLM State Offices, the USFWS, and the USGS (BLM 2016a, BLM 2016b, BLM2014a, BLM2014b, BLM2013, BLM 2012b, USFWS 2016, USGS 2012).

Areas defined here as "excluded" include those where development would be prohibited because of existing functions and activities that may be adversely affected by the proximity of the renewable energy facility (e.g., military bases, ranges, and training areas).

Excluded and protected lands were identified and mapped to determine if they were within or near the renewable resource study areas. In areas protected because of their natural or scenic qualities, visitors have an expectation that they will experience undeveloped, natural settings in the protected area itself and that the views from these lands to nearby unprotected lands will not include substantial development. For military bases, ranges, test areas, and similar uses, the presence of certain types of development could pose safety risks or potentially interfere with operations.

With regard to visual impacts, the visual dominance of development within the landscape diminishes over distance, owing to naturally occurring haze (water vapor and dust) and the perceived muting of colors and shapes with increasing distance between the object and the viewer. Those study areas (or parts of study areas) that are less than 5 miles from a protected land use present a higher potential to create either visual or operational impact. Study areas located between 5 and 10 miles from a protected land use are likely to be at medium potential of impact. Study areas at distances greater than 10 miles have a low likelihood of impact. In practice, other factors and conditions in the landscape may reduce these visual effects. Examples of mitigating conditions include the nature of the protected land use itself, intervening topography, the number and locations of visitors, and the protected land use's elevation and orientation relative to the study area.

Cultural Resources and Tribal Concerns

This study considered a range of possible approaches to studying the effects of regionalization on cultural resources. Establishing a definitive level of risk for impacts to cultural resources requires spatial datasets for each area or area surveys, and an analysis of data gaps, which are unavailable at the scale of this study. Therefore, the environmental study does not include an analysis of potential impacts to cultural resources or tribal concerns.

Study of potential impacts to cultural resources depends on availability of spatial datasets. The following are necessary for least-impact and cost efficient infrastructure planning:

- Spatial data related to tribal places of importance.
- Archaeological site data, including previously recorded prehistoric and historic resources.
- Locations of Districts and Landscapes listed in National and State Registers of Historic Places.
- Prehistoric bio-habitat, hydrology, and soils spatial data, critical to building site sensitivity models that can predict areas of low/medium/high risk for impacts.

All of the renewable resource study areas may be assumed to have moderate to high risk for archaeological and tribal resources. Additional planning considerations include:

- Densities of archaeological data vary across geographical areas.
- Some areas may not have been surveyed, and therefore generalization across those areas may yield an inaccurate understanding of risk.
- Analysis of data gaps is critical to the identification of feasible and efficient methods of gathering new data and/or predicting hypothetical data for modeling.
- Levels of tribal and public interest and/or concern are variable; 1-meter wide site can generate as much interest as a 1-mile long site.

- Interest may also reflect subjective and qualitative factors that are difficult to predict in the absence of focused cultural and tribal studies.

4.1.1 Regulatory Framework

Individual renewable energy facilities may be located wholly on land under a single jurisdiction or may be sited on land under multiple jurisdictions. If on lands under separate jurisdictions, the regulations administered by or applicable to the separate individual agencies having land use authority would apply to the portions of the development falling within their jurisdiction.

Federal Land Use Controls

At the federal level, land-use oriented regulations apply on lands under federal agency jurisdiction, including Bureau of Land Management and Forest Service lands. Typically, an existing land use plan would guide facility siting, or may require amendment to allow a proposed facility. Complementing federal land use regulations and plans are regulations relating to the protection of specific resources. These laws influence how and where a development may be located and operated, and what special requirements may be imposed based on site conditions. Examples of laws and regulations that apply to land use on federal lands include:

- The National Environmental Policy Act of 1969
- The Federal Land Policy and Management Act
- California Desert Protection Act
- Omnibus Public Land Management Act
- Wild and Scenic Rivers Act
- National Trails System Act
- The Bureau of Land Management (BLM) Manual 6320
- Energy Policy Act of 2005
- Executive Orders 13212, 13514, 3285, and 3285A1
- BLM Solar Energy Development Policy

Examples of resource-oriented federal acts that apply nationwide, and not just on federal lands, include:

- The Federal Endangered Species Act
- The Migratory Bird Treaty Act
- The Bald and Golden Eagle Protection Act of 1940, as amended
- The National Historic Preservation Act

State Land Use Controls and Siting Authorities

Each state has laws and regulations pertaining to land use and development. Generally, most land use decisions are made at the local level by county or municipal governments. Approvals may be required at the state level, at the local level, or both. The body having jurisdiction may vary depending on the size and type of facility, with facilities using particular technologies or being below a particular size threshold considered locally, while other technologies and larger facilities are considered at the state level, or through a combination of state and local decision making. As with federal resource protection regulations, states also have specific resource protection laws that affect the siting and operation of facilities.

Siting authority for renewable energy may be shared by various levels of government. In California, for example, thermal power plants of 50 MW or greater in capacity (including solar thermal and geothermal) are in the jurisdiction of the California Energy Commission (CEC); transmission additions by investor-owned utilities are subject to review by the California Public Utilities Commission (CPUC). Non-thermal solar (photovoltaic) and all wind energy development normally undergo review based on the land jurisdiction: locally at the county or municipal level for private land, or by BLM for its land.

Local Jurisdictions

If not preempted by state or federal authority, local regulations may affect whether and how renewable energy development occurs. Conditional use permits under local zoning, property line setback requirement and noise level restrictions, and similar regulations and ordinances are examples of requirements that may apply.

4.1.2 Baseline Conditions in Study Areas

This section presents the baseline land use conditions of the study areas in the order of the renewable energy resource types, as follows:

- Inside California Solar
- Inside California Wind
- Inside California Geothermal
- Out-of-State Solar
- Out-of-State Wind

These baseline conditions are summarized in Table 4.1-2 for solar areas and Table 4.1-3 for wind areas.

Table 4.1-2. Baseline Land Use for Solar Study Areas

Solar Study Area	Population Density *(Potential for Conflict)*	Agriculture Activity *(Potential to Result in Land Use Conversion)*	Proximity to Excluded or Protected Areas *(Potential Incompatibilities)*
Greater Carrizo	Low/Medium	Moderate	Medium
Greater Imperial	Low	Moderate	High
Kramer & Inyokern	Low	Moderate	High
Owens Valley and Inyo	Low	Low	High
Riverside East & Palm Springs	Medium/High	Moderate	High
Tehachapi	Medium	Low	High
Westlands	Medium	Extensive	Medium
Out-of-State Southwest Solar	Low	Low	Low

Table 4.1-3. Baseline Land Use for Wind Study Areas

Wind Study Area	Population Density *(Potential for Conflict)*	Agriculture Activity *(Potential to Result in Land Use Conversion)*	Proximity to Excluded or Protected Areas *(Potential Incompatibilities)*
Central Valley North and Los Banos	Medium	N/A	Low
Greater Carrizo	Medium	N/A	Medium
Greater Imperial	Medium	N/A	High
Riverside East & Palm Springs	Medium/High	N/A	Medium
Solano	High	N/A	High
Tehachapi	Medium	N/A	Medium
Out-of-State Northwest	Low	N/A	Low
Out-of-State Utah	Low	N/A	Low
Out-of-State Wyoming	Low	N/A	Low
Out-of-State New Mexico	Low	N/A	Low

Inside California Solar

Greater Carrizo Solar

The Greater Carrizo solar study area consists of three geographically separate parts. Two are in eastern San Luis Obispo County, in the greater Cholame Valley area of the Temblor Range and in the Carrizo Plain to the south. The third area is in northwestern Santa Barbara County, around Santa Maria and Orcutt.

- The Cholame Valley region consists of a series of valleys and coastal range mountains. A small amount of irrigated agriculture occurs, but most of the land is grassland with some oak woodland. South of this area is the Carrizo Plain, which is bisected by Highway 58 connecting Highway 101 and the San Joaquin Valley. While some irrigated agriculture occurs, most land is rangeland or vacant. Two large solar facilities are already located in the Carrizo Plain area. Most of the two areas have low to medium population density, ranging from 2.8 to 15 persons per square mile.
- The area around Santa Maria and Orcutt includes both developed urban land and extensive irrigated farmland. The central core of the area, along the Highway 101 corridor, is well populated, but east and west of this corridor are extensive agricultural lands, particularly to the east, where the census tract population density is 13.7 persons per square mile.

There are 6 protected land uses in or within 5 miles of the Greater Carrizo solar study area: 2 BLM Areas of Critical Environmental Concern; an Air Force Base; a National Forest; a National Monument; and a Wilderness area.

Greater Imperial Solar

The Greater Imperial Solar study area includes Imperial County and part of San Diego County. In Imperial County the major solar area includes the land east of Salton Sea and extends south to the Mexico border to the eastside of the agricultural land found here. Smaller solar development areas are found to the west of this agricultural area in Imperial County as well. Other portions of this study area are in eastern San Diego County, around Jacumba Hot Springs and Boulevard, Warner Springs, and Borrego Springs, respectively.

- In Imperial County, the solar study areas are largely in desert, outside of the extensive irrigated agricultural land that extends from the Salton Sea south to the Mexico border. These flat lands are either rangeland or vacant, with sparse vegetation. Population density is low, ranging from 0.2 to 5.8 persons per square mile, with most of the area at the low end of the range.
- The three areas in San Diego County are in census tracts with populations densities per square mile of 6.6 persons (Warner Springs area), 4.2 persons (Borrego Springs area), and 16.9 persons (Jacumba Hot Springs/Boulevard area). The Warner Springs area is southeast of Palomar Mountain in rolling terrain that is principally dry rangeland. The Borrego Springs area has a limited area of irrigated agriculture and a moderate density town, Borrego Springs, but most of the area is desert with sparse vegetation. The Jacumba Hot Springs/Boulevard area is along the Mexico Border and extends north past Interstate 8. The land primarily is shrubland and the terrain varies from flat to hilly.

There are 26 protected land uses in or within 5 miles of the Greater Imperial solar study area: 13 BLM Areas of Critical Environmental Concern; 7 military installations or areas; a National Forest; a National Wildlife Refuge; a State Park; and 3 Wilderness areas.

Kramer and Inyokern Solar

The Kramer and Inyokern solar study area consists of four parts: one in Searles Valley near the San Bernardino/Inyo county line, one near Newberry Springs on the north side of Interstate 40, one west of Highway 395 west of Victorville, and one in Lucerne Valley east of Victorville.

- The Searles Valley area is largely vacant flat land with sparse desert vegetation. It is within a census tract having a population density of 1.6 persons per square mile.
- The solar area east of Newberry Springs supports a limited amount of irrigated agriculture, but most of this flat landscape is sparsely vegetated desert. The area is in a census tract with a population is 0.5 persons per square mile.
- The area west of Highway 395 near Victorville is largely a desert landscape with scattered shrub vegetation. Most of the area’s population is in developments near the intersection of Highways 395 and 18. The land to the north and west of the populated area is in a census tract having an overall population density of 29.1 persons per square mile.
- The Lucerne Valley area supports some irrigated agriculture, but much of the area is shrub covered desert, including some playas. The area includes portions of three census tracts having population densities ranging from 2.6 to 71.7 persons per square mile, with nearly half of this solar area in a tract with a density of 11.2 persons per square mile.

There are 23 protected land uses in or within 5 miles of the Kramer and Inyokern solar study area: 14 BLM Areas of Critical Environmental Concern; 3 military installations; 2 National Forests; 2 Research Natural Areas; and 3 Wilderness areas.

Owens Valley Solar

Three of the four Owens Valley solar study area locations are near Highway 395: one at the north end of Inyo County east of Bishop; one south of Lone Pine at Owens Lake; and one farther south in the Dunmovin and Coso Junction vicinity. The fourth area is to the east, on the Nevada border near Pahrump, Nevada.

- The area east of Bishop has limited irrigated agriculture and is mostly shrubby grassland in flat to rolling terrain. The population density in the two census tracts within which the area is located ranges from 4.3 to 8.8 persons per square mile.

- The Owens Lake area is in the former lakebed characterized by shrubland. The area south of Owens Lake (Dunmovin/Coso Junction vicinity) and the area south of Pahrump are flat desert shrubland. These three areas fall within the same census tract, which has a population density of 0.5 persons per square mile.

There are 23 protected land uses in or within 5 miles of the Owens Valley study area: 6 BLM Areas of Critical Environmental Concern; a military installation; a National Forest, and 14 Wilderness areas.

Riverside East and Palm Springs Solar

The Riverside East and Palm Springs solar study area includes two areas in the Palm Springs/Indio vicinity and several locations in the I-10 corridor extending from Desert Center east to Blythe and including the desert area around Blythe. In the Palm Springs/Indio vicinity, one area is primarily north of I-10, between Whitewater and Desert Hot Springs, the other is east and south of Indio in the Coachella Valley.

- The solar area that includes Desert Hot Springs is a mix of open desert and city development. Outside of the main developed part of Desert Hot Springs the desert landscape is divide into large residential parcels and smaller residential properties along widely spaced roads. Numerous energy-related facilities exist in the area, including solar farms, wind farms, transmission lines, and substations. In this solar area, the census tract having most desert has a population density of 83.5 persons per square mile.
- The Coachella Valley solar area is extensively developed over about half the area. The portion of the area on both sides of I-10 is largely desert, and east of Highway 86 is irrigated agriculture. These less developed parts of the solar area have a population density of 0.5 and 115.3 persons per square mile, respectively. The larger value results from the inclusion in the census tract of portions of Coachella and Thermal, as well as farmland.
- The solar areas in Eastern Riverside are in the less developed parts of the desert, with sparse shrub vegetation and little agricultural activity. Several solar facilities have been developed in the area. The population density in this part of Riverside County is 0.5 persons per square mile.

There are 26 protected land uses in or within 5 miles of the Riverside East and Palm Springs solar study area: 10 BLM Areas of Critical Environmental Concern; a National Forest; a National Monument; a National Park; a National Preserve; a State Park; and 11 Wilderness areas.

Tehachapi Solar

The Tehachapi solar study area is east of the Tehachapi Mountains and North of Los Padres National Forest and consists of two geographic areas.

- The larger area is in the desert between the Tehachapi Mountains and Edwards Air Force Base, extending north from about Neenach on Highway 138 to Cantil on Highway 14. There are small communities and rural residences in parts of the area. However, the overall population density is low. The four census tracts that comprise most of the area have densities of 5.6, 7.4, 8.1, and 37.3 persons per square mile.
- The second area is around the City of Lancaster and includes the city and surrounding region, extending south to Palmdale. Much of this area is built up, but large sections in the west and southeast remain open. The grid-based road pattern has a mix of open land, road front residential, and subdivisions that have leapfrogged from the cities. Irrigated agriculture is practiced in portions of the southeast quadrant of the area, where the lowest population density in the area occurs, at 9.8 persons per square mile. In the western portion of the area, several large solar fields have been

developed. In this area, the population density if 567.8 persons per square mile, which contrasts with the tract immediately north of this one that has a density of 48.8 persons per square mile.

There are 13 protected land uses in or within 5 miles of the Tehachapi solar study area: 6 BLM Areas of Critical Environmental Concern; 4 military reservations; a National Forest; and 2 State Parks.

Westlands Solar

The Westlands solar study area covers numerous small land parcels and a few very large parcels throughout southern San Joaquin Valley, from Madera and Fresno Counties south to the Tehachapi Mountains in Kern County. Many individual parcels are in or near populated areas, while others are in sparsely populated agricultural areas. The largest single contiguous area, representing well over half of the total Westlands solar area acreage, is in western Fresno and Kings Counties, east of Interstate 5. High concentrations of heavy metals, salts, and other chemicals in the soils here have adversely affected the quality of water draining from the area, resulting in the need to permanently retire some lands and discontinue irrigation. The population density in the four large census tracts covering much of this contiguous west valley area ranges from 7.1 to 26.1 persons per square mile, with most of the population in crossroad centers, farmsteads, and residences along road frontages.

There are 8 protected land uses in or within 5 miles of the entire Westlands solar study area: 6 BLM Areas of Critical Environmental Concern; a Naval Air Station; and a National Wildlife Refuge.

Inside California Wind

Central Valley North and Los Banos Wind

The Central Valley North and Los Banos wind study area straddles Interstate 5 east of the San Luis Reservoir. Most of the area is west of the Interstate, surrounding the O'Neill Forebay; here the flat to rolling terrain is used for rangeland or hay production. The portion of the area east of the freeway is mostly in irrigated agriculture. Several transmission lines traverse the area and a large solar farm has been developed near the National Cemetery west of the Interstate, and more are planned. The census tract in which nearly all of the area is located has a population density of 6.2 persons per square mile.

There are 4 protected land uses in or within 5 miles of the Central Valley North and Los Banos wind study area: the San Joaquin Valley National Cemetery; 2 State Parks; and a State Recreation Area.

Greater Carrizo Wind

The Greater Carrizo study area for wind includes areas with distinctly different characteristics in San Luis Obispo and Santa Barbara Counties. These areas include:

- The sparsely populated coastal plain and foothills north of San Simeon to about 4 miles south of the county line. The area is in a census tract where the population density is 7.4 persons per square mile and the land is predominately grassland with scattered woodlands in ravines and along drainages. Much of the area is visible for scenic Highway 1 (Cabrillo Highway)
- The coastal hills and mountains east of Atascadero and Santa Margarita, crossed by Highways 229 and 58. This area includes portions of two census tracts, with the population density ranging from 15 to 61 persons per square mile. The area is characterized by widely spaced rural roads and houses, with much of the land covered in oak woodlands and grassland. Views are limited by topography and vegetation.
- The Temblor Range west of the Carrizo Plain, South of Highway 41 and north of Highway 58 near the Kern County border. The area is in two census tracts, with population density ranging from 6 to 15.8

person per square mile. This area is drier than the wind resource areas nearer the coast, and is predominately hilly grassland.

- The coastal mountains east and south of Vandenberg AFB. The wind resource areas here are dispersed across four census tracts having population densities ranging between 14.1 and 60.6 persons per square mile. South of Lompoc to Gaviota, the landscape includes hill and ridge areas on both sides of scenic Highway 1. Inland, the wind resource areas are primarily on grass-covered ridgelines, with much of the intermountain flatlands in row crops and other forms of agriculture.

There are 9 protected land uses in or within 5 miles of the Greater Carrizo wind study area: a BLM Area of Critical Environmental Concern; a military reservation; a National Forest; a National Monument; 2 State parks; and 3 Wilderness Areas.

Greater Imperial Wind

The Greater Imperial wind study area is in four separate parts of eastern San Diego County: a mountainous area west of Holcomb Village and east of Anza-Borrego Desert State Park; a mountainous area south of Warner Springs and east of Highway 79; a mountainous area between Santa Ysabel and Julian; and the Mexico border region between Campo and the Imperial County line, primarily south of Interstate 8.

- The northern area is primarily rolling to steep terrain with dense shrub and tree growth. The flatter areas here are occupied by large-lot homesteads, small agricultural operations, and horse facilities. The area south of Warner Springs varies from flat to steep terrain. The flat lands are primarily rangeland, with the slopes and ridges primarily covered in grass and shrub growth. Trees are found along drainages between ridges. Population density in the census tract where both the northern and Warner Springs areas are located is 5 persons per square mile.
- In the Santa Ysabel and Julian area, flat lands and rolling topography are occupied by low density housing and grasslands, with some agriculture. Slopes and ridges tend to be grassland or mixed woodlands. The area is in two census tracts, with population density ranging from 5 to 43.2 persons per square mile. Based on the distribution of housing in the area, the overall density within the wind area is likely to be at the higher end of the range. Tribal land is not included in this study area.
- The wind area along the Mexican border overlaps to a large degree with the solar area in this area. The flat to rolling topography is covered primarily in shrub growth, with decreasing vegetation moving east toward Imperial County. Flatter and more accessible areas are often large-lot homesteads. The population density in this census tract is 15.9 persons per square mile.

There are 17 protected land uses in or within 5 miles of the Greater Imperial wind study area: 4 BLM Areas of Critical Environmental Concern; 2 military reservations; a National Forest; a National Wildlife Refuge; a Research Natural Area; 2 State Parks; and 6 Wilderness Areas.

Riverside East and Palm Springs Wind

The Riverside East and Palm Springs wind study area includes in two parts. The largest area is north of Thousand Palms, north of Interstate 10. A smaller area is east of Indio.

- The area north of Thousand Palms is mountainous interspersed with flat desert, and supports scattered desert shrub vegetation. Large lot residential properties are found in the flat lands at the northern part of the area. The larger wind area is in two census tracts with population densities ranging from 16 to 31.8 persons per square mile; however; this includes population centers within the census tract but outside the wind area.

- The small area east of Indio and north of Interstate 10 is primarily flat land with sparse desert shrub vegetation. The small area east of Indio is within a vast census tract with a density of 0.7 persons per square mile.

There are 8 protected land uses in or within 5 miles of the Riverside East and Palm Springs wind study area: 3 BLM Areas of Critical Environmental Concern; a National Forest; a National Preserve; a National Wildlife Refuge, 2 Wilderness Areas.

Solano Wind

The Solano wind study area includes a number of separate areas within a region roughly bounded by a triangle from San Francisco Bay northeast to Sacramento and south past Stockton, essentially an enlarged Delta area. Individual wind areas are designated in Yolo, Sacramento, Contra Costa, Alameda, and San Joaquin Counties. Large existing wind developments are found at Montezuma Hills in Solano County and Altamont Pass in Alameda County. The areas comprising the Solano wind study area are found in two topographic conditions: East Bay Hills and delta-valley. Near the bay, the wind areas are on ridges in the East Bay hills, including near Martinez, Concord-Antioch, and Livermore-Tracy. In the delta and Central Valley, the areas are in flat lands influenced by the wind flows between the Golden Gate and the valley.

- The areas in the East Bay hills are predominately along grassland ridges with trees occurring in inter-ridge valleys and on slopes. Many of these areas include public parkland and open space or are protected water supply reservoir watersheds. None of the census tracts for the wind areas in the hills in Contra Costa County have fewer than 100 persons per square mile; they range from 132 to well over 1,000 persons per square mile.
- The areas in the Yolo, Sacramento, and San Joaquin County portions of the San Joaquin and Sacramento River deltas are primarily flat farmland. In Yolo County, the areas are a mix of foothill grasslands and farmland. High value crops, including nuts and grapes, are produced in the region. Here the population density range is from 16.5 to 75.1 persons per square mile. The wind areas in Sacramento County range from 22.7 to 109.4 persons per square mile; in the Tracey area they range from 9.1 to 208.3 persons pes square mile.

There are 11 protected land uses in or within 5 miles of the extended Solano wind study area: a BLM Area of Critical Environmental Concern; 4 military installations; a National Historic Park; 3 National Wildlife Refuges; and 2 State Parks.

Tehachapi Wind

The Tehachapi wind study area is comprised of six geographic areas, five in Kern County and one small area in Ventura County.

- The Kern County areas are on the east side of the Tehachapi Mountains and in the adjacent desert. The mountainous areas have sharply defined ridges and are vegetated in shrubs. The flat desert areas have a moderate shrub cover, and some irrigated agriculture takes place. The population density in the mountainous areas ranges from 3.4 to 8.3 persons per square mile. In the desert areas, the population density ranges from 4.2 to 32.8 persons per square mile, with the higher density tract including residential areas north of Lancaster.
- The wind area in Ventura County is in the steep, shrub covered mountains north of Simi Valley and south of the Santa Clara River. While the mountains are very sparsely populated, the flatlands in the area are heavily populated. The wind area here includes portions of three census tracts with population density ranging from 228.8 to 469.7 persons per square mile.

There are 7 protected land uses in or within 5 miles of the Tehachapi wind study area: 4 BLM Areas of Critical Environmental Concern; a military installation; a National Forest; and a State Park.

Inside California Geothermal

Greater Imperial Geothermal

The geothermal study area in Imperial County is on lands near the south end of the Salton Sea, and in portions of the agricultural land extending south from the Salton Sea, including areas north of Calipatria, Brawley, and Imperial. The areas east and west of the Salton Sea are primarily desert, while the remaining areas are in irrigated agricultural land. The population density in the geothermal areas ranges from 5.4 to 128.7 persons per square mile, reflecting the variety of land uses, from open desert to farmland near urban areas.

There are 21 protected land uses in or within 5 miles of the Greater Imperial geothermal study area: 10 BLM Areas of Critical Environmental Concern; 8 military installations; a National Wildlife Refuge; a State Park; and a Wilderness Area

Out-of-State Solar

Southwest Solar (Arizona)

The two study areas for solar in southwest Arizona are in Maricopa and Yuma Counties.

- The Harquahala study area in Maricopa County is generally flat with sparse desert vegetation. Most of the land is open and uninhabited. However, some irrigated agriculture occurs in the far western portion the study area and along the Gila River in the eastern part of the study area. The primary built land uses are power plants and substations and their associated transmission lines. The area includes the large Palo Verde Nuclear Generating Station as well as conventional power plants, and nearly 2,000 acres of existing solar PV. The census tract that includes most of the Harquahala study area has a population density of 3.5 persons per square mile.
- The Hoodoo Wash area in Yuma County also is generally flat desert, with some areas in the western portion of the study area irrigated agriculture. An existing solar farm nearly 2,000 acres in extent is within the area, along with a substation and transmission lines. The census tract that includes the Hoodoo Wash study area has a density of 0.6 persons per square mile.

There are 5 protected land uses in or within 5 miles of the Southwest solar study area: a BLM Area of Critical Environmental Concern; a military range; and 3 Wilderness Areas.

Out-of-State Wind

Northwest Wind (Oregon)

The two study areas for wind in the Northwest are in the Columbia River vicinity. One, east of The Dalles, includes land in Klickitat County, Washington and Sherman and Gilliam Counties, Oregon, and is roughly bisected by the Columbia River. The second is in Umatilla and Morrow Counties, Oregon, on the Umatilla Plateau southwest of Pendleton and west and north of Umatilla National Forest

- The area centered on the river is hilly terrain with incised drainages and mesas; the vegetation mostly is grass and shrubland. Some areas are irrigated, and the land is used primarily for range and hay production. Rows of existing wind turbines are found along several ridgelines. The area is in portions of three census tracts, which range in density from 1.6 to 6.6 persons per square mile.

- The terrain in the Umatilla and Morrow Counties study area is in rolling to hilly grassland with a dendritic drainage pattern. Much of the land is used as unirrigated pasture. Within the study area the population density in the two census tracts that include most of the area are 1.8 and 1.9 persons per square mile, respectively.

There are 6 protected land uses in or within 5 miles of the Northwest wind study area: a BLM Area of Critical Environmental Concern; 2 National Forests; a National Wildlife Refuge; and 2 State Parks.

Utah Wind

The Utah wind study area consists of five separate areas in southwestern Utah, east of Interstate 15 in Millard and Beaver Counties.

- The desert landscape of the areas in Millard County is sparse shrubland with a dry hilly to mountainous terrain. Millard County has a population density of 2 persons per square mile
- The areas in Beaver County include a similar environment as is found in Millard County, however one area south of the community of Milford supports irrigated alfalfa cropland over about ¼ of the area. Beaver County has a population density of 3 persons per square mile.

There are 3 protected land uses in or within 5 miles of the Utah wind study area: 2 BLM Areas of Critical Environmental Concern and an Experimental National Forest.

Wyoming Wind

The two study areas for wind in Wyoming are in the southeast quadrant of the state. One is primarily in Laramie and Albany Counties in south-central Wyoming, and the other in Carbon County, near the southeast corner of the state. The south-central study area is south of Interstate 80 and Rawlins and is primarily rolling sagebrush steppe scrubland. Over 90percent of the county's farmland is pastureland. The population density in the study area ranges from 0.7 to 1.7 persons per square mile, with most of the area is the lower density census tract.

- The southeastern study area extends east and north of the City of Laramie and consists of foothills and mid-elevation scrublands. Agricultural units tend to be thousands of acres in size. Range grass, hay, and livestock production are the predominant uses. The population density in the three census tracts that include most of the area ranges from 0.5 to 5.5 persons per square mile.

There are 2 protected land uses in or within 5 miles of the Wyoming wind study area: a BLM Area of Critical Environmental Concern and a National Forest.

New Mexico Wind

The two study areas identified for wind in New Mexico are principally in Quay and Curry Counties, along the Texas border, and in Lincoln County, in west-central New Mexico

- The eastern most study area includes the proposed Tres Amigas "super substation" and transmission facilities. Tres Amigas has been granted the right to lease 14,400 acres (22.5 square miles) of land in Clovis by the New Mexico State Land Office for this system. Much of the study area is flat plains, but the northernmost part of the area includes the Caprock Escarpment, a transition between the level high plains and the rolling and incised terrain to the north. The predominant land use in the area is agriculture, with most of Quay County in pasture while Curry County is about equally divided between cropland and pasture. The two census tracts in the study area have population densities of 1.1 and 6.0 persons per square mile.

- The study area in Lincoln County includes the proposed endpoints for SunZia Southwest Transmission Project and the Centennial West Clean Line transmission project. Ranching is the dominant land use. The west-central study area is in two census tracts, with population densities of 0.8 and 2.1 persons per square mile; most of the area is in the lower density tract.

There are 3 protected land uses in or within 5 miles of the New Mexico wind study area: a BLM Area of Critical Environmental Concern and 2 National Forests.

4.1.3 Typical Land Use Impacts of the Buildouts

This section describes the land use impacts that would be common across the scenarios as a result of the incremental buildout of new solar, wind, and geothermal energy. Typical land use impacts associated with development of renewable energy and transmission facilities are categorized as either construction-related or related to operations, as follows:

- During construction activities, short-term impacts result from increased noise and air emissions (exhaust and dust), alterations in the visual landscape and presence of workers and equipment, or exposure to hazards or hazardous materials.
- During ongoing operations and maintenance activities, long-term impacts result from the conversion of existing land uses to a more industrial use and exclusion of alternative or planned land uses.

Note that the SB 350 environmental study is not site-specific and does not reflect or represent a siting study for any particular planned or conceptual construction project. Although environmental impacts are described in general, project-specific impacts can typically be managed through best management practices and mitigation through the siting processes and with review by the siting authorities. Conflicts in land use can often be avoided or reduced on a case by case basis during the state or local siting processes.

Construction Impacts in General

The impacts of construction on adjacent residential, commercial, recreational, and agriculture uses would be similar for solar, wind, geothermal and transmission. Impacts would include dust, noise, traffic, and similar 'nuisance' effects associated with vegetation removal, ground disturbance, and erecting facilities. For agriculture, off-site impacts could include: damage to equipment, crops, and livestock; competition for water resources; water and soil contamination; suppression of crop growth by fugitive dust; soil erosion; and the spread of weeds.

Visual changes due to utility-scale renewable facility and transmission development result from a range of activities, including:

- Disturbance of ground surface.
- Alteration or removal of vegetation and landforms.
- Introduction of structures (e.g., energy collection and generation units, buildings, towers, and ancillary facilities).
- Development of new or upgraded roads.
- New or upgraded utilities and/or rights-of-way (e.g., widening of rights-of-way, addition of transmission lines, and upgrading of transmission capacity).
- Presence and movement of workers, vehicles, and equipment.
- Visible emissions (e.g., dust and water vapor plumes).
- Reflectance, glare, and lighting.

Solar Construction

Large-scale solar generation facilities are normally located on flat to gently sloped or rolling terrain. Installation of large fields of solar arrays typically requires vegetation removal and grading to level the land under linear arrays and to develop access roads. For security, sites are usually fenced.

Solar project visual impacts vary based on the technology used, but they have a number of common features, including grading that creates color and texture contrasts between existing soil and vegetation conditions and the disturbed, unvegetated project footprint. Ground disturbance also creates opportunities for visible windblown dust clouds to occur. Numerous vehicles and pieces of equipment are needed to prepare the site and deliver and install the arrays during construction, resulting in visual effects associated with movement, dust, and the presence of the vehicles and equipment. Glint and glare from equipment and materials may occur during construction. Also, temporary structures may be erected for facilitate assembly and to provide site offices and storage.

Wind Construction

Utility-scale wind energy facilities can preclude certain types of land uses but allow for other compatible land uses to continue. Land disturbance includes creation of access roads and preparation of turbine sites, but does not require disturbing all of the land within the property. Because of the large amount of space between turbines, existing roads within a property may be use to access some turbines, reducing the need for new roads. Spur roads to individual towers would still be required. Agricultural uses could continue to occur during construction in areas not required for individual tower development, roads, or materials laydown.

For wind energy construction, large cranes and other equipment would be needed to prepare foundations and assemble and mount towers, nacelles (turbine housings), and rotors. This construction equipment and its laydown areas would be especially visible and prominent near the activity and from a middle distance (within 5 miles). Construction equipment would produce emissions and may create visible exhaust plumes. Glint and glare from equipment may occur. The disturbed footprint of individual turbines typically would be small, but for a field of turbines can be extensive.

Geothermal Construction

Large geothermal developments may also require large areas for development. Land would be disturbed for surface facilities, well pads, and pipelines between the surface facilities and well pads. Access roads also would be needed. In some cases, these projects may include directional drilling to access geothermal resources from adjacent properties. In addition, geothermal construction can include multiple wells in each well pad, which limits the area of disturbance (surface footprint) for well development.

Visual impacts during construction would include the presence of equipment and materials, vegetation removal and ground disturbance, dust, and glint and glare from equipment and materials.

Operational Impacts in General

The presence of solar and geothermal facilities eliminates potential alternative uses of the land such as residential, commercial, and recreational uses. With some exceptions, most agricultural uses within a utility-scale renewable energy site would be eliminated as well because of the acreage needed and the nature of the energy system's physical components. Wind and transmission development, in contrast, would eliminate agricultural use only within the footprints of turbines, poles, and associated infrastructure.

Typical activities associated with renewable energy developments include ongoing facility operations; dust suppression; equipment maintenance, repair, and replacement; and fire and fuel management. A facility would require the long-term use of tracts of land, converting land from its existing use and limiting alternative uses, and potentially disrupting or degrading adjacent land uses. This impact would be greatest for solar developments, which occupy large portions of a site, as they depend on large surface areas to capture solar energy.

The operation and maintenance of facilities could have some ongoing impacts on adjacent agricultural lands. The range of impacts are similar to those of construction and potentially include: damage to equipment, crops, and livestock from increased traffic on farm roads; competition for water resources; water and soil contamination; soil erosion; spread of weeds; and shading of crops.

The operation and maintenance of renewable energy facilities and related transmission lines and roads, and their associated rights-of-way, would have long-term adverse visual effects. Among these are land scarring, introduction of structural contrast and industrial elements into natural or minimally disturbed settings, view blockage, and skylining (silhouetting of project elements against the sky). Renewable energy facilities generally include both enclosed and open workspaces, exterior lighting around buildings, access roads, fencing, and parking areas. Built structures (buildings, piping, fencing, collector arrays, towers, etc.) would introduce industrial elements into the landscape and contrast with surrounding undisturbed areas in form, line, color, and texture. They also can block views and create skylining, depending on their height and location relative to the viewer. The need for security and safety lighting could contribute to light pollution in areas where night lighting is otherwise absent or minimal. Light impacts may include skyglow, off-site light trespass, and glare or reflection. Localized visible dust may be created by vehicles and equipment operating within the site or along a right-of-way or access road. Without proper disturbed soil management strategies, wind can mobilize dust and create visible plumes or clouds of dust.

Solar Operations

Once in operation, ongoing ground disturbance at solar facilities is not required, although periodic vegetation control and road repair may occur. Dedicating a site to solar development normally precludes most other land uses. However, in certain cases, a solar photovoltaic project can allow limited grazing activities or allow some wildlife movement. The extent to which a site could function as a wildlife corridor would depend on the nature of any fencing that might be required and whether particular small mammal species (especially kit foxes) could pass through the fenced property.

Photovoltaic facilities generally have lower visual impacts than solar-thermal technologies because of the comparatively low profile of the collector arrays and the lower reflectance of photovoltaic panels, as compared with mirrors used in other technologies. Operating photovoltaic facilities do not have steam turbines, cooling towers, or steam plumes and have few lights and a low level of onsite worker activity. Still, some panels can be reflective, especially when viewed from elevated locations or from certain angles or times of day, and can be visible for long distances (up to 20 miles). Power conversion units (inverters) associated with these facilities can also cause visual contrasts. Because photovoltaic facilities do not require the infrastructure of other solar technologies (e.g., towers, turbines, boilers), they are visually simpler, more uniform, and have lower visual contrast. All types of renewable energy facilities require a transmission lines to interconnect to the power grid.

Wind Operations

Operating wind turbines would be compatible with uninhabited land uses such as most agriculture. The area immediately around each turbine tower as well as access roads would be unavailable, but other land within the overall site could be available for agricultural use. Ranchers and farmers can continue the agricultural uses of the land (particularly grazing) while also leasing turbine sites to others or participating directly in wind projects, thereby increasing their income.

Wind energy project components are highly visible because of the large and very tall (over 300 feet) towers and rotating turbines that would be erected in areas where there may be few, if any, comparable tall structures. Night aviation safety lighting (blinking red lights and/or white strobe lights) are required by the FAA. Visibility and contrast would be heightened at locations where they these structures are sited along mesas or ridgelines, silhouetting them against the sky. Wind turbines may create visually incongruous "industrial" associations for viewers, particularly in predominantly natural landscapes. Their moving blades attract visual attention.

Depending on the time of day, the shadows of towers and moving turbine blades extend across the landscape. The direction and length of this effect vary with the relative position of the sun in various seasons and at different times of the day, with morning and evening producing the longest shadows. The regular periodic interruption of sunlight by rotating turbine blades may produce a strobe-like effect, flickering alternating light and shadow over the area where the shadow is cast. During the life of a wind facility, towers, nacelles, and rotor blades may need to be upgraded or replaced, creating visual impacts similar to the impacts occurring during initial tower construction and assembly.

Geothermal Operations

Depending on the location of well pads and surface facilities (including pipelines) some portions of geothermal sites may be available for limited agricultural grazing. However, because geothermal operations normally require extensive pipelines and active wells on the surface, and they are within a controlled site, relatively little land around project components is normally available for other uses.

Visual impacts associated with the operation and maintenance of geothermal energy facilities largely derive from ground disturbance and the visibility of industrial power plants, production and injection well pads, pipes, cooling towers, steam plumes, and transmission lines.

4.1.4 Land Use Impacts of Regionalization

The 2020 CAISO + PAC scenario includes no incremental renewable energy development beyond what is already planned to meet California's 33% RPS by 2020. For limited regionalization in 2020, there would be no incremental construction activities, and no land use changes or adverse effects would occur in this scenario.

Each scenario of regionalization in 2030 requires an incremental buildout of new solar, wind, and geothermal energy facilities that will create environmental impacts in the vicinity of the renewable energy buildout. This section describes the locations of potential land use impacts related to each incremental buildout, inside California and elsewhere, to facilitate a comparison of the scenarios and identify the tradeoffs between in-state versus out-of-state development.

Incremental Buildout for Current Practice Scenario 1 by 2030

Inside California

Solar. Under Current Practice Scenario 1, the solar portfolio in California emphasizes:

- Areas having population densities ranging from low to medium/high, with most occurring in areas of medium density.
- Areas with low to extensive levels of agricultural activity.

- Areas within 5 miles of a medium to high number of excluded or protected areas.

Current Practice Scenario 1 includes 7,601 MW of incremental solar buildout inside California, requiring about 53,000 acres, or about 83 square miles. Over 60 percent of the total generation Current Practice 1 would be in two areas, Tehachapi and Westlands. The remaining 40 percent of the generation would be shared among five other resource areas. The Tehachapi solar area is traversed by Highways 14, 58, and 138. It surrounds the cities of Mojave and Lancaster and is north and west of Edwards AFB. Except for in Mojave and Lancaster and a few small towns and cities in the area, the population density is very low. The land is flat desert with sparse vegetation, with some small areas in irrigated agriculture.

A large contiguous part of the Westlands study area east of Interstate 5 in the southern San Joaquin Valley is primarily in agricultural uses or fallow; this part alone covers over 250,000 acres (390 square miles). The land is flat and the population density across the area is low to moderate, with population occurring primarily in scattered crossroad communities and along road frontages.

Given the overall low population density in the solar study areas, and the lack of widespread agriculture in most of the study areas, impacts on land use and agriculture are expected range from low to moderate. The Westlands area has more agriculture than the other solar study areas, but because of constraints imposed by water availability and extensive soil impairment, the area is less suitable for intensive farming than other regions of the San Joaquin Valley. Several solar projects already exist in this area and more are proposed. While several of the solar study areas are within 5 miles of several land uses considered to be protected (wilderness, recreation areas, National Parks, refuges, military installations, etc.) the low physical profile of solar components is expected to result in little or no adverse visual impact to these areas and to not represent a concern to most military operations.

Wind. Under Current Practice 1, the wind portfolio in California emphasizes:

- Areas having population densities ranging from low to high, with most occurring in areas of medium density.
- Areas within 5 miles of a medium to high number of excluded or protected areas.

Current Practice 1 includes 3,000 MW of incremental wind buildout inside California. This would require 120,000 acres (or just over 31 square miles), assuming 40 acres per MW. Actual ground disturbance would be about 3 acres per MW (the remainder of the land remains open and is needed for setbacks and for siting of individual turbines so as to not interfere with each other's wind flow).

The Riverside East and Palm Springs wind study area would be fully built-out with 500 MW in this scenario, and the Solano study area would include 600 MW. The Solano wind study area is one of the more problematic in terms of wind turbine visibility and potential conflicts with adjacent land uses. Many parts of the Solano study area are in or near parks and water supply watersheds, where turbines would not be allowed. Aside from Riverside East & Palm Springs and Solano study areas, the others are in remote locations where siting would be less problematic. Some are near wilderness areas and parks, but most areas are sufficiently large that it would be feasible to site turbines far from these protected land uses.

Geothermal. As with each scenario, Current Practice 1 includes 500 MW of incremental geothermal buildout. Assuming 6 acres per MW, this would require 3,000 acres, or about 4.6 square miles. Surface facilities (generation stations, pumps, cooling towers, pipelines, well pads) would occupy a portion of the area. Multiple injection and extraction wells can be directionally drilled from a single pad, reducing the number of pads needed and the length of pipelines. In the open desert landscape, pipelines could affect recreational cross country access, which would be restricted for safety. In agricultural land, building and well pads may occupy previously farmed land.

Out of State

Under Current Practice 1, the out-of-state resources would include 1,000 MW of solar in Arizona and 4,551 MW of wind from Oregon, Utah, Wyoming, and New Mexico, including new generation capacity and RECs. Together this capacity would require nearly 220,000 acres, or 343 square miles. These study areas have population densities as low or lower than areas in California, suggesting that fewer people would be affected by land use impacts, either in terms of compatibility and agricultural displacement, and frequency of views.

Solar. Under Current Practice 1, the solar portfolio out-of-state emphasizes:

- Areas having low population densities.
- Areas with low levels of agricultural activity.
- Areas within 5 miles of a low number of excluded or protected areas.

The Arizona solar study area is an open space where solar development would not displace any existing uses or conflict with any mining or agricultural uses. Generation and transmission infrastructure are established uses in the Arizona study area, especially in Maricopa County, and new solar facilities would be compatible with existing uses.

Wind. Under Current Practice 1, the wind portfolio out-of-state emphasizes:

- Areas having low population densities.
- Areas within 5 miles of a low number of excluded or protected areas.

The Oregon, Utah, Wyoming, and New Mexico study areas could each accommodate the levels of wind energy generation identified in the 2030 Portfolios. Based on the sparse population densities within the study areas, and the use of much of the land as open range or pasture land, it is expected that there would be sufficient available land for wind turbines that there would be no significant conflicts with existing land uses. Where wind turbines would be potentially visible to protected land uses, there is sufficient land to site turbines so as to increase the distance between the turbines and the protected land uses in order to reduce this impact.

Incremental Buildout for Regional 2 by 2030

Inside California

Solar. Under Regional 2, the solar portfolio in California emphasizes:

- Areas having population densities ranging from low to medium/high, with most occurring in areas of medium density.
- Areas with low to extensive levels of agricultural activity.
- Areas within 5 miles of a medium to high number of excluded or protected areas.

Regional 2 would include 7,804 MW of incremental solar buildout in California, except with more solar development in the Riverside East and Palm Springs solar area and less in Westlands when compared with Current Practice 1. Generation in the other areas would be the same under both Current Practice 1 and Regional 2. Solar facilities under Regional 2 would require development on about 55,000 acres of land, or about 85 square miles. Impacts would be similar to Current Practice 1 with less acreage required in Westlands and more required in Riverside East and Palm Springs. The overall acreage under both scenarios is the same.

Wind. Under Regional 2, the wind portfolio in California emphasizes:

- Areas having medium population densities.
- Areas within 5 miles of a medium to high number of excluded or protected areas.

Regional 2 would include about 36 percent less wind buildout in California than Current Practice 1 by having no new wind generation in either the Riverside East and Palm Springs wind study area or the Solano wind study area. This scenario would eliminate new wind facility impacts in these areas, both of which have substantially more population than the other wind areas and which have potential land use constraints, especially in the Solano wind study area.

Geothermal. Regional 2 is identical to Current Practice 1.

Out of State

Under Regional 2, out-of-state resources would be about 10 percent less than under Current Practice 1 overall. However, it would increase the solar generation and RECs from Arizona while decreasing wind from Oregon, and generation from the other three out-of-state areas would remain the same. The increase in solar buildout in Arizona would have minimal land use effects, as the population density is very low, and solar and other forms of energy infrastructure are already sited in the area.

Incremental Buildout for Regional 3 by 2030

Inside California

Solar. Under Regional 3, the solar portfolio in California emphasizes:

- Areas having low population densities.
- Areas with moderate levels of agricultural activity.
- Areas within 5 miles of high number of excluded or protected areas.

Regional 3 would involve development of solar inside California on about 24,000 acres of land, or about 38 square miles. This scenario would rely more heavily on renewable energy imports from out of state than other scenarios. Except in the Kramer and Inyokern solar area, which includes 375 MW of solar in each scenario, new solar development in other study areas would be reduced by 30 to 100 percent.

Because of its reduced level of generation, Regional 3 would have less potential impact in California than other scenarios. About half of the affected land under this scenario would be in the Tehachapi solar area, but the amount of land affected here would be 30 percent less than under the other scenarios.

Wind. Under Regional 3, the wind portfolio in California emphasizes:

- Areas having medium population densities.
- Areas within 5 miles of a low to high number of excluded or protected areas.

Regional 3 is identical to Regional 2 in terms of wind generation and potential land use impacts. This scenario would eliminate new wind facility impacts in the Palm Springs and Bay Delta areas (Solano study area), both of which have substantially more population than the other wind areas and which have potential land use constraints, especially in the Solano wind study area.

Geothermal. Regional 3 is identical to Current Practice 1.

Out of State

Regional 3 would increase out-of-state generation while decreasing California generation. Solar generation from Arizona would be the same under Regional 2 and 3. Northwest wind generation from Oregon would be much less, and Utah wind also would be less than in other scenarios. However, Wyoming and New Mexico generation would rise substantially, from 500 to 2,495 MW in Wyoming and from 1,000 to 2,962 MW in New Mexico. This additional wind generation would need to be supported by additional high-voltage transmission. While the amount of land needed for wind generation in Wyoming and New Mexico would increase in Regional 3, much of the land would still be available as rangeland.

Out-of-State Transmission Additions

Under Regional 3, it is assumed that major out-of-state transmission additions would be necessary to integrate renewable generation from Wyoming and New Mexico into the regional power system and for California to achieve 50% RPS. The land use considerations related to the construction and operation of the transmission expansions are summarized in Section 5.

4.1.5 Comparison of Scenarios for Land Use

The change from Current Practice into regional scenarios allows the following comparisons.

Inside California

- Decrease in potential solar buildout in areas with some potential for impact due to land use conversion or potential incompatibilities
- Decrease in potential wind buildout in areas with medium or higher potential for impact due to potential incompatibilities, notably Solano

Out of State

- Increase in potential solar and wind buildout in areas with relatively low potential for impact due to land use conversion or potential incompatibilities

Regional 2 Relative to Current Practice 1

- Increased renewables development would occur in out-of-state areas with less potential for conflicts (lower population densities, less agriculture, fewer excluded or protected areas within 5 miles) as compared to development in California.
- California would have a slight increase in solar development, but a substantial decrease in wind development (eliminating new wind development in Riverside East and Solano wind study areas).

Regional 3 Relative to Current Practice 1

- Increased renewables development would occur in out-of-state areas with less potential for conflicts (lower population densities, less agriculture, fewer excluded or protected areas within 5 miles) as compared to development in California.
- California would have a slight increase in solar development and would decrease development of solar in Westlands but increase it in Riverside East and Palm Springs
- A substantial decrease in wind development would occur (eliminating new wind development in Riverside East and Solano wind study areas).

4.2 Biological Resources

This section describes the potential impacts to biological resources for the incremental renewable energy buildouts and the potential biological impacts of regionalization as compared with the current practice. The approach to the analysis relies upon a narrow set of baseline conditions that are treated as potential indicators or predictors of impacts, as listed in Table 4.2-1.

Table 4.2-1. Baseline Conditions and Indicators of Impacts, Biological Resources

Baseline condition of a study area	How are scenarios analyzed relative to the baseline?	Potential indicator of biological resources impact
Biological Resources		
Sensitivity of crucial habitat	Coincidence of incremental renewable energy buildout with mapped critical habitat or known occurrences of listed species	Special-status species or habitat
Distribution of riparian and wetland habitat	Coincidence of incremental renewable energy buildout with mapped sensitive natural communities, including riparian habitat, wetlands, or other waters	Riparian habitat, wetlands or other waters
Sensitivity of large natural areas and landscape connectivity	Coincidence of incremental renewable energy buildout with established corridors	Wildlife corridors

Assumptions and Methodology for Biological Resources Analysis

This analysis describes the baseline conditions for biological resources, and acknowledges the limitations of available data and the need for site-specific studies at the time of project-specific siting review. In addition, this study identifies the areas and the locations with limited data availability. The background information in this section also summarizes applicable federal, state, and local regulations governing biological resources that would apply to future renewable energy buildouts.

Crucial Habitat Assessment Tool

The Crucial Habitat Assessment Tool (CHAT) is used as the basis for the biological resources analysis. The CHAT was developed by the Western Governors' Wildlife Council as a tool to aid large-scale planning efforts in the western states, and it launched in December 2013. The Western Association of Fish and Wildlife Agencies assumed responsibility of the CHAT in April 2015, and continues to manage it and ensure data are kept current.

State-specific information on priority species and habitat has been developed for nine western states; these include all states within the west-wide region of study in this analysis (California, Arizona, Oregon, Washington, New Mexico, and Wyoming). These data are incorporated into the CHAT model.

For each buildout, biological resources assessment may include maps showing the CHAT scores in each of the following CHAT model output categories. Data are not available in all of the following categories for all areas; each development scenario will report available rankings for that location with an emphasis on categories that are available in all areas and will also report those data that are unavailable.

- Crucial Habitat Rank
- Species of Concern
- Large Natural Areas
- Landscape Connectivity
- Riparian and Wetland Habitat Distribution

Maps would be accompanied by a description of overall habitat sensitivity (Crucial Habitat Rank) along with the specific resources that contribute to the scores (Species of Concern, Landscape Connectivity, etc.). CHAT data is presented in hexagons with a resolution of one square mile for most states, and California and Wyoming map crucial habitat in three-square-mile hexagons. Therefore, multiple CHAT mapping units lie within each study area.

The biological resources assessment includes a description of overall habitat sensitivity within each of the study areas and identifies subareas within each polygon that may be more or less sensitive than other locations within the development area. The narrative describes any particular concerns that may be identified by the CHAT tool, such as a high score for wildlife connectivity in one part of a study area.

Other Data Sources

The CHAT data, which provides relatively standardized aggregate data across the western U.S., is supplemented by state- and species-specific data that is used to provide more detailed information on the biological resources within each study area. Many of these data sets have been incorporated into the CHAT rankings. Where federally listed species or designated critical habitat are identified, the analysis will describe any applicable recovery plans for those species. The following lists those datasets that are considered, in addition to the CHAT model for each buildout area.

California – Wind and Solar

- Local and regional renewable planning and conservation efforts: Desert Renewable Energy Conservation Plan (sensitive biological resources modeling and range data), BLM's Western Solar Energy Program, San Joaquin Valley Solar Assessment, County efforts
- California Natural Diversity Database species occurrence information
- USFWS critical habitat boundaries
- Audubon Important Bird Areas
- Recovery plans for federally listed species

Oregon and Columbia River Gorge in Washington – Wind

- Washington Department of Fish and Wildlife Priority Habitats and Species data
- USFWS raptor breeding survey results
- Audubon Important Bird Areas
- Recovery plans for federally listed species

Wyoming – Wind

- USFWS critical habitat boundaries
- Audubon Important Bird Areas
- Recovery plans for federally listed species

New Mexico – Wind

- USFWS critical habitat boundaries
- Audubon Important Bird Areas
- Recovery plans for federally listed species

Arizona – Solar

- USFWS critical habitat boundaries
- National Wetlands Inventory
- Recovery plans for federally listed species

For each of the study areas, the assessment of potentially adverse effects to biological and ecological resources considers whether the buildouts would be likely to:

- Adversely affect, either directly or through habitat modifications, any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the State or U.S. Fish and Wildlife Service; or
- Interfere with established wildlife corridors or impede the use of native wildlife nursery sites.

Environmental impact assessment documents for similar and proximate projects are reviewed for each study area to inform recommendations of steps that can be taken or the indicators that can be monitored, possibly through an ongoing adaptive management strategy, to mitigate potential environmental impacts. In addition, landscape-level renewable energy planning efforts such as the DRECP and BLM's Western Solar Energy Program overlap with several study areas in the buildouts. As applicable, the analysis summarizes impact avoidance, minimization, and mitigation strategies identified by those efforts.

4.2.1 Regulatory Framework

Federal Protection of Species and Habitat

Federal Endangered Species Act

The Endangered Species Act (ESA) establishes legal requirements for conservation of endangered and threatened species and the ecosystems upon which they depend. Administered by the U.S. Fish and Wildlife Service (USFWS). Under the ESA, the USFWS may designate critical habitat for listed species. Section 7 of the ESA requires federal agencies to consult with the USFWS to ensure that their actions are not likely to jeopardize listed threatened or endangered species, or cause destruction or adverse modification of critical habitat. Section 10 of the ESA requires similar consultation for non-federal applicants.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) prohibits take of any migratory bird, including eggs or active nests, except as permitted by regulation (e.g., licensed hunting of waterfowl or upland game species). Under the MBTA, "migratory bird" is broadly defined as "any species or family of birds that live, reproduce or migrate within or across international borders at some point during their annual life cycle" and thus applies to most native bird species.

Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act prohibits the take, possession, and commerce of bald eagles and golden eagles. Under this act and subsequent rules published by the USFWS, "take" may include actions that injure an eagle, or affect reproductive success (productivity) by substantially interfering with normal behavior or causing nest abandonment. The USFWS may authorize incidental take of bald and golden eagles for otherwise lawful activities.

Clean Water Act

The Clean Water Act (CWA) regulates the chemical, physical, and biological integrity of the nation's waters. Section 401 of the CWA requires that an applicant obtain State certification for discharge into waters of the United States. Section 404 of the CWA establishes a permit program, administered by the U.S. Army Corps of Engineers, to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Individual projects may qualify under "Nationwide General Permits," or may require project-specific "Individual Permits."

Protection of Wetlands (Executive Order 11990)

This Executive Order directs federal agencies to avoid to the extent possible the long- and short-term adverse impacts from the destruction or modification of wetlands, and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative.

Invasive Species (Executive Order 13112)

This Executive Order establishes the National Invasive Species Council and directs federal agencies to prevent the introduction of invasive species, provide for their control, and minimize the economic, ecological, and human health impacts caused by invasive species.

State Protection of Species and Habitat

California Endangered Species Act

The California ESA (CESA) prohibits take of State-listed threatened or endangered species, except as authorized by the California Department of Fish and Wildlife (CDFW). Authorization may be issued as an Incidental Take Permit or, for species listed under both the CESA and the federal ESA, through a Consistency Determination with the federal incidental take authorization.

Native Birds (California Fish and Game Code Sections 3503, 3503.5, and 3513)

This code section prohibits take, possession, or needless destruction of birds, nests, or eggs, except as otherwise provided by the code. Section 3513 provides for the adoption of the MBTA's provisions (above)

Desert Tortoise (California Fish and Game Code Section 5000)

This code section states that it is unlawful to sell, purchase, harm, take, possess, or transport any tortoise (*Gopherus* spp.) or parts thereof, or to shoot any projectile at a tortoise.

Fully Protected Designations (California Fish and Game Code Sections 3511, 4700, 5515, and 5050)

This code section designates 36 fish and wildlife species as "fully protected" from take, including hunting, harvesting, and other activities. The CDFW may only authorize take of designated fully protected species through a Natural Community Conservation Plan (NCCP).

Protected Furbearers (California Code of Regulations Title 14 Section 460)

This code section specifies that "[f]isher, marten, river otter, desert kit fox and red fox may not be taken at any time." The CDFW may permit capture or handing of these species for scientific research, but does not issue Incidental Take Permits for other purposes.

California Native Plant Protection Act (California Fish and Game Code Sections 1900-1913)

Prior to enactment of CESA and the federal ESA, California adopted the Native Plant Protection Act (NPPA), authorizing the California Fish and Game Commission to designate rare or endangered native plants, and requiring state agencies to use their authority to carry out programs to conserve these plants. CESA (above) generally replaces the NPPA for plants originally listed as endangered under the NPPA. However, plants listed as rare retain that designation, and take is regulated under provisions of the NPPA. The California Fish and Game Commission has adopted revisions to the NPPA to allow CDFW to issue incidental take authorization for listed rare plants, effective January 1, 2015.

California Desert Native Plants Act

This act protects California desert native plants from unlawful harvesting on both public and privately owned lands within Imperial, Kern, Los Angeles, Mono, Riverside, San Bernardino, and San Diego Counties. The following native plants, or any part thereof, may not be harvested, except under a permit issued by the commissioner or the sheriff of the county in which the native plants are growing: all species of the Agavaceae (century plants, nolinas, and yuccas); all species of the family Cactaceae; all species of the family Fouquieriaceae (ocotillo, candlewood); all species of the genus *Prosopis* (mesquites); all species of the genus *Cercidium* (palo verdes); catclaw acacia (*Acacia greggii*); desert holly (*Atriplex hymenelytra*); smoke tree (*Dalea spinosa*); and desert ironwood (*Olneya tesota*), both dead and alive. Plants that are listed as rare, endangered, or threatened by federal or State law or regulations are excluded.

Lake and Streambed Alteration Agreements (California Fish and Game Code Section 1600 1616)

Lake and Streambed Alteration Agreements (LSAAs) regulate projects that would divert, obstruct, or change the natural flow, bed, channel, or bank of a river, stream, or lake. Regulation is formalized in a LSAA, which generally includes measures to protect any fish or wildlife resources that may be substantially affected by a project.

Porter-Cologne Water Quality Control Act

This act regulates surface water and groundwater and assigns responsibility for implementing federal CWA Section 401 in California. It establishes the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCBs) to protect State waters.

Arizona Native Plant Law

The Arizona Native Plant Law (Title 3: Agriculture, Chapter 7: Arizona Native Plants), administered by the Arizona Department of Agriculture (AZDA) identifies five categories of protected plants in Arizona:

- Highly Safeguarded (essentially endangered species)
- Salvage Restricted (cacti, ocotillo, etc.)
- Export Restricted
- Salvage Assessed (the common desert trees)
- Harvest Restricted (firewood, bear grass, yucca)

These plants are protected by law and cannot be removed from any lands without a permit from the AZDA. This applies to plants that are owned by a private entity or managed by a government agency.

Arizona Game and Fish Department Regulations

Arizona State Statutes and Arizona Game and Fish Department Commission Policies have been established to conserve, protect, restore, and enhance fish and wildlife populations and their habitats. These statues and policies include, but are not limited to, restrictions on “take” of wildlife, prohibition of taking or harassing nesting birds, and restrictions on closing any state or federal lands to hunting or fishing.

Oregon Endangered Species Act - Threatened or Endangered Plants (ORS 603-073-0001-0110) and Wildlife (ORS 496.171-182)

The Oregon Endangered Species Act codified in the Oregon Revised Statutes (ORS) gives the Oregon Department of Agriculture responsibility for and jurisdiction over state-listed threatened and endangered plants, and the Oregon Department of Fish and Wildlife has responsibility and jurisdiction over state-listed threatened and endangered fish and wildlife. The Act requires Oregon’s state agencies to develop management and protection programs for state-listed endangered species and to comply with Oregon Fish and Wildlife Commission’s adopted guidelines for state-listed threatened species.

Oregon Noxious Weed Control Law (ORS 570.500-600)

This law directs the prevention and eradications of noxious weeds in Oregon, including the establishment of local Weed Districts to oversee education, eradication, and enforcement.

Oregon Wildflower Protection Law (ORS 564.020-040)

This law identifies native wildflowers that are regulated in Oregon, and identifies required permissions to dig up, cut, sell, export, etc., any of these wildflower species.

New Mexico Wildlife Conservation Act

This act provides definitions, legislative policies, and regulations for listing or delisting species in New Mexico, and identifies penalties for violating the Act.

New Mexico Noxious Weed Control Act

This act describes requirements for the establishment and duties of noxious weed control districts.

New Mexico Noxious Weed Management Act

This act directs the New Mexico Department of Agriculture to develop a list of noxious weeds in the state, identify methods of control for noxious weeds, and provide noxious weed education to the public.

Utah Wildlife Resources Code

This law includes a variety of statues including designation of all wildlife as property of the state unless held in private ownership, provisions on invasive species, regulation of taking of wildlife, and penalties for violations.

Utah Division of Wildlife Resources Administrative Rules

These rules are passed by the Utah Wildlife Board and provide regulations on take for a variety of wildlife species, hunting rules and regulations, wildlife control and depredation, and other wildlife-related topics.

Utah Noxious Weed Control Act

This act designates noxious weed species in Utah and governs their prevention and management within the state.

Wyoming Nongame Wildlife (Wyoming Game and Fish Commission Chapter 52)

These regulations govern take of nongame wildlife in Wyoming.

Wyoming Weed & Pest Control Act

This act requires designation of noxious weeds within the state and provides statewide legal authority to regulate and manage designated noxious weeds.

Desert Renewable Energy Conservation Plan (DRECP)

The DRECP is a Land Use Plan Amendment proposed by the BLM that would define protective land designations to protect specific desert ecosystems and would facilitating appropriate development of renewable energy projects in designated areas.

Examples of Other Major Local or Regional Conservation Planning Documents for California

- San Joaquin County Multi-Species HCP (MSHCP)
- Imperial Irrigation District HCP and NCCP
- Northeastern San Luis Obispo County HCP
- Santa Barbara MSHCP
- San Diego East County MSHCP
- Lower Colorado River MSHCP
- Metropolitan Bakersfield HCP
- Coachella Valley MSHCP
- East Fresno HCP
- South Sacramento HCP
- East Contra Costa County HCP and NCCP
- Bakersfield Regional HCP
- East Bay Regional Park District HCP and NCCP
- West Mojave HCP, applicable on BLM lands

4.2.2 Baseline Conditions in Study Areas

The Crucial Habitat Assessment Tool (CHAT) was used as the basis for the biological resources analysis because it provides relatively standardized aggregate data across the western U.S. The CHAT was developed by the Western Governors' Wildlife Council as a tool to aid large-scale planning efforts in the western states, and it launched in December 2013. The Western Association of Fish and Wildlife Agencies assumed responsibility of the CHAT in April 2015, and continues to manage it and ensure data are kept current.

State-specific information on priority species and habitat has been developed for nine western states; these include all states within the west-wide region of study in this analysis (California, Arizona, Oregon, Washington, New Mexico, and Wyoming). These data are incorporated into the CHAT model.

The top two most crucial ranks are considered here to identify the relative biological sensitivity of each study area. For each of the following descriptions of baseline conditions, the overall amount of area ranked as most crucial is reported, and the biological resources that contribute to sensitivity are described. Data that inform the sensitivity ranking of crucial habitat for each state varies but generally includes the following: distribution/presence of listed and other special-status species, presence of Important Bird Areas, designated critical habitat, riparian and wetland habitats and other sensitive habitats, migration and connectivity corridors, large natural areas, and species of economic and recreational importance.

Limitations. The datasets underlying this analysis exist at a variety of spatial and temporal scales, accuracies, and geographic scopes. Few of the datasets offer current, comprehensive coverage for each entire study area, which limits the power of the data to precisely define site-specific opportunities or constraints. Project-level datasets, local experts, field studies, and unpublished data would provide additional site-specific information to fully ascertain the biological resources present and the potential impacts of development of projects under each scenario.

Inside California Solar

Greater Carrizo Solar

Crucial Habitat. The top two most crucial ranks comprise 52 percent of the Greater Carrizo Solar Study Area (Figure 4.2-1). The most sensitive area is the portion of the study area north of Soda Lake. Sensitive biological resources in this study area include but are not limited to giant kangaroo rat (state and federally listed endangered), San Joaquin kit fox (state listed threatened and federally listed endangered), arroyo toad (federally listed endangered and California Species of Special Concern [CSSC]), longhorn fairy shrimp (federally listed endangered), vernal pool fairy shrimp (federally listed threatened), burrowing owl (CSSC), California red-legged frog (federally listed threatened and CSSC), California tiger salamander (state and federally listed threatened), vernal pool habitats, and migratory birds (particularly in coastal areas). A total of 59 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. The most significant riparian/wetland area in the Greater Carrizo Solar Study Area is the Sisquoc River corridor along the north and east boundaries of the portion of the study area near Santa Maria. In addition, multiple small drainages occur throughout the Cholame Hills. Riverine and wetland habitats are mapped in association with Cholame Creek in the Cholame Valley, and scattered agricultural ponds and likely vernal pools occur throughout the study area.

Large Natural Areas and Landscape Connectivity. Landscape connectivity and intactness in agricultural and grassland habitats is particularly important in this study area due to the presence of San Joaquin kit fox. This study area overlaps the Carrizo Plain Important Bird Area, a 162,000-acre area along the San Andreas Fault that supports roosting lesser sandhill cranes and breeding populations of golden eagle, northern harrier, burrowing owl, prairie falcon, Swainson's hawk, the canescens race of sage sparrow, and other listed and special-status birds. It represents one of the most significant swaths of protected lands in California, and is jointly managed by the BLM and several other public agencies and non-profits (Audubon, 2013).

Other Biological Sensitivity. Critical habitat for the following species occurs within the study area: California red-legged frog (federally listed threatened and CSSC), California tiger salamander (state and federally listed threatened), La Graciosa thistle (state listed threatened and federally listed endangered), longhorn fairy shrimp (federally listed endangered), vernal pool fairy shrimp, and steelhead (federally listed threatened).

Greater Imperial Solar

Crucial Habitat. The top two most crucial ranks comprise 44 percent of the Greater Imperial Solar Study Area (Figure 4.2-2). Sensitive biological resources in this study area include but are not limited to migratory birds at the Salton Sea, peninsular bighorn sheep (federally listed endangered, state-listed threatened, and fully protected in California), burrowing owl (CSSC), flat-tailed horned lizard (Candidate for state listing as threatened and CSSC), arroyo toad, desert pupfish (state and federally listed endangered), least Bell's vireo (state and federally listed endangered), southwestern willow flycatcher (state and federally listed endangered), Stephen's kangaroo rat (federally listed endangered and state-listed threatened), Yuma clapper rail (federally listed endangered, state-listed threatened and fully protected in California), and barefoot gecko (state-listed threatened). A total of 90 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. Significant riparian and wetland areas in this study area include the Salton Sea and surrounding wetlands, irrigation canals and stockponds in the agricultural areas around the Salton Sea, Lake Henshaw, the San Luis Rey River, Buena Vista Creek, Borrego Sink, and Tule Lake.

Large Natural Areas and Landscape Connectivity. The Imperial Valley, Salton Sea, San Diego Montane Forests, and San Luis Rey River Important Bird Areas overlap the Greater Imperial Solar Study Area. The southwestern and the eastern portions of this study area are also modeled as important wildlife movement corridors and intact landscape.

The Imperial Valley Important Bird Area lies between the Salton Sea and the U.S.-Mexico border, and is one of the premier wintering bird spots in the U.S. This area supports the largest California populations of several species, including 30-40 percent of the global population of wintering mountain plover, 70 percent of the burrowing owls in the state, and the only population of Gila woodpecker outside of the Colorado River in California. The Salton Sea Important Bird Area supports an exceptionally high bird diversity year-round, with some species regularly occurring here and nowhere else in the U.S. Approximately 30 percent of the North American breeding population of American white pelicans breeds here, one of the largest breeding populations of double-breasted cormorants occurs here, and about 40 percent of the U.S. population of Yuma clapper rails occur in marshes in this Important Bird Area. (Audubon, 2013)

The San Diego Montane Forests (San Diego Peaks) Important Bird Area encompasses high-elevation backcountry in San Diego County. Lake Cuyamaca and scattered grassy meadows attract a large number of birds. Several species occur here at the edge of their global ranges, including red-breasted sapsucker, white-headed woodpecker, and mountain chickadee. The San Luis Rey River Important Bird Area includes some of the most extensive riparian habitat in southern California. This important bird area supports one of three main nesting populations of southeastern willow flycatcher, and least Bell's vireo breeds here in significant numbers. (Audubon, 2013)

Other Biological Sensitivity. Several California Species of Special Concern are of particular conservation focus in Imperial County; these include the burrowing owl and flat-tailed horned lizard. Approximately two-thirds of the burrowing owl population in California occurs in agricultural areas in the Imperial Valley near the Salton Sea (BLM et al., 2014). There are three regional populations of flat-tailed horned lizard in California; two of these (representing the majority of the range in the state) occur in Imperial County. These are on the west side of the Salton Sea/Imperial Valley and on the east side of the Imperial Valley; both populations extend south into Mexico and overlap portions of the Greater Imperial Solar Study Area. Critical habitat for peninsular bighorn sheep and arroyo toad also occurs within the study area.

Kramer and Inyokern Solar

Crucial Habitat. The top two most crucial ranks comprise just 2 percent of the Kramer and Inyokern Study Area (Figure 4.2-3). Sensitive biological resources in this study area include but are not limited to desert tortoise (federally and state-listed threatened), Mohave ground squirrel (state-listed threatened), Cushenbury buckwheat (federally listed endangered), Mohave tui chub (state and federally listed endangered and fully protected in California), burrowing owl, golden eagle (fully protected in California), and desert bighorn sheep (fully protected in California). It is also within a migration route for Swainson's hawks (state listed threatened). A total of 28 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded (including Mohave ground squirrel and California condor).

Riparian and Wetland Habitats. The largest mapped wetland in this study area is Searles Lake, a primarily dry playa lake that supports variable amounts of water during and following rain events. It also contains several large wastewater ponds associated with mining. Other desert playas, including El Mirage Dry Lake near the community of El Mirage, Troy Dry Lake near Newberry Springs, and Lucerne Dry Lake in Lucerne Valley, also occur in the study area. Numerous dry desert washes, some very large, cross through the study area. The Mojave River does not intersect the study area but occurs less than 3 miles from the southwestern subarea and adjacent to the eastern subarea.

Large Natural Areas and Landscape Connectivity. The Mojave River corridor and the eastern portion of the study area in Lucerne Valley are identified as important areas for landscape intactness and wildlife corridors. North Mojave Dry Lakes Important Bird Area overlaps the study area, and encompasses the four dry lakes between Ridgecrest and Barstow in the northern Mojave Desert (China Lake, Searles Dry Lake, Koehn Dry Lake, and Harper Dry Lake). Several spring-fed wetlands and wastewater treatment areas occur here and attract a variety of birds including migrating waterfowl and shorebirds (Audubon, 2013).

Other Biological Sensitivity. Critical habitat for desert tortoise occurs in the study area.

Owens Valley Solar

Crucial Habitat. The top two most crucial ranks comprise 87 percent of the Owens Valley & Inyo Solar Study Area (Figure 4.2-4). Sensitive biological resources in this study area include but are not limited to least Bell's vireo, southwestern willow flycatcher, Owens pupfish (state and federally listed endangered and fully protected in California), Owens tui chub (state and federally listed endangered), burrowing owl, golden eagle, Mohave ground squirrel, northern leopard frog (CSSC), and a wide variety of rare plants. A total of 52 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. The most prominent wetland and riparian habitats in this study area are associated with the Owens River and Owens Lake. Dry desert washes are abundant throughout the study area, particularly in Stewart Valley near the Nevada border.

Large Natural Areas and Landscape Connectivity. The Owens Lake Important Bird Area is a 100-square mile alkali playa at the southern end of the Owns Valley. It is a major migratory stop-over site for shorebirds and waterfowl. (Audubon, 2013)

Other Biological Sensitivity. Critical habitat for Fish Slough milk-vetch occurs within the study area.

Riverside East and Palm Springs Solar

Crucial Habitat. The top two most crucial ranks comprise 30 percent of the Riverside East and Palm Springs Solar Study Area (Figure 4.2-5). Sensitive biological resources in this study area include but are not limited to migratory birds, desert washes, peninsular bighorn sheep, Coachella Valley milk-vetch (federally listed endangered), triple-ribbed milk-vetch (federally listed endangered), desert slender salamander (federally and state listed endangered), least Bell's vireo, elf owl (state-listed endangered), desert tortoise, Coachella Valley fringe-toed lizard (federally listed threatened and state-listed endangered), burrowing owl, and desert bighorn sheep. A total of 58 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. Dry desert washes are abundant in the study area, and include the Whitewater River in the Palm Springs area and McCoy Wash near Blythe. Palen Dry Lake is a playa that overlaps a portion of the eastern study area. The study area is within 2 miles of the Colorado River and its associated riparian and wetland habitats, and the eastern edge of the study area abuts the agricultural plain associated with the river.

Large Natural Areas and Landscape Connectivity. Although no designated Important Bird Areas overlap this study area, its proximity to the Colorado River and its location in the eastern California desert place it within migratory bird pathways. Landscape corridors are modeled along the Whitewater River in the Palm Springs area.

Other Biological Sensitivity. Critical habitat for Coachella Valley milk-vetch and desert tortoise occurs within the study area.

Tehachapi Solar

Crucial Habitat. The top two most crucial ranks comprise 13 percent of the Tehachapi Solar Study Area (Figure 4.2-6). Sensitive biological resources in this study area include but are not limited to migratory birds, least Bell's vireo, desert tortoise, spreading navarretia (federally listed threatened), burrowing owl, golden eagle, Mohave ground squirrel, tricolored blackbird (CSSC), and Swainson's hawk. A total of 39 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. Mapped habitats in this study area are primarily named and unnamed dry desert washes of varying size as well as playa lakes.

Large Natural Areas and Landscape Connectivity. The North Mojave Dry Lakes and Antelope Valley Important Bird Areas overlap the study area. The North Mojave Dry Lakes Important Bird Area encompasses the four dry lakes between Ridgecrest and Barstow in the northern Mojave Desert (China Lake, Searles Dry Lake, Koehn Dry Lake, and Harper Dry Lake). Several spring-fed wetlands and wastewater treatment areas occur here and attract a variety of birds including migrating waterfowl and shorebirds. The Antelope Valley (Lancaster) Important Bird Area supports one of the westernmost populations of LeConte's thrasher, and a wide variety of grassland birds and raptors winter here (Audubon, 2013).

Other Biological Sensitivity. Critical habitat for California condor occurs within the study area.

Westlands Solar

Crucial Habitat. The top two most crucial ranks comprise 5 percent of the Westlands Solar Study Area (Figure 4.2-7). Sensitive biological resources in this study area include but are not limited to San Joaquin kit fox, Buena Vista Lake ornate shew (federally listed endangered and CSSC), Fresno kangaroo rat (state and federally listed endangered), Tipton kangaroo rat (state and federally listed endangered), blunt-nosed leopard lizard (state and federally listed endangered and fully protected in California), giant garter snake (state and federally listed threatened), California tiger salamander, Bakersfield cactus (state and federally listed endangered), California jewelflower (state and federally listed endangered), hairy Orcutt grass (state and federally listed endangered), Kern mallow (federally listed endangered), palmate-bracted salty bird's-beak (state and federally listed endangered), San Joaquin woollythreads (federally listed endangered), San Joaquin adobe sunburst (federally listed threatened and state-listed endangered), least Bell's vireo, longhorn fairy shrimp (federally listed endangered), vernal pool fairy shrimp, western snowy plover (federally listed threatened and CSSC), western yellow-billed cuckoo (federally listed threatened and state-listed endangered), and burrowing owl. A total of 72 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. This study area supports primarily agricultural lands, and numerous stockponds and irrigation ditches occur. Natural waterways with associated wetlands and riparian habitats include the Kings River and various tributaries, the San Joaquin River, Ash Slough, Berenda Slough, Cottonwood Creek, Fresno Slough, and Cole Slough.

Large Natural Areas and Landscape Connectivity. No Important Bird Areas or landscape corridors are mapped within this study area; however, it is located within a broad migratory route for birds along the California coast.

Inside California Wind

Central Valley North and Los Banos Wind

Crucial Habitat. The top two most crucial ranks comprise 77 percent of the Central Valley North and Los Banos Wind Study Area (Figure 4.2-8). Sensitive biological resources in this study area include but are not limited to migratory birds at the San Luis Reservoir, blunt-nosed leopard lizard, San Joaquin kit fox, longhorn fairy shrimp, Swainson's hawk, and burrowing owl. A total of 6 sensitive species are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. The most significant water bodies in and near this study area are the San Luis Reservoir and O'Neill Forebay.

Large Natural Areas and Landscape Connectivity. The area to the east and south of the O'Neill Forebay is an important movement corridor for San Joaquin kit fox and other grassland species.

Greater Carrizo Wind

Crucial Habitat. The top two most crucial ranks comprise 57 percent of the Greater Carrizo Wind Study Area (Figure 4.2-1). Sensitive biological resources contributing to the high crucial habitat ranks in this study area include giant kangaroo rat, San Joaquin kit fox, burrowing owl, arroyo toad, California red-legged frog, California tiger salamander, vernal pool fairy shrimp, longhorn fairy shrimp, southern California DPS of steelhead, Gaviota tarplant (state and federally listed endangered), Kern mallow, La Graciosa thistle, and migratory birds (particularly in coastal areas). There are also overwintering sites for monarch butterflies recorded in the study area. A total of 59 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. Numerous named and unnamed creeks with riparian habitats occur throughout this study area. A portion of the Santa Ynez River and its substantial riparian corridor cross the study area near Buellton. Several scattered agricultural ponds also occur.

Large Natural Areas and Landscape Connectivity. Landscape connectivity and intactness in agricultural and grassland habitats is particularly important in this study area due to the presence of San Joaquin kit fox in the northern area. The Santa Ynez Mountains contain important modeled landscape corridors. This study area overlaps the Santa Ynez River Valley Important Bird Area, which encompasses the intact riparian habitat between Highway 101 and the agricultural region west of Lompoc. This area supports a large population of southwestern willow flycatchers, and other special-status birds include least Bell's vireo, western yellow-billed cuckoo, golden eagle, and tricolored blackbird (Audubon, 2013).

Other Biological Sensitivity. Critical habitat for steelhead, tidewater goby, California red-legged frog, California tiger salamander, southwestern willow flycatcher, Gaviota tarplant, and Lompoc yerba santa occurs in the study area.

Greater Imperial Wind

Crucial Habitat. The top two most crucial ranks comprise 56 percent of the Greater Imperial Wind Study Area (Figure 4.2-2). Sensitive biological resources in this study area are generally the same as described for the Greater Imperial Solar Study Area, and include migratory birds at the Salton Sea, peninsular bighorn sheep, burrowing owl in the Salton Sea agricultural areas, and flat-tailed horned lizard east and west of the Imperial Valley, among other special-status species and sensitive habitats. A total of 96 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. The easternmost portion of this study area overlaps the Colorado River floodplain and associated wetlands and riparian habitat in the vicinity of the Mittry Lake State Wildlife Area. Other mapped areas include Buena Vista Creek, Campo Creek, Tule Creek, Tule Lake, Boundary Creek, and various small ponds near Julian.

Large Natural Areas and Landscape Connectivity. The San Diego Montane Forests, Lower Colorado River Valley, and Imperial Valley Important Bird Areas overlap portions of the study area. The San Diego Montane Forests (San Diego Peaks) Important Bird Area encompasses high-elevation backcountry in San Diego County. Lake Cuyamaca and scattered grassy meadows attract a large number of birds. Several species occur here at the edge of their global ranges, including red-breasted sapsucker, white-headed woodpecker, and mountain chickadee. The Lower Colorado River Valley Important Bird Area contains essential habitats for some of the most imperiled birds in the U.S. Wetlands and riparian thickets support breeding populations and provide migratory stopover and wintering habitat for species including elf owl, yellow-billed cuckoo, northern cardinal, Harris' hawk, and sandhill crane. The Imperial Valley Important Bird Area lies between the Salton Sea and the U.S.-Mexico border, and is one of the premier wintering bird spots in the U.S. This area supports the largest California populations of several species, including 30 to 40 percent of the global population of wintering mountain plover, 70 percent of the burrowing owls in the state, and the only population of Gila woodpecker outside of the Colorado River in California. (Audubon, 2013)

Other Biological Sensitivity. Critical habitat for the following species occurs within the study area: southwestern willow flycatcher, yellow-billed cuckoo, razorback sucker, Quino checkerspot butterfly, and peninsular bighorn sheep.

Riverside East and Palm Springs Wind

Crucial Habitat. The top two most crucial ranks comprise 55 percent of the Riverside East and Palm Springs Wind Study Area (Figure 4.2-5). Sensitive biological resources in this study area include but are not limited to migratory birds, Coachella Valley milk-vetch, triple-ribbed milk-vetch, Coachella Valley fringe-toed lizard, desert tortoise, southwestern willow flycatcher, desert pupfish, burrowing owl, and desert bighorn sheep. A total of 14 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. The Coachella Valley Preserve supports a desert oasis with a pond and extensive riparian habitat adjacent to the study area. Dry desert washes of various sizes cross through the study area.

Large Natural Areas and Landscape Connectivity. Although no designated Important Bird Areas overlap this study area, its proximity to the Coachella Valley Preserve and oasis indicates that it is likely within the movement area for a large number of birds.

Other Biological Sensitivity. Critical habitat for Coachella Valley fringe-toed lizard and Coachella Valley milk-vetch occurs within the study area.

Solano Wind

Crucial Habitat. The top two most crucial ranks comprise 73 percent of the Solano Wind Study Area (Figure 4.2-9). Sensitive biological resources in this study area include but are not limited to migratory birds at the Delta, longfin smelt (state-listed threatened and candidate for federal listing), Delta smelt (federally listed threatened and state-listed endangered), Central Valley DPS of steelhead (federally listed threatened), Valley elderberry longhorn beetle (federally listed threatened), vernal pool fairy shrimp, vernal pool tadpole shrimp (federally listed endangered), longhorn fairy shrimp, Alameda whipsnake (state and federally listed threatened), giant garter snake, California red-legged frog, California tiger salamander, San Joaquin kit fox, western snowy plover, western yellow-billed cuckoo, least Bell's vireo, and several listed plants. A total of 101 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. Extensive riparian corridors and wetlands occur throughout this study area, including the San Joaquin River and various tributaries, Suisan Bay, Putah Creek, Willow Slough, Babel Slough, North and South Mokelumne River and Old River. There is a broad wetland and vernal pool complex south of Saxon and west of the Sacramento River Deep Water Ship Channel.

Large Natural Areas and Landscape Connectivity. Several landscape corridors are modeled within this study area, including along the base of Rocky Ridge and the broad wetland and vernal pool complex south of Saxon and west of the Sacramento River Deep Water Ship Channel. The following Important Bird Areas overlap the study area: Yolo Bypass Area, Sacramento-San Joaquin Delta, Cosumnes River Watershed – Lower, Mount Hamilton Range, San Joaquin River – Lower, and Byron Area. These areas support freshwater and tidal marsh ecosystems, riparian, and grassland habitats that attract a high concentration and wide diversity of songbirds, shorebirds, waterfowl, and raptors. (Audubon, 2013)

Other Biological Sensitivity. Critical habitat for the following species overlaps the study area: Alameda whipsnake, California red-legged frog, Colusa grass, Contra Costa goldfields, large-flowered fiddleneck, Solano grass, vernal tidepool shrimp, Delta smelt, steelhead, and Chinook salmon.

Tehachapi Wind

Crucial Habitat. The top two most crucial ranks comprise 20 percent of the Tehachapi Wind Study Area (Figure 4.2-6). Sensitive biological resources in this study area include but are not limited to migratory birds, burrowing owl, golden eagle, and Swainson's hawk. A total of 30 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. A variety of named and unnamed drainages are mapped within the southern portion of this study area, and many support riparian habitat. Areas within the Antelope Valley support a variety of dry desert washes. Proctor Dry Lake lies within the study area in the Tehachapi Valley.

Large Natural Areas and Landscape Connectivity. The Southern Sierra Desert Canyons and Antelope Valley Important Bird Areas overlap this study area. The Southern Sierra Desert Canyons Important Bird Area includes one of interior California's most important segments of the Pacific Flyway migration corridor, and its canyons provide critical breeding and migratory stopover habitat to countless birds. The Antelope Valley (Lancaster) Important Bird Area supports one of the westernmost populations of LeConte's thrasher, and a wide variety of grassland birds and raptors winter here (Audubon, 2013).

Other Biological Sensitivity. Critical habitat for California condor and coastal California gnatcatcher occurs within the study area.

Inside California Geothermal

Greater Imperial Geothermal

Crucial Habitat. The top two most crucial ranks comprise 33 percent of the Greater Imperial Geothermal Study Area (Figure 4.2-2). Sensitive biological resources in this study area are the same as described for the Greater Imperial Solar Study Area, and include migratory birds at the Salton Sea, peninsular bighorn sheep in the Borrego Springs area, burrowing owl in the Salton Sea agricultural areas, and flat-tailed horned lizard east and west of the Imperial Valley, among other special-status species and sensitive habitats. A total of 48 sensitive species and habitat types are recorded in this study area, and additional resources are likely to be present and unrecorded.

Riparian and Wetland Habitats. Significant riparian and wetland areas in this study area include the Salton Sea and surrounding wetlands, and irrigation canals and stockponds in the agricultural areas around the Salton Sea.

Large Natural Areas and Landscape Connectivity. The Imperial Valley and Salton Sea Important Bird Areas overlap this study area. The eastern portion of this study area is also modeled as an important wildlife movement corridor and intact landscape.

The Imperial Valley Important Bird Area lies between the Salton Sea and the U.S.-Mexico border, and is one of the premier wintering bird spots in the U.S. This area supports the largest California populations of several species, including 30-40 percent of the global population of wintering mountain plover, 70 percent of the burrowing owls in the state, and the only population of Gila woodpecker outside of the Colorado River in California. The Salton Sea Important Bird Area supports an exceptionally high bird diversity year-round, with some species regularly occurring here and nowhere else in the U.S. Approximately 30 percent of the North American breeding population of American white pelicans breeds here, one of the largest breeding populations of double-breasted cormorants occurs here, and about 40 percent of the U.S. population of Yuma clapper rails occur in marshes in this Important Bird Area. (Audubon, 2013)

Other Biological Sensitivity. Critical habitat for peninsular bighorn sheep and arroyo toad occurs within the study area. Other sensitive biological resources are the same as described for the Greater Imperial Solar Study Area.

Out-of-State Solar

Southwest Solar (Arizona)

Crucial Habitat. The top two most crucial ranks comprise 2 percent of the Southwest Solar Study Area (Figure 4.2-10). The Arizona state CHAT ranking is driven by the presence of large natural areas, species of concern, species of economic and recreational importance, and wetland and riparian areas. Raw species occurrence data were not publically available for this study area, but were used by the state to develop Arizona's CHAT model.

Riparian and Wetland Habitats. The Gila River and Centennial Wash are major drainages with associated wetland and riparian habitats in the Harquahala area, and the Gila River and associated riparian corridor cross the southern portion of the Hoodoo Wash area. Numerous named and unnamed dry desert washes of varying sizes occur throughout the study area.

Large Natural Areas and Landscape Connectivity. The Lower Salt and Gila Riparian Ecosystem Important Bird Area overlaps this study area. This Important Bird Area includes portions of the Salt and Gila Rivers, which support a large and diverse fish population. In turn, the area attracts large numbers of a wide variety of fish-eating birds, including osprey, egrets, herons, cormorants, and bald eagles. Yuma clapper rails are widely distributed here, and reach the upstream limit of their distribution on the Gila River in this Important Bird Area (Audubon, 2013).

Other Biological Sensitivity. Critical habitat for the yellow-billed cuckoo occurs in the study area.

Out-of-State Wind

Northwest Wind (Oregon)

Crucial Habitat. The top two most crucial ranks comprise 31 percent of the Northwest Wind Study Area (Figure 4.2-11). The Oregon state CHAT ranking is driven by the presence of large natural areas, species of concern, freshwater integrity, landscape connectivity, wildlife corridors, natural vegetation communities, species of economic and recreational importance, and wetland and riparian areas. A total of 27 sensitive species and habitat types are recorded in this study area, and additional biological resources are likely to be present and unrecorded. Sensitive species in this study area include but are not limited to golden eagle, Washington ground squirrel (Candidate for federal listing), gray wolf (federally listed endangered), Swainson's hawk (Sensitive [Vulnerable] in Oregon), several sensitive invertebrates, and several rare plants.

Riparian and Wetland Habitats. The Columbia River, John Day River, and Rock Creek are major drainages that pass through the study area. Mapped drainages that may support riparian habitat in the Oregon North portion of the study area include Butter Creek and tributaries, Bear Creek, Owings Creek, and Birch Creek.

Large Natural Areas and Landscape Connectivity. Important modeled landscape corridors include the John Day River Corridor, Alkali Canyon, and the Coombs Canyon area. The Columbia Hills and Boardman Grasslands Important Bird Areas overlap the study area. The Columbia Hills Important Bird Area in Washington supports substantial populations of wintering and breeding raptors, including bald eagle, peregrine falcon, golden eagle, prairie falcon, and Swainson's hawk. Over 2,000 waterfowl have been recorded at the Swale Creek wetlands in winter. (Audubon, 2013)

The Boardman Grasslands Important Bird Area consists of two adjacent parcels, the Boardman Conservation Area and the Boardman Bombing Range. This Important Bird Area supports one of the largest remaining intact areas of native shrub-steppe and grassland ecosystems in Oregon. This site supports the largest known breeding populations in Oregon for grasshopper sparrow, long-billed curlew, and burrowing owl. (Audubon, 2013)

Other Biological Sensitivity. Critical habitat for steelhead, Chinook salmon, and bull trout occurs in the study area.

Utah Wind

Crucial Habitat. The top two most crucial ranks comprise 10 percent of the Utah Wind Study Area (Figure 4.2-12). The Utah state CHAT ranking is driven by the presence of large natural areas, sage grouse management areas, species of concern, National Hydrography Dataset results, and the National Wetlands Inventory results. A total of 18 sensitive species are recorded in this study area, and additional biological resources are likely to be present and unrecorded. Sensitive species in this study area include but are not limited to greater sage grouse, Utah prairie dog (federally listed threatened), kit fox, pygmy rabbit, spotted bat, Townsend's big-eared bat, least chub, bald eagle, burrowing owl, dark kangaroo mouse, and several rare plants.

Riparian and Wetland Habitats. The Beaver River, Wah Wah Wash, other named and unnamed dry desert washes, and scattered agricultural ponds are the primary mapped areas within the Utah Wind Study Area.

Large Natural Areas and Landscape Connectivity. No modeled large natural areas, landscape corridors, or Important Bird Areas occur within this study area.

Wyoming Wind

Crucial Habitat. The top two most crucial ranks comprise 31 percent of the Wyoming Wind Study Area (Figure 4.2-13). The Wyoming state CHAT ranking is driven by the presence of large natural areas, species of concern, species of economic and recreational importance, and wetland and riparian areas. Raw species occurrence data were not publically available for this study area, but were used by the state to develop Wyoming's CHAT model.

Riparian and Wetland Habitats. Riparian and wetland habitats in this study area include Sybille Creek, Mule Creek, Chugwater Creek, Spring Creek, Horse Creek, Lodgepole Creek, Farthing Reservoir, Richeau Creek, Bear Creek, Little Sage Creek, Sage Creek, Rasmussen Creek, Sage Creek Reservoir, Kindt Reservoir, and several other drainages and reservoirs. The Wyoming Central subarea is just west of the North Platte River and its associated riparian corridor.

Large Natural Areas and Landscape Connectivity. Most of study area is modeled as important large natural areas. The Laramie Plains Lakes Complex Important Bird Area overlaps the study area, and encompasses four discreet lake complexes and associated wetland areas within the Laramie Plains Basin. This Important Bird Area is an important migratory stopover for a variety of waterfowl, shorebirds, gulls, and waders. It provides breeding habitat for a number of species including one of the three American white pelican breeding populations in Wyoming, as well as black-crowned night heron, American bittern, white-faced ibis, American avocet, and California gull. (Audubon, 2013)

Other Biological Sensitivity. Critical habitat for the Colorado butterfly plant occurs in the study area. The study area is also within big game crucial range.

New Mexico Wind

Crucial Habitat. The top two most crucial ranks comprise 26 percent of the New Mexico Wind Study Area (Figure 4.2-14). The New Mexico state CHAT ranking is driven by the presence of large natural areas, species of concern, species of economic and recreational importance, wetland and riparian areas, natural vegetation communities, freshwater integrity, and wildlife corridors. Raw species occurrence data were not publically available for this study area, but were used by the state to develop New Mexico's CHAT model.

Riparian and Wetland Habitats. The Cola del Gallo Arroyo, Gallo Arroyo, and numerous dry desert washes of various sizes cross the study area. Scattered agricultural ponds occur in the eastern portion of the study area.

Large Natural Areas and Landscape Connectivity. Almost all of the New Mexico Central subarea is modeled as important large natural areas. The Clovis Playas and NM Lesser-Prairie Chicken Complex Important Bird Areas also overlap the study area. The Clovis Playas Important Bird Area consists of grasslands interspersed with agricultural lands at the eastern edge of New Mexico. It provides wintering habitat for a large number of waterfowl, and when playas are full it provides migratory stopover habitat for waterfowl and shorebirds. The NM Lesser Prairie-Chicken Complex Important Bird Area encompasses over 2 million acres in eastern New Mexico, including a number of properties managed specifically for lesser prairie-chicken. This area also supports other declining grassland species such as burrowing owl, scaled quail, Cassin's sparrow, and grasshopper sparrow. When full, the playa lake in this Important Bird Area can host thousands of migrating sandhill cranes. (Audubon, 2013)

Other Biological Sensitivity. Caprock Escarpment provides essential habitat for bats.

Figure 4.2-1. Crucial Habitat Greater Carrizo CREZ Study Areas

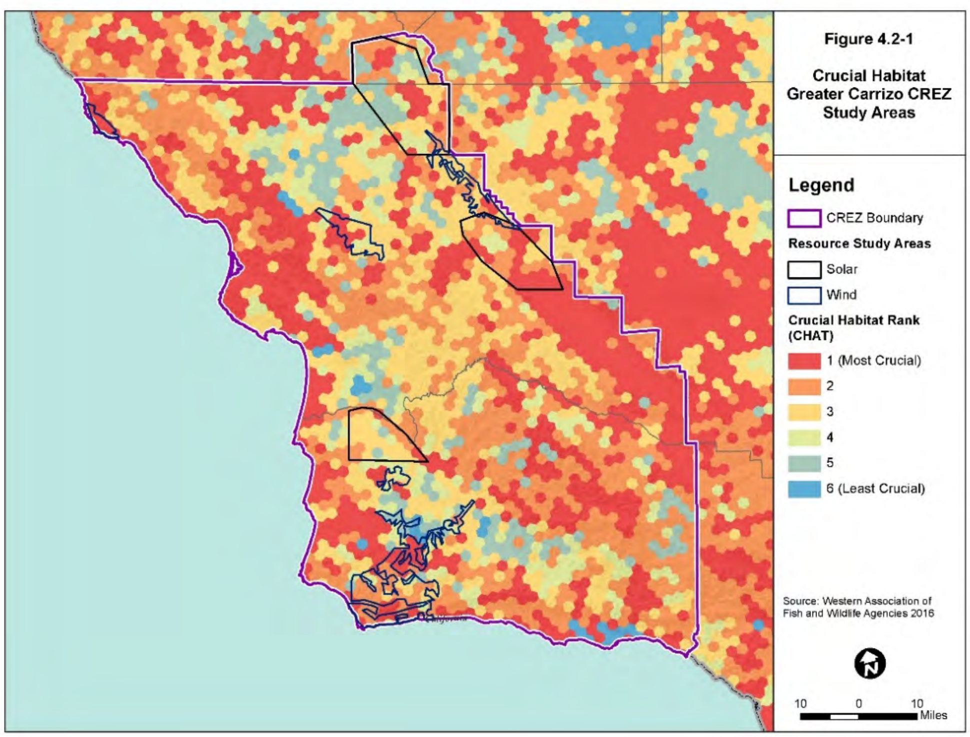


Figure 4.2-2. Crucial Habitat Greater Imperial CREZ Study Areas

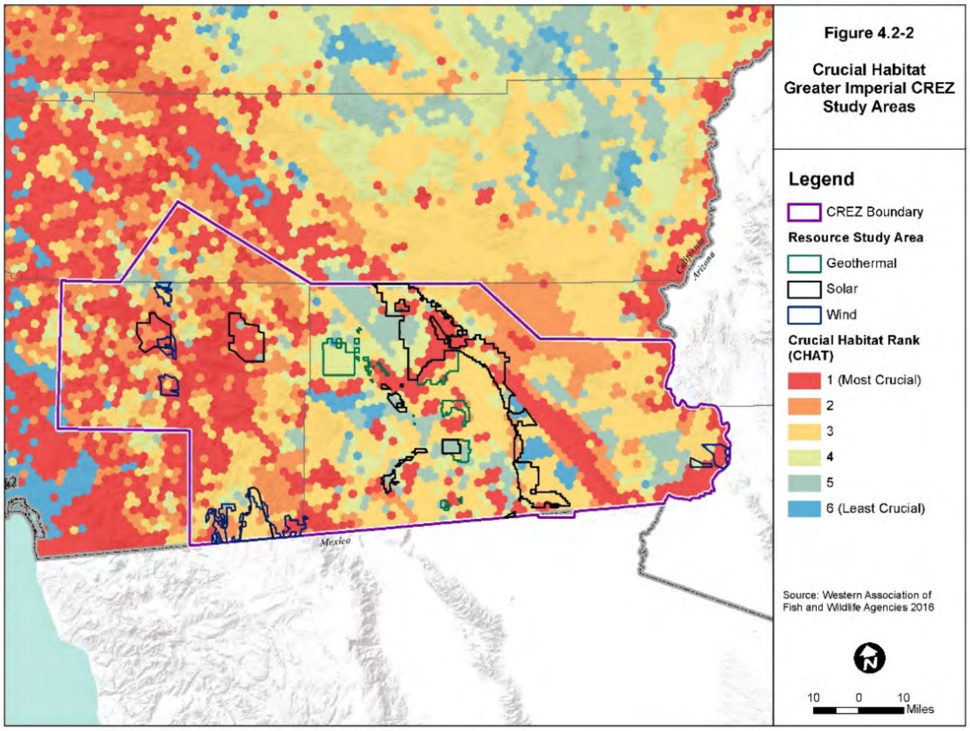


Figure 4.2-3. Crucial Habitat Kramer & Inyokern CREZ Study Areas

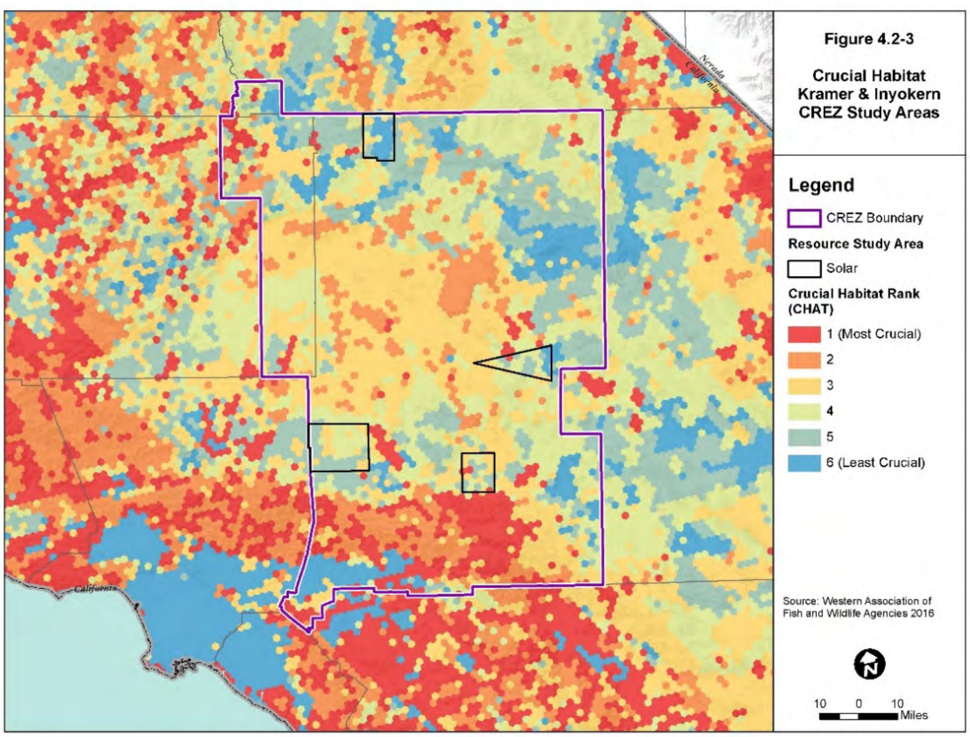


Figure 4.2-4. Crucial Habitat Owens Valley & Inyo CREZ Study Areas

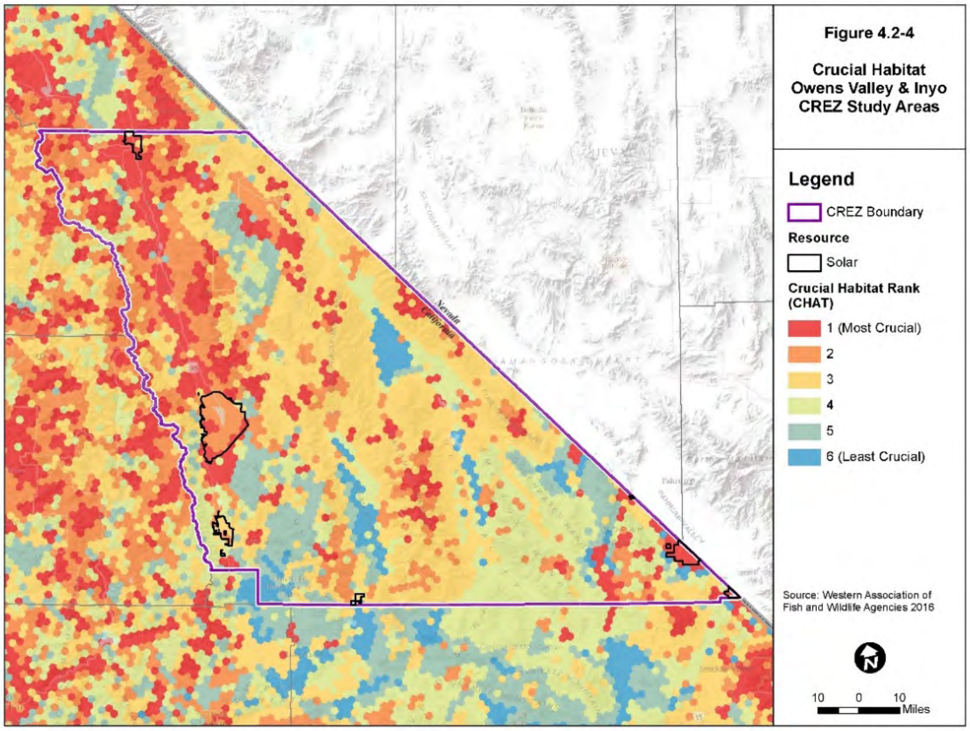


Figure 4.2-5. Crucial Habitat Riverside East & Palm Springs CREZ Study Areas

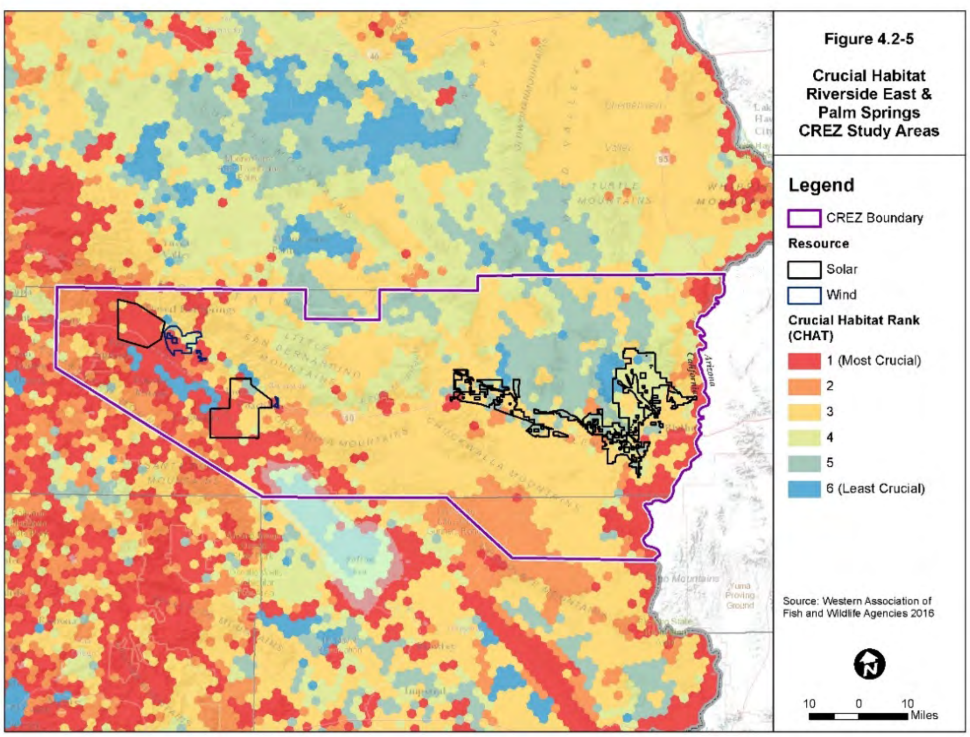


Figure 4.2-6. Crucial Habitat Tehachapi CREZ Study Areas

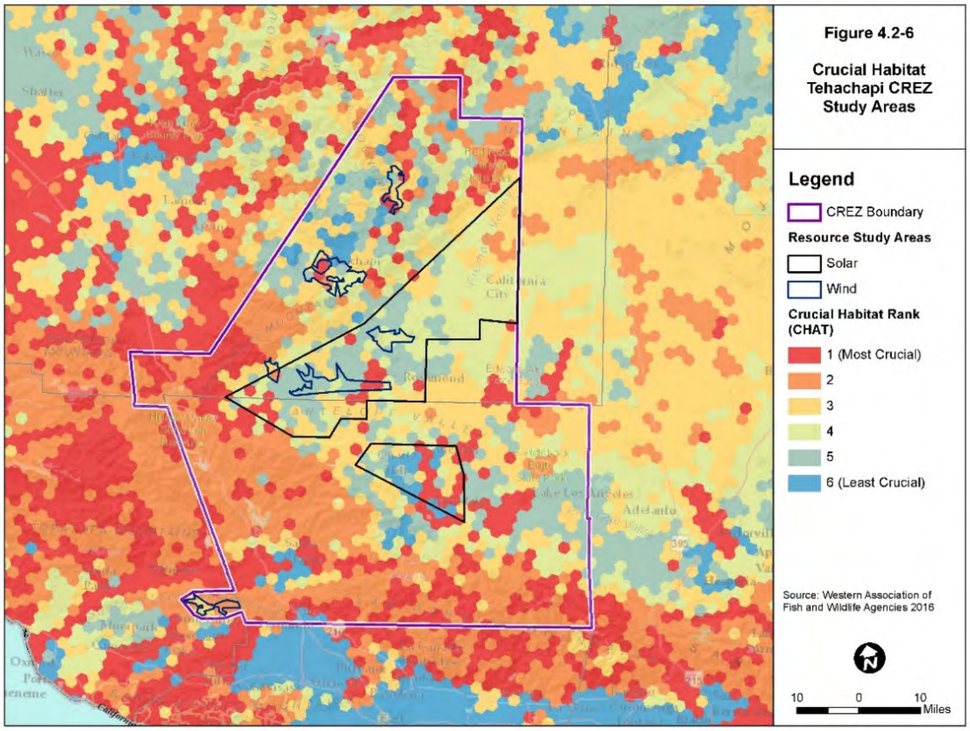


Figure 4.2-7. Crucial Habitat Westlands CREZ Study Areas

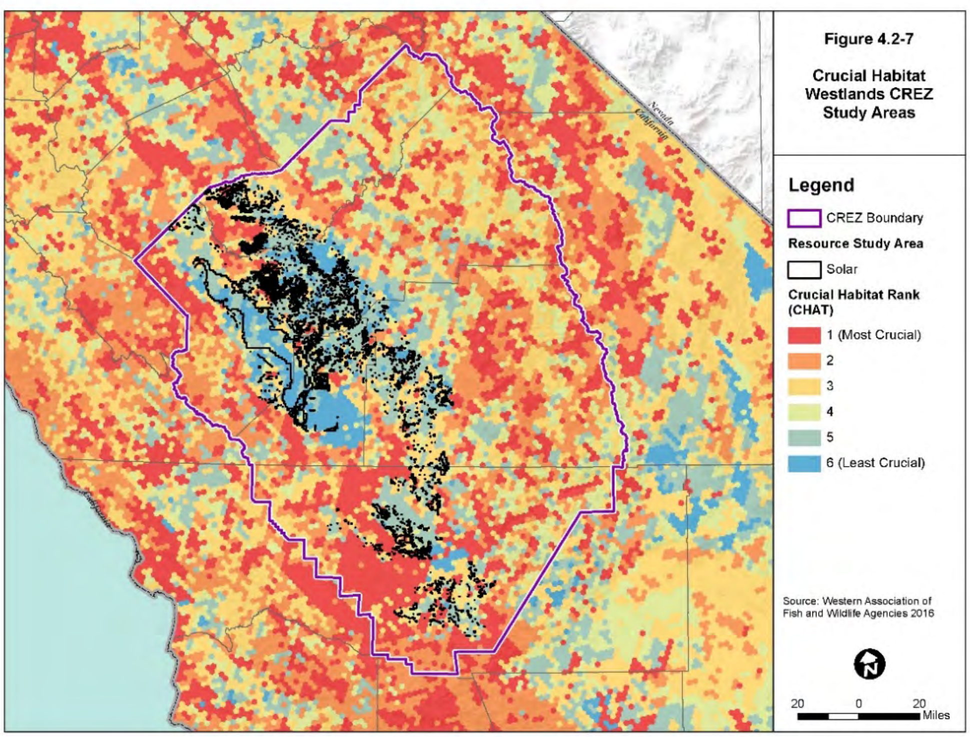


Figure 4.2-8. Crucial Habitat Central Valley North and Los Banos CREZ Study Areas

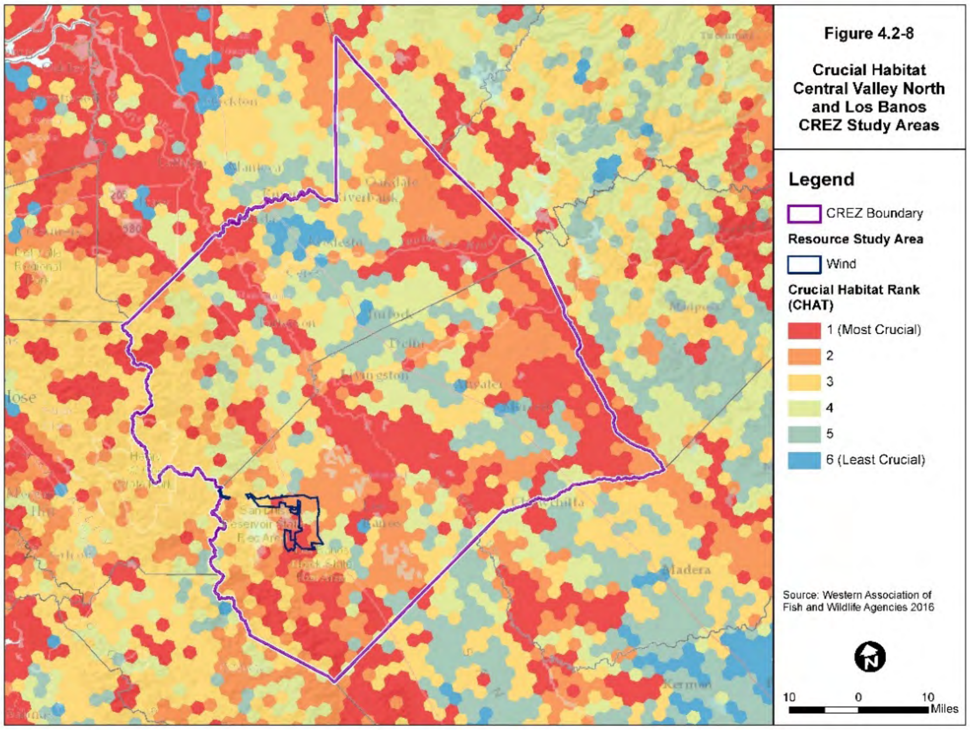


Figure 4.2-9. Crucial Habitat Solano CREZ Study Areas

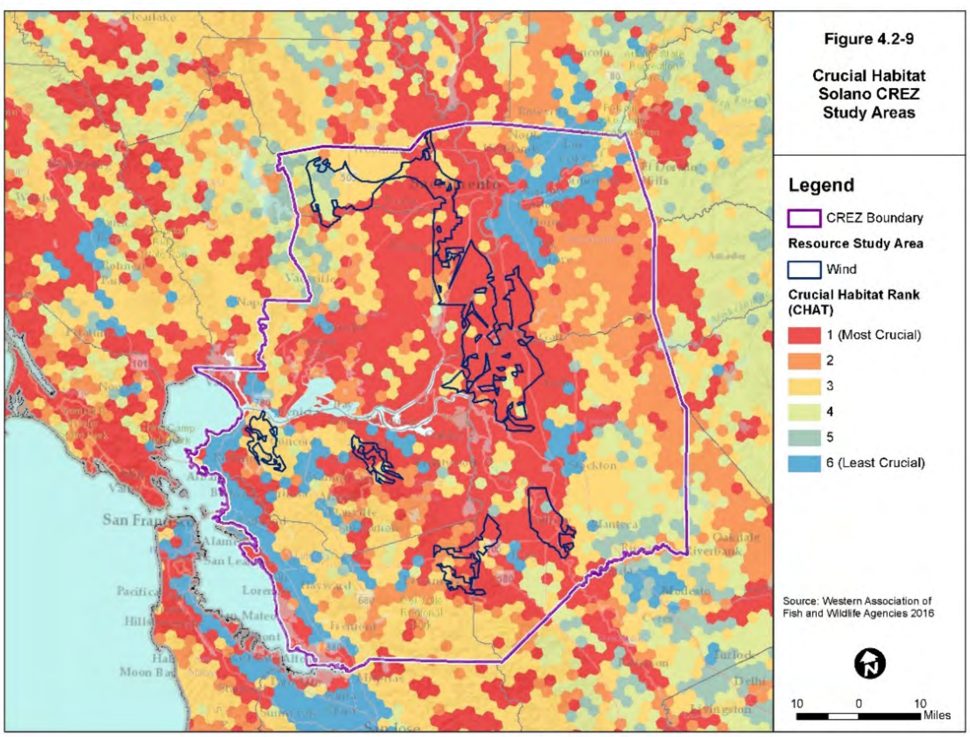


Figure 4.2-10. Crucial Habitat Arizona Solar Study Areas

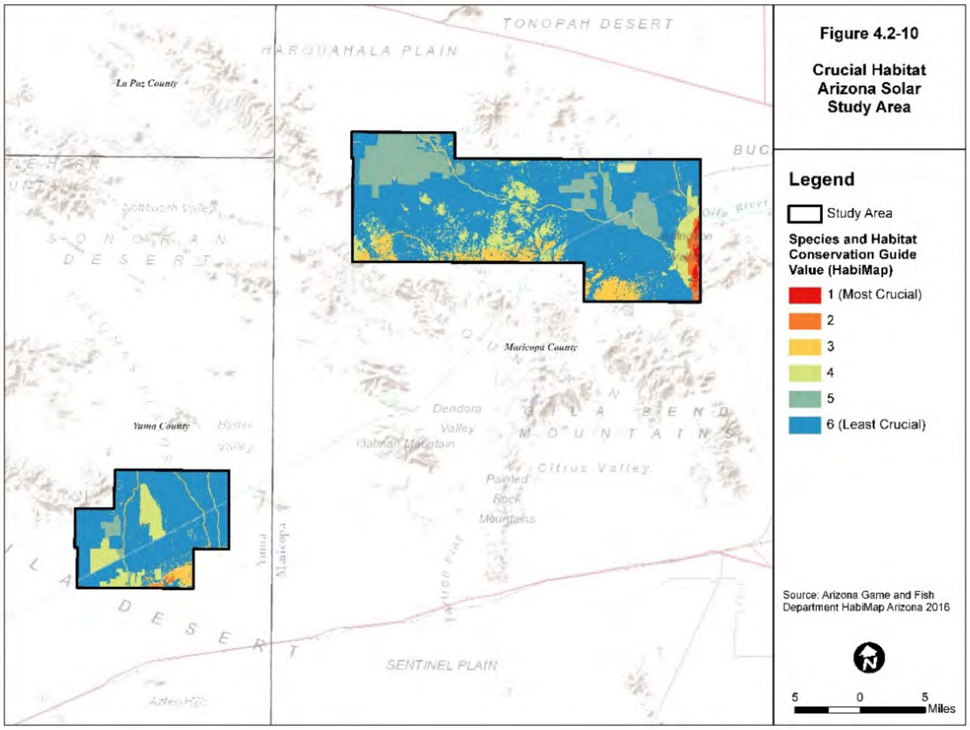
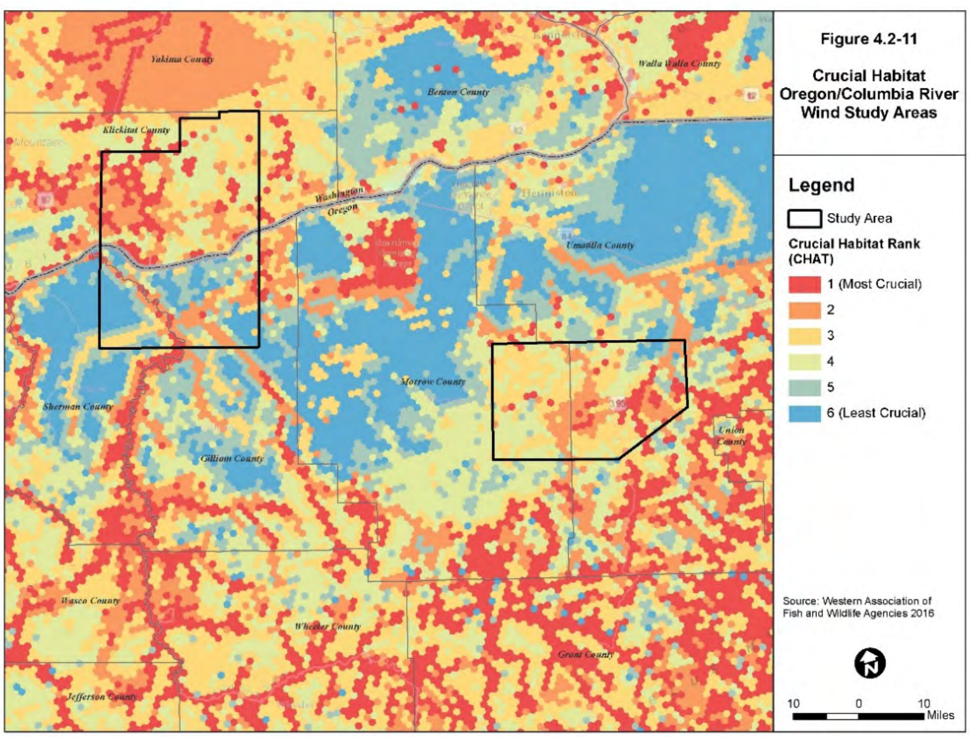


Figure 4.2-11. Crucial Habitat Oregon/Columbia River Wind Study Areas



Aspen Environmental Group

Figure 4.2-12. Crucial Habitat Utah Wind Study Areas

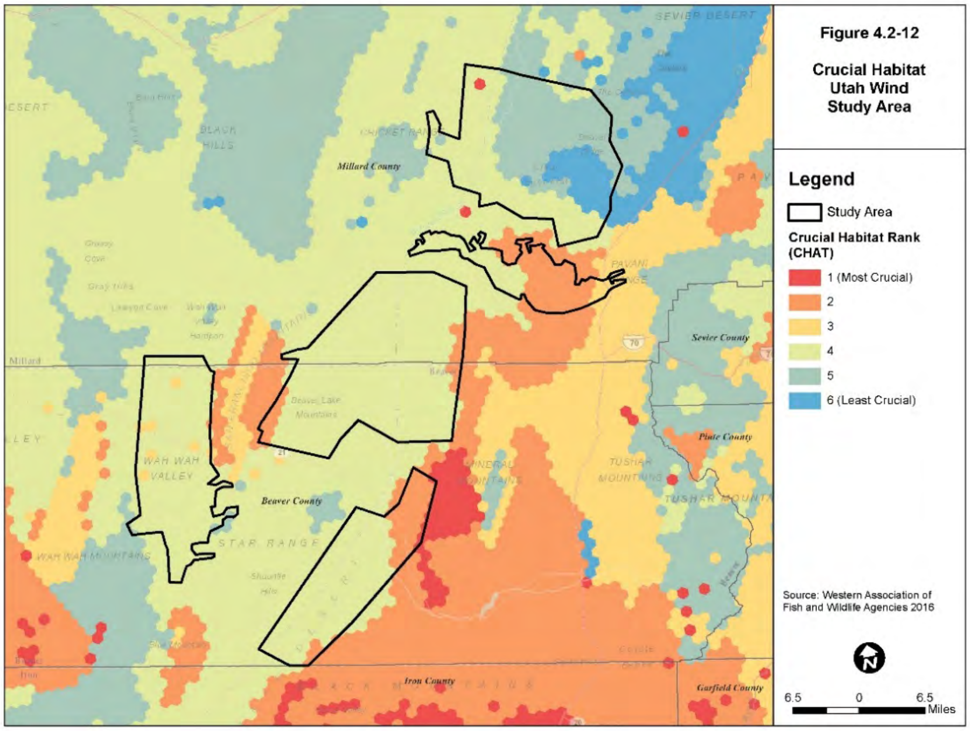


Figure 4.2-13. Crucial Habitat Wyoming Wind Study Areas

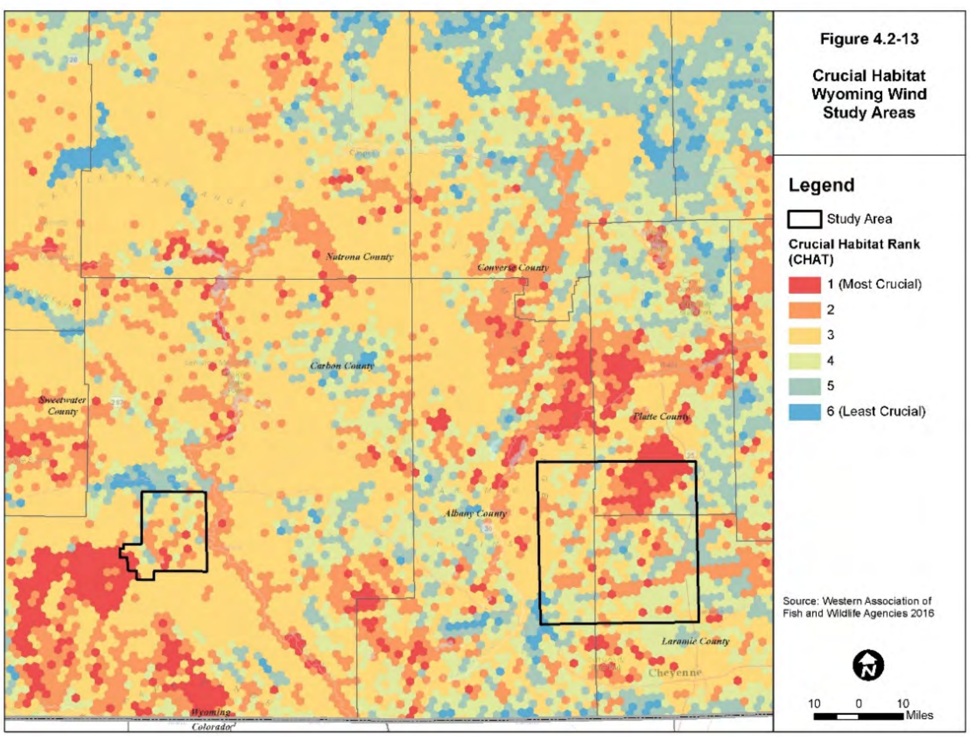
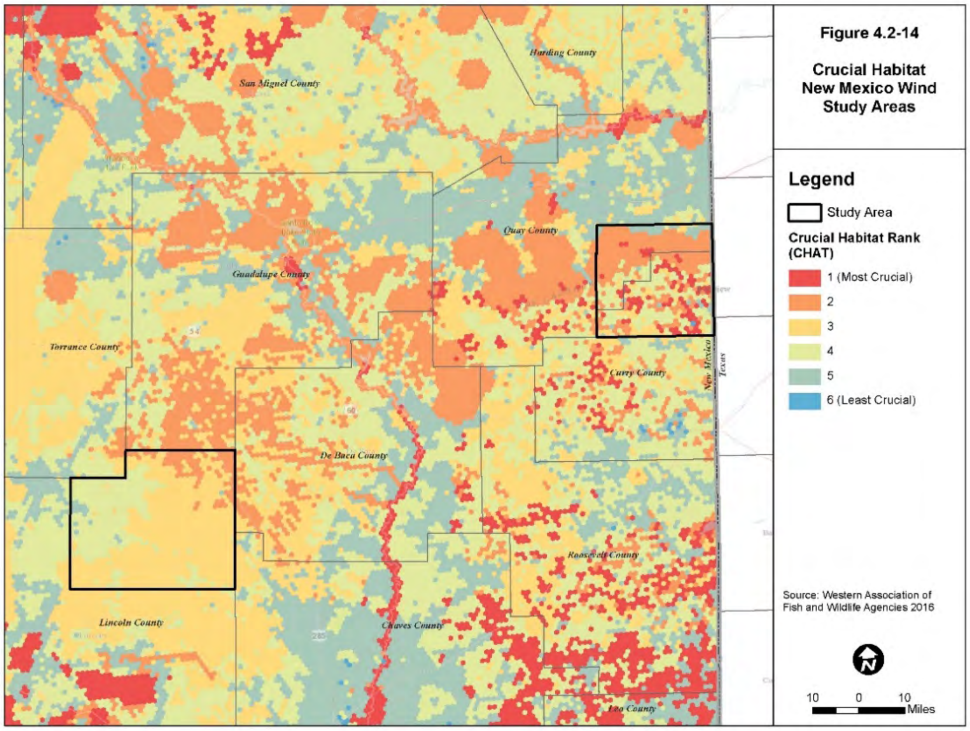


Figure 4.2-14. Crucial Habitat New Mexico Wind Study Areas



4.2.3 Typical Biological Resources Impacts of the Buildouts

The SB 350 environmental study describes environmental impacts in general; it is not site-specific and does not reflect or represent a siting study for any particular planned or conceptual construction project. Impacts to biological resources from large-scale renewable energy development may include habitat conversion, loss, degradation, or fragmentation, as well as through disturbance, injury, or mortality of plants or wildlife. Project-specific impacts would be avoided, minimized or compensated for, to the extent feasible, through site-specific configuration of project components as well as implementation of best management practices and mitigation as developed during the siting processes and required by the siting authorities with jurisdiction over affected biological resources. The impacts typical of construction and ongoing operations and maintenance activities are summarized in this section.

Construction Impacts in General

Buildout of the portfolios introduces some typical impacts to biological resources that may be caused by the construction activities for development of utility-scale renewable energy facilities. Renewable resource-specific impacts are explained in the subsections that follow. In general, typical construction-phase impacts are:

- **Habitat loss.** Conversion of habitat and fill of wetlands and other waters from installation of permanent facilities, including generation equipment, substations, transmission interconnections, and access roads. Cumulative effects throughout species range exacerbate impacts.

- **Habitat degradation.** Indirect damage to habitat from the establishment or expansion of noxious weeds and invasive species populations, sediment disposition or reduced water quality in aquatic habitats/wetlands, and reduced groundwater availability to groundwater-dependent vegetation communities.
- **Habitat fragmentation.** Large installations and roads may restrict wildlife movement, potentially reducing genetic diversity and interfering with migration. Cumulative effects throughout species range exacerbate impacts.
- **Disturbance, injury or mortality of special-status species.** Construction noise and human presence may disturb breeding wildlife and result in abandonment of eggs or young. Vehicles and equipment (including grading) may crush plants and wildlife or their burrows/dens.

Solar Construction

Construction of utility-scale solar facilities generally involves grading of large contiguous areas of land and typically results in extensive habitat loss. Restoration and revegetation of temporary disturbance areas in desert ecosystems can be difficult or impossible and damage to cryptobiotic crust of desert soils is particularly slow to recover, if ever.

Solar arrays can be configured to avoid sensitive biological resources (e.g., wetlands, watercourses, wildlife nursery sites, special-status plants and dense populations of small mammals) and to maintain wildlife movement corridors. Within fenced areas, native vegetation can exist between panels and continue to provide grassland foraging habitat in very limited cases; typically, vegetation is mowed or removed and the fenced facility is designed to deter larger wildlife (e.g., with exclusion fencing) to avoid possible injury to animals and damage to solar equipment and/or to facilitate movement of smaller mammals (e.g., kit fox).

Wind Construction

Habitat loss due to construction of wind energy systems does not typically occur in large contiguous areas and is normally isolated to wind turbine pads, ancillary buildings, substations, and access roads. Therefore, fragmentation is not usually severe; however, some species in wind resource areas (e.g., sage grouse) are particularly sensitive to the presence and use of equipment used for installing the infrastructure. Turbines can be configured to avoid sensitive terrestrial biological resources (e.g., wetlands, watercourses, wildlife nursery sites, special-status plants).

Geothermal Construction

Similar to wind construction, habitat loss resulting from geothermal construction does not typically occur in large contiguous areas and is normally isolated to surface facilities, well pads, pipelines, substations, and access roads. Therefore, fragmentation is not usually severe; however, some species in geothermal resource areas (e.g., peninsular bighorn sheep) are particularly sensitive to the presence and use of equipment used for installing the infrastructure. Wells can be clustered, which would expand the disturbance area at a particular well pad, but reduce total disturbance in the well field. Wells can also be configured to avoid sensitive biological resources (e.g., wetlands, watercourses, wildlife nursery sites, special-status plants), but directional drilling or trenching for pipeline installation would result in construction-phase disturbances.

Drilling requires large amounts of water, and local drawdown of water tables can have a direct effect on wetlands and groundwater flows, which can directly affect riparian vegetation or groundwater-dependent vegetation communities and associated wildlife. Sumps and pits used for storing excess geothermal fluids may be an attractant to wildlife that could result in physical injury or exposure to contaminants.

Drilling can take place up to 24 hours a day. Lighting and construction activity at night can be highly disruptive to wildlife and cause adverse alterations of behavior.

Operational Impacts in General

Buildout of the portfolios introduces some typical impacts to biological resources that may be caused by the operation of utility-scale renewable energy facilities. Renewable resource-specific impacts are explained in the subsections that follow. In general, typical operational impacts are:

- **Introduction of invasive species.** Habitat degradation from the establishment or expansion of noxious weeds and invasive species populations, including increased wildfire risk and changes to native species composition.
- **Predator subsidization.** Provision of additional food, water, nesting/bedding material that attracts predators (e.g., raven, coyote) and increases predation.
- **Disturbance, injury or mortality of special-status species.** Noise, night lighting, and human presence may disturb breeding wildlife, spread disease, and adversely alter wildlife behaviors. Maintenance vehicles and equipment may result in injury or mortality of wildlife along access roads or in unfenced areas of the facility.

Solar Operations

During operations, vehicles and equipment may be occasionally onsite to wash panels, maintain and inspect facilities, and mow vegetation to reduce fire risk. This could result in occasional temporary disturbance, injury or mortality of special-status species. Fencing must be maintained to ensure exclusion of larger wildlife, as necessary, but smaller special-status wildlife not excluded by fencing could be encountered inside or outside project boundaries along access roads.

Runoff water from washing solar panels or dust control could exacerbate the proliferation of invasive plants and attract wildlife if the arrays are unfenced. If groundwater is the water source, degradation of groundwater-dependent vegetation communities and impacts to associated wildlife could occur.

Wind Operations

The primary operational impact of wind energy facilities is bird and bat injury and mortality from collisions with turbines. Collision fatalities of some species, particularly those that are state or federally listed, can have a greater effect on local or regional populations and may affect migration behaviors.

Vehicles and equipment may be occasionally onsite to maintain and inspect facilities. This could result in occasional temporary disturbance, injury or mortality of special-status species.

Geothermal Operations

Vehicles and equipment may be occasionally onsite to maintain and inspect facilities and manage geothermal production waste. As geothermal developments are typically unfenced, this could result in occasional temporary disturbance, injury or mortality of special-status species.

Sumps and pits used for storing excess geothermal fluids may be an attractant to wildlife that could result in physical injury or exposure to contaminants.

4.2.4 Biological Resources Impacts of Regionalization

The 2020 CAISO + PAC scenario does not include any incremental renewable energy development. For limited regionalization in 2020, there would be no incremental construction activities; therefore, no adverse effects to biological resources would occur in this scenario.

Each scenario of regionalization in 2030 requires an incremental buildout of new solar, wind, and geothermal energy facilities, inside California and elsewhere, that will create environmental impacts in the vicinity of the renewable energy buildout. This section describes the potential impacts to biological resources for each incremental buildout to facilitate a comparison of the scenarios and identify the tradeoffs between in-state versus out-of-state development.

Incremental Buildout for Current Practice Scenario 1 by 2030

Inside California

Current Practice Scenario 1 emphasizes solar development in the Tehachapi and Westlands study areas, which account for 60 percent of total solar generation under this scenario (Tehachapi: 2,500 MW; Westlands: 2,323 MW), as shown in Section 2. These study areas also have low coverage of crucial habitat (Tehachapi: 13%, Westlands: 5%) and therefore have relatively low baseline biological resources sensitivity. In Tehachapi, solar development would primarily affect desert tortoise and Mohave ground squirrel, which are particularly sensitive to cumulative habitat loss and degradation. The Westlands study area is characterized by active and fallow agricultural land, which provides foraging habitat for various species including raptors; however, similar foraging habitat is widespread in the Central Valley. San Joaquin kit fox may move across the landscape through this study area, but fencing and facility design considerations could minimize any corridor constriction.

Wind generation would be distributed across six California study areas under Current Practice 1, with the greatest amount (28% of total or 850 MW) occurring in Tehachapi. The Tehachapi study area has the lowest crucial habitat coverage of the California wind study areas at 20 percent. Sensitive resources potentially affected by wind development in this study area include California condor, Swainson’s hawk, golden eagles, and a diversity of birds at the Antelope Valley and Southern Sierra Desert Canyons Important Bird Areas, which include one of interior California’s most important segments of the Pacific Flyway migration corridor. In general, impacts across the six wind study areas would be typical of those described in Section 4.2.3 and would include bird and bat injury and mortality from collisions with turbines. Collision impacts would be particularly severe in the Central Valley North/Los Banos and Solano study areas, which have high crucial habitat coverage (Central Valley North/Los Banos: 77%, Solano: 73%) attributable to their proximity to large water bodies that attract birds (Central Valley North/Los Banos: San Luis Reservoir, Solano: Sacramento-San Joaquin Delta).

Geothermal development would only occur in the Greater Imperial study area, which has 33% coverage of the highest crucial habitat ranks. Impacts would be typical of those described in Section 4.2.3.

Out of State

Current Practice 1 emphasizes wind development in the Northwest study area (44% of total or 2,447 MW) followed by wind development in New Mexico (18% of total or 1,000 MW). There is high potential for avian collision with turbines in the Northwest study area due to its proximity to the Columbia River and associated riparian habitat, which runs through the study area, as well as the Boardman Grasslands Important Bird Area, which supports one of the largest remaining intact areas of native shrub-steppe and grassland ecosystems in Oregon and the largest known breeding populations in Oregon for grasshopper sparrow, long-billed curlew, and burrowing owl. The New Mexico study area overlaps portions of the NM Lesser Prairie-Chicken Complex Important Bird Area. The federally threatened lesser prairie-chicken is highly sensitive to the presence of vertical infrastructure, including wind turbines, and cumulative effects of infrastructure development are the main threat to this species.

Under this scenario, most solar development would occur in the Southwest study area (18% of total or 1,000 MW), which has the lowest crucial habitat coverage of any study area (2%). Although not many sensitive biological resources occur in this study area, impacts to those present would be typical of those described in Section 4.2.3 and likely avoided or minimized by implementation of standard measures.

Incremental Buildout for Regional 2 by 2030

Inside California

Regional 2 would increase solar development in the Riverside East & Palm Springs study area, decrease solar development in Westlands, and eliminate incremental wind development in the Riverside East & Palm Springs and Solano study areas in comparison to Current Practice 1. A comparison of biological resources impacts from Regional 2 and Current Practice 1 for each California study area is presented in the Comparison of Scenarios in Section 4.2.5, in Table 4.2-2 (solar) and Table 4.2-3 (wind).

Regional 2 emphasizes solar development in the Riverside East & Palm Springs study area; this represents an increase of 1,653 MW in this study area in comparison to Current Practice 1, which assumes 331 MW. Accordingly, the severity of impacts to biological resources in the Riverside East & Palm Springs study area would increase. In particular, development would result in more habitat loss for several listed species and greater constriction of movement corridors for desert tortoise and bighorn sheep (peninsular and desert) than under Current Practice 1. Solar development in the Westlands study area would decrease by 1,450 MW in comparison to Current Practice 1; however, this study area has a low baseline sensitivity, so this reduction in development would not reduce any major impacts.

The elimination of incremental wind development in the Riverside East & Palm Springs and Solano study areas under Regional 2 would also eliminate impacts to biological resources in these study areas that would occur under Current Practice 1. Most importantly, bird and bat injury and mortality from collisions with turbines in the Solano study area in the highly-sensitive Sacramento-San Joaquin Delta would not occur.

Out of State

A comparison of biological resources impacts from Regional 2 and Current Practice 1 for each out-of-state study area is presented in the Comparison of Scenarios in Section 4.2.5, in Table 4.2-4.

Regional 2 would increase solar development in the Southwest study area by 500 MW in comparison to Current Practice 1. This would not substantially increase the severity of biological resource impacts in the Southwest study area given its low baseline sensitivity. However, wind development in the Northwest study area would decrease by 885 MW in this scenario. This study area has a relatively high baseline sensitivity due to the Columbia River and associated high-quality bird habitat; a decrease in wind development would result in a decrease in avian and bat mortality from turbine collisions.

Importantly, Regional 2 would greatly increase wind development in the Wyoming and New Mexico study areas by 2,000 MW and 3,000 MW, respectively, in comparison to Current Practice 1, due to renewable energy development facilitated by the regional market. These study areas have high baseline sensitivity attributable to the presence of Important Bird Areas. This increase in wind development would result in much greater impacts to birds and bats in comparison to Current Practice 1. Impacts to the lesser prairie-chicken in the New Mexico study area would be particularly severe.

Incremental Buildout for Regional 3 by 2030

Inside California

Regional 3 would eliminate incremental solar development in the Riverside East & Palm Springs and Carrizo study areas and decrease solar development in the Westlands, Tehachapi, Owens Valley and Greater Carrizo study areas in comparison to Current Practice 1. A comparison of biological resources impacts from Regional 3 and Current Practice 1 for each California study area is presented in the Comparison of Scenarios in Section 4.2.5, in Table 4.2-2 (solar) and Table 4.2-3 (wind).

Regional 3 would eliminate or reduce impacts to biological resources in all California solar study areas, except in the Kramer and Inyokern study area, where there would be no change in solar development between scenarios. The reduction of impacts in Owens Valley and Greater Imperial study areas are particularly notable given the relatively high baseline sensitivity of these study areas (crucial habitat coverage: Owens Valley – 87%, Greater Imperial – 44%), which is attributable to the occurrence of numerous listed species in these study areas.

With regard to wind development in California, Regional 3 is the same as Regional 2. Impacts to biological resources in the Riverside East & Palm Springs and Solano study areas that would occur under Current Practice 1 would be eliminated under Regional 3. Most importantly, bird and bat injury and mortality from collisions with turbines in the Solano study area in the highly-sensitive Sacramento-San Joaquin Delta would not occur.

Out of State

A comparison of biological resources impacts from Regional 3 and Current Practice 1 for each out-of-state study area is presented in the Comparison of Scenarios in Section 4.2.5, in Table 4.2-4.

As with Regional 2, Regional 3 would increase solar development in the Southwest study area by 500 MW in comparison to Current Practice 1. This would not substantially increase the severity of biological resource impacts in the Southwest study area given its low baseline sensitivity. However, wind development in the Northwest study area would decrease by 2,129 MW in comparison to Current Practice 1, which assumed 2,447 MW. This study area has a relatively high baseline sensitivity due to the Columbia River and associated high-quality bird habitat; this substantial decrease in wind development would result in a decrease in avian and bat mortality from turbine collisions in comparison to Current Practice 1.

Importantly, Regional 3 would immensely increase wind development in the Wyoming and New Mexico study areas by 3,995 MW and 4,962 MW, respectively, in comparison to Current Practice 1, due to renewable energy development facilitated by the regional market. This represents a nine-fold increase in Wyoming and six-fold increase in New Mexico in wind generation in these study areas in comparison to Current Practice 1. These study areas have high baseline sensitivity attributable to the presence of Important Bird Areas. This increase in wind development would result in much greater impacts to birds and bats in comparison to Current Practice 1. Impacts to the lesser prairie-chicken in the New Mexico study area would be particularly severe.

Out-of-State Transmission Additions

Under Regional 3, it is assumed that major out-of-state transmission additions would be necessary to integrate renewable generation from Wyoming and New Mexico into the regional power system and for California to achieve 50% RPS. The biological resources considerations related to the construction and operation of the potential transmission expansions are summarized in Section 5.

4.2.5 Comparison of Scenarios for Biological Resources

The change from Current Practice into regional scenarios allows the following comparisons.

Inside California

- Regional 2 exchanges potential impacts, by slightly increasing impacts to resources in Riverside East & Palm Springs (e.g., desert tortoise, bighorn sheep) and reducing impacts elsewhere
- Regional 2 and Regional 3 reduce impacts to avian resources (e.g., migratory birds) by eliminating wind in Riverside East & Palm Springs and Solano
- Regional 3 eliminates or reduces impacts to biological resources in all California solar study areas, except no change in Kramer and Inyokern (which is has relatively low baseline sensitivity).

Out of State

- Regional 2 and Regional 3 reduces impacts to avian resources (e.g., migratory birds) in Northwest wind area with a relatively high baseline sensitivity
- Regional 3 increases impacts to avian resources (e.g., migratory birds) in Wyoming and New Mexico due to wind for the California RPS
- Regional 2 and Regional 3 also increase impacts to avian resources (e.g., migratory birds) in Wyoming and New Mexico due to renewable energy development facilitated by the regional market (5,000 MW wind)

Important differences of the scenarios are described in the sections following the tables. The results of the comparison of scenarios are summarized in Table 4.2-2 for solar and Table 4.2-3 for wind areas inside California, and in Table 4.2-4 for renewable energy resources outside of California.

Table 4.2-2. Biological Resources, Comparison of Scenarios for California Solar Buildout

California Solar Study Areas	Coverage of Most Crucial Habitat Ranks	Difference: Regional 2 Relative to Current Practice 1	Difference: Regional 3 Relative to Current Practice 1
Greater Carrizo Solar	52%	No change	Impacts eliminated
Greater Imperial Solar	44%	No change	Impacts reduced
Kramer and Inyokern Solar	2%	No change	No change
Owens Valley Solar	87%	No change	Impacts slightly reduced
Riverside East and Palm Springs Solar	30%	Impacts increased	Impacts eliminated
Tehachapi Solar	13%	No change	Impacts reduced
Westlands Solar	5%	Impacts reduced	Impacts reduced

Table 4.2-3. Biological Resources, Comparison of Scenarios for California Wind Buildout

California Wind Study Areas	Coverage of Most Crucial Habitat Ranks	Difference: Regional 2 Relative to Current Practice 1	Difference: Regional 3 Relative to Current Practice 1
Central Valley North and Los Banos Wind	77%	No change	No change
Greater Carrizo Wind	57%	No change	No change
Greater Imperial Wind	56%	No change	No change
Riverside East and Palm Springs Wind	55%	Impacts eliminated	Impacts eliminated
Solano Wind	73%	Impacts eliminated	Impacts eliminated
Tehachapi Wind	20%	No change	No change

Table 4.2-4. Biological Resources, Comparison of Scenarios for Out-of-State Buildout

Out-of-State Solar & Wind Study Areas	Coverage of Most Crucial Habitat Ranks	Difference: Regional 2 Relative to Current Practice 1	Difference: Regional 3 Relative to Current Practice 1
Southwest Solar (Arizona)	2%	Impacts increased	Impacts increased
Northwest Wind (Oregon)	31%	Impacts reduced	Impacts reduced
Utah Wind	10%	No change	Impacts slightly reduced
Wyoming Wind	31%	Impacts greatly increased (beyond RPS)	Impacts greatly increased (beyond RPS plus RPS portfolio)
New Mexico Wind	26%	Impacts greatly increased (beyond RPS)	Impacts greatly increased (beyond RPS plus RPS portfolio)

Regional 2 Relative to Current Practice 1

Relative to Current Practice 1, in California, Regional 2 would result in increased habitat loss for several listed species and greater constriction of movement corridors for desert tortoise and bighorn sheep (peninsular and desert) in the Riverside East & Palm Springs study area from greater solar development and the elimination of bird and bat injury and mortality from collisions with turbines in the highly-sensitive Solano study area due to the elimination of wind development.

Regarding out-of-state biological resources impacts, relative to Current Practice 1, Regional 3 would decrease avian and bat mortality from turbine collisions in Northwest study area due to a reduction in wind development and greatly increase these impacts in the Wyoming and New Mexico study areas due to an increase in wind development for the California RPS and wind development facilitated by the regional market beyond RPS.

Regional 3 Relative to Current Practice 1

Relative to Current Practice 1, Regional 3 would eliminate or reduce impacts to biological resources in all California solar study areas, except in the Kramer and Inyokern study area (no change), which has relatively low baseline sensitivity. Regional 3 would also eliminate bird and bat injury and mortality from collisions with turbines in the highly-sensitive Solano study area due to the elimination of wind development.

Regarding out-of-state biological resources impacts, relative to Current Practice 1, Regional 3 would decrease avian and bat mortality from turbine collisions in Northwest study area due to a reduction in wind development and immensely increase these impacts in the Wyoming and New Mexico study areas due to an increase in wind development for the California RPS portfolio and wind development facilitated by the regional market beyond RPS.

4.3 Water

This section describes the potential impacts to water resources for each of the four buildouts. The approach to the analysis relies upon a narrow set of baseline conditions that are treated as potential indicators or predictors of impacts, as listed in Table 4.3-1.

Table 4.3-1. Baseline Conditions and Indicators of Impacts, Water Resources

Baseline condition of a study area	How are scenarios analyzed relative to the baseline?	Potential indicator of water impact
Water		
Level of groundwater basin overdraft	Coincidence of incremental renewable energy buildout with areas of substantially constrained groundwater availability	Water supply and water quality
Level of groundwater basin overdraft	Changes in fossil fuel generation by technologies that rely heavily on cooling water	Water supply

Assumptions and Methodology for Water Analysis

The water methodology considers the following issues:

- How the construction of the renewable buildout for each portfolio may affect Critically Overdrafted Groundwater Basins in California as defined by the California Department of Water Resources (CDWR)
- How the construction of renewable buildout for each portfolio may affect areas in low to medium, medium to high, and high water risk based on the World Resources Institute (WRI) risk characterization
- The water requirement for the operation of renewable and non-renewable resources under each of the PSO scenarios

Critically Overdrafted Groundwater Basins

The CDWR defines critically overdrafted groundwater basins as basins and subbasins in California in conditions of critical overdraft, resulting from seawater intrusion, land subsidence, groundwater depletion, and/or chronic lowering of groundwater levels. In this report, study areas are evaluated to define whether they would overlap areas of critically overdrafted groundwater basins. The study areas do not align completely with groundwater basin boundaries, and this analysis does not attempt to calculate how much water would be used from the basins.

Water Risk

The WRI published an *Aqueduct Water Risk Atlas,* which is a publicly available, global database and interactive tool that maps indicators of water-related risks. This tool provides an overall score of water risk that incorporates water quantity, water variability, water quality, public awareness of water issues, access to water, and ecosystem vulnerability. Because the data set covers the entire U.S., it allows for a comparison among the states that are included in the RESOLVE renewable portfolios.

In order to confirm the relevance of the WRI water risk assessment dataset, it has been compared to other U.S. reports, such as the United States Geological Survey (USGS) Groundwater Depletion in the United States (1900-2008) and NASA GRACE-Based monitoring tools.[2]

[2] See for example the GRACE-Based Surface Soil Moisture Drought Indicator, GRACE-based Ground Water Storage, and GRACE-Based Shallow Groundwater Drought Indicator.

The resource study areas were mapped using the WRI data to determine the percentage of each area that overlapped with low to medium, medium to high, or high water risk areas. This information was used to calculate the potential amount of water used for construction under each risk category. In order to calculate the amount of water used during construction, state-based estimates were developed (6 acre-feet per MW for construction in Arizona and 2 acre-feet per MW for construction in California). This data was take from the Sandia Report "Water Use and Supply Concerns for Utility-Scale Solar Projects in the Southwestern United States" (July 2013).[3] Wind turbine construction water use assumed at 0.4 acre-feet per MW[4]. Geothermal construction use assumed 1.4 acre-feet per MW for construction.[5]

It should be noted that the study areas are much larger than would be needed to develop the amount of energy assumed under each scenario. Therefore, while this analysis allows for comparison among the scenarios, more energy could be developed in any one of the risk areas than the calculations would indicate.

Operational Water Use

The production cost simulation model provided the changes in overall generation (in MWh) in the WECC under each of the scenarios. This information was used to define an estimated change in water consumption both inside and outside of California under each scenario. The model provides the MWh by technology (combined cycle, coal, geothermal, wind, etc.). The National Renewable Energy Laboratory's (NREL) *A review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies* (2011) provides water consumption factors for each type of electricity generation and was used to calculate the estimated water use under each scenario. The analysis uses the following consumption factors for renewable and conventional technologies (gallons per MWh):

■ Solar PV	26	■ Solar thermal	78
■ Wind	0	■ Geothermal flash technology	10
■ Geothermal binary technology	3,600	■ Natural gas combined cycle	198
■ Natural Gas steam turbine	826	■ Natural gas combustion turbine	0
■ Coal	687		

Water consumption factors[6] were used instead of water withdrawal factors[7] because they provide a better representation of the effect of energy on water use. The numbers presented in the NREL article were comparable to other reports regarding water use in energy. Nonetheless, due to solar technology advancements, some solar technologies may now use less than 26 gallons per MWh.

4.3.1 Regulatory Framework

The following is the regulatory framework for water in the study areas.

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[3] This report is available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.490.1952&rep=rep1&type=pdf.

[4] A discussion regarding the amount of water used during construction of wind turbines was not found. Instead, the authors reviewed several CEQA and NEPA documents for proposed wind projects to review how much water per MW was anticipated for use during construction.

[5] A discussion regarding the amount of water used during construction of geothermal projects was not found. The authors reviewed several CEQA document for proposed geothermal projects in the Imperial Valley to review how much water per MW was anticipated for use during construction.

[6] Water consumption is the portion of the total freshwater input that has become unavailable for reuse due to evaporative losses, incorporation into the produced energy, or transfer to another catchment or sea (Madani and Khatami, 2015).

[7] Water withdrawal is the total freshwater input into the energy production system (Madani and Khatami, 2015).

Federal Protection of Surface Water and Groundwater

Clean Water Act

The federal Clean Water Act (CWA 33 United States Code [U.S.C.] 1251 et seq.) requires that states set standards to protect water quality, including the regulation of stormwater and wastewater discharges during construction and operation of projects (Section 402). The CWA also establishes regulations and standards to protect wetlands and navigable waters (Section 404). The U.S. Army Corps of Engineers issues Section 404 permits for discharges of dredge or fill material. These permits cover discharges to waters of the United States, and are subject to Section 401 water quality federal license and permit certification. Section 401 certification is required if U.S. surface waters, including perennial and ephemeral drainages, streams, washes, ponds, pools, and wetlands, could be adversely impacted. The U.S. Army Corps of Engineers and, in California, a Regional Water Quality Control Board (RWQCB) can require that impacts to these waters be quantified and mitigated. Whenever a discharge is made to U.S. waters the RWQCB issues National Pollution Discharge Elimination System (NPDES) and Waste Discharge Requirement (WDR) permits. If a discharge is confined to California state waters only a WDR permit is required.

Reclamation Reform Act

Under the Reclamation Reform Act of 1982 (Public Law 97–2933; 96 Stat. 1261), the U.S. Bureau of Reclamation (USBR) manages, develops, and protects U.S. waters and related resources.

Safe Drinking Water Act

The Safe Drinking Water Act (42 U.S.C. 300[f] et seq.) establishes requirements and provisions for the Underground Injection Control Program. One way this law safeguards the public health is by protecting underground drinking water sources from injection well contamination. General provisions for the Underground Injection Control Program (including state primacy for the program) are described in Sections 1421 through 1426. The California Division of Oil, Gas, and Geothermal Resources has the authority to issue federal Class V Underground Injection Control permits for geothermal fluid injections.

Environmental Protection Agency Sole Source Aquifer Protection Program

The EPA Sole Source Aquifer Protection Program, established in Section 14245(e) of the Safe Drinking Water Act, requires that EPA review proposed federally assisted projects to determine their potential for aquifer contamination.

Colorado River Water Accounting Surface

Colorado River diversions are governed by the Colorado River Compact, signed in 1922, and by associated documents subsequently affirmed by the United States Supreme Court in Arizona v. California (547 U.S. 150 2006) (Consolidated Decree). Following the historical growth in water demand outside California, in 2001 the U.S. Department of the Interior (DOI) issued Interim Surplus Guidelines that define Lake Mead reservoir elevations below which California would not be able to use "surplus" water. The USBR monitors and accounts for all water use in areas with diversions from the Lower Colorado River.

State Protection of Surface Water and Groundwater

California Porter–Cologne Water Quality Control Act

California's Porter–Cologne Water Quality Control Act, enacted in 1969 (Cal. Stats. 1969, Ch. 482), provides the legal basis for water quality regulation in California. It predates the CWA and regulates discharges to state waters. This law requires a Report of Waste Discharge for any discharge of waste (liquid, solid, or gaseous) to land or surface waters that may impair beneficial uses for surface or groundwater of the state. Waters of the state are more than just waters of the United States and include, for example, groundwater and some surface waters that do not meet the definition for waters of the United States. In addition, it prohibits waste discharges or the creation of water-related "nuisances," which are more broadly defined than the CWA definition of "pollutant." Discharges under the Porter–Cologne Act are permitted with waste discharge requirements and may be required even when the discharge is already permitted or exempt under the CWA.

California Water Quality, Supply and Infrastructure Improvement Act and Sustainable Groundwater Management Act

In 2014 the Water Quality, Supply and Infrastructure Improvement Act and the Sustainable Groundwater Management Act were signed into law. The Water Quality, Supply and Infrastructure Improvement Act includes funding for integrated regional water management, water recycling, groundwater sustainability, and watershed protection and ecosystem restoration. The Sustainable Groundwater Management Act provides for sustainable management of groundwater basins, establishes minimum standards for effective and continuous management of groundwater, avoids or minimizes impacts of land subsidence, increases groundwater storage and removes impediments to recharge, and improves data collection and understanding of groundwater resources and management. Sustainable groundwater management is defined as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results. The act requires local agencies to establish groundwater sustainability agencies and develop groundwater sustainability plans for groundwater basins or sub-basins that are designated as medium or high priority basins.

Arizona Groundwater Management Code

Arizona enacted the Ground Water Management Code in 1980 because of historic groundwater overdraft, where groundwater recharge is exceeded by discharge. The Code describes three main goals for the state regarding the management of groundwater: (1) controlling severe overdraft, (2) allocation of the limited water resources of the state, and (3) enhancement of the state's groundwater resources using water supply development. Arizona's groundwater management laws are separated using a three tier system based on the Code. The lowest level of management includes provisions that apply statewide, Irrigation Non-Expansion Areas (INAs) have an intermediate level of management, and Active Management Areas (AMAs) have the highest level of management with the most restrictions and provisions. There are currently five AMAs and three INAs in the state, each of which has its own specific rules and regulations regarding the appropriation of groundwater.

The ADWR has created guidelines regarding the appropriation of water for solar generating facilities, specifically detailing what information needs to be submitted for permit evaluation. The information required includes the proposed method of power generation, the proposed amount of water to be consumed, the point of diversion, and to what or whom the power is to be distributed. To secure water rights for a solar facility located within an AMA, the applicant must demonstrate that there is an "assured water supply" for the life of the project. The ADWR then makes a decision based on whether the proposed water right will be detrimental to public welfare and general conservation of water.

Arizona Underground Water Storage, Savings, and Replenishment Act

The Underground Water Storage, Savings, and Replenishment Act created the Arizona Water Banking Authority, which has two programs: (1) Underground Storage Facilities, which use excess Central Arizona Project (CAP) water, other surface water, or effluent to artificially recharge a groundwater aquifer, and

(2) Groundwater Savings Facilities, which provide water supplies (CAP water, other surface water or effluent) in lieu of using groundwater, allowing the groundwater to stay in storage and become "savings." The ADWR is in charge of the distribution of the program's waters as well as the evaluation of permits to store and recover their waters. To put this water to use, the ADWR must first award a recovery well permit. If a recovery well permit is submitted for use inside an AMA, a "hydrologic impact analysis" report may also need to be submitted.

Oregon Water Resources Department Chapter 690 Division 310

Under Oregon law, all water is publicly owned. With some exceptions, cities, farmers, factory owners and other users must obtain a permit or water right from the Water Resources Department to use water from any source — whether it is underground, or from lakes or streams. Landowners with water flowing past, through, or under their property do not automatically have the right to use that water without a permit from the Department.

Oregon Drinking Water Quality Act of 1981

The purpose of the act is to ensure that all Oregonians have safe drinking water, to provide a simple and effective regulatory program for drinking water systems; and to provide a means to improve inadequate drinking water systems.

Oregon Water Quality, Pollution Prevention Control

Oregon's Nonpoint Source Program is implemented by land use in order to address water quality issues on agricultural lands; state, private, or federal forest lands; or in urban areas. The goal of the program has been broadened to safeguard groundwater resources as well as surface water. The state has been divided into 21 watershed basins and 91 sub-basins. The state's permitting and assessment work has been aligned and prioritized according to these sub-basins. Forty-three local, state, and federal regulatory and non-regulatory programs address nonpoint source control and treatment.

Washington Surface Water Code

The 1917 Water Code was a comprehensive code that established a substantive and procedural system. An important element of the code is the provision for general adjudications of particular bodies of water, basins, or aquifers. Since 1917, no surface water may be appropriated without a permit. In considering permit applications, the State considers whether there is water available, if the application is for a beneficial use, will granting the application adversely affect existing water rights, and will granting the application be detrimental to the public interest.

Washington Ground Water Code

The Washington Legislature passed the Ground Water code in 1945. In general, this meant treating ground water like surface water for the purpose of obtaining permits for water rights. In 1973, the Legislature amended the definition of "ground water" to make it clear that the code covered all ground water.

Washington Water Resources Act of 1971

The Water Resources Act of 1971 set out general policy statements regarding water use in both surface and groundwater areas. It required the department to create a comprehensive state water resources program that would provide a process for making decisions on future water resource allocation and use. It listed beneficial uses and recognized allocation will be based generally on the securing of the maximum net benefits for the people of the state.

Utah Water Quality Act

Utah water law is governed under the doctrine of prior appropriation. The agency responsible for the regulation, appropriation, and distribution of the state's water is the Utah Division of Water Rights, headed by the State Engineer. Water rights are assessed regionally in one of the seven regional offices of the Utah Division of Water Rights. The Utah Division of Water Rights assesses proposed water right applications based on whether the proposed right will have available unappropriated water, whether the right will impair existing rights, and whether granting the proposed right will be detrimental to the public welfare.

Wyoming Water Statutes

In 1957 Wyoming enacted a comprehensive code for handling underground water. Those laws provided that wells for domestic and stock uses would have preferred rights over other groundwater uses even though they were still exempt from filing requirements, and that all other wells would need to be permitted by the State Engineer before construction could commence. The appointment of a Division Advisory Committee on groundwater matters was required for each of the four historic water divisions, and the State Engineer was directed to establish aquifer districts and sub-districts within those water divisions. In districts of sub-districts where concerns for the condition of an aquifer existed, the laws provided the designation of "critical areas" and the election of an advisory board to manage the concerns of that area.

This legislature was expanded in 1969 such that all groundwater wells, even previously exempted stock and domestic wells, required a permit from the State Engineer before drilling could be commenced. Domestic and stock water wells still had a preferred right over wells for other purposes, with the term "domestic" being well-described and conditioned.

New Mexico Water Statutes

Water law in New Mexico is governed under the doctrine of prior appropriation. All waters (both groundwater and surface water) are public and subject to appropriation by a legal entity with plans of beneficial use. A water right in New Mexico is a legal entity's right to appropriate water for a specific beneficial use and is defined by seven major elements: owner, point of diversion, place of use, purpose of use, priority date, amount of water, and periods of use. Water rights in New Mexico are administered through the Water Resources Allocation Program under the New Mexico Office of the State Engineer.

Under Title 19, Chapter 27 Part 1, a water use permit from State Engineer's Office is required to drill a well and to use the water. The two major exemptions from the permitting process are minimal domestic uses and wells deeper than 2500 feet.

New Mexico Ground Water Storage and Recovery Act

In 1999, the State legislature passed the Ground Water Storage and Recovery Act to save money through groundwater recharge, storage, and recovery, to reduce the rate of decline in aquifers, to promote conservation, to serve the public welfare, and to lead to more effective use of the State's water resources. It set production limits for ground water based on proportionate reduction, rate of withdrawal, and prevention of well interferences.

4.3.2 Baseline Conditions in Study Areas

Water use for development of energy can be surface water or groundwater. Surface water includes streams, rivers, lakes, and reservoirs. In California, renewable development would not use surface water during construction unless it were purchased through a management entity. Outside of California, it is possible that developers might use surface water for construction but they are more likely to use groundwater during construction.

Groundwater is a part of the hydrologic cycle and is recharged from deep percolation of rainfall, streamflow, and other sources. Groundwater discharges to streams, lakes or the ocean, where water evaporates, condenses to form clouds, and returns to the earth's surface as precipitation. In general, groundwater flows from areas of higher hydraulic head to low hydraulic head and takes the path of least resistance through sediments and rocks, such as those with relatively high permeability. At a regional scale, groundwater flows from recharge areas to discharge areas. Some groundwater pathways are shallow, short, and quick and some pathways may be very long, deep within a basin and prolonged. At a local scale, groundwater flow may be intercepted by a water supply well, where pumping creates drawdown and a cone of depression (low hydraulic head) around the well. A pumping well is an artificial point of discharge from the aquifer.

Inside California Solar

A groundwater basin — typically underlying a valley or coastal plain — contains one or more connected and interrelated aquifers and often represents a groundwater reservoir capable of providing substantial water supply. The CDWR has defined groundwater basins throughout California, designating 515 basins and subbasins.

Groundwater resources play a vital role in maintaining California's economic and environmental sustainability. During an average year, California's 515 alluvial groundwater basins and subbasins contribute approximately 38 percent toward the State's total water supply. During dry years, groundwater contributes up to 46 percent (or more) of the statewide annual supply, and serves as a critical buffer against the impacts of drought and climate change. Many municipal, agricultural, and disadvantaged communities rely on groundwater for up to 100 percent of their water supply needs. Groundwater extraction in excess of natural and managed recharge has caused historically-low groundwater elevations in many regions of California.

CDWR has a long-standing history of collecting and analyzing groundwater data, investigating and reporting groundwater conditions, implementing local groundwater assistance grants, encouraging integrated water management, and providing the technical expertise needed to improve statewide groundwater management practices. CDWR is responsible for characterizing California's groundwater basins through updates to Bulletin 118.

Groundwater balance describes the portion of the hydrologic cycle in a groundwater basin in terms of inflows, outflows, and change in storage. The basic equation is: Inflows – Outflows = Change in Storage. Under long-term natural conditions, groundwater basins remain basically full, change in storage is zero and inflows equal outflows. Under historical and current conditions in many California groundwater basins, the rate of groundwater pumping and consumption (e.g., evapotranspiration) has been much greater than the rate of recharge. Consequently, outflows are greater than inflows and the groundwater storage decreases. This is manifested by falling groundwater levels and often is accompanied in the long term by adverse impacts such as loss of well yields, land subsidence, water quality degradation, and other environmental impacts. This long-term adverse condition is called overdraft. In California, overdraft occurs in parts of the Central Valley, especially the Tulare Basin, and in some coastal and southern California basins with limited surface water supplies and intensive agriculture.

This report uses the *Aqueduct Water Risk Atlas,* to determine the overall score of water risk incorporating water quantity, water variability, water quality, public awareness of water issues, access to water, and ecosystem vulnerability. The risk categories within California are shown in Table 4.3-2.

Many locations in California experience either medium to high or high water risk. A discussion of the groundwater basins in California follows this table. This discussion explains the primary concerns in the California groundwater basins underlying the solar and wind study areas.

Table 4.3-2. California Water Risk Categories

	Low to Medium	Medium to High	High
Solar Study Areas			
Greater Carrizo Solar	0%	92%	8%
Greater Imperial Solar	38%	0%	62%
Kramer Inyokern Solar	39%	61%	0%
Owens Valley Solar	87%	0%	13%
Riverside East Palm Springs Solar	34%	25%	41%
Tehachapi Solar	27%	73%	0%
Westlands Solar	0%	8%	92%
Wind Study Areas			
Central Valley North Los Banos Wind	0%	100%	0%
Greater Carrizo Wind	0%	95%	5%
Greater Imperial Wind	50%	4%	46%
Riverside East Palm Springs Wind	0%	0%	100%
Solano Wind	51%	46%	3%
Tehachapi Wind	27%	49%	24%

In California, the CDWR publishes California's Groundwater Bulletin 118 that provides information regarding the groundwater quantity and quality for every groundwater basin and subbasin. Information regarding the basins and subbasins that underlie the locations of renewable energy resources selected by the RESOLVE model is summarized below. Bulletin 118 data for each basin is available through the Groundwater Information Center Interactive Map Application (CDWR, 2016).

Greater Carrizo Solar

Three groundwater basins underlie the Greater Carrizo solar study areas, the Santa Maria Valley Basin (3-12), the Paso Robles Area subbasin of the Salinas Valley Basin (3-4.06), and the Cholame Valley Basin (3-05). The Santa Maria Valley basin is an adjudicated groundwater basin. Court adjudications are a form of groundwater management where the groundwater rights of all the overliers and appropriators are determined by the court. The court also decides: (1) who the extractors are; (2) how much groundwater those well owners can extract; and (3) who the Watermaster will be to ensure that the basin is managed in accordance with the court's decree.

The Paso Robles Area subbasin is designated a critically overdrafted groundwater basin. It supplies water for 29 percent of San Luis Obispo County's population and an estimated 40 percent of the agriculture production in the county (San Luis Obispo County, 2011). Agricultural water use accounts for an estimated 67 percent of the pumping in the basin. Multiple groundwater studies indicated that the basin outflow, including groundwater pumping, would soon be greater than basin inflow, or recharge. The Paso Robles Groundwater Basin Management Plan was developed in 2011 to develop a common understanding of the groundwater issues and management opportunities in the Basin and identify and support projects such as conjunctive use, recycled wastewater, and demand management, which will improve groundwater management

Greater Imperial Solar

The Greater Imperial solar study area covers the Amos Valley (7-34), Imperial Valley Basin (7-30), East Salton Sea Basin (7-33), Ocotillo Clark Valley Basin (7-25), Borrego Valley Basin (7-24), and the Warner Valley basin (9-08). The water levels in these groundwater basins have generally declined since the mid-1900s. The Imperial Valley Basin recharge is primarily from irrigation return. Groundwater in the Imperial Valley Basin, the Ocotillo Clark Valley, and the Borrego Valley is poor, with high total dissolved solids.

The Borrego Valley Basin is designated a critically overdrafted groundwater basin. Groundwater is used for agricultural, recreational, and municipal purposes. Over time, groundwater withdrawal through pumping has exceeded the amount of water that has been replenished, causing groundwater-level declines of more than 100 feet in some parts of the basin. Continued pumping has resulted in an increase in pumping lifts, reduced well efficiency, dry wells, changes in water quality, and loss of natural groundwater discharge. Groundwater studies shows that little recharge is occurring under the current climatic conditions. (Faunt, *et al.*, 2015).

Kramer and Inyokern Solar

The Kramer and Inyokern solar study area covers the Searles Valley Basin (6-52), Caves Canyon Valley (6-38), the Lower Mojave River Valley (6-40), the Upper Mojave River Valley Basin (6-42), the El Mirage Valley Basin (6-43), Antelope Valley (6-44) and the Lucerne Valley Basin (7-19). Groundwater levels in portions of the El Mirage Valley and Lucerne Valley have declined significantly. There is evidence of subsidence from overdraft in Lucerne Valley. The Lower and Upper Mojave River Basins, Lucerne Valley Basins, and a portion of the Antelope Valley Basin are adjudicated.

The Lower Mojave River Valley Groundwater Basin underlies an elongate east-west valley, with the Mojave River flowing (occasionally) through the valley from the west across the Waterman fault and exiting the valley to the east through Afton Canyon. Groundwater levels in wells in the floodplain unit near the Mojave River tend to vary in concert with rainfall and runoff rates, whereas groundwater levels in the fan unit do not show significant changes due to local rainfall.

The Upper Mojave River Valley Groundwater Basin underlies an elongate north-south valley, with the Mojave River flowing (occasionally) through the valley from the San Bernardino Mountains on the south, northward into the Middle Mojave River Valley Groundwater Basin at the town of Helendale. Impacts to the basin include overdraft. Additionally, water quality impacts in basin including nitrates, inorganics, and fuel additives. There is a superfund site within basin.

Owens Valley Solar

The Owens Valley solar study area covers the Mesquite Valley (6-29), Owens Valley (6-12), Pahrump Valley (6-28), Rose Valley (6-56) and Searles Valley Basin (6-52). Both the Pahrump Valley and Mesquite Valley basins extent into Nevada. Water levels in the Pahrump Valley are generally declining and the State of Nevada Department of Water Resources has documented overdraft and subsidence conditions in this basin. Much of the groundwater in the Owens Valley is exported to Los Angeles, resulting in limited irrigated acres and domestic development. Impacts to the Mesquite Valley basin include declining water levels and locally high total dissolved solids in the southern portion of basin that makes the groundwater marginal to inferior for domestic uses.

Riverside East and Palm Springs Solar

The Riverside East and Palm Springs solar study area includes the Palo Verde Mesa Basin (7-39), the Chuckwalla Valley (7-5), and the Coachella Valley Indio (7-21.01), Mission Creek (7-21.02), and Desert Hot Springs (7-21.03) subbasins. The Palo Verde Mesa Basin has high concentrations of arsenic, selenium, fluoride, chloride, boron, sulfate, and total dissolved solids. The Chuckwalla Valley Basin has high concentrations of sulfate, chloride, fluoride, and total dissolved solids. The high boron and total dissolved solids concentrations and high sodium percentage impair groundwater for irrigation use. All subbasins of the Coachella Valley have some levels of concern, the Indio Subbasin has nitrates and salts due to the Colorado River imported water as well as local areas of elevated fluoride. The Mission Creek Subbasin has radiological and nitrate issues and high total dissolved solids and declining water levels have been documented in the Desert Hot Springs Subbasin.

Tehachapi Solar

The Tehachapi solar study area includes the Fremont Valley Basin (6-46) and the Antelope Valley (6-44). The Fremont Valley Basin has naturally high TDS locally and other constituents. Groundwater levels have shown significant decline throughout the basin. The Antelope Valley Basin is a closed basin where extractions likely exceed natural recharge. The basin is pending adjudication and has water reliability issues and subsidence.

Westlands Solar

The Westlands solar study area overlays the San Joaquin Valley Basin (5-22) which is surrounded on the west by the Coast Ranges, on the south by the San Emigdio and Tehachapi Mountains, on the east by the Sierra Nevada and on the north by the Sacramento-San Joaquin Delta and Sacramento Valley. The northern portion of the San Joaquin Valley drains toward the Delta by the San Joaquin River and its tributaries, the Fresno, Merced, Tuolumne, and Stanislaus Rivers. The southern portion of the valley is internally drained by the Kings, Kaweah, Tule, and Kern Rivers that flow into the Tulare drainage basin including the beds of the former Tulare, Buena Vista, and Kern Lakes.

The Westlands Solar area includes the Chowchilla Subbasin (5-22.05), Madera Subbasin (5-22.06), Delta-Mendota Subbasin (5-22.07), Kings Subbasin (5-22.08), Westside Subbasin (5-22.09), Pleasant Valley Subbasin (5-22.10), Kaweah Subbasin (5-22.11), Tulare Lake Subbasin (5-22.12), Tule Subbasin (5-22.13), and Kern County Subbasin (5-22.14). The primarily concern for the Westlands Solar area are overdraft, subsidence and water quality degradation. This entire area is an important agriculture region. The following subbasins are critically overdrafted basins:

- Chowchilla Subbasin (5-22.05)
- Madera Subbasin (5-22.06)
- Delta-Mendota Subbasin (5-22.07)
- Kings Subbasin (5-22.08)
- Westside Subbasin (5-22.09)
- Kaweah Subbasin (5-22.11)
- Tulare Lake Subbasin (5-22.12)
- Tule Subbasin (5-22.13)
- Kern County Subbasin (5-22.14)

Inside California Wind

Central Valley North and Los Banos Wind

The Central Valley North and Los Banos wind study area overlays the San Joaquin Valley Delta Mendota Subbasin (5-22.07). This subbasin is described under Westlands Solar.

Greater Carrizo Wind

The Greater Carrizo wind study area includes the Salinas Valley Basin (3-04.06), the Santa Maria Valley Basin (3-12), the San Antonio Creek Valley (3-14), the Santa Ynez River Valley Basin (3-15), Carrizo Plain (3-19), the San Carpoforo Valley (3-33), and the Arroyo de la Cruz Valley Basin (3-34). See the Greater Carrizo Solar area for details for the Salinas Valley Paso Robles Area subbasin and the Santa Maria Valley Basin.

The San Antonio Creek Valley and Santa Ynez River Basin have issues of concern that include overdraft and water quality degradation. The Carrizo Plain Groundwater Basin underlies a narrow northwest trending valley that lies between the Temblor Range on the east and the Caliente Range and San Juan Hills on the west. The valley has internal drainage to Soda Lake. The San Andreas fault zone passes through the valley. Few impacts to this groundwater basin have been identified. The San Carpoforo Valley and Arroyo de la Cruz Valley are very small basins adjacent to the Pacific Ocean. No impacts to these basins have been identified.

Greater Imperial Wind

The Greater Imperial wind study area includes the Yuma Valley Basin (7-36), the Jacumba Valley Basin (7-47), the Warner Valley Basin (9-8) and the Campo Valley Basin (9-28). See Greater Imperial Solar for details about the Warner Valley Basin.

The Yuma Valley groundwater basin underlies a southeast trending valley in southeast Imperial County. No impacts to groundwater quality for this valley were identified. The Jacumba Valley groundwater basin lies within the southeastern Peninsular Ranges. According to San Diego County documents, some wells are going reportedly dry; this basin is a small basin with no source of imported water. The Campo Valley groundwater basin underlies Campo Valley, which is approximately 40 miles east of the city of San Diego and adjacent to the Mexican border. The basin is listed by the EPA as a “Sole Source Aquifer”, meaning it supplies at least 50 percent of the drinking water for this area and there are no reasonably available alternative drinking water sources should it become contaminated.

Riverside East and Palm Springs Wind

The Riverside East and Palm Springs wind study area includes the Coachella Valley Basin: Indio (7-21.01), Mission Creek (7-21.02), and Desert Hot Springs (7-21.03) subbasins. See Riverside East and Palm Spring Solar for details about the subbasins.

Solano Wind

The Solano wind study area includes the Livermore Valley Basin (2-10), the Sacramento Valley: Solano (5-21.66), South American (5-21.65, Yolo (5-21.67) and Colusa (5-21.52) subbasins, and the San Joaquin Valley: Tracy (5-22.15), Eastern San Joaquin (5-22.01), and Cosumnes (5-22.16) subbasins. The Livermore Valley Basin lies about 40 miles east of San Francisco and 30 miles southwest of Stockton within a structural trough of the Diablo Range. The San Joaquin Valley Basin comprises the southernmost portion of the Great Valley Geomorphic Province of California. The Great Valley is a broad structural trough bounded by the tilted block of the Sierra Nevada on the east and the complexly folded and faulted Coast Ranges on the west. Areas of poor water quality exist throughout the basin. The Sacramento Valley: South American subbasin has seven sites with significant groundwater contamination, including three US EPA Superfund sites (Aerojet, Mather Field, and the Sacramento Army Depot). Groundwater quality in the Solano and Yolo subbasins is considered generally good. The San Joaquin Valley comprises the southernmost portion of the Great Valley Geomorphic Province of California. There is little published data about the groundwater budget for the Tracy subbasin. The Eastern San Joaquin subbasin has shown a fairly continuous decline in groundwater level in Eastern San Joaquin County and significant groundwater depressions are shown in some areas. As a result of overdraft poor quality groundwater has been migrating throughout the subbasin. This subbasin is a critically overdrafted groundwater basin.

Tehachapi Wind

The Tehachapi wind study area includes the Antelope Valley Basin (6-44), Fremont Valley Basin (6-46), Kelso Lander Valley Basin (6-69), Tehachapi Valley East Basin (6-45), and Tehachapi Valley West Basin (5-28). See Tehachapi Solar for details about the Antelope Valley and Fremont Valley Basins.

The Kelso Lander Valley Groundwater Basin is a small basin that underlies a northwest-trending valley in eastern Kern County. Little is known about the groundwater quantity in this basin, impairments to the groundwater quality include elevated levels of fluoride concentrations making it inferior for domestic use but appropriate for irrigation uses. Both the Tehachapi Valley East and West Basins are adjudicated basins under the Tehachapi-Cummings County Water District. An alluvial high (surface drainage divide) forms the boundary between these two basins. Runoff waters west of this divide flow to Tehachapi Creek northwest to the San Joaquin Valley. Surface drainage to the east of this divide either ponds in Proctor Dry lake or flows eastward down Cache Creek toward Freemont Valley. However, heavy pumping in areas south of Tehachapi and Monolith has altered the movement of groundwater due to the creation of a large pumping depression. Between the 1950s to the 1970s, the groundwater level decreased substantially. Since the start of basin adjudication in the early 1970’s, groundwater levels have increased to those of the late 1940s when the overdraft problem became apparent. The groundwater quality of these basins has not be characterized.

Inside California Geothermal

Greater Imperial Geothermal

The Greater Imperial geothermal study area includes the Amos Valley (7-34), Imperial Valley Basin (7-30), East Salton Sea Basin (7-33), Ocotillo Clark Valley Basin (7-25), and West Salton Sea Basin (7-22). See Greater Imperial Solar for details about the Amos Valley, Imperial Valley, East Salton Sea, and Ocotillo Clark Valley Basins.

The West Salton Sea Groundwater Basin underlies a valley along the western shores of the Salton Sea in central Imperial County. Groundwater levels from one well in the northeast part of the basin close to Salton Sea show groundwater levels declined by about 64 feet in 1979 through 2000. The quality of the groundwater is marginal to poor for domestic and irrigation purposes because of elevated concentrations of fluoride, boron, and total dissolved solids.

Out-of-State Solar

As with California, this report uses the *Aqueduct Water Risk Atlas,* to determine the overall score of water risk. The risk categories out of state are shown in Table 4.3-3. A discussion of the groundwater basins out of state follows the table. This discussion explains the primary concerns in the groundwater basins underlying the solar and wind study areas.

Table 4.3-3. Out-of-State Water Risk Categories

	Low to Medium	Medium to High	High
Solar Study Areas			
Southwest Solar (Arizona)	0%	0%	100%
Wind Study Areas			
Oregon/Washington Wind	0%	100%	0%
Utah Wind	0%	99%	1%
Wyoming Wind	0%	86%	14%
New Mexico Wind	15%	15%	70%

Southwest Solar (Arizona)

The southwest solar study areas are located in the Lower Colorado River Water Planning District and the Active Management Area Planning Area. The Harquahala study area would be located on an Irrigation Non-Expansion Area. The Harquahala study area would be within the Lower Gila groundwater basin, the Harquahala basin, and the Phoenix groundwater basin. The Hoodoo Wash study area is located entirely within the Lower Gila groundwater basin.

The Lower Gila Basin has been impacted by irrigation pumping at some locations. Historically, cones of depression occurred in irrigated areas north of Hyder, east of Dateland, and in the Palomas Plain west of Hyder (ADWR, 2009). Irrigation water in the western part of the basin has created groundwater mounds in the floodplain aquifer. Colorado River water was brought to the area in 1952 and groundwater pumping for irrigation stopped. Groundwater quality in the western part of the basin, in the Gila River floodplain, is unsuitable for many uses due to elevated total dissolved solids and fluoride and arsenic (ADWR, 2009).

The Harquahala Basin has been impacted by agricultural pumping that caused severe overdraft from the 1950s through the mid-1980s, resulting in large water level declines and formation of a cone of depression (ADWR, 2009). Groundwater recharge is minimal. Introduction of water from the Central Arizona Project in the late 1980s replaced a significant volume of groundwater pumping allowing groundwater levels to rise. A portion of the Harquahala Basin was designated an Irrigation Non-Expansion Area in 1984. Groundwater quality is generally suitable for irrigation but may require treatment for drinking water standards due to elevated total dissolved solids, fluoride, and arsenic (ADWR, 2009).

The Harquahala solar study area is partially within the Phoenix groundwater basin in the Phoenix Active Management Area established pursuant to the 1980 Groundwater Management Act (ADWR, 2010). In several areas, groundwater flows have been altered by well pumping. Agriculture pumping had produced localized depressions by 1983 (ADWR, 2010). In the early 1990s and 2000s, water levels were stable or rose or declined slightly in the western part of the Management Area where the study zone is located. Groundwater quality is generally suitable for most uses, although specific industrial and other activities are present throughout the basin. A number of these activities are located near the Harquahala study area (ADWR, 2010: at Figure 8.1-10).

Out-of-State Wind

Northwest Wind (Oregon and Washington)

The Northwest Wind area is located within the Columbia Plateau, a wide basalt plateau between the Cascade Range and the Rocky Mountains that covers parts of Washington, Oregon, and Idaho. The Columbia River Gorge area falls within the Yakima Fold Belt structural region with the majority of the

Oregon North area within the Blue Mountains structural region (Vaccaro, *et al.*, 2015). A large quantity of the water used in this area is derived from local and imported surface-water sources although groundwater use is also substantial, with the Columbia Plateau aquifer system as the primary source (Konikow, 2013).

Groundwater levels in localized areas within the Plateau aquifer system have risen substantially in areas of high recharge from surface-water imports due to heavy irrigation and decreased in areas where surface-water is not imported and water use is high (Konikow, 2013). Water level rises occurred primary between the 1950s and 1960s, after which water level rises were balanced by water level declines and water level declines dominated the system after 1970 (Konikow, 2013).

Increasing demands for water for municipal, fisheries/ecosystems, agricultural, domestic, hydropower, and recreational uses must be met by additional groundwater withdrawals and (or) by changes in the way water resources are allocated and used throughout the hydrologic system. As of 2014, most surface-water resources in the study area were either over allocated or fully appropriated, especially during the dry summer season (Vaccaro, *et al.*, 2015).

Utah Wind

Groundwater in the Utah Wind Study Area occurs in unconsolidated deposits in the Lower Sevier River Watershed, Escalante Valley-Milford Area sub-basin, Escalante Valley-Black Rock Area sub-basin, Pahvant Valley Area sub-basin, and the Wah Wah Valley and Sevier Lake Area sub-basin. Unconsolidated basin fill deposits within the area are generally composed of clay and sand and recharge to the principal aquifer system is from infiltration of surface water, precipitation, and irrigation.

The Escalante Valley-Milford Area and Escalante Valley-Black Rock Area drainage basin includes the watersheds of Shoal Creek, Pinto Creek, and Little Pinto Creeks in the south, and the watershed of Cove Creek and the Beaver River in the north. Generally shallow groundwater conditions are prevalent within 5,000 to 10,000 feet of the Beaver River. Surface waters in the area are considered fully appropriated (UDWR, 2013). Most of the area is closed to new appropriations of groundwater except in the Black Rock Area where small, fixed time or temporary, and non-consumptive appropriations are allowed (UDWR, 2013).

Pahvant Valley, in southeastern Millard County, extends from the vicinity of McCornick in the north to Kanosh in the south, and from the Pahvant Range and Canyon Mountains on the east and northeast to a low basalt ridge known as The Cinders on the west. Groundwater drains west to the valley from the mountainous terrain to the east. Water levels have declined from 1985 to 2015 in all parts of the Pahvant Valley, primarily due to continued large withdrawals for irrigation (USGS, 2015). As of February 20, 2003, Pahvant Valley is closed to ground-water appropriations (UDWR, 2011).

The Wah Wah Valley and Sevier Lake Area is composed of two sub-basins, Wah Wah Valley and the area around Sevier Lake. The area includes several intermittent streams that flow from the surrounding mountains to the Wah Wah Valley Hardpan (a dry lake bed) or Sevier Lake (UDWR, 2014). The Utah State Engineer has not adjudicated the minimal number of established water rights and there is no state-administered water distribution system in this sub-basin (UDWR, 2014). Surface waters of the basin are generally considered to be fully appropriated, but there is likely unappropriated water available in the aquifer system.

Wyoming Wind

Both of the Wyoming wind study areas are underlain by the Platte River Basin. The Platte River Basin drainage basin covers approximately one quarter of the state in southeastern and central Wyoming.

Perennial streams receive a large percentage of their source waters from overland flow associated with snowmelt and rainfall that originate in semi-humid and humid mountainous headwater regions and persistent baseflow (Taucher, *et al.,* 2013). The basin encompasses the North Platte River and its headwater drainage system, and the northern part of the headwater drainage of the South Platte River (however, the South Platte River does not flow through Wyoming). The Platte River is the major tributary to the Missouri-Mississippi River Basin (Taucher, *et al.,* 2013).

Groundwater use in the state of Wyoming is managed by the Wyoming State Engineer's Office. The North Platte River basin has special conditions restricting new uses of water, including groundwater that is hydrologically connected to surface water (BLM, 2012). Water in the North Platte Basin has been fully appropriated, and these agreements effectively prevent the development of new uses with the exception of stock, domestic, and municipal uses (BLM, 2012). The State Engineer's Office has a process in place to protect the historic and current uses of groundwater that are in good standing with the agency. Current groundwater permittees/appropriators can file an interference complaint against other water users as outlined in the Groundwater Regulations and Instructions. These regulations prevent the pumping activity at a well from negatively impacting the pumping of water from nearby wells.

New Mexico Wind

The water supply in New Mexico is difficult to quantify because of high natural variability in the surface water supply; data limitations of groundwater; variation in yearly obligations of in-state and interstate delivery; the interrelationship between groundwater and streamflows; and the complication caused by groundwater quality, economic constraints, local land use regulations, and land ownership (BLM, 2010). The Office of the State Engineer and Interstate Stream Commission of New Mexico in the 2003 State Water Plan concluded that the water supply barely accommodates and has sometimes fallen short of existing demand, even during the unusually wet years of the 1980s and 1990s. During times of average water supply, the demand for water exceeds the supply (BLM, 2010).

The New Mexico central wind study area is underlain by the Roswell Artesian declared underground water basin. Water-producing zones in the carbonate aquifer rise stratigraphically from north to south and from west to east. Some wells may penetrate as many as five water-producing zones. Recharge occurs by direct infiltration of precipitation and by runoff from intermittent losing streams flowing eastward across a broad area east of the Sacramento Mountains. During the initial development of the artesian aquifer in the late 1800s, many wells flowed to the surface and high volume springs fed the Pecos River. Decades of intensive pumping caused substantial declines in hydraulic head in the aquifer, and by the mid-20th century it was estimated that withdrawals exceeded recharge. Most down-gradient flow is intercepted by irrigation wells in the Artesian Basin. Mineral content of the water rapidly increases in an eastward direction. The freshwater-saltwater interface migrates westward during periods of low rainfall. (USGS, 2012)

The New Mexico east wind study area is underlain by the Tucumcari and Curry County declared underground water basins. The High Plains aquifer is the primary source of water in the Curry County basin and consists of water bearing formations from the Ogallala Formation. Modeling studies and observed water declines indicate that large areas of this aquifer cannot sustain the amount of water currently withdrawn (OSE, 2010). Due to the limited groundwater, the High Plains aquifer within Curry County is closed to the filing of applications. Applications are considered on a case by case basis.

4.3.3 Typical Water Impacts of the Buildouts

Construction and operation of utility-scale renewable energy facilities under the buildout of the portfolios would introduce impacts to water resources. Resource-specific impacts are explained in the subsections that follow. In general, typical construction-phase impacts are:

- **Disruption of drainage patterns.** Land disturbing activities such as clearing and grading, road construction, or vegetation removal could disrupt drainage patterns, especially to stream channels. Stream disturbance can also alter and diminish riparian habitat and the wildlife that depends upon it.
- **Flooding**. Ground disturbances (e.g. paving) and renewable structures can impede or redirect flood flows. Flooding may cause environmental damage beyond facility sites and include erosion, sedimentation, and soil and water contamination from hazardous materials transport.
- **Water Quality Degradation.** During construction, hazardous materials, particularly oil-based and liquid chemical products, can spill and cause contamination to soils, surface water bodies, and groundwater.
- **Consumption of Water – Construction.** Installation of water supply wells and consumption of water during construction can affect groundwater levels and storage volumes. Water volumes used during the construction period, particularly for dust control, are relatively high but occur for a short duration.
- **Consumption of Water – Operation.** Changes in the overall operation of the portfolios could change the amount of water required for cooling renewable and non-renewable technologies. Different technologies require different amounts of water for cooling, with fossil fuel generation typically requiring more water than renewable energy.

Construction Impacts in General

Flooding, conditions that could worsen flooding, and impacts to other hydrologic surface water features and drainage patterns generally depend upon how widespread the land disturbance may be from renewable energy. The broader and more intensive the land disturbance, the greater the likelihood it could affect surface water and groundwater.

Solar Construction

Construction of utility-scale solar facilities generally convert large areas of land, requiring large amounts of grading and clearing of vegetation. Grading removes all vegetation, disturbs biological soil crust, and causes the greatest disturbance to surface water and drainage patterns. Disturbance to vegetation and surface soils changes infiltration and runoff, which in turn leads to greater potential for erosion, sedimentation, flooding, and water quality degradation. A number of existing regulations are designed to protect the water quality and reduce these effects, the primary one being the Clean Water Act. Under the Clean Water Act, any project disturbing more than 1 acre of land would be required to obtain a NPDES General Permit for Storm Water Discharges Associated with Construction Activity. Compliance with the NPDES would require a Storm Water Pollution Prevention Plan (SWPPP) that would describe Best Management Practices (BMPs) to prevent the acceleration of natural erosion and sedimentation rates and to reduce the risk of accidental spills and releases into the environment and specifically into surface water or groundwater.

The construction of utility-scale solar projects require water for dust control and engineering purposes. While the exact amount of water required would be determined on a case by case basis, this report assumes the use of 2.2 acre-feet (AF) per MW in California and 5.6 AF per MW in Arizona (Sandia, 2013). Groundwater extraction and consumption by renewable energy projects can cause groundwater levels to decline. Declining groundwater levels could have the following effects (BLM, 2015):

- Increase the needed pumping lift in wells, and gradually cause pumping rates to decrease and eventually cease altogether.
- Lower groundwater gradients and reduce groundwater discharge to springs, streams, rivers, and down-gradient hydraulically connected groundwater basins.
- Lessen the areal extent and vigor of wetland, riparian, or other groundwater-dependent vegetation areas or playas.
- Cause certain types of sediments (e.g., saturated clay units) to dewater and compress. This compression reduces their volume and can lower land surface elevations (land subsidence). This can potentially (1) cause damage to existing structures, roads, and pipelines; (2) reverse flow in sanitary sewer systems and water delivery canals; and (3) alter the magnitude and extent of flooding. This sediment compression can also permanently reduce aquifer storage capacity.

These types of effects are especially problematic in the southwestern United States where groundwater is typically limited. However, these effects would be short-term, during construction only. Other than California, all the states where the renewable portfolio would be constructed have regulations that require the developer to obtain a permit for the use of surface or groundwater. Such permits would consider the state of the groundwater basin or aquifer and ensure that the one-time use of water for construction would not affect the groundwater basin. In California, the effects of groundwater use would typically be considered and mitigated as necessary in the environmental permitting for the project under the California Environmental Quality Act or the National Environmental Policy Act.

Wind Construction

Construction of utility-scale wind facilities requires grading and clearing large areas of land, resulting in impacts similar to those described for solar construction. Wind facilities do not require these areas to be contiguous, grading is typically limited to wind turbine pads, ancillary buildings, substations, and access roads. While the grading and clearing would disrupt drainage patterns, the natural vegetation surrounding the grading would help stabilize soils and reduce the potential effects. Permit requirements, including a Stormwater Pollution Prevention Plan (SWPPP) and Best Management Practices (BMPs), would account for construction on steep slopes, frequently a requirement for wind projects.

Utility-scale wind projects require water for dust control and engineering purposes. While the exact amount of water required would be determined on a case by case basis, this report assumed 0.4 AF per MW. Groundwater extraction and consumption by renewable energy projects can cause groundwater levels to decline as described under solar construction.

Geothermal Construction

Construction of utility-scale geothermal facilities requires grading and clearing land for the geothermal well pads and access roads, resulting in impacts similar to those described for solar construction. Geothermal typically uses only a small amount of land for the well pads. While the grading and clearing would disrupt drainage patterns, the natural vegetation surrounding the well pads would help stabilize soils and reduce the potential effects. Permit requirements, including a SWPPP and BMPs, would further reduce effects.

Utility-scale geothermal projects require water for dust control, grading, drilling, and other uses. While the exact amount of water required would be determined on a case by case basis, this report assumed 1.4 AF per MW. Groundwater extraction and consumption by renewable energy projects can cause groundwater levels to decline as described under solar construction.

Operational Impacts in General

Project facilities, roads, and their surrounding environments can be flooded during operations and maintenance. Considering the large area required for many renewable energy projects, ephemeral streams may flow through the project areas, and drainage paths and processes are at risk of being altered. This can cause developed drainage systems to exceed their design capacities, which in turn could damage both the project and the environment, both on and off site (e.g., erosion, sedimentation, and contamination of soil and water by transport of project-related hazardous materials and wastes). Disturbance to streams can also alter and diminish riparian habitat.

Hazardous material and waste storage during operations and maintenance can be disturbed by stormwater and flooding if not properly contained, or if stormwater drainage facilities are not properly designed. These project-related activities can cause degradation and long-term adverse effects to water quality and the beneficial uses of surface waters and groundwater.

The operation of renewable and non-renewable facilities requires water, generally for cooling purposes but also for other uses such as panel cleaning. Regionalization would change the overall generation makeup in the WECC. As noted in the methodology, this information was used to generate an estimated change in water use both inside and outside of California.

Solar Operations

Groundwater consumption affects both groundwater levels and storage volumes. While the exact amount of water required for operations of a facility would be determined on a case by case basis, this report assumes the use of 26 gallons per MWh for solar PV and 78 gallons per MWh for solar thermal energy.

Wind Operations

Wind energy uses minimal amount of water during operations. While the exact amount of water required during operations would be determined on a case by case basis, the amount is anticipated to be minimal so this report does not calculate operational water use for wind energy.

Geothermal Operations

Geothermal plant operations may require substantial amounts of water for steam generation, cooling, and other industrial processes. While the exact amount of water required for operations of a geothermal facility would be determined on a case by case basis, this report assumes the use of 3,600 gallons per MWh for binary geothermal energy and 10 gallons per MWh for flash geothermal energy.

4.3.4 Water Impacts of Regionalization

The 2020 CAISO + PAC scenario includes no incremental renewable energy development so no construction effects would occur inside or outside of California.

Incremental Buildout for All Scenarios by 2030

Inside California

This report considers three factors pertaining to water use inside California. First it considers development in critically overdrafted groundwater basins, followed by construction in areas of different water risk factors, and finally it looks at water consumption during operations.

Construction of the 2030 renewable portfolios under any scenario would require a substantial amount of ground disturbance in California that could result in flooding, conditions that could worse flooding, and impacts to other hydrologic surface water features and drainage patterns. As noted above, this effect would be reduced through implementation of a SWPPP and BMPs required for all construction greater than one acre.

Critically Overdrafted Groundwater Basins

Development of the renewable portfolio under 2030 Current Practice 1 would require construction of solar and wind projects in the following study areas that overlap with critically overdrafted groundwater basins (see Figures 4.3-1 and 4.3-2):

- Greater Carrizo Solar
- Westlands Solar
- Solano Wind
- Greater Imperial Solar
- Greater Carrizo Wind
- Central Valley and Los Banos Wind

While it is possible that the development in these areas could avoid using water from the critically overdrafted groundwater basins, the basins underlie almost the entire Central Valley and Los Banos wind and Westlands solar areas. Construction of the renewable portfolios would increase the need for water from these basins. However, because neither wind nor solar require large amounts of water during operations, this effect would be short-term in nature. Water used for construction purposes could come from a variety of sources that would be determined on a case by case basis depending on the specific circumstances. If groundwater were not available, a project developer would likely work with a local water provider, for example the Westlands Water District, to ensure sufficient water is available for construction. Additionally, if the development of renewable energy were to displace a use, such as agriculture, that requires large amounts of water, it could result in a net benefit to the underlying groundwater basin. This type of benefit is most likely to occur in the Westlands solar study area due to the groundwater basin overdraft and the abundant agriculture in the region.

Figure 4.3-1. Solar Resource Study Areas and Critically Overdrafted Basins

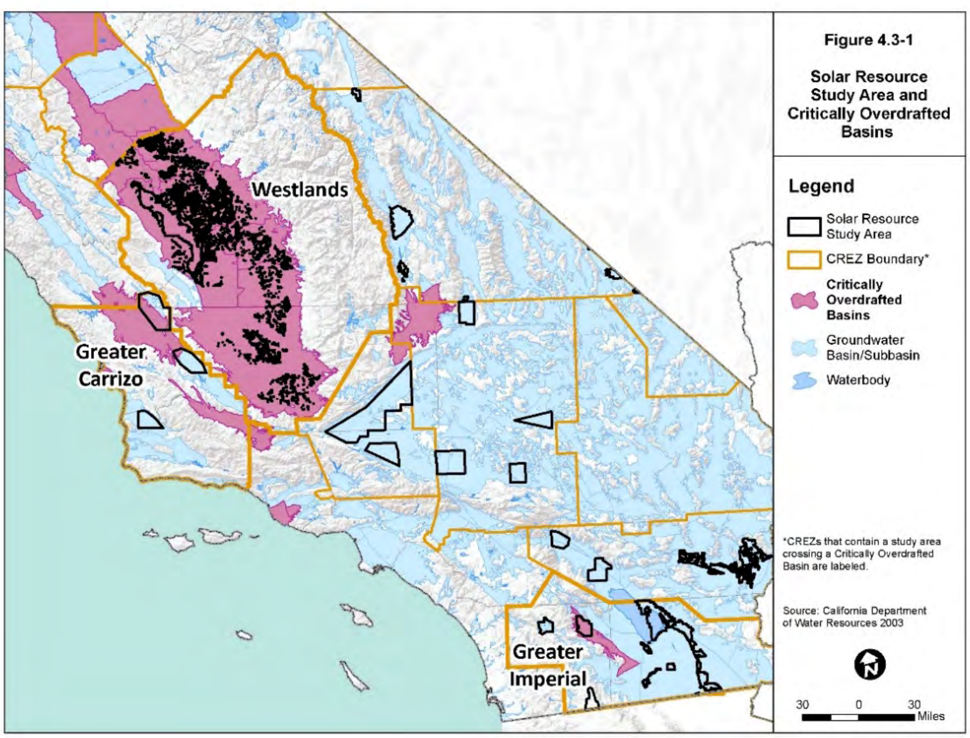
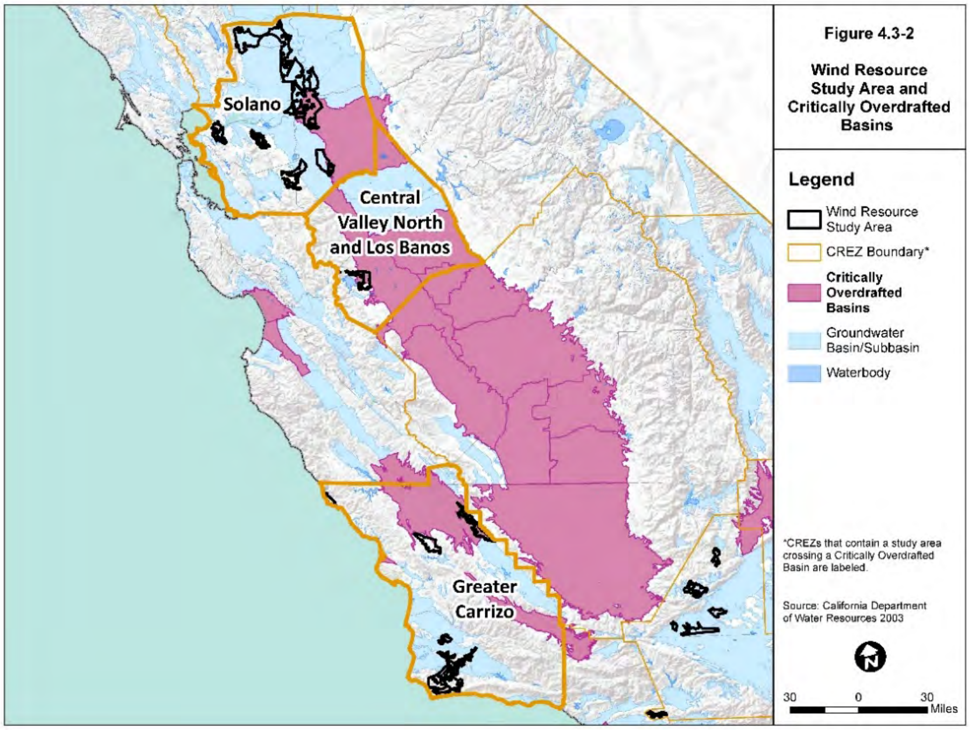


Figure 4.3-2. Wind Resource Study Areas and Critically Overdrafted Basins



The 2030 regionalization scenarios would reduce the construction water use in critically overdrafted groundwater basins as follows:

- All scenarios would reduce the amount of construction and associated water use in Westlands solar study area compared with the 2030 Current Practice 1.
- 2030 Regional 2 and 2030 Regional 3 (and the sensitivity scenario of Regional 3 without Beyond RPS generation) would reduce construction and associated water use in the Solano wind study area.
- 2030 Regional 3 would reduce construction in the Greater Carrizo and Greater Imperial study areas.

Construction in Areas of Water Risk

This study considers the use of water for construction in areas of different categories of water risk using the WRI risk atlas. Table 4.3-4 presents the acre feet of water required for construction of renewable energy in California under the different portfolios.

Table 4.3-4. Construction Water Use by Risk Category

Water Risk (acre feet)	2030 Current Practice 1	2030 Regional 2	2030 Regional 3
Low to Medium	4,364	5,512	2,646
Medium to High	7,019	7,580	3,984
High	7,562	5,871	2,467

Out of State

The analysis outside California does not consider specific groundwater basins as there is not a consistent dataset available to analyze. As such, it uses the WRI index to allow for consistent comparison for use of water during construction.

Construction in Areas of Water Risk

As with the analysis for inside California, Table 4.3-5 presents the acre feet of water required for construction of renewable energy outside California under the different portfolios.

Table 4.3-5. Construction Water Use by Risk Category Out of State

Water Risk (acre feet)	2030 Current Practice 1	2030 Regional 2	2030 Regional 3
Low to Medium	1,039	685	305
Medium to High	471	471	1,202
High	5,998	8,842	9,503

Out-of-State Transmission Additions

Under Regional 3, it is assumed that major out-of-state transmission additions would be necessary to integrate renewable generation from Wyoming and New Mexico into the regional power system and for California to achieve 50% RPS. The water resources considerations related to the construction and operation of the potential transmission expansions are summarized in Section 5.

Operational Impacts of Regionalization

Inside California

The production cost simulation model provided the changes in overall generation (in MWh) in the WECC under each of the 2020 and 2030 scenarios. This information was used to generate an estimated change in water consumption use inside California for each scenario. Table 4.3-6 presents the water use for operations of generators, excluding wind, which uses very little water, under the Current Practice and regionalization scenarios.

Table 4.3-6. Total Water Use for Energy Generation in California

Water Consumption by Technology (af)	2020 Current Practice	2020 CAISO + PAC	2030 Current Practice 1	2030 Regional 2	2030 Regional 3
Solar PV	1,859	1,859	3,540	3,836	2,881
Solar Thermal	1,041	1,041	1,039	1,040	1,040
Natural Gas Combined Cycle	50,240	49,371	41,486	39,309	37,504
Natural Gas Steam Turbine	3,195	3,195	2,710	2,658	2,601
ST Coal	163	162	0	0	0
Total (excluding Geothermal)	56,498	55,628	48,776	46,843	44,025
Geothermal	142,126	142,225	205,897	206,475	207,806
Impact of Regionalization (af)		–870		–1,933	–4,750
Impact of Regionalization (%)		*–1.5%*		*–4.0%*	*–9.7%*

The 2020 Current Practice scenario would use over 56,000 acre-feet of water inside California during operations excluding geothermal energy. Limited regionalization (2020 CAISO + PAC) would reduce the water use by 870 acre feet, facilitating a reduction in water use for electricity generation in California of 1.5%. Geothermal water use would remain constant.

Under 2030 Current Practice 1, an estimated 48,776 acre-feet of water would be used for energy generation for all resources excluding geothermal.[8] Geothermal production would use almost 206,000 acre-feet of water; however, geothermal water use can and frequently does include brine rather than potable water.[9] A small portion of potable water would likely be required for geothermal generation for make-up water. Regionalization by 2030 would reduce the water used for electricity generation in California by at least 4%.

Out of State

The production cost simulation model provided the changes in overall generation (in MWh) in the WECC under each of the 2020 and 2030 scenarios. This information was used to generate an estimated change in water consumption use outside California for each scenario. This water use is presented in Table 4.3-7 for all of the scenarios.

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8 According to the California Water Plan, Chapter 3, California Water Today, urban applied water use in 2010, which includes industrial water use such energy generation, was 8.3 million acre-feet (DWR, 2013). Compared to the overall water use in California, the amount of water used for energy generation is a very small amount.

9 “Binary geothermal plants” use a closed-loop system such that 100 percent of the geothermal brine produced is injected back into the geothermal reservoir. Because the water is not used for other purposes, a brackish water supply is adequate for the cooling system. This is different from a “geothermal flash plant” where the condensed geothermal steam is used for the cooling water. Geothermal flash plants are used with higher temperature geothermal resources than binary geothermal plants.

Table 4.3-7. Total Water Use for Energy Generation Outside California

Water Use by Technology (af)	2020 Current Practice	2020 CAISO + PAC	2030 Current Practice 1	2030 Regional 2	2030 Regional 3
Solar PV	458	458	989	1,102	1,103
Solar Thermal	635	635	634	634	634
Combined Cycle	86,529	85,944	169,032	163,271	163,641
Steam Turbine	239	222	297	179	220
ST Coal	454,302	459,289	295,450	286,454	292,279
Total (excluding Geothermal)	542,163	546,548	466,401	451,640	457,877
Geothermal	149,913	149,916	140,805	140,261	140,334
Impact of Regionalization (af)		4,385		–14,761	–8,524
Impact of Regionalization (%)		*0.8%*		*–3.2%*	*–1.8%*

The 2020 Current Practice scenario would use 542,163 acre-feet of water outside California during operations excluding geothermal energy. Limited regionalization with CAISO + PAC would increase the water use by 4,385 acre feet, an increase in water use of 0.8%. Geothermal water use would remain constant.

Under 2030 Current Practice 1, an estimated 466,401 acre-feet of water would be used for energy generation for all resources excluding geothermal. Geothermal production would use approximately 140,805 acre-feet of water. Regionalization by 2030 would reduce the water used for electricity generation outside California by 1.8%.

4.3.5 Comparison of Scenarios for Water Resources

The change from Current Practice into regional scenarios allows the following comparisons.

Inside California

Section 4.3.4 lists the amount of water used for construction in areas of different categories of water risk in Table 4.3-4. Using this information, Table 4.3-8 lists the change in water use due to regionalization.

Table 4.3-8. Change in Construction Water Use by Risk Category in California

Water Risk (acre feet)	2030 Regional 2 Relative to Current Practice Scenario 1	2030 Regional 3 Relative to Current Practice Scenario 1
Low to Medium	1,148	–1,718
Medium to High	562	–3,035
High	–1,691	–5,095

As shown in Table 4.3-8, 2030 Current Practice 1 would require the most water for construction in areas designated as high risk. These scenarios, along with 2030 Regional 2, would use the most water for construction in areas designated as medium to high risk. 2030 Regional 3 would reduce the amount of water used for construction in all three categories because it reduces the amount of renewable energy built in California.

Table 4.3-9 highlights the change in water use for operations under the Current Practice and regionalization scenarios.

Table 4.3-9. Change in total Water Use for Energy Generation in California

Water Use	2020 CAISO + PAC Relative to Current Practice	2030 Regional 2 Relative to Current Practice Scenario 1	2030 Regional 3 Relative to Current Practice Scenario 1
Impact of Regionalization (af)	–870	–1,933	–4,750
Impact of Regionalization (%)	*–1.5%*	*–4.0%*	*–9.7%*

In the limited regionalization of 2020, water use by generators in California would decrease (–1.5%). Regionalization by 2030 would affect the operational water use as follows:

- 2030 Regional 2 would reduce water use by 1,933 acre feet, about 4%.
- 2030 Regional 3 would reduce water use by 4,750 acre feet, about 10%.

The amount of water used for geothermal energy remains relatively constant regardless of the scenario. Overall, the greatest reduction of water use compared to 2030 Current Practice 1 is for the 2030 Regional 3 which reduces water consumption by almost 10 percent.

Out of State

Section 4.3.4 lists the amount of water used for construction in areas of different categories of water risk in Table 4.3-5. Using this information, Table 4.3-10 lists the change in water use due to regionalization.

Table 4.3-10. Change in Construction Water Use by Risk Category Out of State

Water Risk (acre feet)	2030 Regional 2 Relative to Current Practice Scenario 1	2030 Regional 3 Relative to Current Practice Scenario 1
Low to Medium	–354	–734
Medium to High	0	731
High	2,844	3,504

As shown in Table 4.3-10, 2030 Current Practice 1 would require the least water for construction in areas designated as high risk. 2030 Regional 3 would increase the amount of water used for construction in medium to high and high risk categories as the amount of renewable energy built outside California would increase under this scenario.

Table 4.3.11 highlights the change in water use for operations under the Current Practice and regionalization scenarios.

Table 4.3-11. Change in Total Water Use for Generation Out of State

Water Use	2020 CAISO + PAC Relative to Current Practice	2030 Regional 2 Relative to Current Practice Scenario 1	2030 Regional 3 Relative to Current Practice Scenario 1
Impact of Regionalization (af)	4,385	–14,761	–8,524
Impact of Regionalization (%)	*0.8%*	*–3.2%*	*–1.8%*

In the limited regionalization of 2020, water use by generators outside of California would increase slightly (0.8%). Regionalization by 2030 would affect the out-of-state operational water use, relative to the scenario of 2030 Current Practice 1 as follows:

- 2030 Regional 2 would reduce water use by 14,761 acre feet, about 3%.
- 2030 Regional 3 would reduce water use by 8,524 acre feet, about 2%.

The amount of water used for geothermal energy remains relatively constant regardless of the scenario. Overall, the greatest reduction of water use compared to 2030 Current Practice 1 is for the 2030 Regional 2 which reduces water consumption outside California by over 3 percent.

4.4 Air Emissions

This section describes the potential impacts to air resources for each of the incremental renewable energy buildouts and the potential air emissions changes of a regional power market as compared with emissions from electricity generators in the current practice. The approach to the analysis relies upon a narrow set of baseline conditions that are treated as potential indicators or predictors of impacts, as listed in Table 4.4-1.

Table 4.4-1. Baseline Conditions and Indicators of Impacts, Air Resources

Baseline condition of a study area	How are scenarios analyzed relative to the baseline?	Potential indicator of air quality impact
Air Emissions		
Ozone levels	Changes in NOx emissions in designated nonattainment areas	Criteria air pollutant exposures and public health
Particulate matter levels	Changes in SO_2 and PM2.5 emissions from fossil fuel use in designated nonattainment areas	Criteria air pollutant exposures and public health

Assumptions and Methodology for Air Emissions Analysis

This portion of the environmental study explores the locations where changing emissions from fossil fuel generators may occur as a result of regionalization. The methodology focuses on the modeled changes in power plant operations, and how they may bring about a change in air emissions from these sources. Separate discussion is also provided regarding the incremental buildouts and how construction-related activities can locally influence air pollutant concentrations.

The production cost simulation modeling provides the changes in generator starts, generation output in terms of megawatt-hours (MWh), and fuel use by type of fuel and heat-input rate (MMBtu). These data are used as input the air emissions analysis as a way to estimate the changes in nitrogen oxides (NOx), PM2.5, and sulfur dioxide (SO_2). Greenhouse gas (GHG) emissions analysis and carbon dioxide (CO_2) rates are presented in the Production Cost Analysis (Volume V).

Our study methodology includes an estimate of the annual emissions on a unit-specific basis, for all units in the WECC-wide fleet, but our presentation shows aggregated emission for each geographical location. This means the results are aggregated temporally and geographically. The temporal result is for either the near-term (2020) or longer-term (2030) study year. This study aggregates the criteria air pollutant emissions results and totals the emissions rates for the California natural gas fleet emissions by air basin. Out of state, emissions from the remainder of the WECC-wide fleet are provided from PSO, for NOx and SO_2. The production cost model does track unit-specific NOx and SO_2 emissions. However, there are some limitations to interpreting absolute levels of unit-specific air emissions from the production cost model, since the model does not mimic the precise accounting of emissions rates or control equipment use.

Other important limitations and considerations relevant to the air emissions analysis include:

- The SB 350 study does not include an ambient air quality impact analysis of ambient ozone or PM2.5 levels or other air pollutant concentrations.
- The production cost analysis conducted for the SB 350 study was employed at a regional scale, with assumptions about how power may be traded between California and the rest of the WECC under different market configurations.

- The production cost analysis provides a potential dispatch profile for the generators in the region with a given set of assumptions about the power plants.
- The SB 350 study involves an analysis of greenhouse gases and other air pollutant emissions changes of the power sector. The study does not make any assumptions or analyze emissions from other categories of sources in California, and it does not analyze the potential reactions from other sectors of the economy when emissions from the power sector change.
- For the purposes of the Disadvantaged Communities (DAC) analysis, the regional modeling output for generators in specific communities was examined at the air basin level. Emissions are summed up by air basins. The DAC results are based on these basin-wide totals, not emissions from specific power plants in or near DACs.
- The regional modeling utilizes general characteristics of each generator type in the state, not actual generator specific data, which most of the time are proprietary to the owner of the generator. Thus, there are limits to how well a regional model can discern specific activities at specific generators when general characteristics about the generators are used in the simulations.
- Emissions are presented for the annual periods of the two study years: the near-term (2020), and the longer-term (2030), with separate presentation of average emissions rates within the three months of the summer season, for consideration of the effects on ozone levels.
- The results do not use any generator specific permit limits, as those are specific to each source in each air district. Note that emissions changes from the fleet of existing stationary sources are required to be well within the limits allowed by the permitting authorities, depending on the permitted terms that apply to each generating unit. This study assumes that no existing source would need to change its permitted terms of operation. New fossil-fueled stationary sources are not contemplated by this study.

Approach to Estimating NOx Emissions

Review of production cost simulation results indicated that the dispatch could change with certain generating units running overnight to save cycling and startup costs. To quantify the effect that changing dispatch could have on NOx emissions, startup emissions are quantified separately from steady-state emissions. This is accomplished by adding a startup penalty ratio, which is the ratio of the increased emissions due to a startup to the emissions from the unit during one hour of full-load (steady state) operation.

The steady-state levels of NOx emissions from California's natural gas fleet were estimated based on a review of factors published by the CEC (CEC, 2015), as summarized in Table 4.4-2.

Table 4.4-2. California Natural Gas Fleet, Modeled Emission Factors

Generating Technology (subset)	NOx Steady (lb/MWh)	NOx due to Starts (lb/MW cap)	PM2.5 (lb/MMBtu)	SO_2 (lb/MMBtu)
Combined Cycle (Aero)	0.07	0.53	0.0066	0.0007
Combined Cycle (Industrial)	0.076	0.53	0.0066	0.0007
Combined Cycle (Single-Shaft)	0.07	0.53	0.0066	0.0007
Combustion Turbine (Aero)	0.099	0.79	0.0066	0.0007
Combustion Turbine (Industrial)	0.279	0.79	0.0066	0.0007
Internal Combustion Engine	0.5	0.79	0.01	0.0007
Steam Turbine, Boiler	0.15	0.84	0.0075	0.0007

Source: CEC, 2015; NREL, 2013.

The startup penalty ratio for NOx from the California natural gas fleet is based on the following points:

- NREL conducted a review of actual continuous emissions monitoring (CEM) data records and derived an approximation of a startup penalty for plants responding to the integration of solar and wind in WECC (NREL, 2012; NREL, 2013).
- The generation-weighted average WECC-wide shows that combined cycle natural gas–fired units emit about as much NOx during a startup as approximately 7 hours of full-load operation, and simple cycle units emit about as much NOx during a startup as approximately 3 hours of full operation; NREL also expressed these startup emissions per MW of unit capacity as 0.53 lb/MW for CC units and 0.79 lb/MW for CT units (NREL, 2013).
- Simple cycle configurations of combustion turbines start much more quickly and emit less excess NOx during each startup event, because of the nature of simple-cycle units having no secondary steam turbine or steam cycle as a part of the design (RMB, 2002; NREL, 2012; NREL, 2013).
- Unit-specific startup distinctions are not made in this environmental study in light of the consideration that startup performance characteristics of combined-cycle units vary tremendously, even when focusing on an identical make and model or units within one specific facility (RMB, 2002). Additionally, as portions of the emissions occur at uncontrolled rates, they are partially beyond the ability to regulate.
- Distinctions between hot starts and cold starts are not made here because the production cost simulations data were not developed to make that distinction.
- Increased NOx emissions due to partial load operations or hours of ramping are not quantified from an emissions perspective (although partial and full load efficiency was considered in the plant dispatch of the production cost simulations); during these hours, part load penalties may be around 30% and ramping penalties are less than 10% (NREL, 2012; NREL, 2013). Production cost simulation results indicate that regionalization would generally reduce the need for generation unit cycling. As such, the excess NOx emissions of partial loads and ramping would be more likely to occur in the baseline conditions, and not modeling the additional emissions likely results in a more conservative estimate of the emissions reductions achieved by a regional market.
- The penalty ratios published by NREL as a gauge of actual WECC-wide emissions are reasonable in light of air permit records reviewed for facilities in California's fleet, which contain permit limits at levels that are higher than the actual WECC-wide rate by a factor of two- to five-times. Permits always provide a safety margin above the anticipated actual emission rates; and California's natural gas-fired fleet is generally better controlled than the WECC-wide average.

The ratios for NOx startup emissions from combined cycle and simple cycle units are shown in Table 4.4-3.

Table 4.4-3. Startup Ratios for NOx from Natural Gas–Fired Units

Examples of NOx Limits	Location or Citation	Cumulative Startup Emissions (lb per event)	Full-Load Steady State (lb NOx/hr)	Startup Ratio (start / steady state hour)
Combined-Cycle Units (CC)				
Colusa 657 MW CC (permit amended 12/15/2015)	Colusa Co APCD	260 to 779	20.7	12.6 to 38
Gateway 530 MW CC (permit licensed in 2007)	BAAQMD	189 to 452	20	9.5 to 23
Los Medanos, 520 MW CC (permit amended 4/19/2004)	BAAQMD	240 to 600	20	12 to 30
La Paloma 1048 MW CC (permit amended 10/6/2004)	SJVAPCD	1200	69.2 (17.3 x 4)	17.3
Lodi Energy Center 294 MW CC (permit amended 8/27/2013)	SJVAPCD	160	15.5	10.3
Theoretical Example (GE 7FA CC)	(RMB, 2002)	275	24	11.5
Approximate WECC-wide CC (based on review of CEMs)	(NREL, 2012)	—	—	6.1
Approximate WECC-wide CC (based on review of CEMs)	(NREL, 2013)	Excess: 0.53 lb/MW	Typical CA CC: 0.08 lb/MWh (CEC, 2015)	6.6
Simple-Cycle Units (CT, CTG)				
TID Almond2 3 x 58 MW aero-CTG (permit licensed in 2010)	SJVAPCD	25	5.02	5.0
Approximate WECC-wide CT (based on review of CEMs)	(NREL, 2012)	—	—	1.8
Approximate WECC-wide CT (based on review of CEMs)	(NREL, 2013)	Excess: 0.79 lb/MW	Typical CA CT: 0.28 lb/MWh (CEC, 2015)	2.8

Sources: NREL, 2012; NREL, 2013; supplemented by a review of CEC siting case records.

Approach to Estimating PM2.5 Emissions

This study identifies the levels of PM2.5 emissions changes using emission factors typical of the nationwide fleet for each basic technology (U.S. EPA AP-42), as shown in Table 4.4-2. All natural gas–fired PM10 emissions are presumed to qualify as PM2.5. Although the typical particulate matter emission factors are known to be somewhat uncertain, they are well-established in documentation vetted by U.S. EPA, drawn from comparable measurement methods independent of combustion technology, and available on a heat-input basis (per MMBtu) rather than an energy-output basis, which helps to avoid biases that arise from different test methods and variations in the thermal efficiencies of generating units.

For natural gas generating units, the directly-emitted PM2.5 factors are:

- Internal combustion engines (4-stroke, lean burn): 0.01 lb/MMBtu (EPA AP-42, Ch. 3.2, 2000).
- Gas turbines, combined cycle and simple cycle configuration: 0.0066 lb/MMBtu (EPA AP-42, Ch. 3.1, 2000).
- Boilers and steam generators: 0.0075 lb/MMBtu (EPA AP-42, Ch. 1.4, 1998).

Coal-fired units emit particulate matter at a wide range of rates that varies depending on the unit-specific the firing method, configuration, and the post-combustion controls (e.g., these include electrostatic precipitators, baghouses, and scrubbers). Because very little coal firing occurs in California, and PM10 or

PM2.5 emission factors are not available for each unit-specific configuration in the west-wide PSO model, the SB 350 studies provide a review of the WECC-wide changes in terms fuel use, total generation, and changes in production from coal-fired units as presented in Volume I and in the Production Cost Analysis (Volume V).

Approach to Estimating SO_2 Emissions

This study identifies the levels of SO_2 emissions changes as sulfur oxides are an important precursor to PM2.5 formation. As with the study of PM2.5, the SO_2 results also focus on PM2.5 nonattainment areas and those air basins with the highest scoring disadvantaged communities.

Electric generating station fuel types across California include agricultural and wood waste, diesel, digester gas, distillate oil, landfill gas, municipal solid waste, process or refinery gas, and natural gas. The vast majority of the fossil fuel–fired generating capacity in California uses natural gas. California's pipeline quality natural gas has negligible sulfur, which limits sulfur compound emissions (CEC, 2003).

Sulfur dioxide emissions due to the natural gas portion of the fleet are calculated based on a mass balance of the very low total sulfur content of the gas being fully converted to SO_2 by the combustion process.

For California's natural gas–fired units, an SO_2 emission factor can be derived as:

- 0.0007 lb/MMBtu, based on a typical annual average sulfur content of 0.25 gr S/100 scf of natural gas.

4.4.1 Regulatory Framework

Federal and State-Level Air Quality Management

Federal Clean Air Act and Ambient Air Quality Standards

The federal Clean Air Act [42 USC Section 7401 et seq. (1970)] is the comprehensive federal law that regulates air emissions from stationary and mobile sources. The Clean Air Act gives U.S. EPA the responsibility for implementing nationwide programs for air pollution prevention and control. This entails defining the National Ambient Air Quality Standards and the efforts to attain these standards. National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS) are planning standards that define the upper limits for airborne concentrations of pollutants. The criteria air pollutant standards are designed to protect the most sensitive individuals and ensure public health and welfare with a reasonable margin of safety.

Criteria Air Pollutants

The NAAQS and CAAQS are established for "criteria air pollutants." These are ozone, respirable particulate matter (PM10), fine particulate matter (PM2.5), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and lead. Ozone is an example of a secondary pollutant that is not emitted directly from a source (*i.e.*, not a product of combustion), but it is formed in the atmosphere by chemical and photochemical reactions. Reactive organic gases (ROG), including volatile organic compounds (VOC), are regulated as precursors to ozone formation.

Each state must prepare an air quality control plan referred to as a State Implementation Plan (SIP), and each SIP must incorporate the control measures necessary to reduce air pollution in nonattainment areas. The SIP is periodically modified to reflect the latest emissions inventories, planning documents, and rules and regulations for the air basins. The U.S. EPA has responsibility to review each SIP to determine if implementation will achieve air quality goals. In California, air quality management and regulation is the shared responsibility of the California Air Resources Board (ARB) and local air quality management and air pollution control districts. Regardless of jurisdiction, stationary sources must operate in compliance with permit conditions set by the local air district in order to avoid creating a conflict with the SIP.

Toxic Air Contaminants and Hazardous Air Pollutants

Toxic air contaminants (TACs) are air pollutants that may lead to serious illness or increased mortality, even when present in relatively low concentrations. Potential human health effects of TACs include birth defects, neurological damage, cancer, and death. The Health and Safety Code defines a TAC as an air pollutant which may cause or contribute to an increase in mortality or serious illness, or which may pose a present or potential hazard to human health. There are almost 200 compounds designated in California regulations as TACs (17 CCR Sections 93000-93001). The list of TACs also includes the substances defined in federal statute as hazardous air pollutants (HAPs) pursuant to Section 112(b) of the federal Clean Air Act (42 USC Section 7412(b)).

4.4.2 Baseline Air Quality Conditions

California Nonattainment Areas

California is divided geographically into air basins for the purpose of managing the air resources on a regional basis. An air basin generally has similar meteorological and geographic conditions throughout. California is divided into 15 air basins.

California's urbanized areas and inland valleys cover the air basins with the most persistent air quality problems. The nonattainment areas with the most persistent air quality nonattainment conditions are shown in Table 4.4-4.

Table 4.4-4. California's Federal Nonattainment Areas

California Air Basin	Ozone Nonattainment Designation (8-hour NAAQS)	PM10 Nonattainment Designation (24-hour NAAQS)	PM2.5 Nonattainment Designation (24-hour NAAQS)
San Joaquin Valley	Extreme	Maintenance	Serious
South Coast	Extreme	Maintenance	Serious
Salton Sea	Severe (Riverside); Marginal (Imperial)	Serious	Moderate (Imperial)
North Central Coast	—	—	—
Mojave Desert	Severe (West Mojave Desert); Marginal (Eastern Kern)	Moderate; Serious (Eastern Kern)	—
Sacramento Valley	Severe (Sacramento metro)	Maintenance	Moderate (Sacramento metro)
San Francisco Bay Area	Marginal	—	Moderate
South Central Coast	Serious (Ventura); Marginal (Eastern San Luis Obispo)	—	—
San Diego	Marginal	—	—

Note: "—":Attains NAAQS.
Source: https://www3.epa.gov/region9/air/maps/index.html.

The federally-designated nonattainment areas are mapped for ozone in Figure 4.4-1 and for PM2.5 in Figure 4.4-2.

Figure 4.4-1. California's Federal Ozone Nonattainment Areas

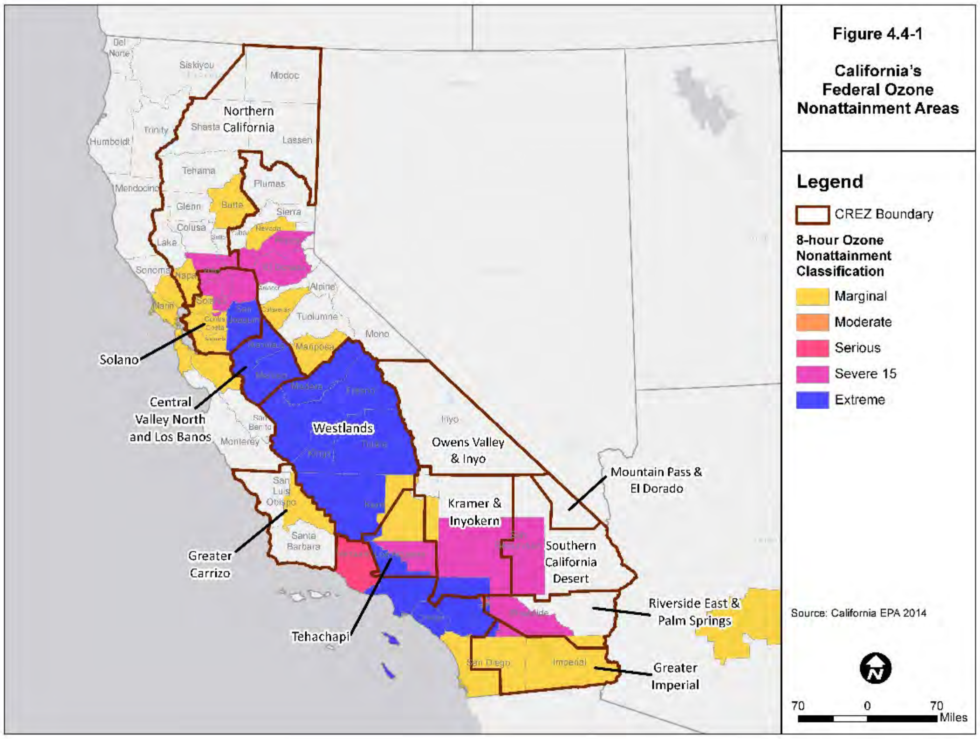
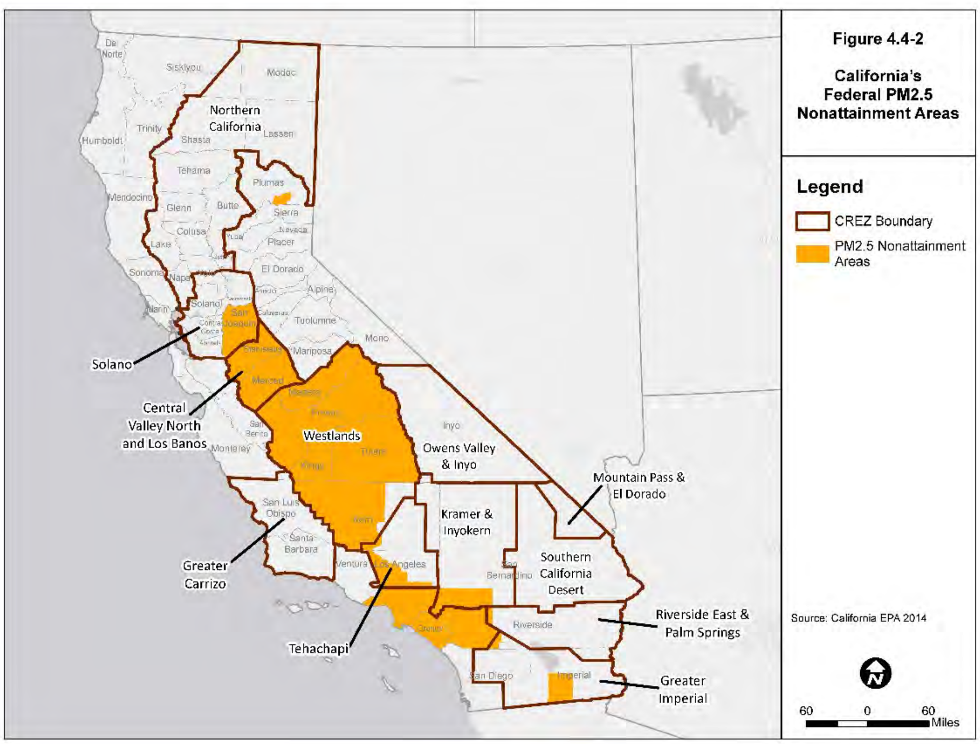


Figure 4.4-2. California's Federal PM2.5 Nonattainment Areas



Statewide Emissions from Electric Utilities

Emissions of criteria air pollutants are inventoried by ARB into stationary source subcategories, with all mobile sources and numerous area-wide sources treated separately. The stationary source category of Fuel Combustion, includes the emissions from all power plants, along with cogeneration facilities, and the combustion emissions from oil and gas production, refining, and other industrial, manufacturing, agricultural and service-sector sources. The combustion emissions from power plants (i.e., as stationary sources that produce electricity in California aside from cogeneration) are inventoried in a subcategory called Electric Utilities.

The ARB has a forecasting tool to estimate future-year criteria pollutant emissions, called California Emissions Projection Analysis Model (CEPAM). Table 4.4-5 shows the forecasted emissions of the 2020 California inventory across the entire state for all source categories, excluding natural sources. Statewide, combustion-fired electric generation comprises a small portion or roughly 1 to 2% of California's average daily inventories of NOx and PM2.5.

Table 4.4-5. California Statewide Emissions Inventory for 2020 (tons per day)

Source Categories	NOx	ROG	PM10	PM2.5	SOx
Area-wide Source Category	---	---	---	---	---
Miscellaneous Processes	73.8	265.9	1,258.2	278.3	6.4
Solvent Evaporation	0.0	364.2	0.0	0.0	0.0
Mobile Source Category	---	---	---	---	---
On-Road Motor Vehicles	544.8	220.2	67.8	31.5	5.5
Other Mobile Sources	643.3	285.7	35.7	32.6	15.4
Stationary Source Category	---	---	---	---	---
Industrial Processes	71.7	61.4	107.1	40.5	21.2
Petroleum Production and Marketing	4.4	127.8	1.8	1.6	4.4
Waste Disposal	4.6	42.1	1.8	0.8	1.5
Cleaning and Surface Coatings	0.3	166.8	3.2	3.1	0.2
Fuel Combustion	---	---	---	---	---
Food and Agricultural Processing	9.5	2.3	1.1	1.1	0.4
Manufacturing and Industrial	64.9	8.3	5.8	4.8	8.4
Oil and Gas Production (Combustion)	8.4	2.1	1.7	1.7	0.6
Other (Fuel Combustion)	13.5	0.9	2.1	0.5	0.4
Petroleum Refining (Combustion)	19.6	3.0	1.8	1.8	8.1
Service and Commercial	47.2	5.4	4.7	4.7	3.1
Cogeneration	20.6	2.5	3.5	3.2	1.4
Electric Utilities	---	---	---	---	---
Electric Utilities, Natural Gas	11.8	1.1	2.4	2.5	0.6
Electric Utilities, Other Fuels	15.0	1.3	3.1	2.5	5.0
Total, All Source Categories	1,553.4	1,560.8	1,502.0	411.2	82.4

Source: ARB Almanac Emission Projection Data (published in 2013); http://www.arb.ca.gov/ei/emissiondata.htm.

The ARB forecasts that emissions of criteria air pollutants (NOx, PM2.5, and SOx) from Electric Utilities statewide will remain steady or increase slightly from 2015 to 2020 and 2030. Table 4.4-6 shows the trend of historical and forecasted emissions for the portion of the electric utilities subcategory fired by natural gas in California.

Table 4.4-6. Statewide Inventory: Electric Utilities Subcategory, Natural Gas Only (tons per day)

Criteria Air Pollutant	2000	2005	2010	2012	2015	2020	2030
NOx	49.73	15.91	10.88	8.80	11.68	11.84	12.28
PM2.5	4.64	3.89	3.15	2.90	2.48	2.52	2.66
SOx	0.57	0.63	0.56	0.65	0.59	0.58	0.60

Source: ARB Almanac Emission Projection Data (published in 2013); http://www.arb.ca.gov/ei/emissiondata.htm.

4.4.3 Typical Air Quality Impacts of the Buildouts

This section describes the air quality impacts that would be common across the scenarios as a result of the incremental buildout of new solar, wind, and geothermal energy. Construction activities and operation of utility-scale renewable energy facilities under the buildout of the portfolios would introduce some localized air quality impacts by creating relatively minor levels of emissions, as summarized in this section.

Note that the SB 350 environmental study is not site-specific and does not reflect or represent a siting study for any particular planned or conceptual construction project. Although environmental impacts are described in general, project-specific impacts can typically be managed through best management practices and mitigation through the siting processes and with review by the siting authorities. Localized air quality impacts of construction activities can often be avoided or reduced on a case by case basis during the state or local siting processes.

Construction Impacts in General

Construction-phase air quality impacts are the result of the construction activities necessary to mobilize the workforce and equipment to install a given renewable energy development. These construction activities are similar for the incremental renewable energy buildouts across all scenarios. Therefore, these are the types of impacts that could occur on a community-scale for construction of renewable energy facilities and associated transmission interconnections. Because construction is limited in duration, the potential to create construction-related emissions essentially ends with the end of construction.

The typical construction-related air quality impacts are caused by fugitive dust from grading, vehicles driving on unpaved surfaces or roadways, and emissions from heavy-duty construction equipment and vehicles carrying construction materials and workers. These emissions occur during site development and preparation, transmission line development, and from building and roadway construction. The types of emissions would be the same for each renewable energy technology.

Construction activities may include mobilization, land clearing, earth moving, road construction, ground excavation, drilling and blasting, foundation construction, and installation activities. Heavy equipment used during site preparation would also include bulldozers, scrapers, trucks, cranes, rock drills, and possibly blasting equipment. These activities and equipment use would temporarily increase the amounts of particulate matter, including PM2.5, and precursors to particulate matter. Similarly, increased amounts of ozone precursors (VOCs and NOx) would occur from engine exhaust emissions, further exacerbating ozone nonattainment conditions.

Increased health risks would result for people exposed to excessive concentrations of dust, potentially including valley fever, and hazardous or toxic air pollutants routinely caused by gasoline and diesel-powered equipment. Diesel particulate matter is designated as a toxic air contaminant in California.

High levels of construction-phase emissions can exacerbate regional nonattainment conditions or expose sensitive receptors to substantial concentrations of hazardous or toxic air pollutants during project construction. Assessing the air quality impacts from construction emissions usually involves project-specific quantification of air pollutants emitted by construction activities for each phase of site development for each project.

Operational Impacts in General

Emissions are caused by operations and maintenance activities of the renewable energy buildout, through routine upkeep of the sites, security patrols, use of emergency generators, employee transportation, and vegetation removal. Dust emissions come from ground disturbance from access and spur road maintenance. Products of combustion are emitted by the use of natural gas, auxiliary heating of solar thermal technologies, and by the use of gasoline and diesel fuel for facility maintenance activities. Backup power supplies or fire water-pumping engines could also generate emissions if long-term operations and maintenance include diesel-powered emergency-use engines at substations and renewable energy facility sites.

Geothermal well-venting emissions include hydrogen sulfide (H_2S), carbon dioxide (CO_2), mercury, arsenic, and boron (when these compounds are contained in geothermal steam). H_2S is generally the primary pollutant of concern, and typically an air monitoring system is installed during geothermal field development. People exposed to high concentrations of H_2S or other hazardous or toxic air pollutants could experience adverse health effects, including cancer and non-cancer health risks; even at very low concentrations.

Producing electricity from the renewable energy resources displaces the need to produce electricity and the associated air contaminants from conventional fossil fuel–fired power generation facilities. These benefits would be felt at a regional or statewide level, but could also reduce the pollutant burden at the local level due to decreased emissions from conventional power generation facilities.

Reductions of SO_2 and NOx emissions and directly-emitted PM2.5 would yield health benefits. Sulfur oxides, which include SO_2, are precursors to PM2.5 formation in the ambient air, and NOx is a precursor to PM2.5 and ground-level ozone formation. As such, reductions of SO_2 and NOx can facilitate lower overall ambient concentrations of PM2.5 and ozone. Lower PM2.5 and ozone concentrations would generally reduce the exposure of persons to the adverse health effects and facilitate the associated human health benefits, such as avoided mortality and morbidity.

4.4.4 Air Emissions Impacts of Regionalization

The limited regionalization in the 2020 CAISO + PAC scenario includes no incremental renewable energy development so no incremental construction effects would occur inside or outside of California. Each scenario of regionalization in 2030 requires an incremental buildout of new solar, wind, and geothermal energy facilities that will create environmental impacts in the vicinity of the renewable energy buildout.

Incremental Buildout for All Scenarios by 2030

Inside California

Construction of the 2030 renewable portfolios under any scenario would require a substantial amount of ground disturbance and use of heavy-duty (diesel-powered) equipment that would be likely to create dust emissions and diesel exhaust emissions in California.

Nonattainment Areas and Construction-Related Emissions

Development of the renewable portfolio under 2030 Current Practice 1 would require construction of solar and wind projects in the following study areas that overlap with federally designated nonattainment areas (see Figures 4.4-1 and 4.4-2). The locations of the various renewable resource study areas are summarized in Table 4.4-7.

Table 4.4-7. Nonattainment Areas and California Study Areas

Federally-Designated Nonattainment Area	California Study Area
Mojave Desert Ozone Nonattainment Area	■ Tehachapi Wind and Solar ■ Kramer & Inyokern Solar
Sacramento Metropolitan Ozone Nonattainment Area	■ Solano Wind
Salton Sea Ozone Nonattainment Area	■ Riverside East & Palm Springs Solar and Wind ■ Greater Imperial Solar and Geothermal
San Diego County Ozone Nonattainment Area	■ Greater Imperial Wind
San Francisco Bay Area Ozone Nonattainment Area	■ Solano Wind
San Joaquin Valley Ozone and Particulate Matter Nonattainment Area	■ Westlands Solar ■ Solano Wind ■ Central Valley and Los Banos Wind
San Luis Obispo County Ozone Nonattainment Area	■ Greater Carrizo Solar and Wind

Although all scenarios include the incremental buildout, Current Practice 1 would emphasize solar in the Tehachapi, Westlands, and Greater Imperial areas, which are persistent nonattainment areas. The dust emissions and diesel exhaust emissions related to the buildout would temporarily increase the air pollutant burdens in these air basins.

When compared with 2030 Current Practice 1, the regional scenarios would reduce the construction emissions in California's nonattainment areas as follows:

- All regional scenarios would reduce the amount of construction and associated emissions in the San Joaquin Valley ozone and particulate matter nonattainment area (Westlands solar study area; Solano wind and Central Valley North and Los Banos wind study areas) compared with the 2030 Current Practice 1.
- 2030 Regional 3 would reduce construction and associated emissions in the Mojave Desert ozone nonattainment area (primarily in the Tehachapi solar study area).
- 2030 Regional 3 would reduce construction and associated emissions in the Salton Sea ozone nonattainment area (portions of the Riverside East & Palm Springs and Greater Imperial study areas).

Out of State

Wind and solar development out of state would involve certain amount of ground disturbance and use of heavy-duty equipment that depends on the relative incremental buildouts for California to achieve 50% RPS by 2030. Construction-phase emissions of ozone precursors and particulate matter would occur outside of California in the form of dust and diesel exhaust in the immediate vicinity of the buildout locations. A portion of the out-of-state buildout could occur in an ozone nonattainment area in Maricopa County Arizona, but all other out-of-state wind and solar buildout would avoid nonattainment areas. To the extent that regionalization could increase the buildout of the Southwest solar study area, construction-phase activities could temporarily increase the localized air pollutant concentrations in the Maricopa County ozone nonattainment area.

Out-of-State Transmission Additions

Under Regional 3, it is assumed that major out-of-state transmission additions would be necessary to integrate renewable generation from Wyoming and New Mexico into the regional power system and for California to achieve 50% RPS. Construction-phase emissions of ozone precursors and particulate matter would occur outside of California during the limited period of construction, and these would temporarily increase localized air pollutant concentrations in immediate vicinity of the activity. The potential transmission expansions are summarized in Section 5.

Operational Impacts of Regionalization

The production cost simulation model provided the changes in overall generation (in MWh) in the WECC under each of the 2020 and 2030 scenarios. This information was used to generate an estimated change in air emissions from the natural gas fleet inside California and out of state, or the remainder of the WECC, for each scenario. The changes in fossil fuel MWh production brought about by regionalization are almost exclusively an exchange between natural gas inside California and coal or natural gas outside California. Between 2020 and 2030, California natural gas dispatch by 2030 is modeled to be notably lower (-14% to -21%) than in the 2020 Current Practice scenario. Across this timeframe, out-of-state coal dispatch decreases and natural gas dispatch increases by 2030 when compared with the 2020 Current Practice scenario. Reductions in dispatch of the fossil fuel–fired units drive the emissions results presented in this section. Details on simulated dispatch results, including fuel use and fuel type trends, are presented in the Production Cost Analysis (Volume V).

Inside California

California's transition to achieving the RPS goals, including the incremental renewable buildout to 2030, relies partially upon the flexibility of California's existing fossil fuel–fired generators. The flexibility is reflected in the number of startups of the natural gas units, which would generally be more frequent in 2030 than in 2020.

Baseline forecasts of the California statewide emissions inventory (summarized in Table 4.4-6) indicate that emissions from natural gas-fired electric utilities statewide should remain steady or increase slightly between 2020 and 2030; however, the official forecast may not fully reflect current RPS goals. Between the time of California achieving the 33% RPS and achieving the 50% RPS by 2030, the retail demand for non-renewable and fossil fuel energy should continue to fall. Growth to serve California load is expected to come from renewable resources between 2020 and 2030, and the scenarios of this study include no new fossil fuel power plants. In sum, between 2020 and 2030, a decreasing amount of energy would be produced by California's fossil fuel fleet, and accordingly, overall criteria air pollutant emissions from California's generators would also decrease by 2030, even without regionalization.

Modeling of limited regionalization in 2020 (CAISO + PAC) indicates that the San Joaquin Valley and South Coast air basins could experience slightly increased PM2.5 and SO_2 emissions due to changes in natural gas–fired power plant dispatch, but these changes would occur in conjunction with a NOx decrease. By 2030, however, regionalization would decrease the emissions of NOx, PM2.5, and SO_2 from power plants statewide and in the air basins with persistent nonattainment conditions.

Tables 4.4-8, 4.4-9, and 4.4-10 present the modeled average daily air emissions rates for NOx, PM2.5, and SO_2, respectively, for the annual periods of 2020 and 2030 due the operation of California's natural gas–fired fleet under the Current Practice and regionalization scenarios.

Table 4.4-8. Modeled NOx Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
Mojave Desert	0.74	0.74	0.55	0.46	0.40
North Central Coast	0.41	0.41	0.47	0.46	0.46
North Coast	0.22	0.22	0.21	0.22	0.21
Sacramento Valley	1.30	1.27	1.35	1.21	1.13
Salton Sea	0.06	0.05	0.10	0.00	0.00
San Diego County	0.49	0.46	0.48	0.36	0.35
San Francisco Bay	2.63	2.58	2.75	2.67	2.51
San Joaquin Valley	6.46	6.43	6.44	6.22	6.06
South Central Coast	0.20	0.20	0.20	0.19	0.19
South Coast	2.74	2.70	2.67	2.42	2.33
Statewide Total	**15.24**	**15.06**	**15.21**	**14.23**	**13.66**
(% of All CA Sources)	*1.0%*	*1.0%*	*1.2%*	*1.2%*	*1.1%*
Impact of Regionalization		**–0.18**		**–0.99**	**–1.56**
(Relative to Current Practice)		*–1.2%*		*–6.5%*	*–10.2%*
Difference from 2020 Current Practice			**–0.03**	**–1.01**	**–1.58**
(Relative to 2020)			*–0.2%*	*–6.6%*	*–10.4%*

Table 4.4-9. Modeled PM2.5 Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
Mojave Desert	0.45	0.46	0.26	0.22	0.20
North Central Coast	0.24	0.24	0.25	0.25	0.25
North Coast	0.03	0.03	0.03	0.03	0.03
Sacramento Valley	0.88	0.87	0.80	0.74	0.70
Salton Sea	0.02	0.02	0.02	0.00	0.00
San Diego County	0.31	0.29	0.26	0.22	0.21
San Francisco Bay	1.64	1.61	1.45	1.52	1.46
San Joaquin Valley	2.60	2.61	2.28	2.24	2.20
South Central Coast	0.16	0.16	0.16	0.16	0.16
South Coast	1.45	1.46	1.31	1.19	1.15
Statewide Total	**7.78**	**7.75**	**6.82**	**6.55**	**6.36**
(% of All CA Sources)	*1.9%*	*1.9%*	*1.6%*	*1.5%*	*1.5%*
Impact of Regionalization		**–0.04**		**–0.27**	**–0.47**
(Relative to Current Practice)		*–0.5%*		*–4.0%*	*–6.8%*
Difference from 2020 Current Practice			**–0.96**	**–1.24**	**–1.43**
(Relative to 2020)			*–12.4%*	*–15.9%*	*–18.4%*

Table 4.4-10. Modeled SO_2 Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
Mojave Desert	0.05	0.05	0.03	0.02	0.02
North Central Coast	0.03	0.03	0.03	0.03	0.03
North Coast	0.00	0.00	0.00	0.00	0.00
Sacramento Valley	0.09	0.09	0.09	0.08	0.07
Salton Sea	0.00	0.00	0.00	0.00	0.00
San Diego County	0.03	0.03	0.03	0.02	0.02
San Francisco Bay	0.17	0.17	0.15	0.16	0.15
San Joaquin Valley	0.28	0.28	0.24	0.24	0.23
South Central Coast	0.02	0.02	0.02	0.02	0.02
South Coast	0.15	0.15	0.14	0.13	0.12
Statewide Total	**0.82**	**0.82**	**0.72**	**0.69**	**0.67**
(% of All CA Sources)	*1.0%*	*1.0%*	*0.8%*	*0.7%*	*0.7%*
Impact of Regionalization		**0.00**		**–0.03**	**–0.05**
(Relative to Current Practice)		*–0.5%*		*–4.0%*	*–6.8%*
Difference from 2020 Current Practice			**–0.10**	**–0.13**	**–0.15**
(Relative to 2020)			*–12.4%*	*–15.9%*	*–18.4%*

Managing ambient levels of ozone across California is a major focus of air quality management activity in many of California's air basins and in the SIP for the entire state. The planning period that is most relevant to the air basins with ozone nonattainment conditions generally spans the summertime months, and achieving reductions in NOx during those months is especially beneficial because NOx is a strong precursor to ground-level ozone along with being a PM2.5 precursor. To evaluate the potential impacts to ozone levels as a result of NOx emissions during summertime months (June, July, and August), the production simulation results for this three-month period were reviewed.

Table 4.4-11 presents the daily average modeled air emissions rates for NOx during the summer season from the natural gas fleet under the Current Practice and regionalization scenarios. Tables 4.4-12 and 4.4-13 show the summer season emissions rates for PM2.5 and SO_2, respectively. The results show that the two regionalization scenarios generally achieve similar levels of NOx emissions reductions in the summer season when compared with 2030 Current Practice 1.

Table 4.4-11. Modeled Summer Season NOx Emissions Rates, California Natural Gas Fleet

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
Mojave Desert	0.86	0.89	0.69	0.61	0.60
North Central Coast	0.67	0.66	0.69	0.68	0.72
North Coast	0.23	0.24	0.23	0.23	0.24
Sacramento Valley	1.41	1.39	1.49	1.33	1.34
Salton Sea	0.07	0.06	0.10	0.00	0.00
San Diego County	0.70	0.67	0.65	0.53	0.55
San Francisco Bay	2.78	2.74	2.95	2.85	2.82
San Joaquin Valley	6.73	6.71	6.69	6.50	6.45

Table 4.4-11. Modeled Summer Season NOx Emissions Rates, California Natural Gas Fleet

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
South Central Coast	0.20	0.20	0.20	0.20	0.20
South Coast	3.73	3.69	3.51	3.24	3.28
Statewide Total	**17.38**	**17.24**	**17.20**	**16.18**	**16.19**
Impact of Regionalization		**–0.14**		**–1.02**	**–1.01**
(Relative to Current Practice)		*–0.8%*		*–5.9%*	*–5.9%*
Difference from 2020 Current Practice			**–0.18**	**–1.20**	**–1.19**
(Relative to 2020)			*–1.0%*	*–6.9%*	*–6.9%*

Table 4.4-12. Modeled Summer Season PM2.5 Emissions Rates, California Natural Gas Fleet

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
Mojave Desert	0.53	0.56	0.33	0.31	0.32
North Central Coast	0.41	0.40	0.33	0.35	0.39
North Coast	0.03	0.03	0.03	0.03	0.03
Sacramento Valley	0.94	0.94	0.88	0.83	0.84
Salton Sea	0.02	0.02	0.02	0.00	0.00
San Diego County	0.43	0.41	0.32	0.27	0.28
San Francisco Bay	1.74	1.72	1.61	1.68	1.68
San Joaquin Valley	2.72	2.73	2.40	2.40	2.42
South Central Coast	0.16	0.16	0.16	0.16	0.16
South Coast	1.85	1.85	1.59	1.45	1.47
Statewide Total	**8.82**	**8.83**	**7.67**	**7.48**	**7.57**
Impact of Regionalization		**0.00**		**–0.19**	**–0.10**
(Relative to Current Practice)		*0.0%*		*–2.5%*	*–1.3%*
Difference from 2020 Current Practice			**–1.15**	**–1.34**	**–1.25**
(Relative to 2020)			*-13.1%*	*-15.2%*	*-14.2%*

Table 4.4-13. Modeled Summer Season SO_2 Emissions Rates, California Natural Gas Fleet

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
Mojave Desert	0.06	0.06	0.03	0.03	0.03
North Central Coast	0.04	0.04	0.04	0.04	0.04
North Coast	0.00	0.00	0.00	0.00	0.00
Sacramento Valley	0.10	0.10	0.09	0.09	0.09
Salton Sea	0.00	0.00	0.00	0.00	0.00
San Diego County	0.05	0.04	0.03	0.03	0.03
San Francisco Bay	0.18	0.18	0.17	0.18	0.18
San Joaquin Valley	0.29	0.29	0.25	0.25	0.26
South Central Coast	0.02	0.02	0.02	0.02	0.02

Table 4.4-13. Modeled Summer Season SO_2 Emissions Rates, California Natural Gas Fleet

Air Basin	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
South Coast	0.20	0.20	0.17	0.15	0.16
Statewide Total	**0.93**	**0.93**	**0.81**	**0.79**	**0.80**
Impact of Regionalization		**0.00**		**–0.02**	**–0.01**
(Relative to Current Practice)		*0.0%*		*–2.4%*	*–1.3%*
Difference from 2020 Current Practice			**–0.12**	**–0.14**	**–0.13**
(Relative to 2020)			*–13.1%*	*–15.2%*	*-14.2%*

Out of State

In 2020 CAISO + PAC scenario, production simulation indicates a slight (+0.5%) increase in out-of-state coal use and a slight (-0.3%) decrease in out-of-state natural gas use. This slightly increases emissions from the WECC-wide fleet outside California when compared with 2020 Current Practice.

Air pollutant reductions outside of California by 2030 are driven by the transition away from coal. Between 2020 and 2030, out-of-state coal dispatch decreases and natural gas dispatch increases. This reduces emissions in all 2030 scenarios when compared with the 2020 conditions.

In 2030 Regional 2 and Regional 3, production simulation indicates overall reductions in out-of-state coal and natural gas use (-0.7% to -5.3%) when compared with 2030 Current Practice 1. The modeled emissions and changes in NOx and SO_2 emissions from the WECC fleet, excluding California sources, are shown in Table 4.4-14.

Table 4.4-14. Modeled Out-of-State Emissions Rates from Production Simulation

Criteria Air Pollutant	2020 Current Practice (tons/day)	2020 CAISO + PAC (tons/day)	2030 Current Practice 1 (tons/day)	2030 Regional 2 (tons/day)	2030 Regional 3 (tons/day)
NOx	1,522	1,533	1,166	1,143	1,150
Impact of Regionalization		**10**		**–23**	**–16**
(Relative to Current Practice)		*0.7%*		*–2.0%*	*–1.4%*
SO_2	1,509	1,527	1,113	1,102	1,110
Impact of Regionalization		**18**		**–11**	**–2**
(Relative to Current Practice)		*1.2%*		*–1.0%*	*–0.2%*

4.4.5 Comparison of Scenarios for Air Emissions

The change from Current Practice into regional scenarios allows the following comparisons.

Inside California

Modeling of limited regionalization in 2020 (CAISO + PAC) indicates that the San Joaquin Valley and South Coast air basins could experience slightly increased PM2.5 and SO_2 emissions due to changes in natural gas–fired power plant dispatch, but these changes would occur in conjunction with a NOx decrease. By 2030, however, regionalization would decrease the emissions of NOx, PM2.5, and SO_2 from power plants statewide and in the air basins with persistent nonattainment conditions.

Tables 4.4-15, 4.4-16, and 4.4-17 summarize the relative changes in criteria air pollutant emissions from the existing system of natural gas–fired generating units in California's air basins.

Table 4.4-15. NOx Emissions Changes, California Natural Gas Fleet by Air Basin

Air Basin	2020 CAISO + PAC Relative to Current Practice (% NOx)	2030 Regional 2 Relative to Current Practice Scenario 1 (% NOx)	2030 Regional 3 Relative to Current Practice Scenario 1 (% NOx)
Mojave Desert	0.2%	–15.6%	–26.8%
North Central Coast	–0.6%	–2.5%	–2.1%
North Coast	–0.3%	0.3%	–1.0%
Sacramento Valley	–2.6%	–9.7%	–16.2%
Salton Sea	–5.1%	–99.4%	–99.4%
San Diego County	–6.8%	–24.6%	–26.9%
San Francisco Bay	–1.7%	–3.0%	–8.7%
San Joaquin Valley	–0.5%	–3.3%	–5.8%
South Central Coast	–0.1%	–0.3%	–0.3%
South Coast	–1.4%	–9.2%	–12.8%
Difference Statewide NOx (California natural gas fleet)	**–1.2%**	**–6.5%**	**–10.2%**

Table 4.4-16. PM2.5 Emissions Changes, California Natural Gas Fleet by Air Basin

Air Basin	2020 CAISO + PAC Relative to Current Practice (% PM2.5)	2030 Regional 2 Relative to Current Practice Scenario 1 (% PM2.5)	2030 Regional 3 Relative to Current Practice Scenario 1 (% PM2.5)
Mojave Desert	0.7%	–14.2%	–23.3%
North Central Coast	–0.7%	0.3%	2.9%
North Coast	10.0%	–0.9%	–2.6%
Sacramento Valley	–1.3%	–8.5%	–12.6%
Salton Sea	–1.4%	–99.2%	–98.8%
San Diego County	–6.4%	–17.3%	–18.9%
San Francisco Bay	–1.4%	4.4%	0.1%
San Joaquin Valley	0.4%	–2.0%	–3.8%
South Central Coast	0.0%	0.0%	0.0%
South Coast	0.4%	–9.7%	–12.2%
Difference Statewide PM2.5 (California natural gas fleet)	**–0.5%**	**–4.0%**	**–6.8%**

Table 4.4-17. SO_2 Emissions Changes, California Natural Gas Fleet by Air Basin

Air Basin	2020 CAISO + PAC Relative to Current Practice (% SO_2)	2030 Regional 2 Relative to Current Practice Scenario 1 (% SO_2)	2030 Regional 3 Relative to Current Practice Scenario 1 (% SO_2)
Mojave Desert	0.7%	–14.2%	–23.3%
North Central Coast	–0.7%	0.3%	2.9%
North Coast	10.0%	–0.9%	–2.6%
Sacramento Valley	–1.3%	–8.6%	–12.7%
Salton Sea	–1.4%	–99.2%	–98.8%
San Diego County	–6.4%	–17.3%	–18.9%
San Francisco Bay	–1.4%	4.5%	0.1%
San Joaquin Valley	0.3%	–1.9%	–3.8%
South Central Coast	0.0%	0.0%	0.0%
South Coast	0.4%	–9.7%	–12.2%
Difference Statewide SO_2 (California natural gas fleet)	**–0.5%**	**–4.0%**	**–6.8%**

During the ozone management summer season, Table 4.4-18 summarizes the relative changes in NOx emissions from the existing system of natural gas–fired generating units in California's air basins. Tables 4.4-19 and 4.4-20 summarize the relative changes in PM2.5 and SO_2 within the summer season.

Table 4.4-18. Modeled Summer Season NOx Emissions Changes, California Natural Gas Fleet

Air Basin	2020 CAISO + PAC Relative to Current Practice (% NOx)	2030 Regional 2 Relative to Current Practice Scenario 1 (% NOx)	2030 Regional 3 Relative to Current Practice Scenario 1 (% NOx)
Mojave Desert	3.0%	-11.3%	-13.6%
North Central Coast	-1.3%	-1.4%	5.0%
North Coast	4.0%	-0.1%	1.5%
Sacramento Valley	-1.6%	-10.2%	-9.7%
Salton Sea	-13.2%	-98.4%	-98.0%
San Diego County	-4.3%	-17.4%	-15.7%
San Francisco Bay	-1.6%	-3.6%	-4.4%
San Joaquin Valley	-0.3%	-2.8%	-3.6%
South Central Coast	-0.5%	-0.8%	-0.7%
South Coast	-1.1%	-7.7%	-6.7%
Difference Statewide NOx (California natural gas fleet)	**–0.8%**	**–5.9%**	**–5.9%**

Table 4.4-19. Modeled Summer Season PM2.5 Emissions Changes, California Natural Gas Fleet

Air Basin	2020 CAISO + PAC Relative to Current Practice (% PM2.5)	2030 Regional 2 Relative to Current Practice Scenario 1 (% PM2.5)	2030 Regional 3 Relative to Current Practice Scenario 1 (% PM2.5)
Mojave Desert	4.5%	-5.5%	-3.9%
North Central Coast	-1.6%	5.1%	16.5%
North Coast	15.9%	-2.2%	-0.1%
Sacramento Valley	-0.5%	-5.4%	-4.6%
Salton Sea	-8.5%	-98.2%	-96.9%
San Diego County	-3.8%	-13.6%	-12.4%
San Francisco Bay	-0.8%	3.8%	3.8%
San Joaquin Valley	0.6%	0.1%	0.8%
South Central Coast	0.2%	0.0%	0.0%
South Coast	0.0%	-8.6%	-7.4%
Difference Statewide PM2.5 (California natural gas fleet)	**0.0%**	**–2.5%**	**–1.3%**

Table 4.4-20. Modeled Summer Season SO_2 Emissions Changes, California Natural Gas Fleet

Air Basin	2020 CAISO + PAC Relative to Current Practice (% SO_2)	2030 Regional 2 Relative to Current Practice Scenario 1 (% SO_2)	2030 Regional 3 Relative to Current Practice Scenario 1 (% SO_2)
Mojave Desert	4.5%	-5.5%	-3.9%
North Central Coast	-1.6%	5.1%	16.5%
North Coast	15.9%	-2.2%	-0.1%
Sacramento Valley	-0.5%	-5.5%	-4.6%
Salton Sea	-8.4%	-98.2%	-96.9%
San Diego County	-3.8%	-13.6%	-12.4%
San Francisco Bay	-0.8%	3.8%	3.8%
San Joaquin Valley	0.6%	0.1%	0.9%
South Central Coast	0.2%	0.0%	0.0%
South Coast	0.0%	-8.6%	-7.4%
Difference Statewide SO_2 (California natural gas fleet)	**0.0%**	**–2.4%**	**–1.3%**

Out of State

In the 2020 CAISO + PAC scenario, production simulation indicates a slight (+0.5%) increase in out-of-state coal use and a slight (-0.3%) decrease in out-of-state natural gas use, when compared with 2020 Current Practices, and this slightly increases emissions out of state (+0.7% for NOx and +1.2% for SO_2).

Regionalization by 2030 would affect the emissions from electricity generating units in the remainder of the Western Interconnection as follows:

- Regional 2 decreases NOx (-1.9%) and SO_2 (-0.9%) emissions out of state relative to 2030 Current Practice 1.

- Regional 3 decreases NOx (-1.3%) and SO_2 (-0.2%) emissions out of state relative to 2030 Current Practice 1.

4.5 Discussion of Sensitivities

Along with the primary scenarios of the SB 350 study, summarized in Section 2 (Summary of Scenarios), the study team tested how certain assumptions could affect the results through sensitivity analyses. The full range of sensitivity analyses is described within Volume III (Description of Scenarios and Sensitivities). The environmental study focuses on two of these sensitivities to illustrate potential differences in the buildout of the renewable resources by 2030 or the operational characteristics of generators.

The 2030 Current Practice 1B sensitivity (Sensitivity 1B) assumes a higher flexibility in bilateral markets with CAISO's net bilateral export capability increased from 2,000 MW to 8,000 MW. This sensitivity is characterized by a portfolio that includes a somewhat larger buildout of solar resources in California and less emphasis on out-of-state wind than in the 2030 Current Practice Scenario 1.

Additionally, a sensitivity for testing the 2030 Scenario 3 without renewables beyond RPS is also reviewed. The renewable buildout for this sensitivity is the same incremental renewable buildout as for 2030 Regional Scenario 3; the only change from Regional 3 was the overall generation in the WECC, which would not include 5,000 MW of added wind capacity distributed as 3,000 MW in Wyoming and 2,000 MW in New Mexico. As such, the sensitivity without the renewables beyond RPS is analyzed for potential changes in water use and air emissions from operation of the generators across the WECC. While this sensitivity removes the impacts of developing these presumed resources (5,000 MW), there would be no other difference in the impacts to land use or biological resources when compared with Regional 3 because this sensitivity has an identical buildout for satisfying RPS goals.

As with the analysis of all 2030 scenarios, the analysis of the Sensitivity 1B starts by presuming construction of the renewable portfolios defined through the use of the RESOLVE model. The incremental renewable buildout between 2020 and 2030 is presented in Table 4.5-1 for inside and outside California. Current Practice Scenario 1 is presented for comparison purposes.

Table 4.5-1. Incremental Renewable Buildout for Sensitivity 1B (MW)

Portfolio Composition	2030 Current Practice Scenario 1	2030 Sensitivity 1B
California Solar	7,601	8,279
California Wind	3,000	3,000
California Geothermal	500	500
Out-of-State Solar	1,000	1,272
Out-of-State Wind	4,551	2,551
Total California New Capacity	11,101	11,779
Total Out-of-State New Capacity	5,551	3,823
Total New Renewable Capacity	16,652	15,602
Major Out-of-State Transmission Additions for California RPS?	No	No
Renewables Beyond RPS, Out of State	No	No

Source: Results from the RESOLVE model; adding renewable development beyond RPS facilitated by regional market.
Notes:
- All portfolios also include energy storage (batteries and/or pumped hydro);
- Incremental California geothermal located in Greater Imperial.

Incremental Buildout Inside California

The renewable portfolios as developed through the RESOLVE model reflect MW of renewable buildout by CREZ and technology for the entire state of California including both CAISO and non-CAISO utilities. The buildout for solar is presented in Table 4.5-2 and for wind is presented in Table 4.5-3.

Table 4.5-2. California Solar, Incremental Buildout Details in Sensitivity 1B (MW)

California Solar Portfolio	2030 Current Practice Scenario 1	2030 Sensitivity 1B
Greater Carrizo Solar	570	570
Greater Imperial Solar	923	923
Kramer and Inyokern Solar	375	375
Owens Valley Solar	578	578
Riverside East and Palm Springs Solar	331	2,459
Tehachapi Solar	2,500	2,500
Westlands Solar	2,323	873
Total California New Solar Capacity	7,601	8,279

Source: Results from the RESOLVE model.

Table 4.5-3. California Wind, Incremental Buildout Details in Sensitivity 1B (MW)

California Wind Portfolio	2030 Current Practice Scenario 1	2030 Sensitivity 1B
Central Valley North and Los Banos Wind	150	150
Greater Carrizo Wind	500	500
Greater Imperial Wind	400	400
Riverside East and Palm Springs Wind	500	500
Solano Wind	600	600
Tehachapi Wind	850	850
Total California New Wind Capacity	3,000	3,000

Source: Results from the RESOLVE model.

Incremental Buildout Out of State

The renewable portfolios also include the MW of renewable buildout outside California. The buildout for solar and wind is presented in Table 4.5-4.

Table 4.5-4. Out-of-State Solar and Wind, Incremental Buildout Details in Sensitivity 1B (MW)

Out-of-State Portfolio for California	2030 Current Practice Scenario 1	2030 Sensitivity 1B
Southwest Solar (Arizona)	1,000	1,272
Northwest Wind (Oregon)	2,447	447
Utah Wind	604	604
Wyoming Wind	500	500
New Mexico Wind	1,000	1,000
Total Out-of-State New Capacity	5,551	3,823
Major Out-of-State Transmission Additions for California RPS?	No	No
Renewables Beyond RPS, Out-of-State	No	No

Source: Results from the RESOLVE model; adding renewable development beyond RPS facilitated by regional market.

4.5.1 Land Use Impacts of Sensitivity 1B

Inside California

Solar. Under Sensitivity 1B, the solar portfolio in California would be similar to the Current Practice Scenario 1, and would emphasize:

- Areas having population densities ranging from medium/high to low, with most occurring in areas of medium/high density.
- Areas with extensive to low levels of agricultural activity.
- Areas within 5 miles of a high to medium number of excluded or protected areas.

Sensitivity 1B would include 8,279 MW of California solar capacity, about 9 percent more than Scenario 1, with the increase occurring in the Riverside East and Palm Springs Solar area, while decreasing generation in Westlands. This scenario would require development on about 58,000 acres of land, or about 90 square miles. While projects would be located in all study areas, nearly 60 percent of the total used area under Sensitivity 1B would be in two study areas: Tehachapi and Riverside East and Palm Springs. The only difference between the buildout for Scenario 1 and Sensitivity 1B is a decrease in solar development in the Westlands area and an increase in the Riverside East and Palm Springs solar area. As described for Scenario 1, the Tehachapi solar area surrounds Lancaster, Mojave, and lands north and west of Edwards AFB. Except for in Lancaster and a few small towns in the area, the population density is very low. The land is flat desert with sparse vegetation, with some small areas of irrigated agriculture. The Riverside East and Palm Springs solar study area is a patchwork of lands located in two general areas: the lands west of Blythe to near Desert Center in eastern Riverside County, and in the Palm Springs area near Desert Hot Springs and between Indio and Thermal. The solar area's terrain is flat, sparsely vegetated desert with some areas of irrigated agriculture. Much of the area has a very low population density, except in urbanized areas in the vicinity of Palm Springs.

Impacts on land use and agriculture would be similar between Scenario 1 and Sensitivity 1B, except that there is a greater population density in the Palm Springs portion of the Riverside East and Palm Springs area as compared to the Westlands area. However, the population density in the eastern part of Riverside East between Blythe and Desert Center is extremely low. Less agricultural land would potentially be affected in Sensitivity 1B when compared with Scenario 1.

Wind. In terms of wind powered generation in California, Scenario 1 and Sensitivity 1B are identical and would have similar land use impacts.

Geothermal. Sensitivity 1B is identical to Scenario 1.

Out of State

Out of state, under Sensitivity 1B, solar generation would slightly increase in Arizona as compared to Scenario 1. This would partially offset a large reduction in wind generation in the Oregon area. Wind generation in Utah, Wyoming, and New Mexico would be the same as in Scenario 1. Overall, Sensitivity 1B would include nearly 30 percent less out-of-state buildout than Scenario 1. Impacts would be similar to those in Scenario 1, except there would be somewhat more land used in Arizona for solar, and the land needed in Oregon for wind generation would decrease notably.

4.5.2 Biological Resources Impacts of Sensitivity 1B

Inside California

Sensitivity 1B emphasizes solar in the Tehachapi (30% of total or 2,500 MW) and Riverside East & Palm Springs (29.7% of total or 2,459 MW) study areas. Impacts of solar development in the Tehachapi study area under Sensitivity 1B would the same as those described under Current Practice Scenario 1 as generation capacity would be the same. The Riverside East & Palm Springs has 30% coverage of the highest crucial habitat ranks. Development would result in habitat loss for several listed species and constriction of movement corridors for desert tortoise and bighorn sheep (peninsular and desert), which are also susceptible to cumulative effects of habitat fragmentation and associated population-level impacts of genetic isolation.

Impacts of wind and geothermal development under Sensitivity 1B would be the same as those described under Current Practice 1 as generation capacity across all study areas would be the same.

Out of State

Sensitivity 1B would use the fewest out-of-state resources when compared with other buildouts by 2030 with the most generation occurring in the Southwest solar study area and the New Mexico wind study area. Impacts in these study areas would be consistent with those described in Section 4.2.3 and under Current Practice Scenario 1 for these study areas as generation capacity would be similar.

4.5.3 Water Impacts of Sensitivity 1B and Sensitivity without Renewables Beyond RPS

Inside California

As with the primary scenarios and impacts described in Section4.3, this analysis considers three factors pertaining to water use inside California for Sensitivity 1B. First it considers development in critically overdrafted groundwater basins, followed by construction in areas of different water risk factors, and finally it looks at water consumption during operations.

Critically Overdrafted Groundwater Basins

Sensitivity 1B would reduce the construction water use in critically overdrafted groundwater basins as follows:

- It would reduce the amount of construction and associated water use in Westlands solar study area compared with the 2030 Current Practice 1.

Construction in Areas of Water Risk

Table 4.5--5 presents the acre feet of water required for construction of renewable energy in California under the sensitivity. Current Practice Scenario 1 is provided for comparison purposes. Sensitivity 1B would require more water in California in low to medium and medium to high risk areas and less water in areas of high risk.

Table 4.5-5. Construction Water Use by Risk Category for Sensitivity 1B

Water Risk (acre feet)	2030 Current Practice Scenario 1	2030 Sensitivity 1B
Low to Medium	4,364	6,000
Medium to High	7,019	7,959
High	7,562	6,518

Water Consumption during Operations

Table 4.5-6 presents the results of the operational water use for the sensitivity analyses for regionalization in 2030.

Table 4.5-6. Total Water Use for Energy Generation in California – Sensitivity Analyses

Water Consumption by Technology (af)	2030 Current Practice Scenario 1	2030 Sensitivity 1B	2030 Scenario 3 w/o Renewables Beyond RPS
Solar PV	3,540	3,926	2,883
Solar Thermal	1,039	1,040	1,040
Natural Gas Combined Cycle	41,486	42,105	42,382
Natural Gas Steam Turbine	2,710	2,715	2,721
ST Coal	0	0	0
Total (excluding Geothermal)	48,776	49,786	49,026
Geothermal	205,897	201,955	208,231
Change Relative to Current Practice 1 (af)		1,010	250
Change Relative to Current Practice 1 (%)		2.1%	0.5%

Under the sensitivity analyses in comparison with Current Practice Scenario 1, the following would occur inside California:

- 2030 Sensitivity 1B would increase water use for electricity generation by 1,010 acre feet, about 2%.
- 2030 Scenario 3 without renewables beyond RPS would increase water use by 250 acre feet, about 0.5%.

Out of State

Construction in Areas of Water Risk

As with the analysis for inside California, Table 4.5-7 presents the acre feet of water required for construction of renewable energy outside California under the different portfolios. Sensitivity 1B would require less water outside California in low to medium areas and more water in areas of high risk.

Table 4.5-7. Construction Water Use by Risk Category Out of State for Sensitivity 1B

Water Risk (acre feet)	2030 Current Practice Scenario 1	2030 Sensitivity 1B
Low to Medium	1,039	239
Medium to High	471	471
High	5,998	7,546

Water Consumption during Operations

Table 4.5-8 presents the operational water use for the out-of-state electricity generation in the sensitivity analyses for regionalization in 2030.

Table 4.5-8. Total Water Use for Energy Generation Outside California – Sensitivity Analyses

Water Consumption by Technology (af)	2030 Current Practice Scenario 1	2030 Sensitivity 1B	2030 Scenario 3 w/o Renewables Beyond RPS
Solar PV	989	1,049	1,108
Solar Thermal	634	634	634
Natural Gas Combined Cycle	169,032	168,420	210,437
Natural Gas Steam Turbine	297	353	215
ST Coal	295,450	292,391	297,832
Total (excluding Geothermal)	466,401	462,847	510,226
Geothermal	140,805	140,577	140,599
Change Relative to Current Practice 1 (af)		–3,554	1,442
Change Relative to Current Practice 1 (%)		–0.8%	0.3%

Under the sensitivity analyses in comparison with Current Practice Scenario 1, the following would occur outside California:

- 2030 Sensitivity 1B would reduce water use by 3,554 acre feet, about 1%.
- 2030 Scenario 3 without renewables beyond RPS would increase water use by 1,442 acre feet, about 0.3%.

4.5.4 Air Emissions Impacts of Sensitivity 1B and Sensitivity without Renewables Beyond RPS

Inside California

Tables 4.5-9, 4.5-10, and 4.5-11 present the modeled average daily air emissions rates for NOx, PM2.5, and SO_2, respectively, for the two sensitivity cases considered for 2030.

Table 4.5-9. Modeled Sensitivities NOx Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2030 Current Practice 1 (tons/day)	2030 Sensitivity 1B (tons/day)	2030 Scenario 3 w/o Renewables Beyond RPS (tons/day)
Mojave Desert	0.55	0.55	0.51
North Central Coast	0.47	0.49	0.50
North Coast	0.21	0.22	0.22
Sacramento Valley	1.35	1.40	1.28

Table 4.5-9. Modeled Sensitivities NOx Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2030 Current Practice 1 (tons/day)	2030 Sensitivity 1B (tons/day)	2030 Scenario 3 w/o Renewables Beyond RPS (tons/day)
Salton Sea	0.10	0.09	0.00
San Diego County	0.48	0.51	0.43
San Francisco Bay	2.75	2.84	2.74
San Joaquin Valley	6.44	6.46	6.28
South Central Coast	0.20	0.20	0.19
South Coast	2.67	2.71	2.50
Statewide Total	**15.21**	**15.47**	**14.65**
(% of All CA Sources)	*1.2%*	*1.3%*	*1.2%*
Change Relative to Current Practice 1		**0.25**	**–0.56**
(Relative to Current Practice 1)		*1.7%*	*–3.7%*
Difference from 2020 Current Practice	**–0.03**	**0.23**	**–0.59**
(Relative to 2020)	*–0.2%*	*1.5%*	*–3.9%*

Table 4.5-10. Modeled Sensitivities PM2.5 Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2030 Current Practice 1 (tons/day)	2030 Sensitivity 1B (tons/day)	2030 Scenario 3 w/o Renewables Beyond RPS (tons/day)
Mojave Desert	0.26	0.26	0.25
North Central Coast	0.25	0.26	0.27
North Coast	0.03	0.03	0.03
Sacramento Valley	0.80	0.83	0.79
Salton Sea	0.02	0.02	0.00
San Diego County	0.26	0.27	0.24
San Francisco Bay	1.45	1.48	1.59
San Joaquin Valley	2.28	2.29	2.32
South Central Coast	0.16	0.16	0.16
South Coast	1.31	1.32	1.23
Statewide Total	**6.82**	**6.90**	**6.88**
(% of All CA Sources)	*1.6%*	*1.6%*	*1.6%*
Change Relative to Current Practice 1		**0.08**	**0.06**
(Relative to Current Practice 1)		*1.1%*	*0.9%*
Difference from 2020 Current Practice	**–0.96**	**–0.89**	**–0.90**
(Relative to 2020)	*–12.4%*	*–11.4%*	*–11.6%*

Table 4.5-11. Modeled Sensitivities SO_2 Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2030 Current Practice 1 (tons/day)	2030 Sensitivity 1B (tons/day)	2030 Scenario 3 w/o Renewables Beyond RPS (tons/day)
Mojave Desert	0.03	0.03	0.03
North Central Coast	0.03	0.03	0.03

Table 4.5-11. Modeled Sensitivities SO_2 Emissions Rates, California Natural Gas Fleet by Air Basin

Air Basin	2030 Current Practice 1 (tons/day)	2030 Sensitivity 1B (tons/day)	2030 Scenario 3 w/o Renewables Beyond RPS (tons/day)
North Coast	0.00	0.00	0.00
Sacramento Valley	0.09	0.09	0.08
Salton Sea	0.00	0.00	0.00
San Diego County	0.03	0.03	0.03
San Francisco Bay	0.15	0.16	0.17
San Joaquin Valley	0.24	0.24	0.25
South Central Coast	0.02	0.02	0.02
South Coast	0.14	0.14	0.13
Statewide Total	**0.72**	**0.73**	**0.73**
(% of All CA Sources)	*0.8%*	*0.8%*	*0.8%*
Change Relative to Current Practice 1		**0.01**	**0.01**
(Relative to Current Practice 1)		*1.1%*	*1.0%*
Difference from 2020 Current Practice	**–0.10**	**–0.09**	**–0.10**
(Relative to 2020)	*–12.4%*	*–11.4%*	*–11.6%*

Under the sensitivity analyses in comparison with Current Practice Scenario 1, the following would occur inside California:

- Emissions in California would increase slightly (1% to 2%) in Sensitivity 1B, as operation of California's natural gas fleet would slightly increase.
- 2030 Scenario 3 without renewables beyond RPS similarly results in a slight increase in operation of California's natural gas–fired fleet, but this scenario would avoid some of the excess startup emissions of NOx that would occur under the 2030 Current Practice Scenario 1.

Out of State

For the sensitivity analyses, the modeled emissions and changes in NOx and SO_2 emissions from the WECC fleet, excluding California sources, are shown in Table 4.5-12.

Table 4.5-12. Modeled Sensitivities Out-of-State Emissions Rates from Production Simulation

Criteria Air Pollutant	2030 Current Practice 1 (tons/day)	2030 Sensitivity 1B (tons/day)	2030 Scenario 3 w/o Renewables Beyond RPS (tons/day)
NOx	1,166	1,158	1,170
Change Relative to Current Practice 1		**–8**	**4**
(Relative to Current Practice 1)		*–0.7%*	*0.4%*
SO_2	1,113	1,104	1,126
Change Relative to Current Practice 1		**-9**	**14**
(Relative to Current Practice 1)		*–0.8%*	*1.2%*

Under the sensitivity analyses in comparison with Current Practice Scenario 1, the following would occur outside California:

- Emissions would decrease slightly (0.7% to 0.8%) in Sensitivity 1B, as operation of out-of-state generators would slightly decrease.

- 2030 Scenario 3 without renewables beyond RPS results in an increase in operation of out-of-state generators to replace the energy that would otherwise be provided by the renewable resources facilitated by the regional market, and subsequently, emissions outside California would increase slightly (0.4% to 1.2%).

5. Impacts of Out-of-State Transmission for Regional 3

The 2030 expanded regionalization scenario (Regional 3) includes construction and operation of major out-of-state transmission additions to integrate renewable generation from Wyoming and New Mexico into the regional power system and for California to achieve 50% RPS. This section summarizes the potential adverse environmental impacts that could be caused by transmission additions, depending on siting of the specific projects.

While no specific project is assumed to be developed, several proposals that could be used to import wind are currently in different stages of the permitting process, as summarized in Section 2 (Scenarios), in Table 2-8. Because it is assumed that transmission expansion would be necessary for California to achieve 50% RPS in the Regional 3 scenario, the environmental study anticipates that construction must be completed by 2030. The additional transmission identified here would built to support interconnecting renewables on to the high-voltage transmission system, but renewable resources for California would use only a portion of the added transmission capacity.

The analysis considers the following transmission line proposals (also listed in Table 2-8), that are pending review or under review by siting authorities:

- **Gateway West (Segment D)** for access to Wyoming wind at Hemingway in Idaho (PacifiCorp)
- **Gateway South (Segment F)** for access to Wyoming wind at Mona or Clover in Utah (PacifiCorp)
- **TransWest Express** for access to Wyoming wind at southern Nevada (TransWest Express LLC, subsidiary of the Anschutz Corporation and Western Area Power Administration)
- **Zephyr Power Transmission Project** for access to Wyoming wind at southern Nevada (Duke-American Transmission Company)
- **SunZia Southwest Transmission Project** for access to New Mexico wind from SunZia East to Pinal Central in Arizona (SunZia)
- **Western Spirit Clean Line** for access to New Mexico wind at northern Arizona (Clean Line Energy Partners)

5.1 Land Use and Biological Resources Considerations in Siting Major Transmission

The following land use and biological resources constraints have been generally identified as potential transmission routing constraints affecting access to Wyoming and New Mexico wind resources:

- National Forests
- Tribal Lands
- National Parks
- Historic Trails
- National Monuments
- National Wildlife Refuges
- Wilderness Areas and Wilderness Study Areas
- Areas of Critical Environmental Concern
- National Conservation Areas
- National Historic Landmarks and Sites
- Sage Grouse Habitat
- Desert Tortoise Habitat
- Department of Defense Areas
- Department of Energy Areas
- Inventoried Roadless Areas
- Wild and Scenic Rivers
- State-managed Lands
- Wetlands, Rivers, and Lakes
- Vegetation Cover
- Private Lands

The following discussion highlights some of the specific issues of environmental concern for construction of new transmission in each region.

Transmission for Wyoming Wind Resources by 2030

Four proposals could provide access to Wyoming wind resources: Gateway West (Segment D) Gateway South (Segment F), TransWest Express, and the Zephyr Power Transmission Project. Because these potential projects cross similar lands and have similar environmental constraints, the following discussion applies to all four.

- **Lands with Special Status**. The transmission lines would be routed to avoid or minimize impacts to sensitive areas and lands with special status, some of which may prohibit new transmission lines. Impacts from construction and operation to lands with special designations depend on the location of the crossing as well as the relevant and important values for which land was or is being proposed to be designated. Examples of areas with special management designations along these routes include:
  - BLM Areas of Critical Environmental Concern
  - BLM Wilderness & Wilderness Study Areas
  - United States Forest Service (USFS) Inventoried Roadless Areas & Unroaded/Undeveloped Areas
  - Conservation Easements
  - National Conservation Areas
  - National Monuments & Landmarks
  - National Wildlife Refuges
  - National Scenic & Historic Trails, and
  - State & federal parks
- **Visual Resources**. The transmission lines could modify viewsheds and alter landscape characteristics in areas, such as Flat Top Mountain, Wasatch Plateau, Reservation Ridge, Cherokee Historic Trail, Wyoming Highway 789 (a county-designated scenic drive), Dinosaur National Monument from the east entrance, Energy Loop Scenic Byway, and the Green River.
- **BLM and USFS Visual and Land Use Conformity**. Conformance with land use plans and BLM Visual Resource Management (VRM) Class Objectives, or consistency with USFS Visual Quality Objectives or Scenic Integrity Objectives could require amendments to several land use plans.
- **Sensitive Land Uses**. There are constraints and public concern in areas where the transmission lines would cross existing agricultural operations, grazing allotments, existing and authorized residential land uses, recreation facilities, and the Ioka cemetery.
- **Special Use Airspace Designations.** Routing is constrained by airspace/structure height restrictions around National Guard Orchard Training Area.
- **Wild Horses**. Transmission lines would cross nine herd management areas/herd areas and certain alignments could cause a potential hazard to BLM helicopters used during wild horse roundups.
- **Landslides and Ground Subsidence**. There are engineering constraints and a high risk of landslides in in areas of mountainous terrain. Electrical transmission lines have been impacted by ground stability hazards on the Wasatch Plateau.
- **Paleontological and Mineral Resources**. There are large number of geological formations known to produce fossils, as well as major mineral resources in the area that could be impacted by construction of the transmission lines.
- **Cumulative Impacts.** Numerous transmission lines are being proposed within already crowded transmission corridors.

Transmission for New Mexico Wind Resources by 2030

Two proposals could provide access to New Mexico wind resources: SunZia Southwest Transmission Project and the Western Spirit Clean Line project. The major issues facing these lines are the following:

- **Lands with Special Status**. The transmission lines would be routed to avoid or minimize impacts to sensitive areas and lands with special management status. Examples in the project area include:
  - Sevilleta and Bosque del Apache National Wildlife Refuges
  - Peloncillo Mountains and Rincon Mountains Wilderness Areas
  - BLM Hot Well Dunes Recreation Area
  - Stallion, Veranito, Presilla and Peloncillo Mountains Wilderness Study Areas
  - Johnson (Gordy's) Hill Special Recreation Management Area
  - Arizona National Scenic Trail and Buehman Canyon Trail
  - Rio Grande River crossing
- **Special Use Airspace Designations**. Transmission line routing is constrained by airspace/structure height restrictions around White Sands Missile Range.
- **Visual Resources**. The transmission lines could modify viewsheds and alter landscape characteristics to viewers on the lands listed above with special management designations and to travelers along several scenic byways in the area.
- **BLM Visual and Land Use Plan Conformity**. Conformance with land use plans and BLM VRM Class Objectives, would require amendments to the Socorro and Mimbres Resource Management Plans.
- **Sensitive Land Uses**. The areas are mostly rural, but there are constraints and public concern where the transmission lines would cross existing and authorized residential land uses, as well as where they would be located nearby to recreational facilities, such as the lands listed above with special status.
- **Other Federal Agencies**. Coordination and separate NEPA decisions by the Bureau of Indian Affairs and Bureau of Reclamation would be required to grant right-of-way crossings of canals or other facilities, such as the San Carlos Irrigation Project canal system and Reclamation lands along the Rio Grande and along the Central Arizona Project canal.

Transmission safety requirements may eliminate direct land use conflicts, because occupied land uses and high-voltage transmission lines cannot be co-located and safety requirements ensure adequate separation. Most existing agriculture can continue in and around transmission line rights of way, as the only disturbed area is individual tower footprints and, where needed, access roads. The visibility of transmission lines from protected uses is a potential issue, and this can sometimes be resolved by rerouting the lines around sensitive areas, using appropriate non-reflective materials, and micro-siting individual towers to reduce opportunities for skylining. Transmission lines also may need to be routed so as to avoid areas where they could pose an aviation hazard, such as around airports or military installations.

5.2 Cultural and Tribal Considerations in Siting Major Transmission

The following cultural and tribal resources impacts were identified for the transmission projects proposed to access Wyoming and New Mexico wind resources.

Transmission for Wyoming Wind Resources by 2030

- **National Scenic and Historic Trails**. The transmission line could cause significant adverse effects on historic properties for which visual setting is important, such as National Scenic and Historic Trails, including the Oregon, California, Mormon Pioneer, Pony Express, and Old Spanish National Historic Trails, as well as the Continental Divide National Scenic Trail.

- **Traditional Cultural Properties (TCPs)**. The transmission line would affect Native American TCPs and respected places, such as the Gypsum Cave TCP, which is held as sacred to the Nuwu (Paiute) people.
- **Tribal Land**. The transmission line would cross the Ute Indian Tribe of the Uintah and Ouray Reservation and would require Tribal approval.

Transmission for New Mexico Wind Resources by 2030

- **Cultural Landscape**. The transmission line would result in visual and cultural resource impacts to the Gran Quivira unit of the Salinas Pueblo Missions National Monument.
- **Archaeological Resources**. The transmission line could potentially impact seven known habitation sites and the McClellan Wash Archaeological District.
- **National Historic Trails**. The transmission line would cross the El Camino Real, Butterfield, Gila, Janos Copper, Zuñiga, Southern Pacific Mail, and General Cooke's Wagon Road/Mormon Battalion National Historic Trails.

5.3 Water Resources Consideration in Siting Major Transmission

All surface-disturbing activities have the potential to cause erosion that could result in adverse impacts to water resources. In addition, the following water-related impacts were identified for the major transmission projects proposed to access Wyoming and New Mexico wind resources.

Transmission for Wyoming Wind Resources by 2030

- **Floodplains**. There would likely be some locations where structures would be placed in floodplains, such as within the Bear River floodplain, which could negatively impact wetlands and riparian habitat and structures could be damaged by flooding.
- **Water Supply**. Any new water withdrawals in the watersheds of the Platte River, Utah Lake/Provo River, and Colorado River would require either participation in the recovery programs for those rivers (provided for in programmatic biological opinions for each) or a separate consultation with the USFWS.

Transmission for New Mexico Wind Resources by 2030

- **Floodplains**. There would likely be some locations where structures would be placed in floodplains, such as within the Rio Grande floodplain, which could negatively impact wetlands and riparian habitat and structures could be damaged by flooding.

6. Environmental Study Results

In 2020, we assume no incremental buildout of renewable resources or transmission beyond what is already planned to meet the state's 33% RPS by 2020. With limited regionalization in 2020, we also assume no incremental renewable energy development and no associated ground disturbance. Therefore, there would be no effects to land use or biological resources from the implementation of the limited regional market. However, there would be changes associated with how the wholesale electric system might respond to the limited regional market in 2020 (CAISO + PAC), in terms of changes to the operations of existing resources. These operational changes would have effects on water use and air emissions.

The 2020 results for water use and emissions are summarized as follows:

- By achieving a small decrease in fossil fuel use for electricity production in California, limited regionalization in 2020 results in a small but beneficial decrease in the electric power sector's use of water resources (water used by electricity generation decreases by 1.5% statewide).
- Limited regionalization in 2020 reduces air pollutant emissions from natural gas-fired electricity generation in California on average (decrease 0.5% to 1.2% statewide, depending on pollutant), depending on the dispatch of the fleet of natural gas–fired power plants. Certain air basins would experience slight increases in PM2.5 and SO_2 emissions (increase 0.4% in San Joaquin Valley and South Coast air basins and increase 0.7% in Mojave Desert air basin), but the San Joaquin Valley and South Coast air basins would experience greater benefits through decreases in NOx, which is a precursor to both ozone and PM2.5.

By 2030, a significant incremental renewable generation buildout would be required to satisfy California's 50% RPS under any scenario. This buildout would require developing land, which is associated with ground disturbance and environmental effects. Changes associated with how the wholesale electric system might respond to regionalization would also be a part of the 2030 scenarios. The potential changes in land use and potential impacts to biological resources depend on the geographic distribution of the portfolios modeled in the 2030 scenarios. With regionalization, we find that land use and the acreage required decreases in California by 42,600 acres in the Regional 2 scenario and by 73,100 acres in the Regional 3 scenario. Outside of California, land use decreases by 31,900 acres in Regional 2, and increases by at least 69,300 acres in Regional 3, largely due to assumed wind resource development. While the development footprint associated with wind resources is larger, the actual ground disturbance would be much smaller; wind resources normally require only a portion of the acreage to be disturbed by the access roads and foundations for wind turbines while the remainder of the site may remain undisturbed and available for other uses. Under Scenario 3, additional land and acreage would be devoted to out-of-state transmission right-of-way to integrate the high-quality out-of-state renewable generation into the regional power system. Results for Regional 2 versus Regional 3 illustrate an inherent tradeoff of building renewables for RPS in state versus out of state.

The 2030 results for water use and emissions are summarized as follows:

- Scenarios Regional 2 and Regional 3 decrease the amount of water used by power plants statewide, when compared with Current Practice Scenario 1. By decreasing fossil fuel use for electricity production in California, regionalization results in a beneficial decrease in the electric power sector's use of California water resources (decrease by 4.0% to 9.7% statewide).
- Scenarios Regional 2 and Regional 3 decrease the emissions of NOx, PM2.5, and SO_2 from power plants statewide and also decrease these emissions in several air basins with nonattainment designations, because of the changed dispatch of the fleet of natural gas-fired power plants. In particular, the San

Joaquin Valley, South Coast, Mojave Desert, and Salton Sea air basins experience decreased emissions of all pollutants when compared with Current Practice Scenario 1. Modeling for 2030 shows very small increases in PM2.5 and SO_2 emissions in certain other locations, namely the San Francisco Bay and North Central Coast air basins, although these other locations would experience greater benefits through decreases in NOx. Statewide, combustion-fired electric generation comprises a small portion or roughly 1% to 2% of California's average daily inventories of NOx and PM2.5; this means that the transformation into regional wholesale electricity market is likely to have a negligible impact on California's overall criteria air pollutant inventories.

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Appendices

Appendix 1. Study Areas for In-State Renewable Resources

Appendix 2. Study Areas for Out-of-State Renewable Resources

Appendix 1: California Renewable Study Areas

RESOLVE Portfolios of Inside-California Resources

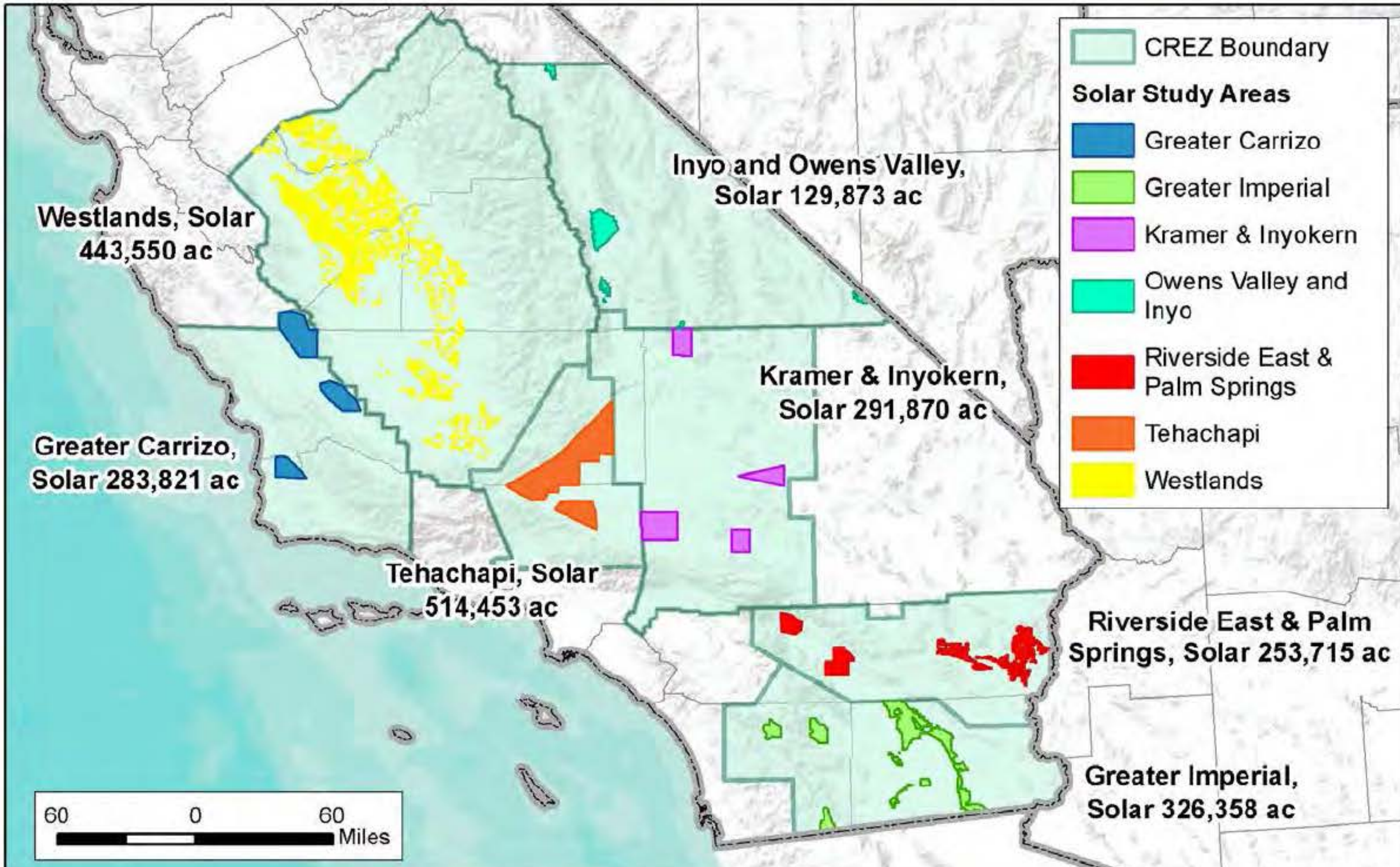
- This presents various "study areas" in Aggregated CREZs as proxy locations
- Need to focus environmental study on meaningful locations
- Need to cover the following potential resource regions in California:

– Greater Carrizo	Solar and Wind
– Central Valley North, Los Banos	Wind
– Greater Imperial	Solar, Wind and Geothermal
– Kramer, Inyokern	Solar
– Owens Valley, Inyo	Solar
– Riverside East, Palm Springs	Solar and Wind
– Solano	Wind
– Tehachapi	Solar and Wind
– Westlands	Solar

General Methodology - Solar

- Use RPS Calculator solar potential that avoids RETI Category 1 lands
- Review renewable resource and siting considerations
- Review local / state / federal renewable planning documents and processes
- Review existing and planned renewable projects to help determine viability
- Draft polygons of sufficient size / shape as proxy locations to facilitate study of portfolios
- Tailor polygons to eliminate clear "no go" areas within the boundaries (Protected Areas Data: National Parks, National Forest, BLM wilderness and ACECS, State Parks, and military)

Solar Overview



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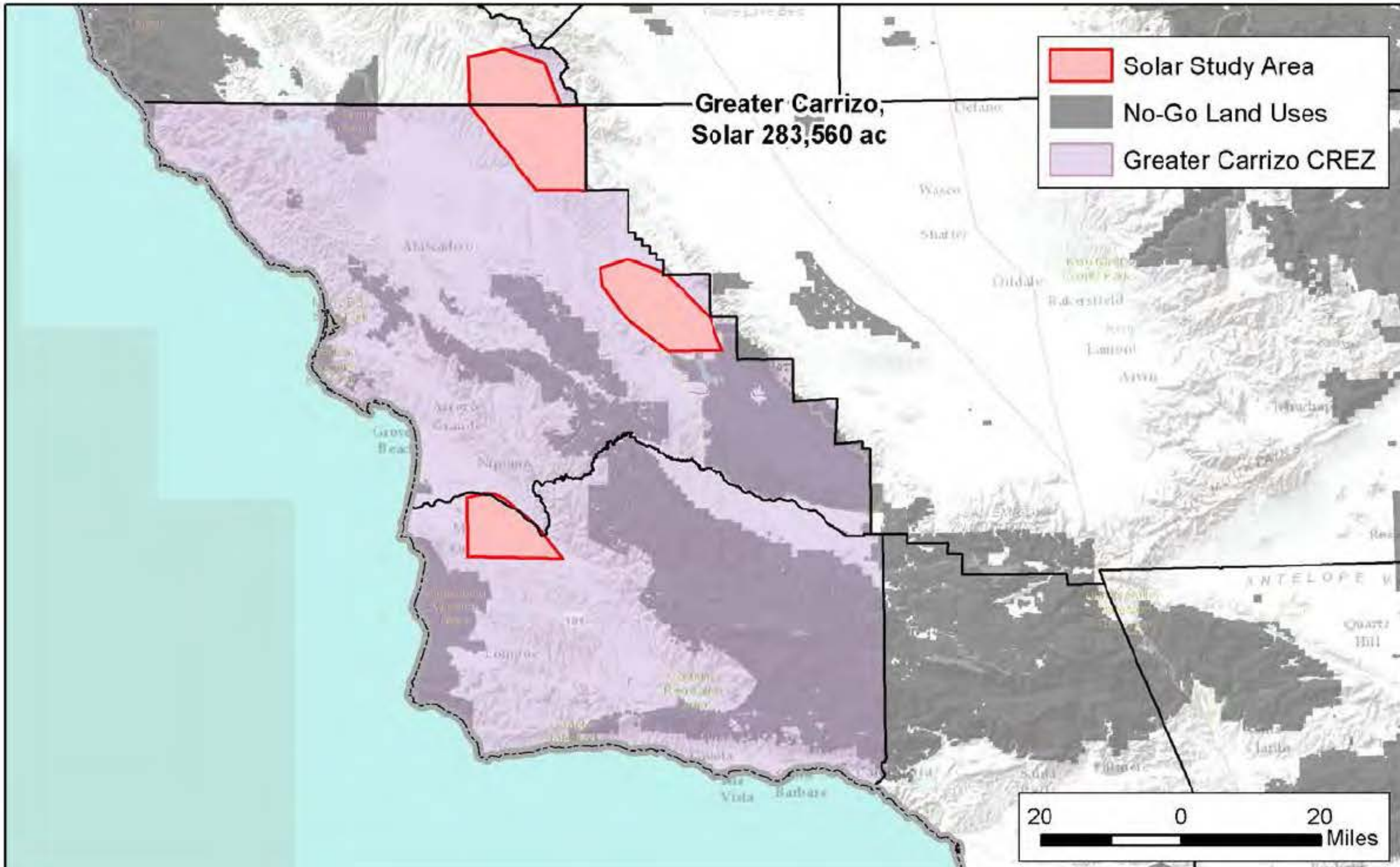
Greater Carrizo Solar, Overview

- Solar resource: throughout most of the CREZ
- Slope consideration: lots of rolling hills with some large valleys in eastern part of CREZ
- Existing successful large development: mainly in Carrizo Plains and California Flats
- Tailored three polygons of representative areas
  - California Flats: San Luis Obispo and Monterey counties
  - Carrizo Plain: San Luis Obispo County
  - Santa Maria: northern Santa Barbara County

Greater Carrizo Solar



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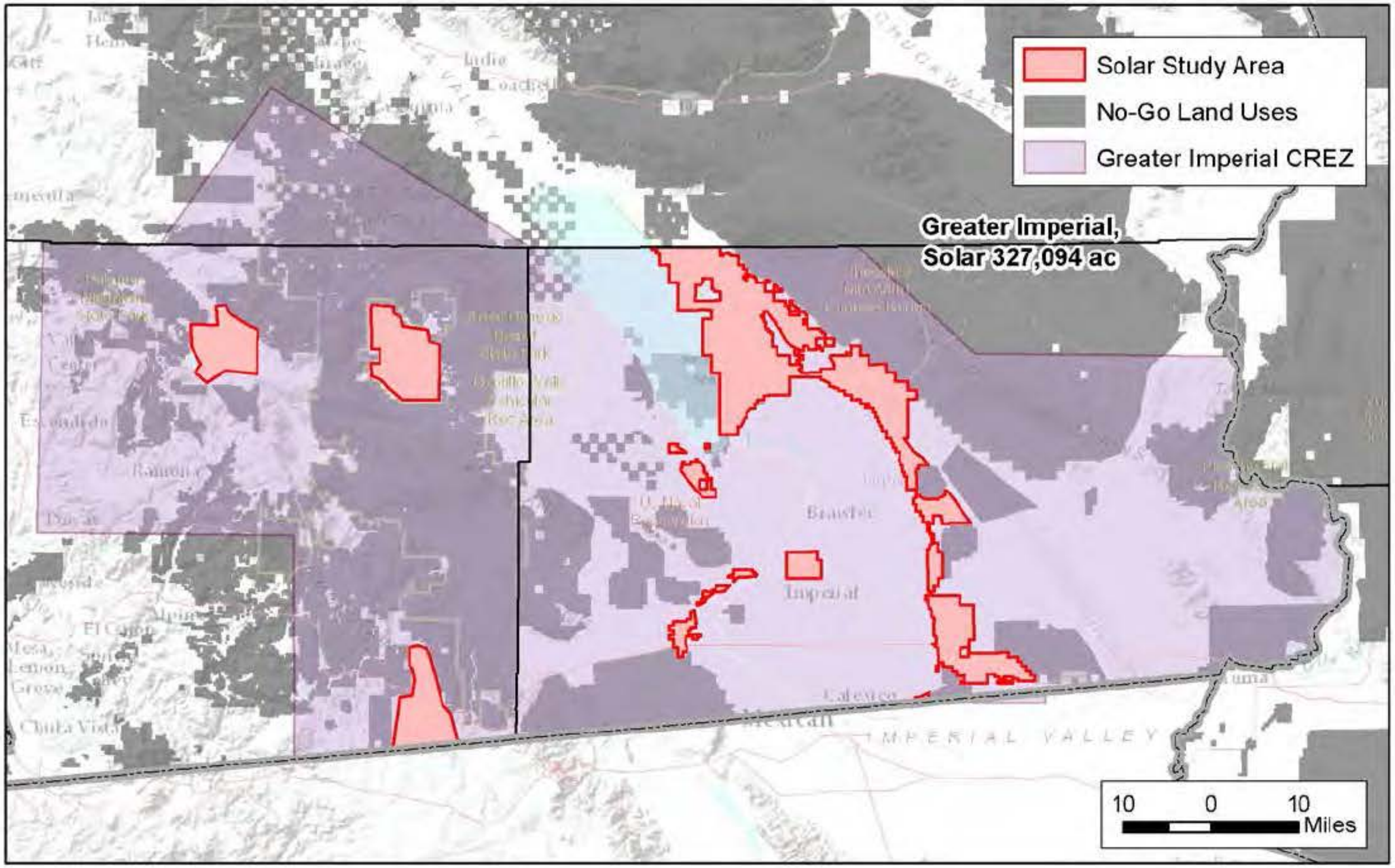
Greater Imperial Solar, Overview

- Solar resource: throughout all of the CREZ
- Slope consideration: lots of rocky hills in the western part of the CREZ
- Existing successful large development: mainly in Imperial Valley and Borrego Valley
- Used existing planning from DRECP and Imperial County General Plan
- Tailored four representative areas
  - Imperial Valley: DRECP DFAs and General Plan Energy Overlay
  - San Diego County: Boulevard, Borrego Springs, and Warner Springs

Greater Imperial Solar



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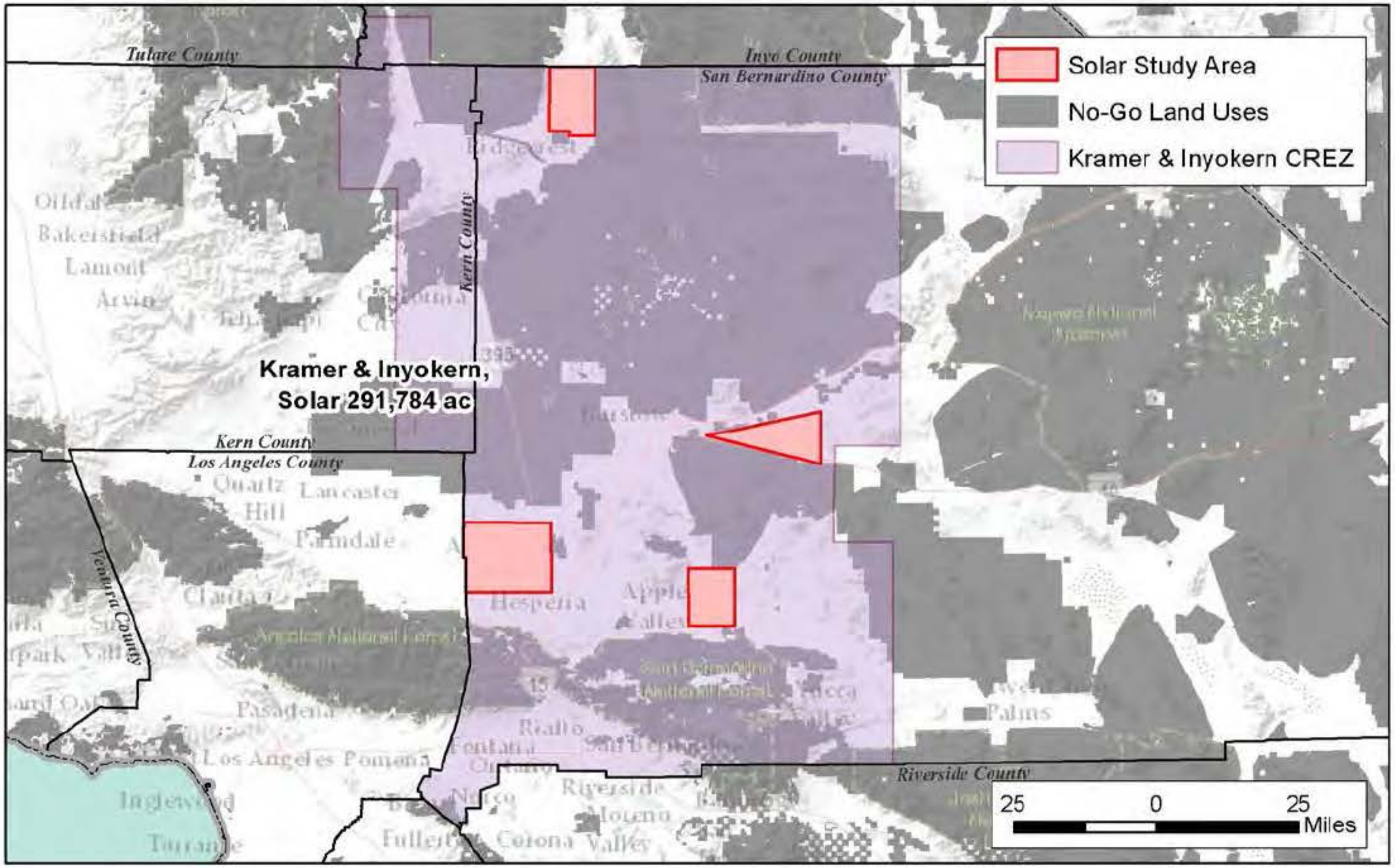
Kramer & Inyokern Solar, Overview

- Solar resource: covers entire CREZ
- Slope consideration: primarily flat valleys with some mountains
- Much of the CREZ is encumbered with land designations that prohibit solar (such as wilderness or ACECs / NLCS under the DRECP)
- Tailored four polygons covering a variety of representative areas
  - Searles Valley: DRECP Development Focus Area on BLM land
  - Barstow: private agriculture land
  - Lucerne Valley and Adelanto: rural residential / private undeveloped land

Kramer & Inyokern Solar



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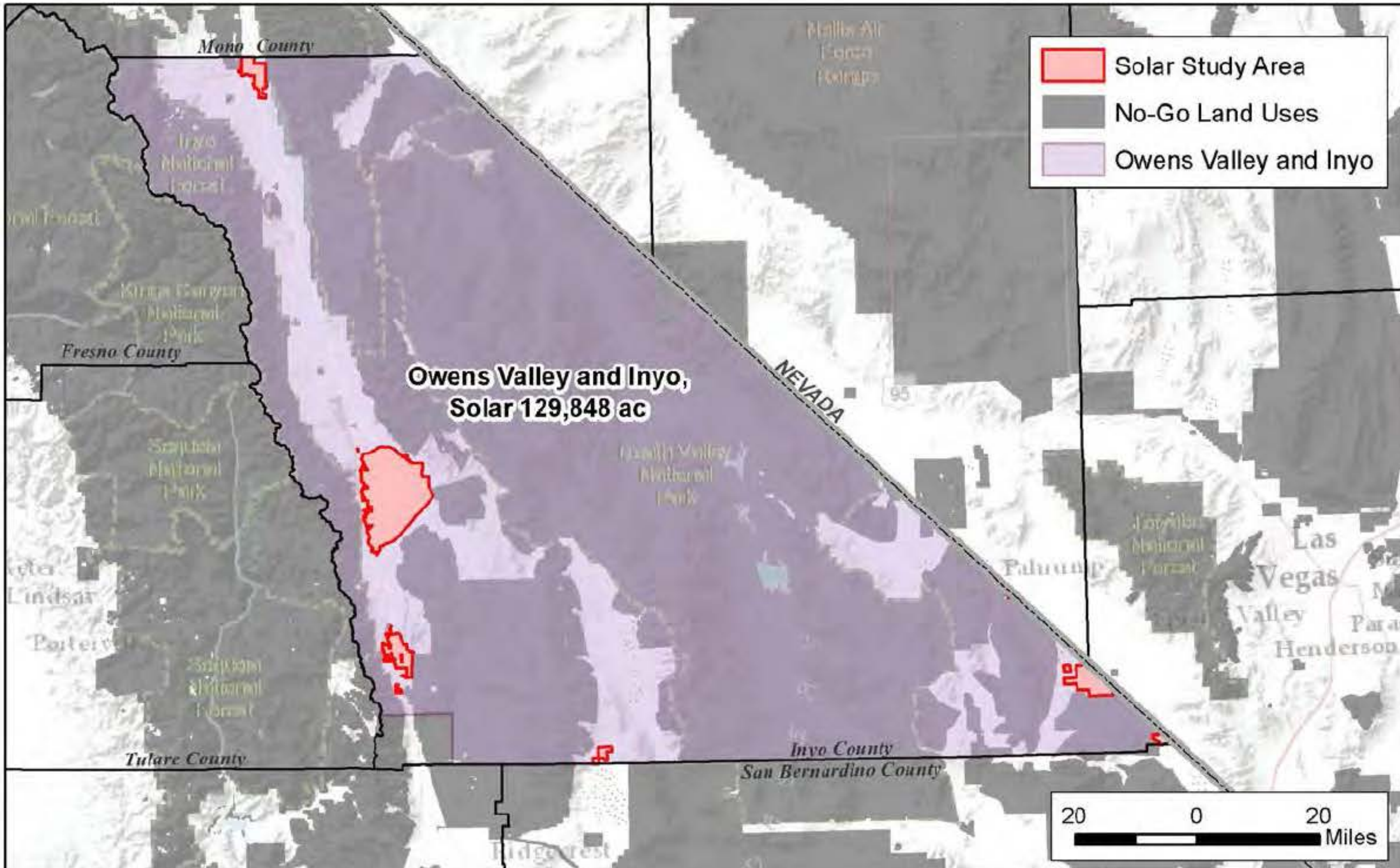
Owens Valley & Inyo Solar, Overview

- Solar resource: throughout all of the CREZ
- Slope consideration: majority of the CREZ is mountainous with a valley running through the western side and other smaller valleys
- No existing large development but some projects proposed in valleys
- Used existing planning from DRECP and Inyo County General Plan
- Tailored six representative areas
  - Owens Valley: DRECP DFAs and General Plan Solar Energy Development Areas
  - Eastern border: Solar Energy Development Areas near Nevada

Owens Valley & Inyo Solar



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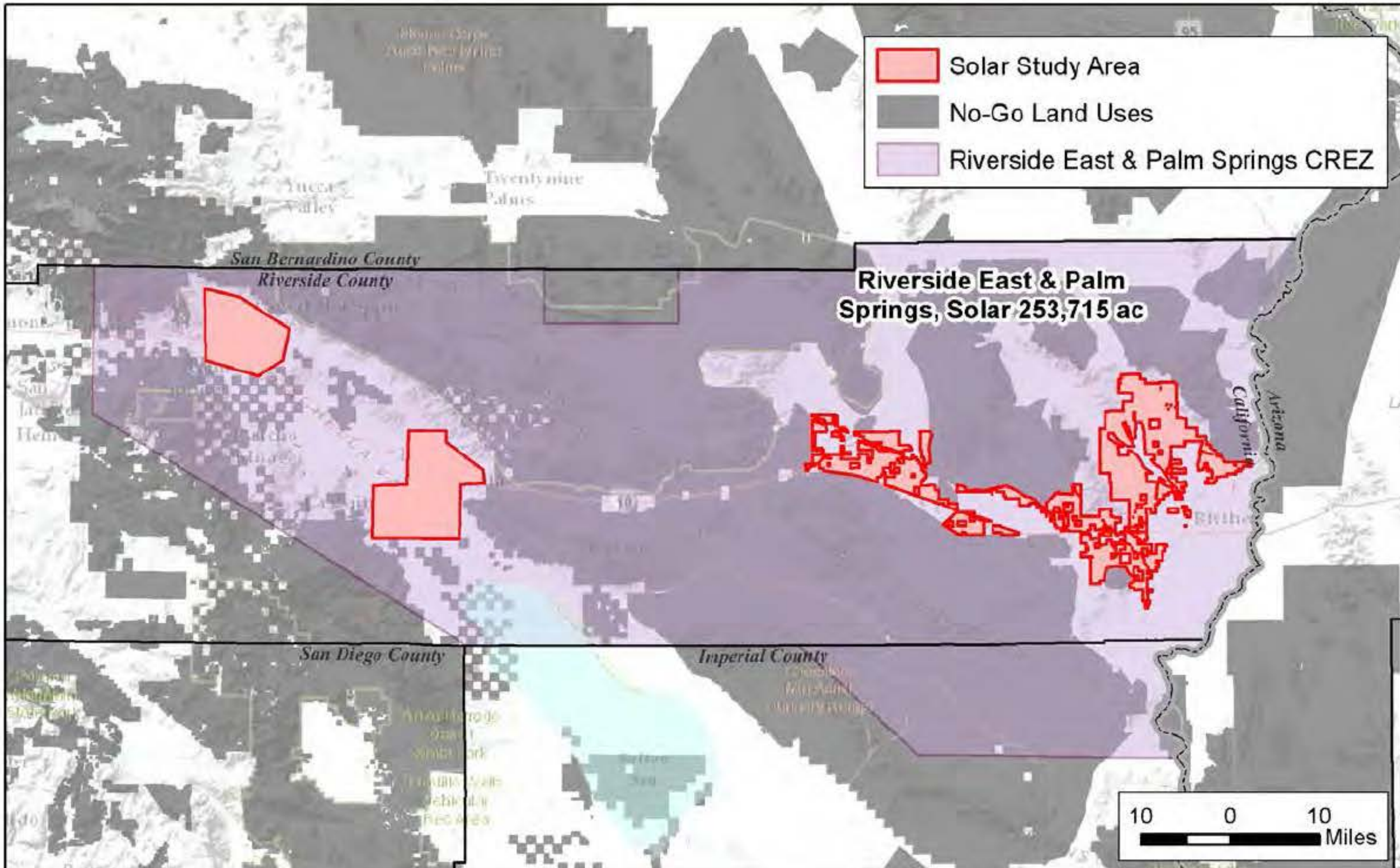
Riverside East & Palm Springs Solar, Overview

- Solar resource: abundant, most of the CREZ
- Slope consideration: many valleys surrounded by mountains
- Tailored three polygons to allow for flexibility for development (size and land use)
  - Eastern Riverside: used DRECP development focus area plus private land in Desert Center
  - Indio: private, agriculture land
  - Palm Springs region: private, undeveloped or existing infrastructure land

Riverside East & Palm Springs Solar



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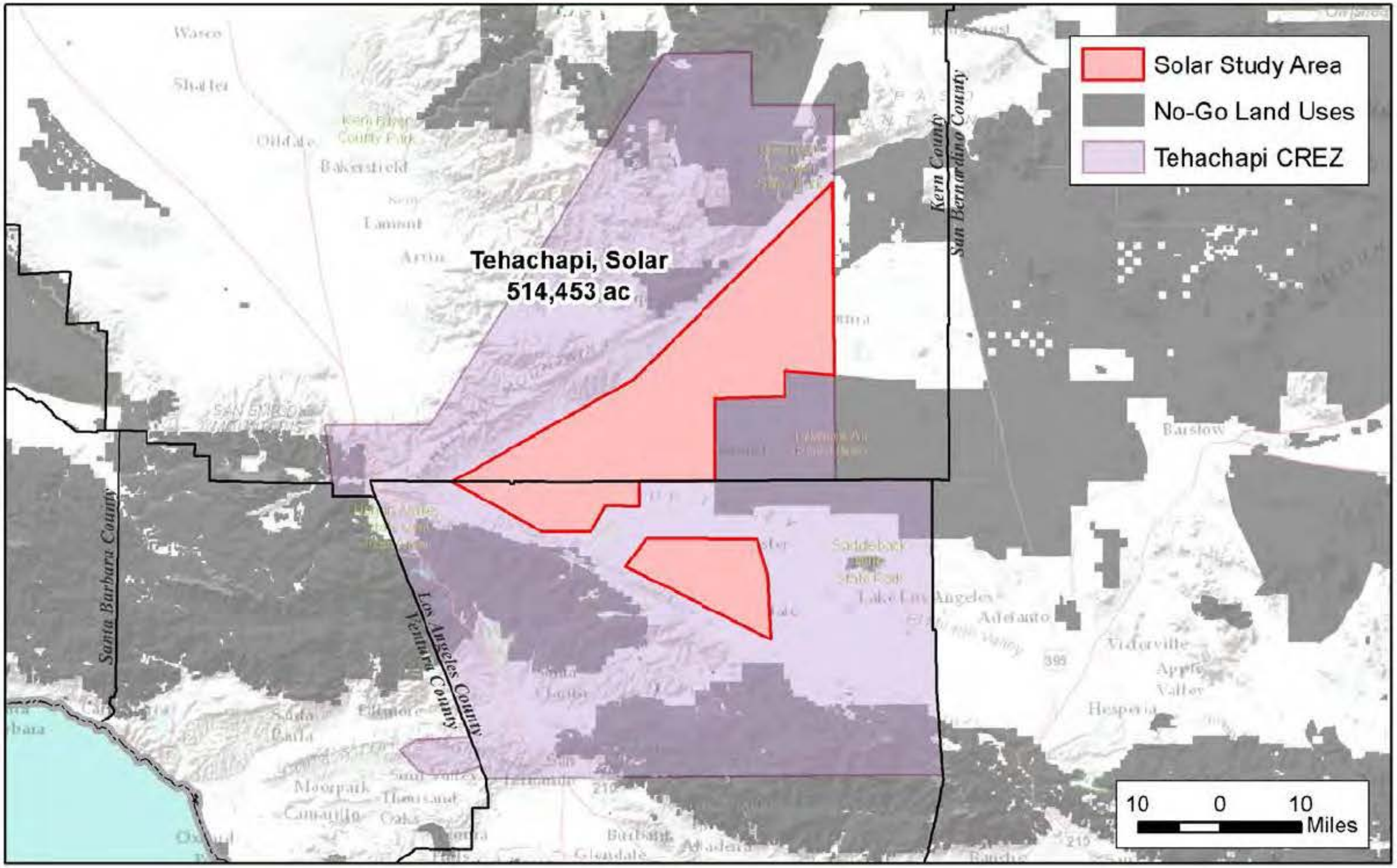
Tehachapi Solar, Overview

- Solar resource: covers entire CREZ
- Slope consideration: western part of CREZ has steep slopes
- Considered the Draft DRECP DFAs in Kern and Los Angeles County
- Incorporated the Los Angeles County Renewable Energy Ordinance exclusion areas
- Tailored three polygons with flexibility in terms of size and land use
  - Kern County: used DRECP draft development focus area / RPS solar layer
  - Los Angeles County (two polygons): private land, some agriculture

Tehachapi Solar



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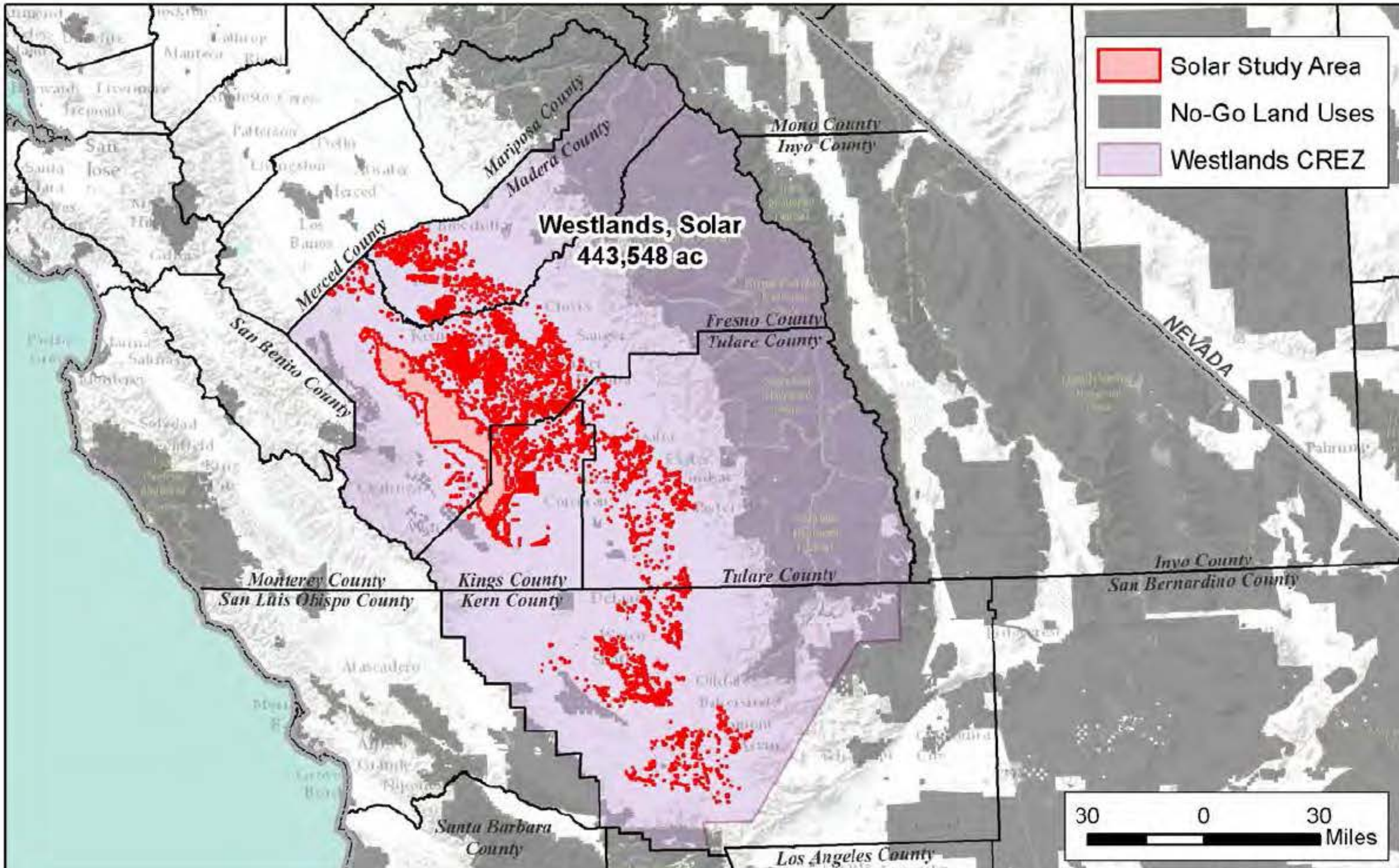
Westlands Solar, Overview

- Solar resource: covers the majority of the CREZ
- Slope consideration: valley is flat but surrounded by rolling hills on the eastern and western boundaries of the CREZ
- Use the San Joaquin Valley collaborative effort, including 3 categories from the "least-conflict lands":
  - Priority least conflict
  - Least conflict
  - Potential least conflict

Westlands Solar



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General Methodology – Wind and Geothermal

- Use RPS Calculator wind potential polygons
- Review local / state / federal renewable planning documents and processes and eliminated areas where wind is likely to be prohibited
  - Tehachapi CREZ: Los Angeles County prohibited wind within the county as part of the Renewable Energy Ordinance
  - Riverside East, Palm Springs and Greater Imperial CREZs: DRECP prohibits wind within ACEC and NLCS designations
  - All other CREZs use RPS Calculator polygons with no tailoring
- Review local and federal planning documents and included areas open to geothermal
  - Included DRECP DFAs
  - Included Imperial County renewable zoning ordinance overlay

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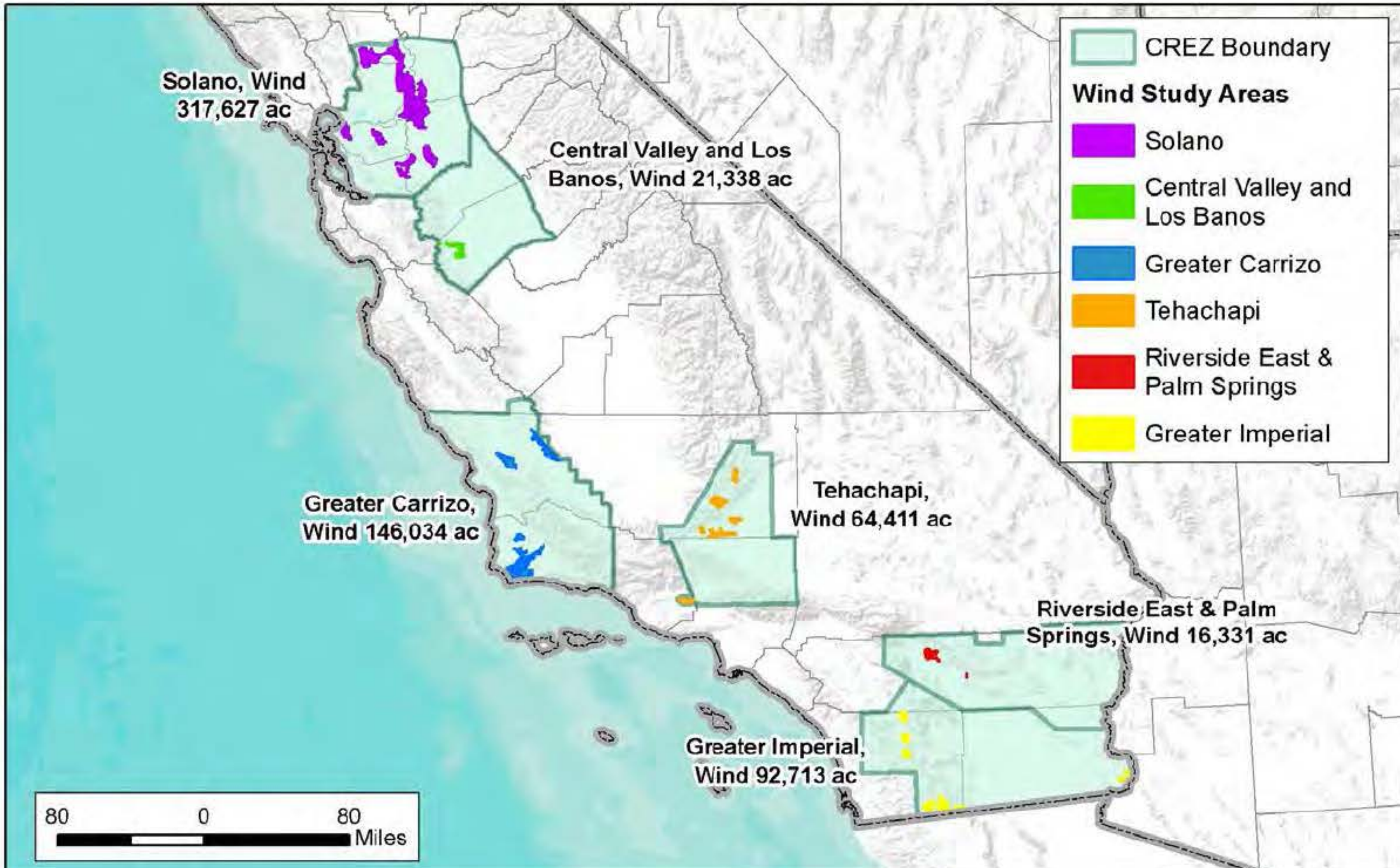
Wind Overview



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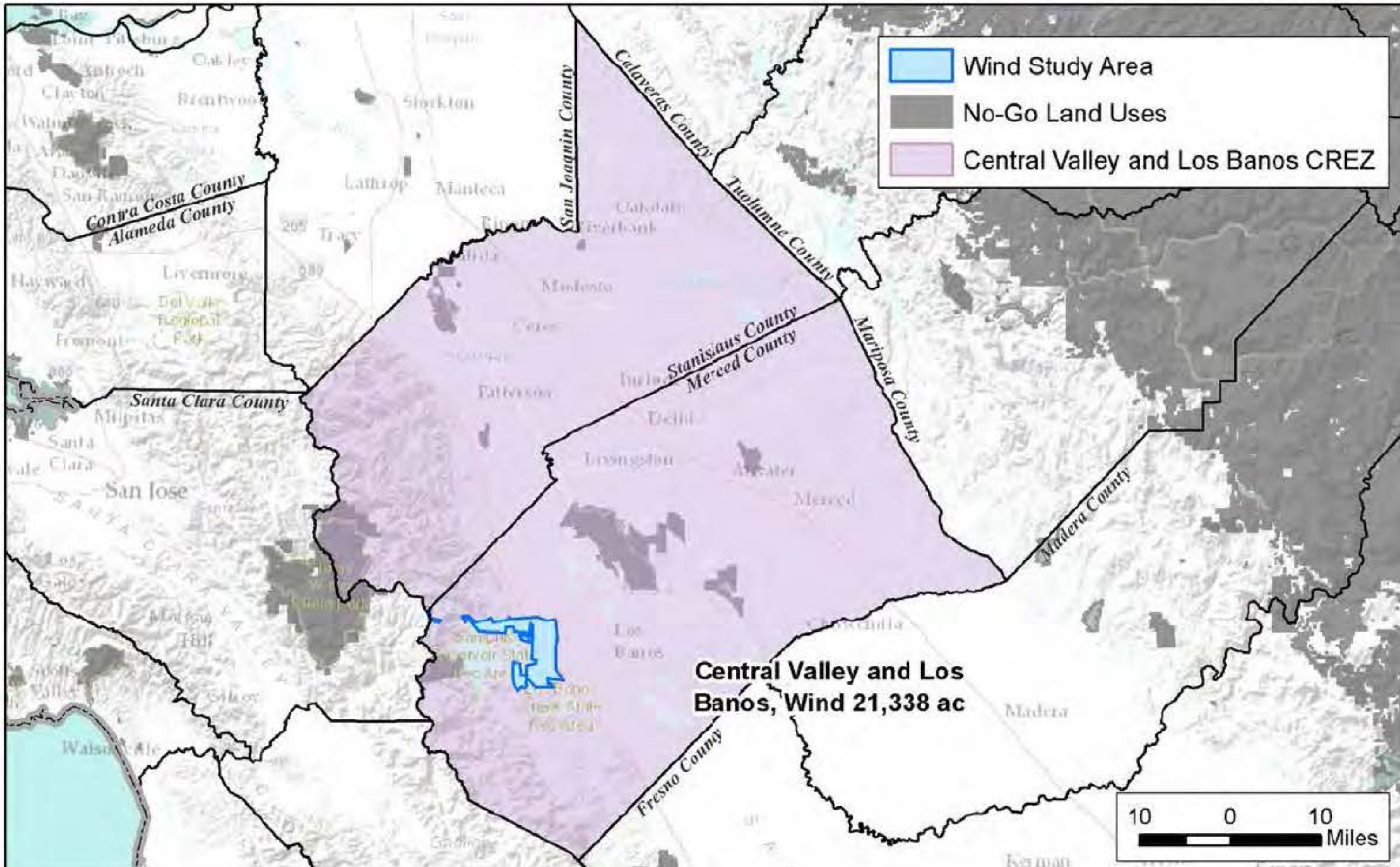
Central Valley North & Los Banos Wind



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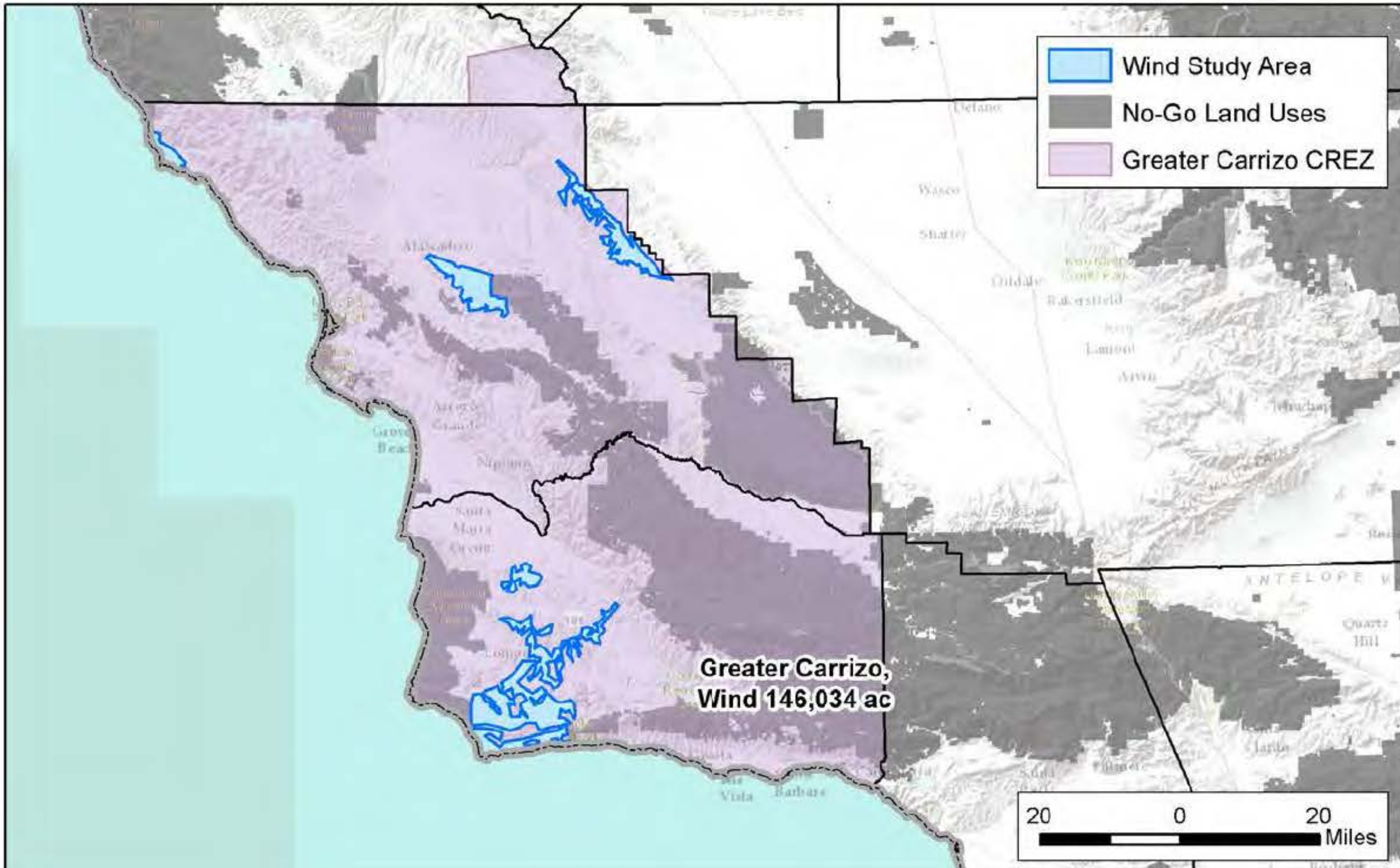
Greater Carrizo Wind



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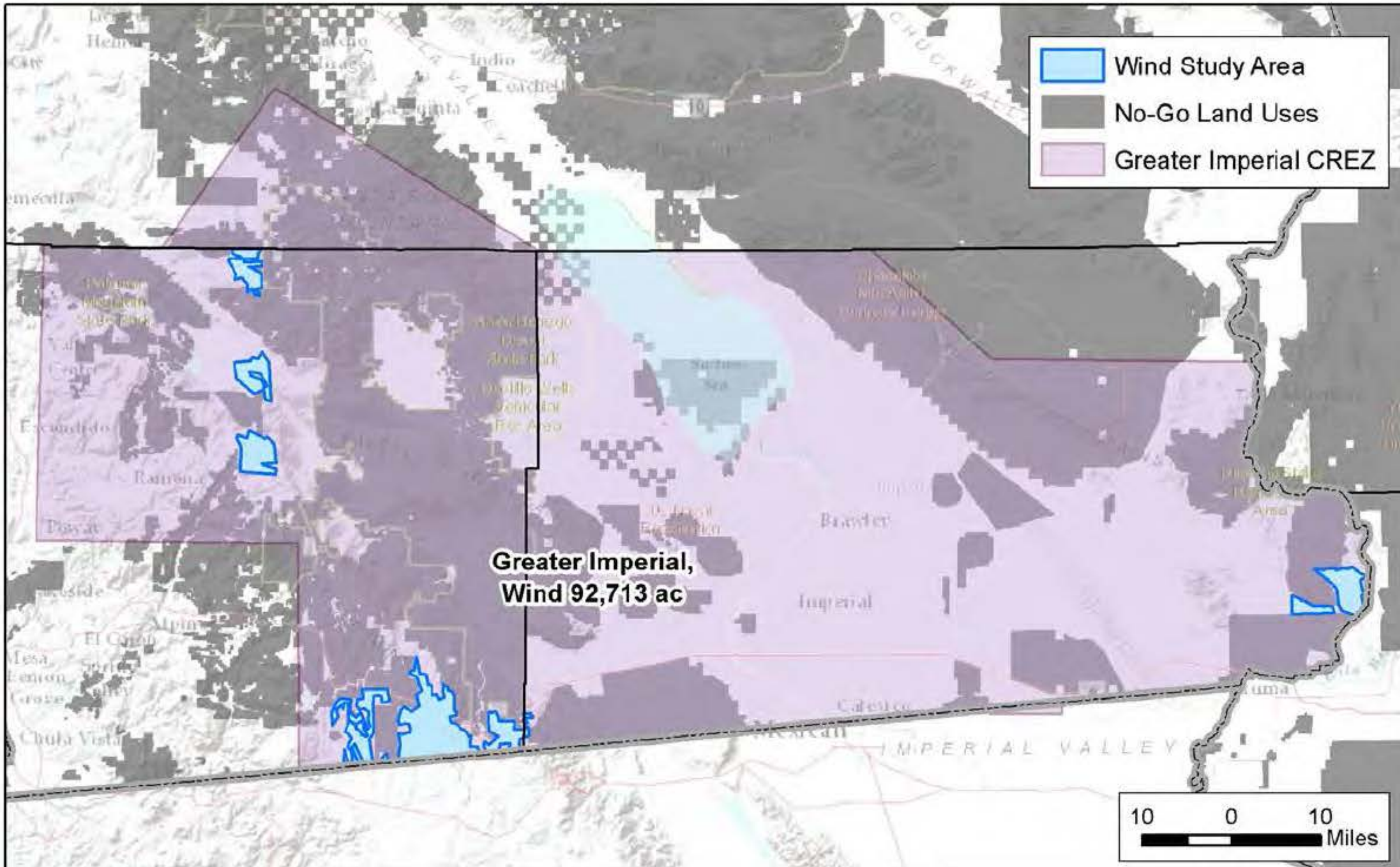
Greater Imperial Wind



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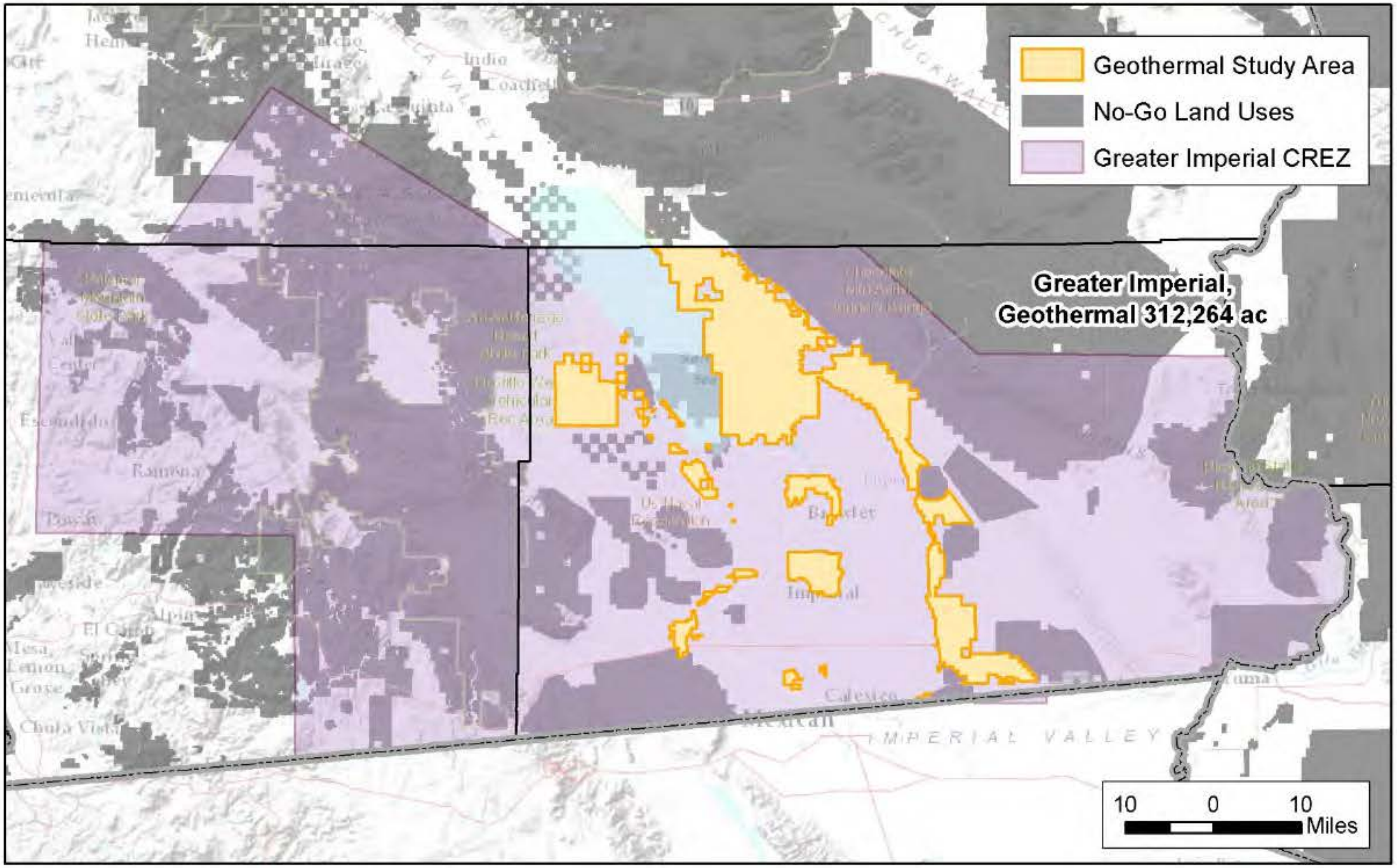
Greater Imperial Geothermal



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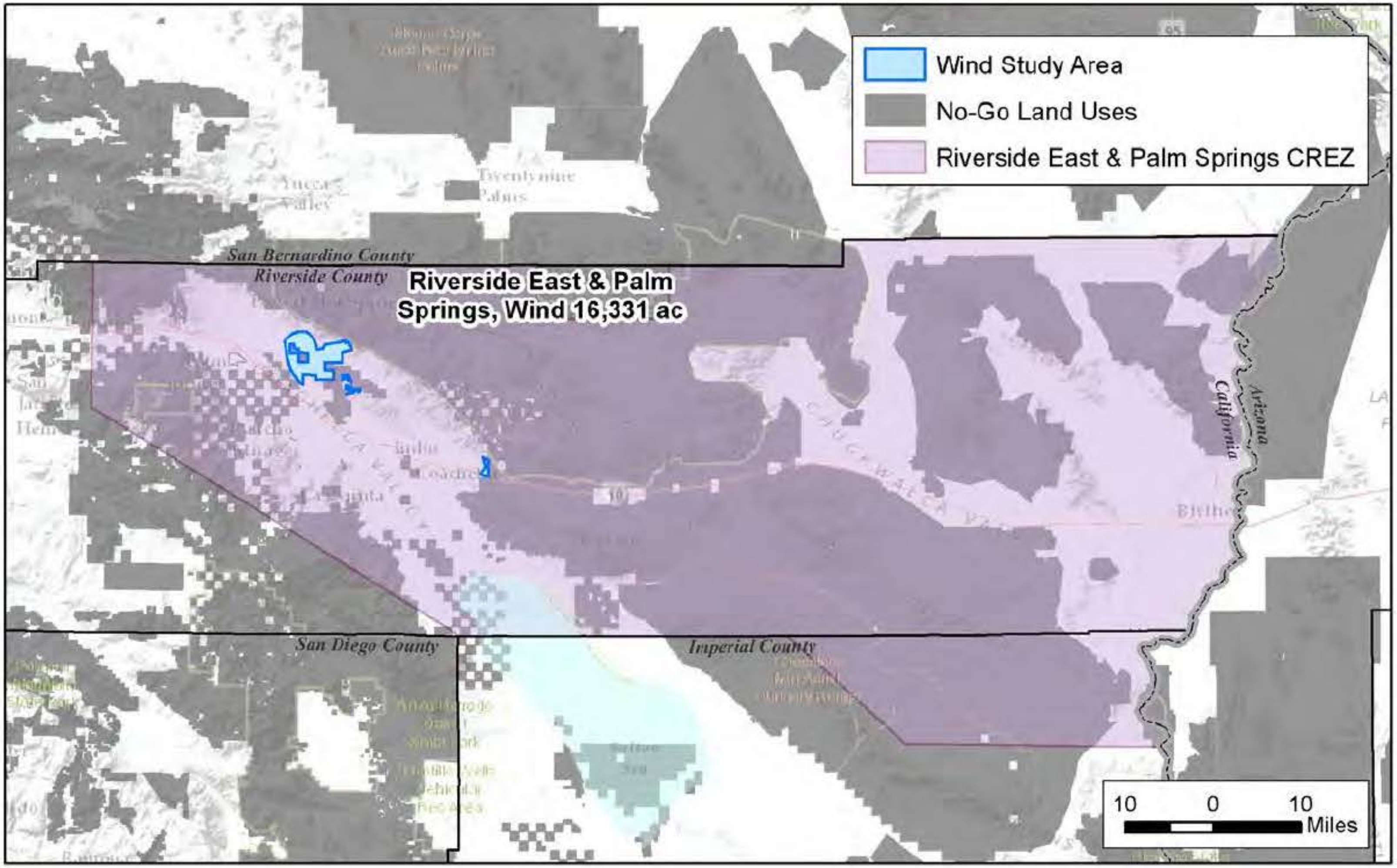
Riverside East & Palm Springs Wind



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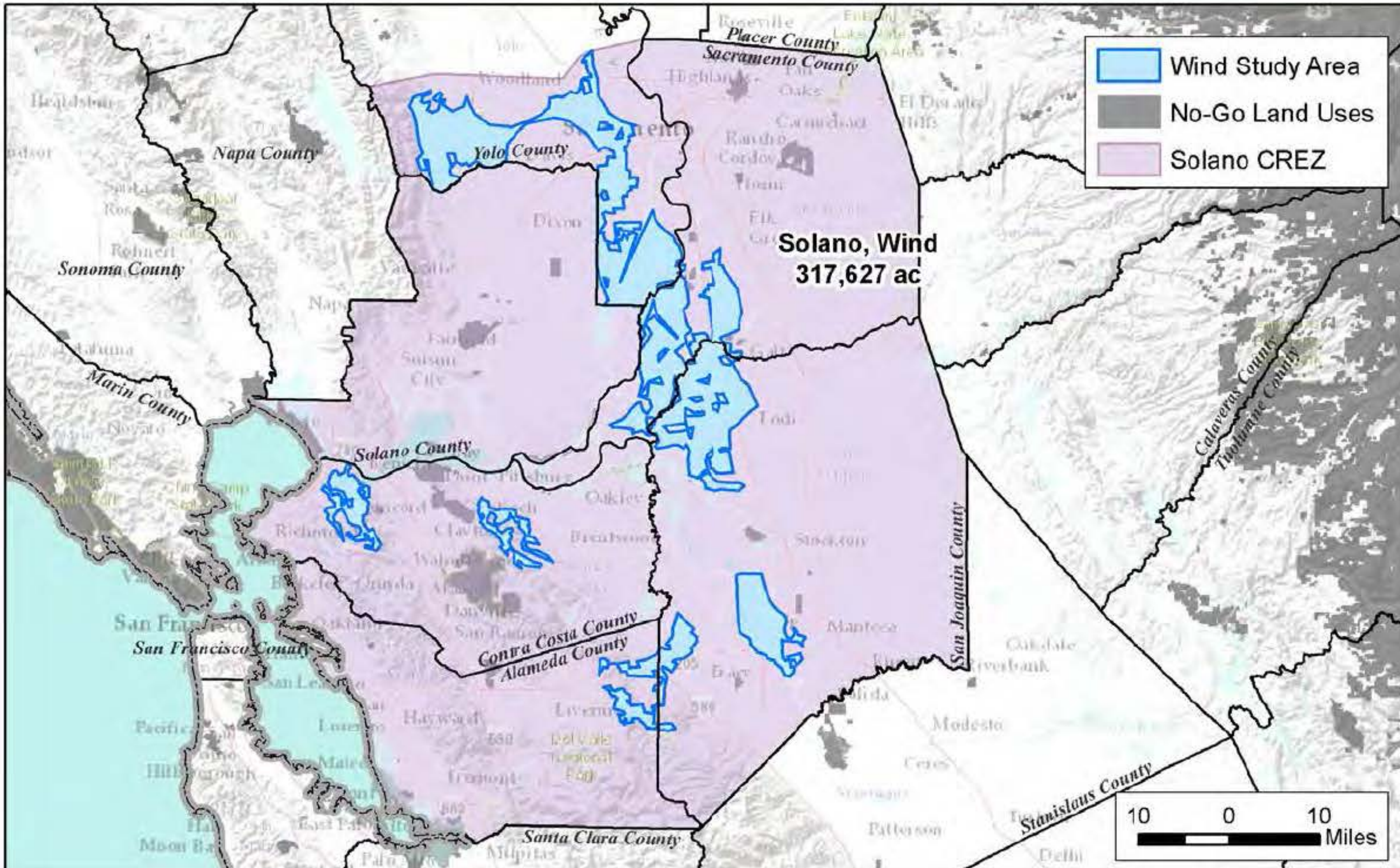
Solano Wind



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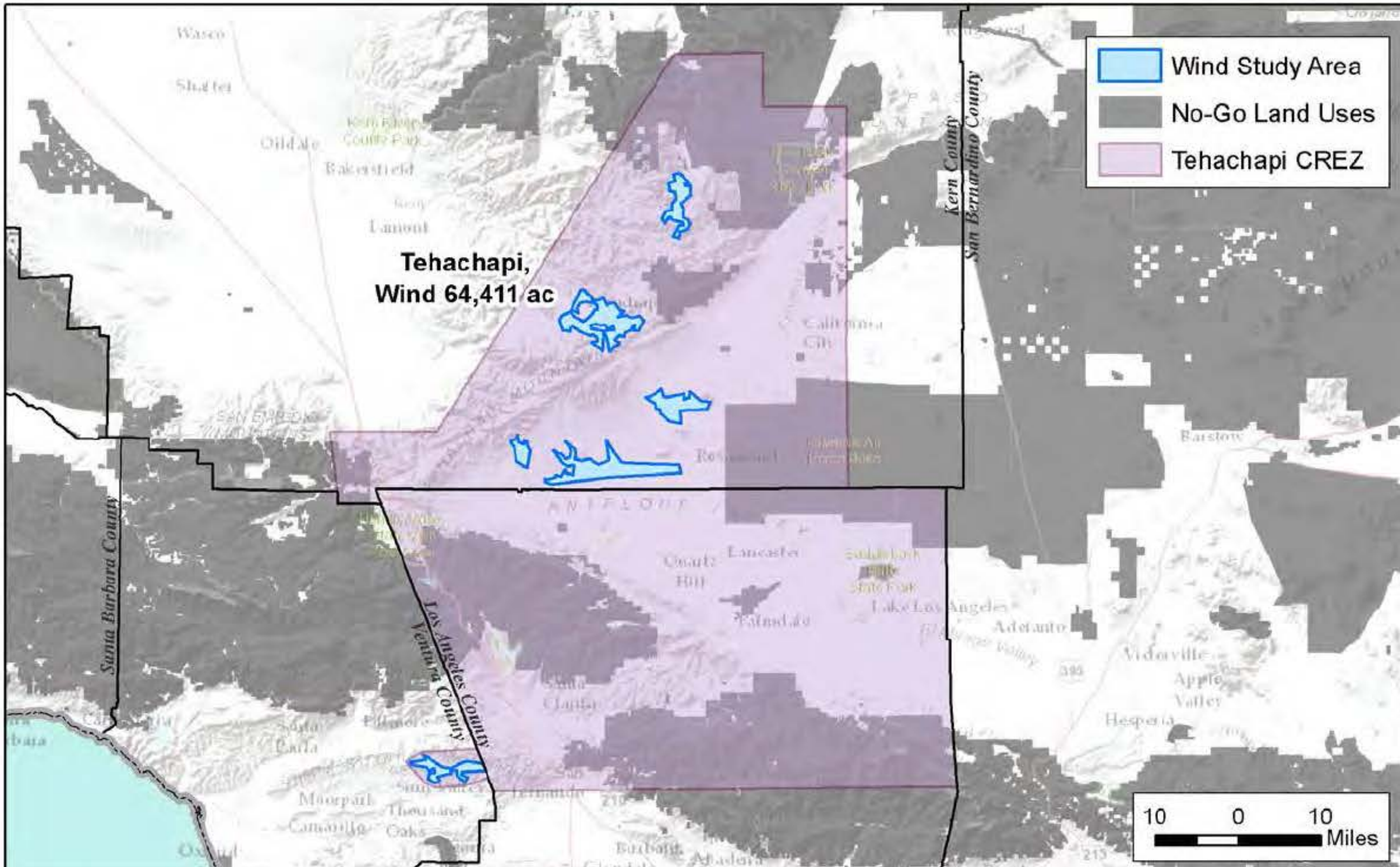
Tehachapi Wind



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Appendix 2: Out of State Renewable Study Areas

RESOLVE Portfolios include Out of State Resources

- This presents various "study areas" as proxy locations
- Need to focus environmental study on meaningful locations
- Need to cover five potential regions of Out of State Resources:
  - Southwest Solar (Arizona)
  - Northwest Wind (Oregon)
  - Utah Wind
  - Wyoming Wind
  - New Mexico Wind

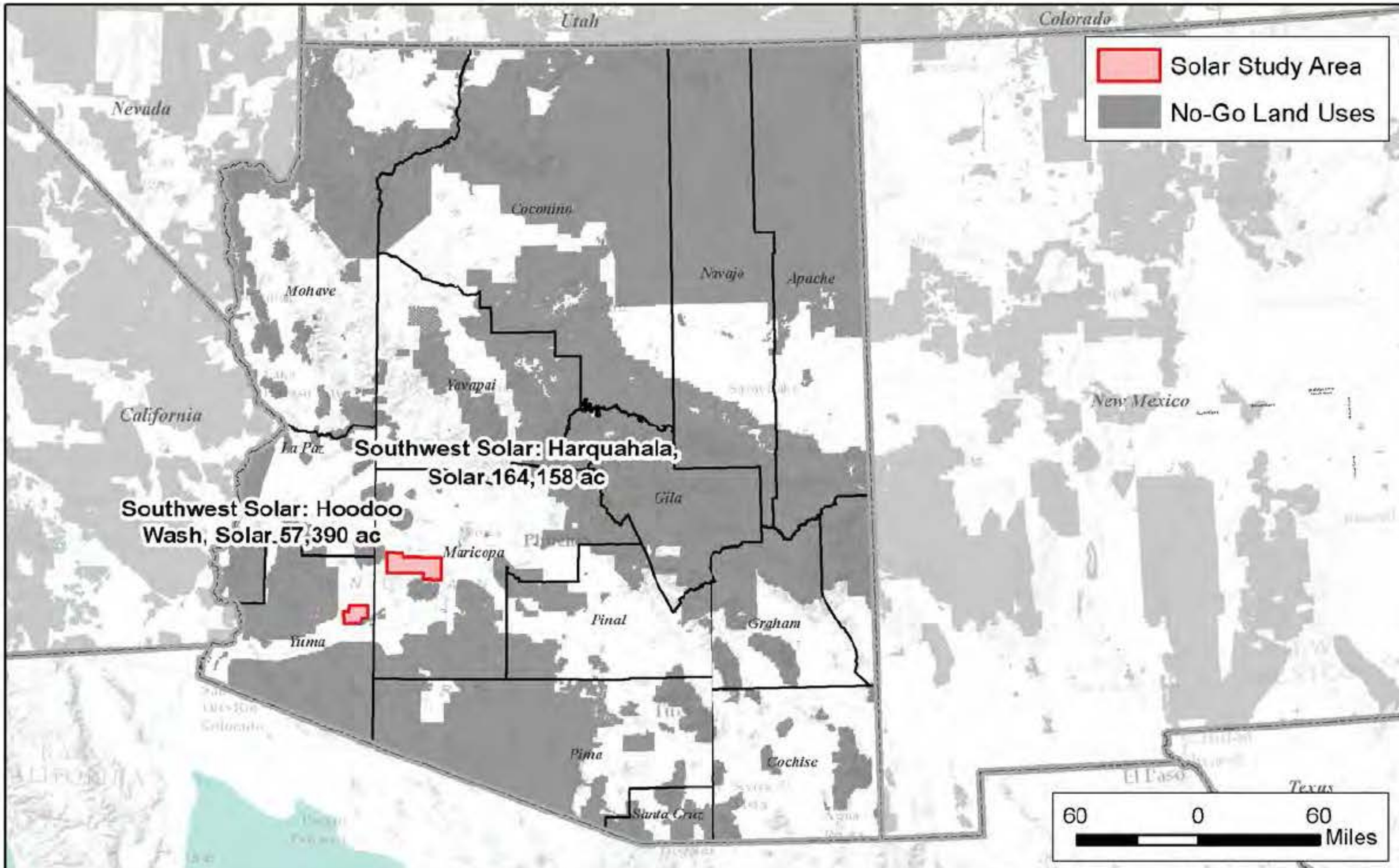
General Methodology

- Review renewable resource and siting considerations
- Review state / federal renewable planning documents and processes
- Review existing and planned transmission
- Review existing and planned renewable projects to help determine viability of renewable development
- Draft polygons of sufficient size / shape as proxy locations to facilitate study of portfolios
- Tailor polygons to eliminate clear "no go" areas within the boundaries (Protected Areas Data: National Parks, National Forest, BLM wilderness and ACECS, State Parks, and military)

Southwest Solar (Arizona), Overview

- Solar resource: abundant, most of the State
- Reviewed previous BLM Renewable Energy Development Areas
- Considered likely substation interconnection points, including:
  - Harquahala, Hassayampa, Delaney or Palo Verde Hub
  - Hoodoo Wash
- Tailored two polygons where either polygon could allow for more than 500 MW of solar energy with substantial flexibility

Arizona Solar, Overview



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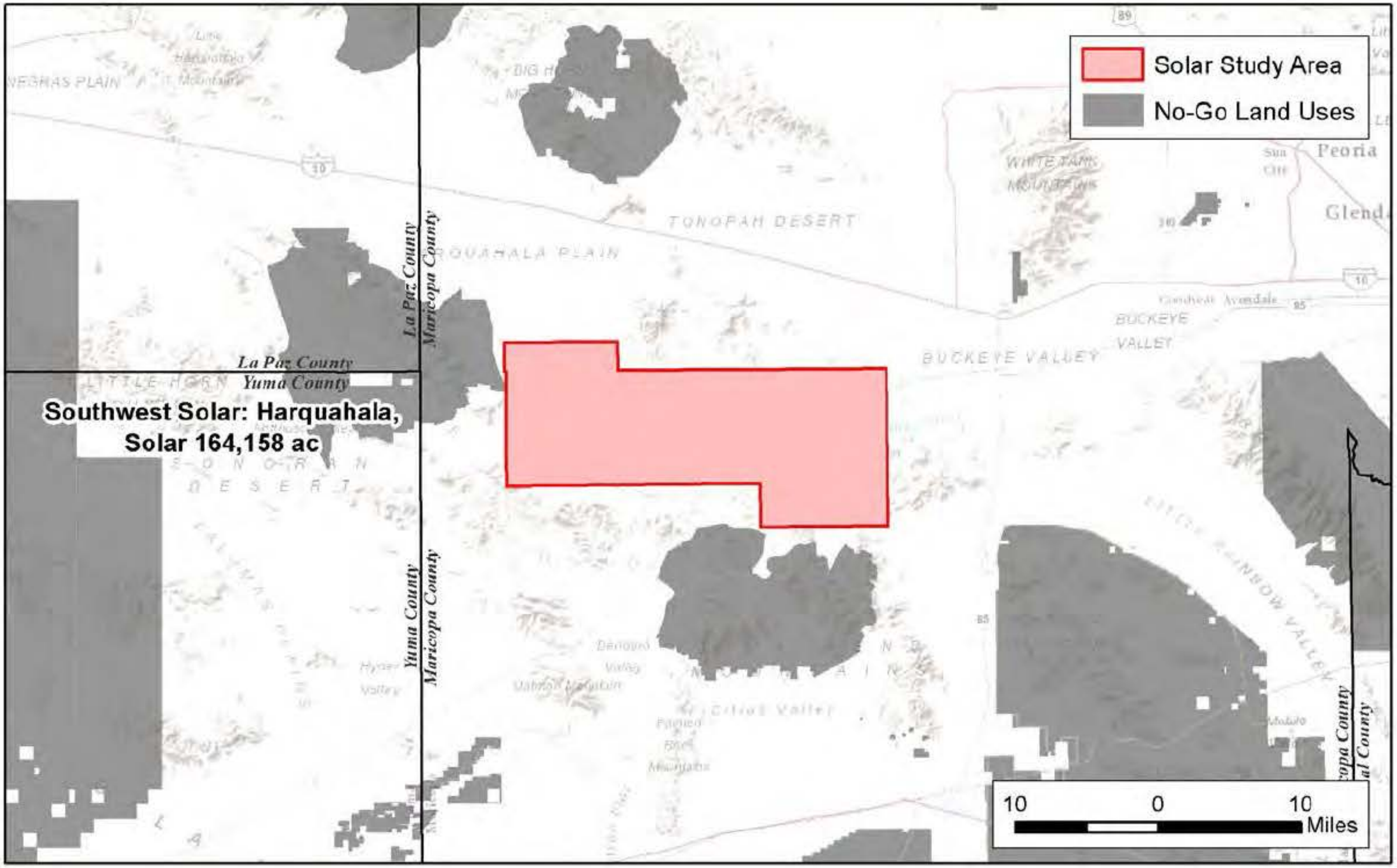
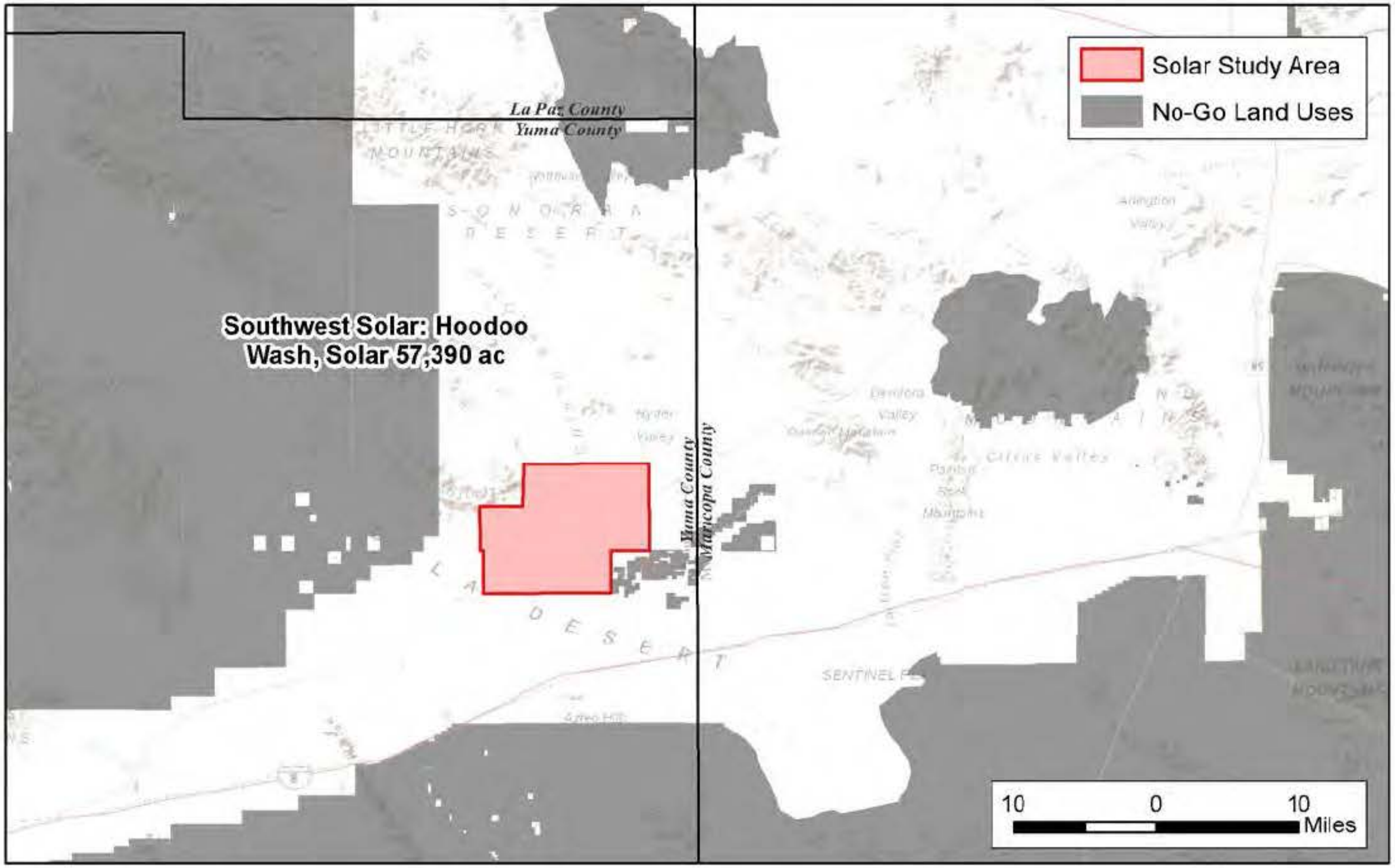
Arizona Harquahala



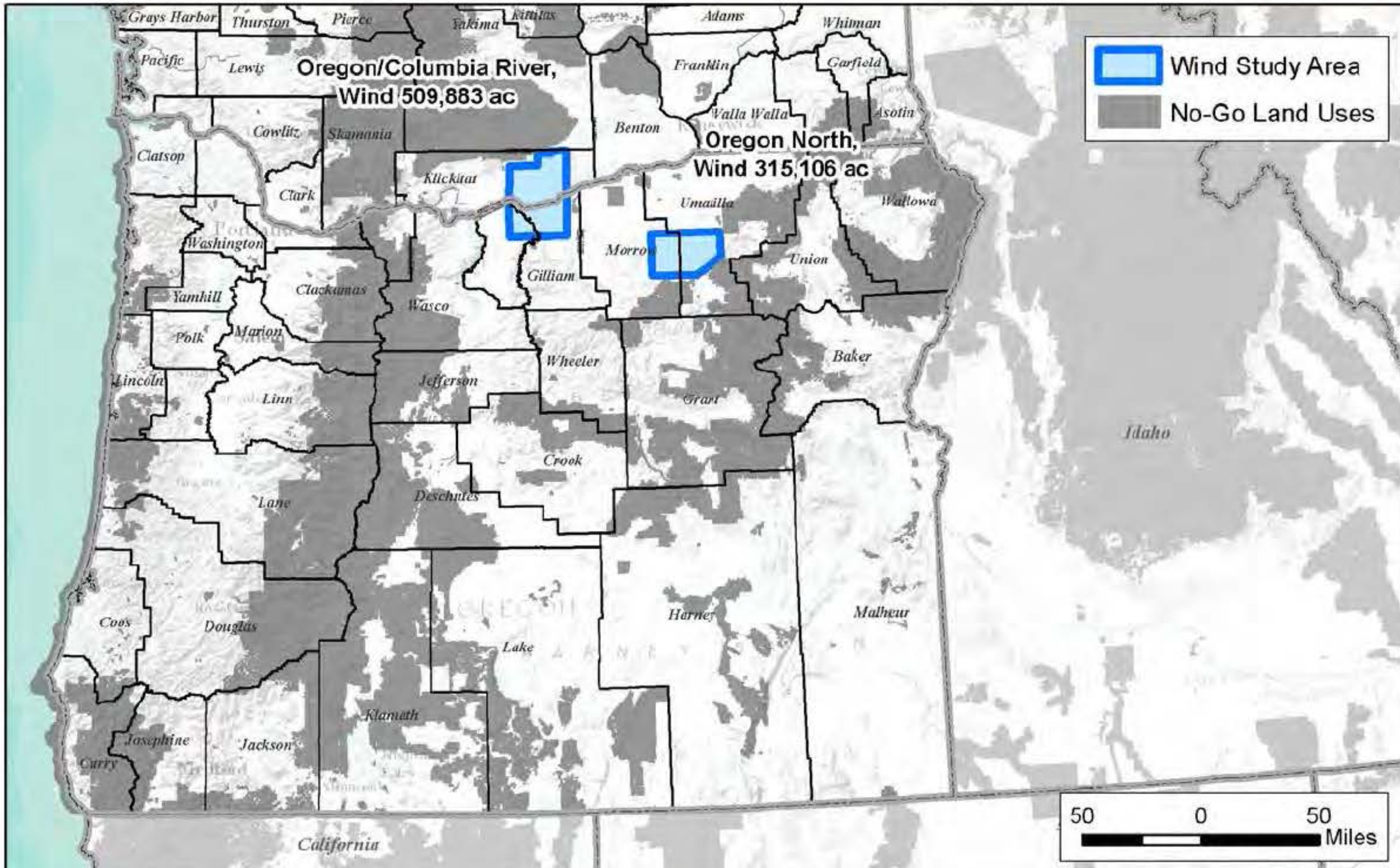
Arizona Hoodoo Wash



Northwest Wind (Oregon), Overview

- Wind resource: scant potential in south
- Existing successful development: mainly in Columbia Gorge
- Previous BLM planning document and earlier process regarding
  - Existing ROWs
  - Renewable Energy Development Challenges and Opportunities
- Tailored two polygons of representative areas
  - Oregon side of the Columbia Gorge, outside of existing sites
  - Southern Oregon BLM land, near existing wind testing ROWs and transmission

Oregon Wind, Overview



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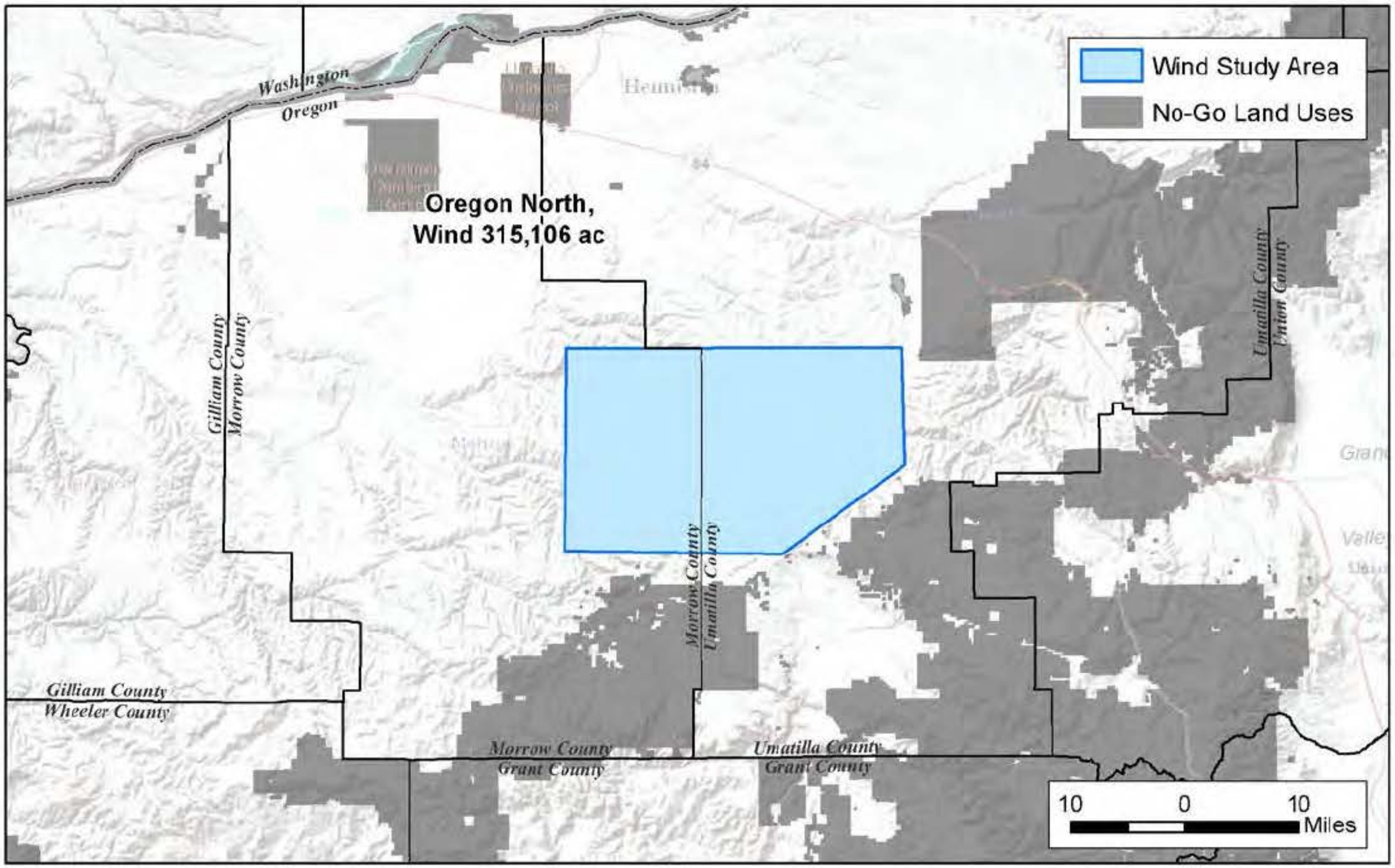
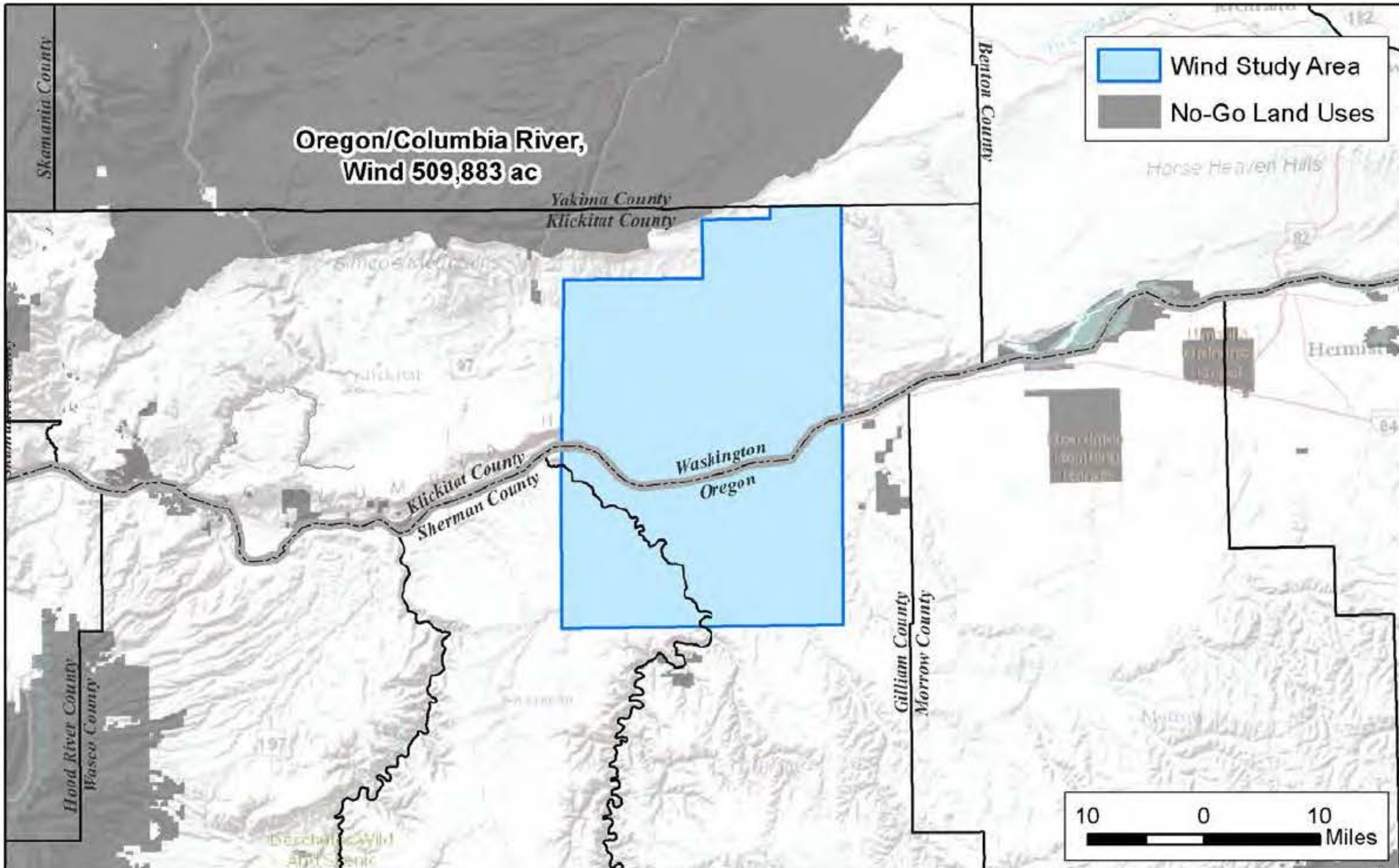
Oregon North



Columbia River Gorge



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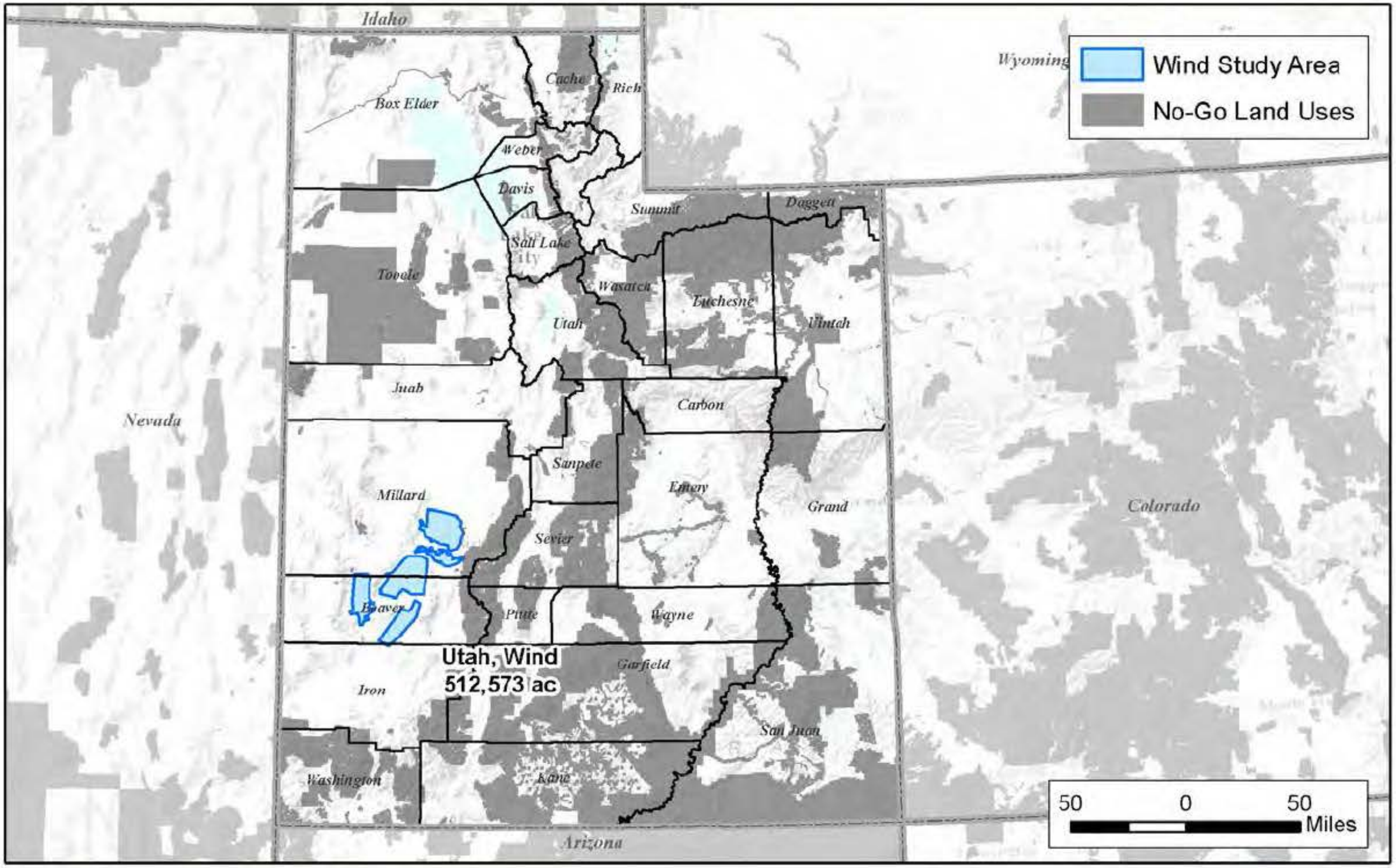
Utah Wind, Overview

- Wind resource: best resource covers western half of the State, south of the Great Salt Lake
- Utah governor commissioned a Utah Renewable Energy Zones task Force to identify areas where utility-scale energy could occur
- Zones screened out environmentally sensitive areas and military airspace and set parameters regarding development
- Use five clustered polygons that allow for more than 600 MW of wind with substantial flexibility
  - Locations are near the Wah Wah Valley and Cricket Range

Utah Wind, Overview



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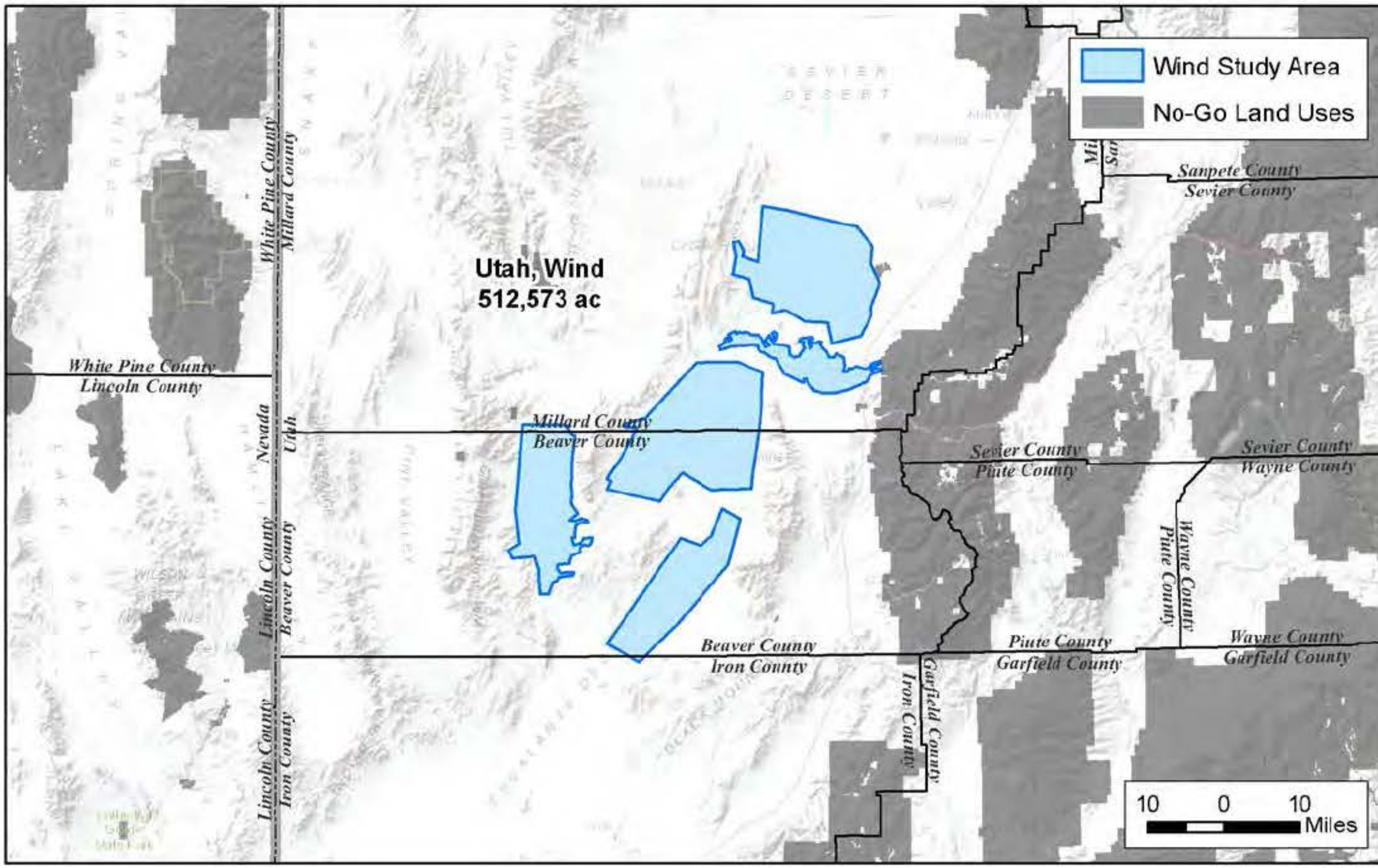
Utah Wind



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Wyoming Wind, Overview

- Wind resource: resource covers eastern two-thirds of State
- No specific state / federal renewable coordinated planning processes
- Two previously-documented transmission-driven wind projects:
  - Anschutz Corp., Sierra Madre/Chokecherry – 3,000 MW (EIS in 2012)
  - Duke, Windstar – 2,100 MW (proposed)
- Tailored two polygons where either polygon could allow for more than 2,495 MW of wind with substantial flexibility

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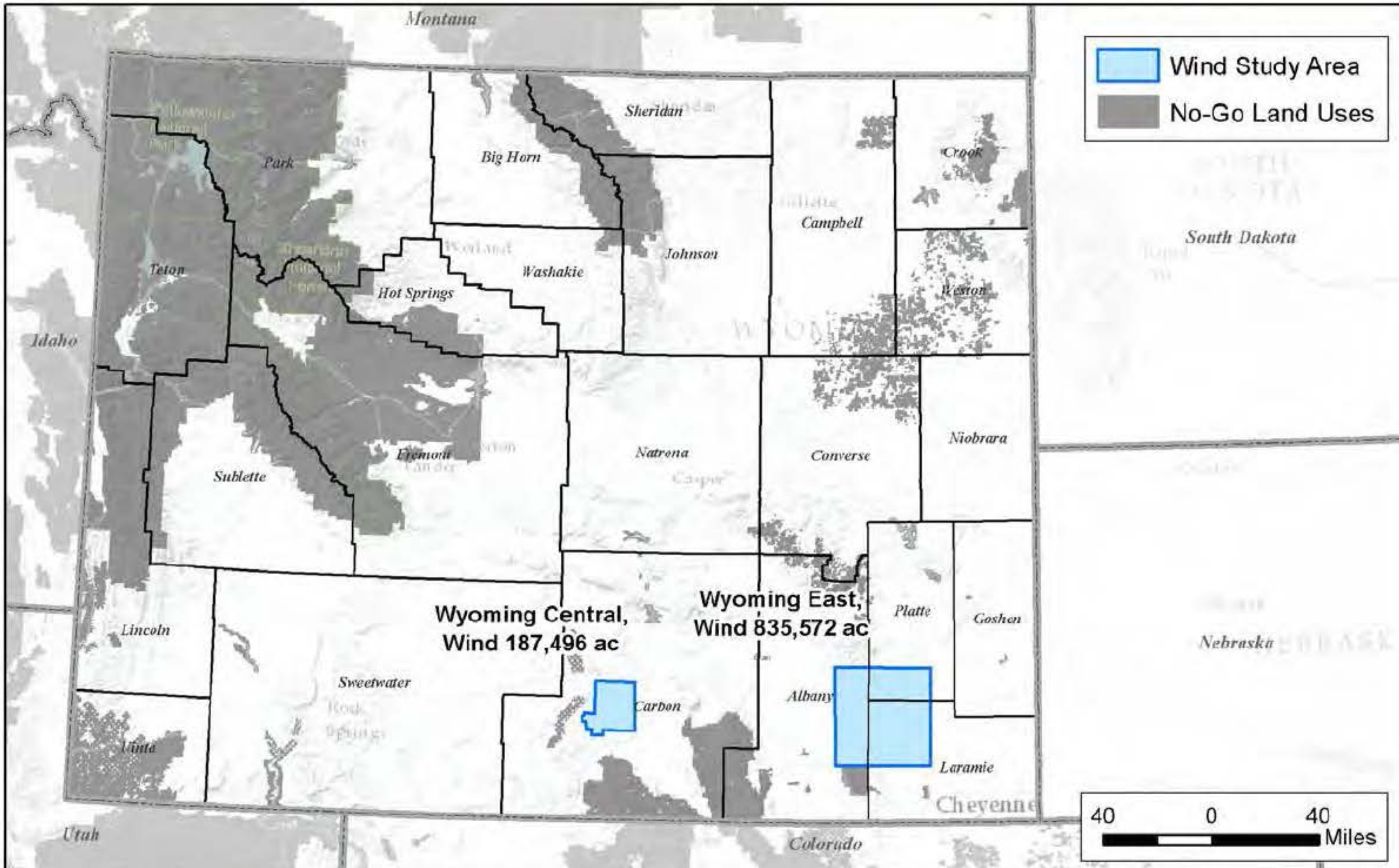
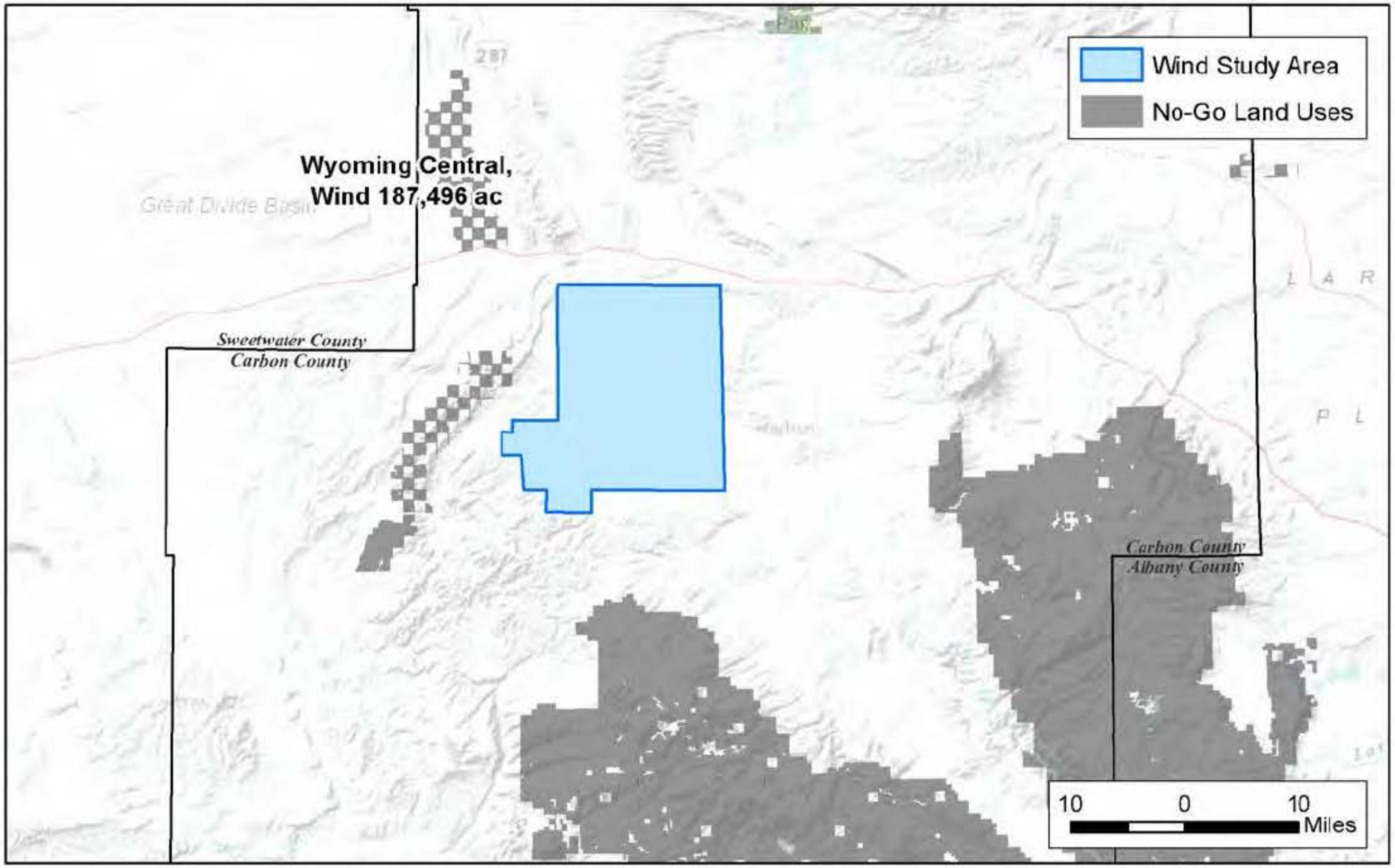
Wyoming Wind, Overview



Wyoming Central



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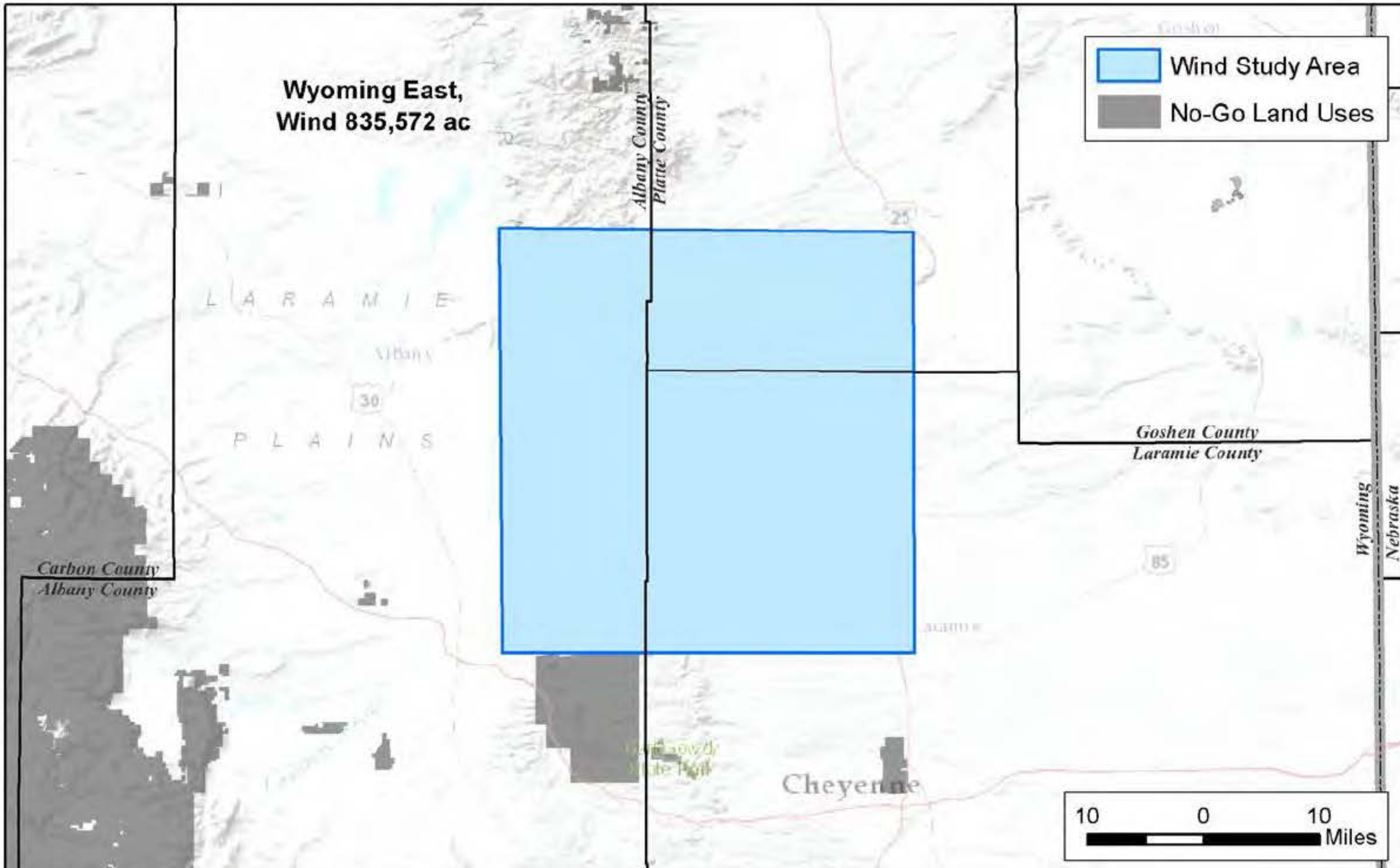
Wyoming East



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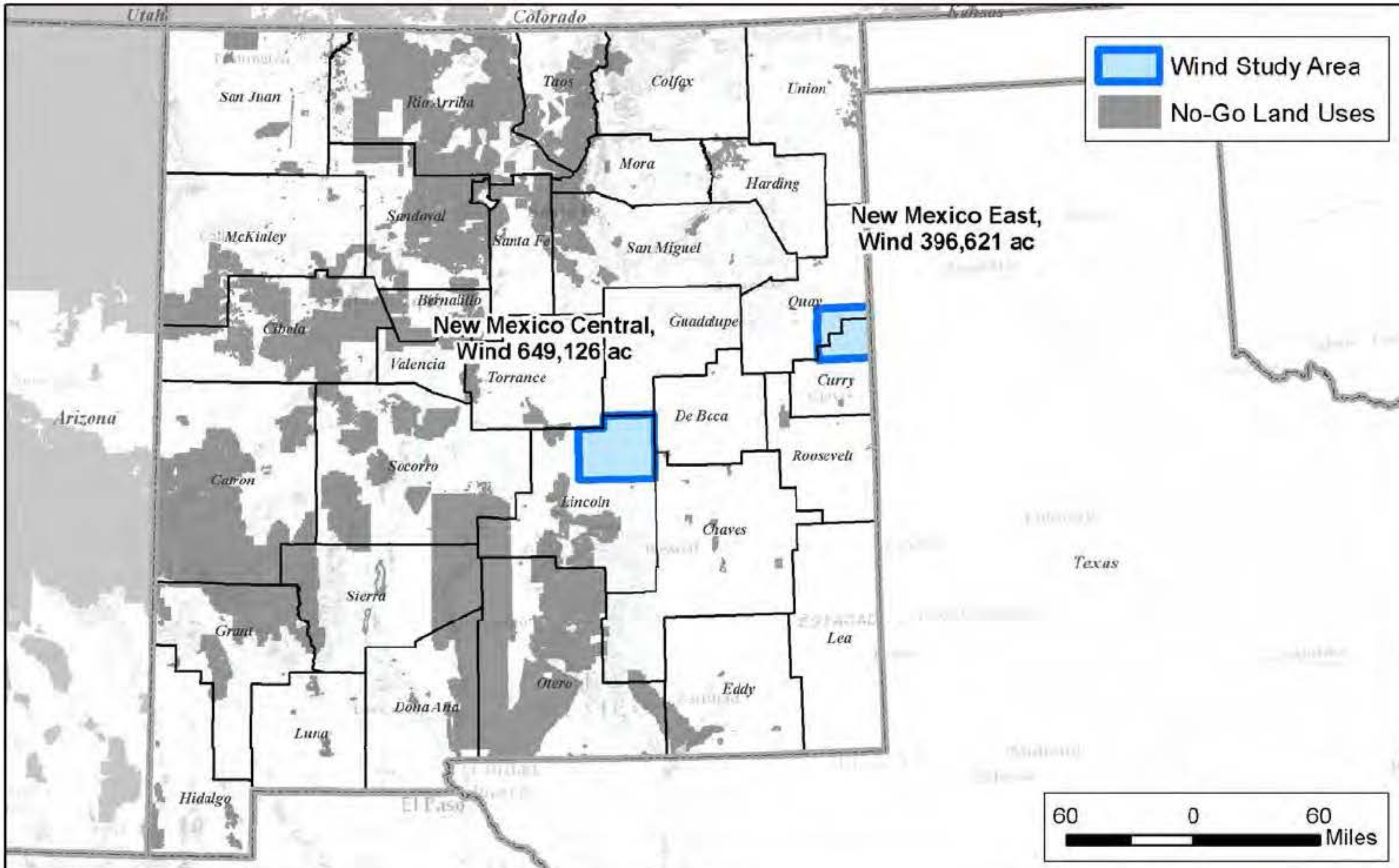
New Mexico Wind, Overview

- Wind resource: best resource covers eastern half of the State
- No specific state / federal renewable coordinated planning processes
- Tailored two polygons where either polygon could allow for more than 2,962 MW of wind with substantial flexibility
  - Central study area covering proposed endpoints for SunZia East and Centennial West Cleanline
  - Eastern study area centered around proposed Tres Amigas vicinity

New Mexico Wind, Overview



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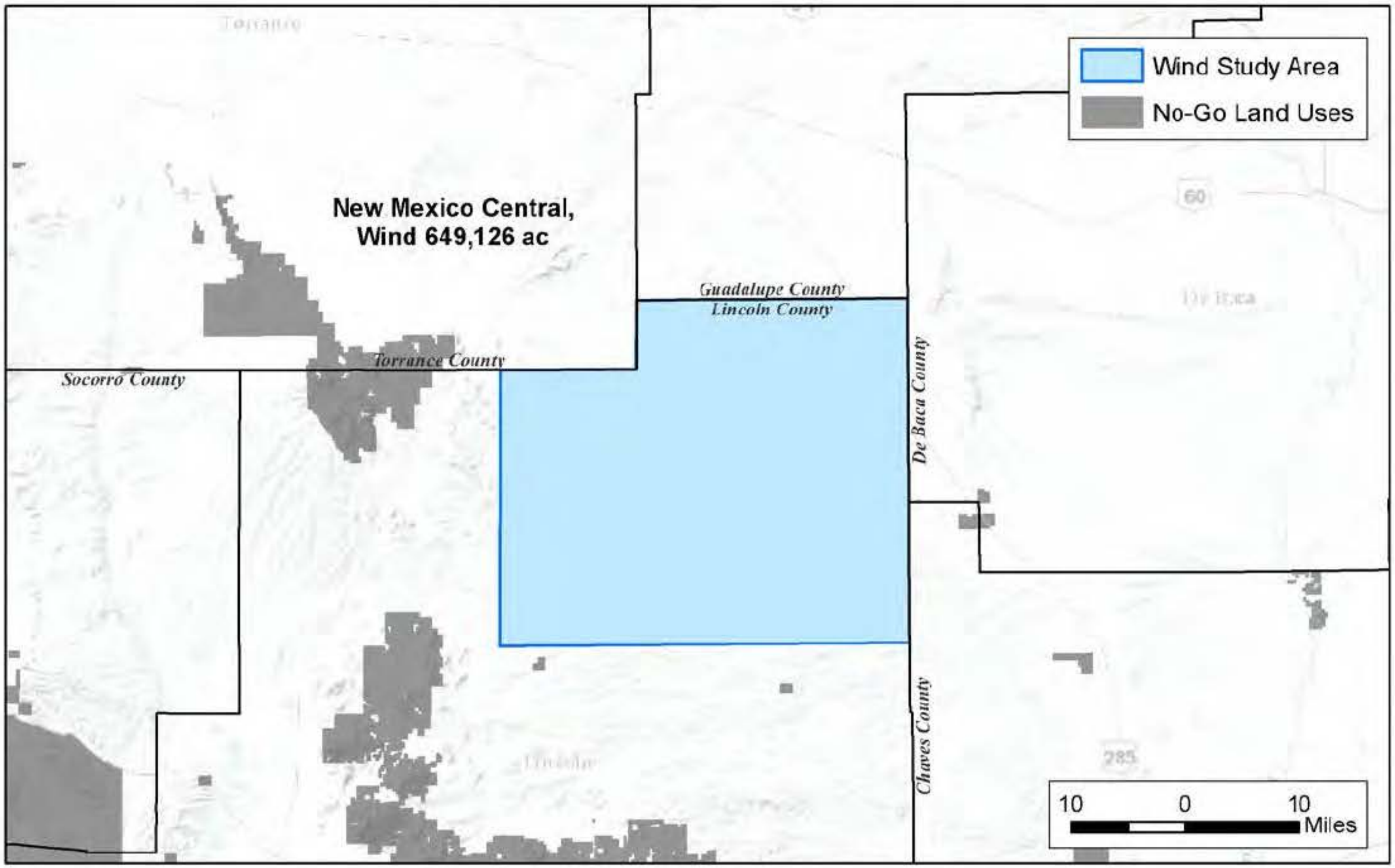
New Mexico Central



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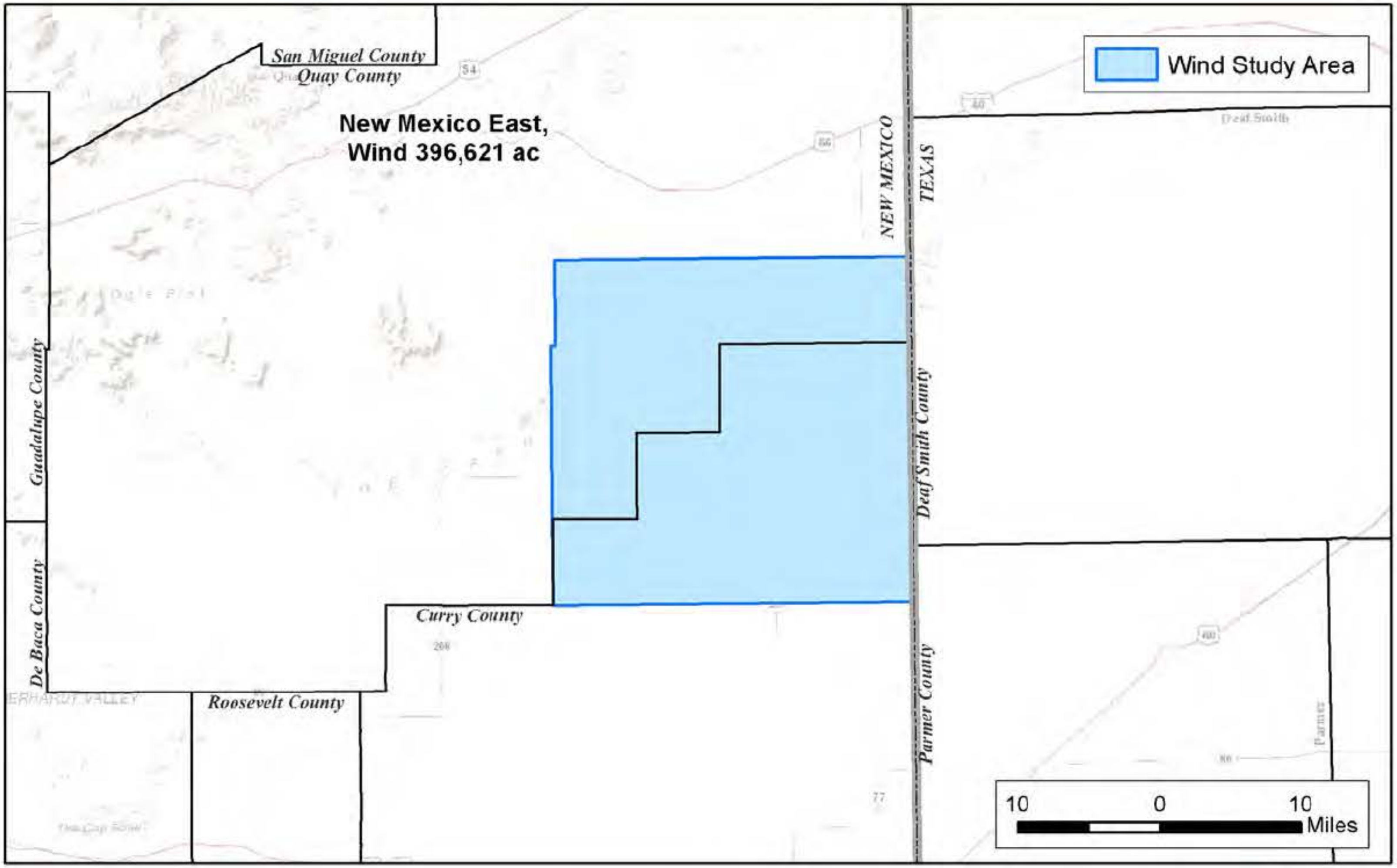
New Mexico East



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Senate Bill 350 Study

Volume X: Disadvantaged Community Impact Analysis

PREPARED FOR

California ISO

PREPARED BY

Aspen Environmental Group

BEAR

Berkeley Economic Advising and Research

July 8, 2016

Senate Bill 350 Study

The Impacts of a Regional ISO-Operated Power Market on California

List of Report Volumes

Senate Bill 350 Study

Volume X

Disadvantaged Community Impact Analysis

Prepared by:

Aspen Environmental Group

Berkeley Economic Advising and Research

July 2016

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Volume X. Disadvantaged Communities Impact Analysis

California's Senate Bill No. 350—the Clean Energy and Pollution Reduction Act of 2015 — (SB 350) requires the California Independent System Operator (CAISO, Existing ISO, or ISO) to conduct one or more studies of the impacts of a regional market enabled by governance modifications that would transform the ISO into a multistate or regional entity (Regional ISO). SB 350, in part, specifically requires an evaluation of "impacts in disadvantaged communities in California." Aspen Environmental Group and Berkeley Economic Advising and Research have been engaged to study these impacts. This report is Volume X of XII of an overall study in response to SB 350's legislative requirements.

This report begins by defining disadvantaged communities, identifies them by location, and presents environmental and economic assessments of energy policy impacts on them. Aspen Environmental Group conducted the environmental study, and Berkeley Economic Advising and Research (BEAR) conducted the economic assessment. More detailed information on methodologies and assumptions, and on impacts across the entire study region, including areas outside of disadvantaged communities, can be found in the Environmental Study (Volume IX) and in the Economic Impact Analysis (Volume VIII).

As discussed in detail below, the limited regionalization in 2020 causes no adverse environmental impact in California's disadvantaged communities and may result in small but beneficial environmental effects by generally reducing water use and NOx emissions. Modeling of the 2020 CAISO + PAC scenario indicates that the San Joaquin Valley and South Coast air basins could slightly increase PM2.5 and SO_2 emissions due to changes in the dispatch of natural gas-fired power plants, but these changes would occur in conjunction with a NOx decrease.

The most severely disadvantaged communities from an economic perspective lie in three regions: Los Angeles (56%), Central Valley (22%), and Inland Valley (13%). For these communities, there are economic benefits right from the start of regionalization in 2020. For 2030, the current practice results in a renewable buildout impacting seven solar resource areas and six different wind resource areas, including four that have a high level of concern for impacts to disadvantaged communities (Westlands; Central Valley North & Los Banos; Kramer & Inyokern; Greater Imperial). The Regional 2 and Regional 3 buildout by 2030 occurs across a smaller number of resource areas in California, when compared with Current Practice 1, although two buildout areas have a high level of concern for impacts to disadvantaged communities (Kramer & Inyokern; Greater Imperial). Thus with expanded regionalization and increased renewable buildout out of state, the impact to California's disadvantaged communities would decline. Regional 2 and Regional 3 both produce more jobs in 2030 in disadvantaged communities than Current Practice 1, arising primarily from job growth induced by ratepayer savings. The economic analysis also considers how income effects differ between disadvantaged and non-disadvantaged communities across scenarios. Once again the state trend with Regional 2 shows the largest increases in incomes and employment across both disadvantaged and non-disadvantaged communities.

1. Screening for Disadvantaged Communities - Overview

The methodology begins with an initial screening of California's disadvantaged communities through maps and tables. The study of disadvantaged communities is limited to California and does not consider out of state effects or out-of-state communities.

1.1 Definition of Disadvantaged Communities

The term "disadvantaged community" is associated with minority and low-income populations in several California laws (e.g., Safe Drinking Water Act, Affordable Housing and Sustainable Communities Program [Public Resources Code, Division 44, Part 1, Section 75200]). Additionally, in 2012 the California Legislature passed Senate Bill 535 (De León), regarding the Greenhouse Gas Reduction Fund, which required the California Environmental Protection Agency (CalEPA) to implement a more comprehensive approach to identifying disadvantaged communities in California through the use of public health and environmental hazard criteria in addition to socioeconomic data (CalEPA, 2014). Through this refined approach, the state definition of disadvantaged communities was expanded to include areas that are disproportionately impacted by environmental pollution and negative public health effects.

This study uses current California definitions and tools to define a disadvantaged community as an area that is:

- Disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation; and/or
- Characterized by concentrations of people that are of low income, high unemployment, low levels of home ownership, high rent burden, sensitive health, or low levels of educational attainment.

1.2 Determination of Disadvantaged Communities

Implementing the provisions of SB 535 is a multi-agency effort among the California Environmental Protection Agency (CalEPA), the Office of Environmental Health Hazard Assessment (OEHHA), and the Air Resources Board (ARB) (ARB, 2016). In addition to targeting a statewide reduction of greenhouse gas emissions, SB 535 earmarked 25 percent of the Greenhouse Gas Reduction Fund for projects that provide a benefit to disadvantaged communities. The CalEPA was tasked with the responsibility for identifying disadvantaged communities for the purpose of SB 535. CalEPA developed CalEnviroScreen (California Communities Environmental Health Screening Tool) as a science-based tool for evaluating multiple pollutants and stressors in communities, and ultimately for identifying disadvantaged communities (CalEPA, 2014).

CalEnviroScreen uses existing environmental, public health, and socioeconomic data to develop indicators to create a screening score for communities across the state. An area with a high score would be expected to experience more severe environmental impacts than areas with low scores. CalEnviroScreen 2.0 (updated October 2014) uses a quantitative method to evaluate multiple pollution sources and stressors, and vulnerability to pollution, in California's approximately 8,000 U.S. Census Tracts. Using data from federal and state sources, the tool consists of indicators (Table 1) that are divided into two broad groups:

- Indicators for exposure and environmental effects comprise a Pollution Burden group; and
- Indicators for sensitive populations and socioeconomic factors comprise a Population Characteristics group.

Table 1. CalEnviroScreen Indicators Used for Identifying Disadvantaged Communities

Environmental Indicators: Pollution Burden (12)	▪ Ozone Levels ▪ Particulate Matter 2.5 Concentrations ▪ Diesel Particulate Matter Emissions ▪ Drinking Water Contaminants ▪ Pesticide Use ▪ Toxic Releases from Facilities ▪ Traffic Density ▪ Cleanup Sites ▪ Groundwater Threats ▪ Hazardous Waste Sites/Facilities ▪ Impaired Water Bodies ▪ Solid Waste Sites/Facilities
Demographic Indicators: Population Characteristics (7)	▪ Children/Elderly ▪ Asthma Emergency Departmental Visits ▪ Low Birth-Weight Births ▪ Educational Attainment ▪ Linguistic Isolation ▪ Poverty ▪ Unemployment

Source: CalEPA, 2014.

Census tracts are used as a geographic scale for identifying disadvantaged communities within California. For each census tract, CalEnviroScreen calculates an overall score by combining the individual indicator scores within each of the two groups (i.e., Pollution Burden and Population Characteristics), then multiplying the Pollution Burden and Population Characteristics scores to produce a final score.[1] Based on these final scores, the census tracts across the state are ranked relative to one another.

CalEnviroScreen Methodology

The CalEnviroScreen model is designed to use the 19 indicators shown in Table 1 that measure a community's exposure, environmental effects, sensitive population, and socioeconomic factors. Table 2 provides more detail on how each of these indicators is developed and the data sources used. As noted above, many of these data sources are California-specific, which provides a more relevant analysis when identifying disadvantaged communities within the state.

Table 2. CalEnviroScreen Indicators and Data Sources

Issue	Indicator	Data Source
Environmental Indicators (12)		
Air Quality: Ozone	Amount of the daily maximum 8-hour ozone concentration over the California 8-hour standard (0.070 ppm), averaged over three years (2009 to 2011)	▪ Air Monitoring Network, California Air Resources Board
Air Quality: Fine Particulate Matter (PM2.5)	Annual mean concentration of PM2.5 (average of quarterly means), over three years (2009-2011)	▪ Air Monitoring Network, California Air Resources Board

[1] The maximum score within each of the Pollution Burden and Pollution Characteristics groups is 10. The maximum CalEnviroScreen Score is 100.

Table 2. CalEnviroScreen Indicators and Data Sources

Issue	Indicator	Data Source
Diesel Particulate Matter	Spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2010 summer day in July (kg/day)	▪ California Air Resources Board ▪ San Diego Association of Governments
Drinking Water Contaminants	Drinking water contaminant index for selected contaminants	▪ Public Water System Location Data (PICME Database), CDPH ▪ Safe Drinking Water Information System, U.S. EPA ▪ Water Quality Monitoring Database, CDPH ▪ Domestic Well Project, Groundwater Ambient Monitoring and Assessment (GAMA) Program, State Water Resources Control Board (SWRCB) ▪ Priority Basin Project, GAMA Program, SWRCB and U.S. Geological Survey
Pesticide Use	Total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile	▪ Pesticide Use Reporting, California Department of Pesticide Regulation
Toxic Releases from Facilities	Toxicity-weighted concentrations of modeled chemical releases to air from facility emissions and off-site incineration	▪ Risk Screening Environmental Indicators ▪ U.S. EPA Toxic Release Inventory
Traffic Density	Sum of traffic volumes adjusted by road segment length (vehicle-kilometers per hour) divided by total road length (kilometers) within 150 meters of the census tract boundary	▪ Environmental Health Investigations Branch, CDPH ▪ San Diego Association of Governments
Cleanup Sites	Sum of weighted sites within each census tract	▪ EnviroStor Cleanup Sites Database, Department of Toxic Substances Control (DTSC) ▪ US EPA, Region 9 NPL Sites (Superfund Sites) Polygons
Groundwater Threats	Sum of weighted scores for sites within each census tract	▪ GeoTracker Database, SWRCB
Hazardous Waste Generators and Facilities	Sum of weighted permitted hazardous waste facilities and hazardous waste generators within each census tract	▪ EnviroStor Hazardous Waste Facilities Database and Hazardous Waste Tracking System, DTSC
Impaired Water Bodies	Summed number of pollutants across all water bodies designated as impaired within the area	▪ 303(d) List of Impaired Water Bodies, SWRCB
Solid Waste Sites and Facilities	Sum of weighted solid waste sites and facilities	▪ Solid Waste Information System and Closed, Illegal, and Abandoned Disposal Sites Program, California Department of Resources Recycling and Recovery, CalRecycle

Table 2. CalEnviroScreen Indicators and Data Sources

Issue	Indicator	Data Source
▪ Population Characteristics (7)		
Age: Children and Elderly	Percent of population under age 10 or over age 65	▪ U.S. Census Bureau
Asthma	Spatially modeled, age-adjusted rate of emergency department (ED) visits for asthma per 10,000 (averaged over 2007-2009)	▪ California Office of Statewide Health Planning and Development (OSHPD) ▪ Environmental Health Investigations Branch, California Department of Public Health
Low Birth Weight Infants	Percent low birth weight, spatially modeled (averaged over 2006-2009)	▪ California Department of Public Health (CDPH)
Educational Attainment	Percent of the population over age 25 with less than a high school education (5-year estimate, 2008-2012)	▪ American Community Survey ▪ U.S. Census Bureau
Linguistic Isolation	Percentage of households in which no one age 14 and over speaks English "very well" or speaks English only	▪ American Community Survey ▪ U.S. Census Bureau
Poverty	Percent of the population living below two times the federal poverty level (5-year estimate, 2008-2012)	▪ American Community Survey ▪ U.S. Census Bureau
Unemployment	Percent of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2008-2012)	▪ American Community Survey ▪ U.S. Census Bureau

Source: CalEPA and OEHHA, 2014.

For a census tract-level analysis, the 19 indicators are averaged into two groups (Pollution Burden and Population Characteristics) to generate a score for each group. Group scores are calculated as follows:

Pollution Burden Score. Pollution Burden scores for each census tract are derived from the average percentiles of the seven exposures indicators (ozone and PM2.5 concentrations, diesel PM emissions, drinking water contaminants, pesticide use, toxic releases from facilities, and traffic density) and the five environmental effects indicators (cleanup sites, impaired water bodies, groundwater threats, hazardous waste facilities and generators, and solid waste sites and facilities). Indicators from the environmental effects component are given half the weight of the indicators from the exposures component. The calculated average Pollution Burden score (average of the indicators) is divided by 10 and rounded to one decimal place for a Pollution Burden score ranging from 0.1 to 10.

Population Characteristics Score. Population Characteristics scores for each census tract are derived from the average percentiles for the three sensitive population indicators (children/elderly, low birth weight, and asthma) and the three socioeconomic factor indicators (educational attainment, linguistic isolation, and poverty). The calculated average percentile divided by 10 for a Population Characteristic score ranging from 0.1 to 10.

CalEnviroScreen Score and Maps

The CalEnviroScreen 2.0 model uses the following formula to calculate an overall CalEnviroScreen Score for a particular census tract:

(Pollution Burden) x (Populations Characteristics) = CalEnviroScreen Score

As demonstrated in the above formula, the CalEnviroScreen Score is calculated by multiplying the Pollution Burden score with the Populations Characteristics score. Since each of the two groups (i.e., Pollution Burden and Populations Characteristics) has a maximum score of 10, the maximum CalEnviroScreen Score is 100.

Additional considerations involved with the CalEnviroScreen system and scoring include:

- Geographic Resolution of Data: CalEnviroScreen 2.0 (utilized within this report) uses census tract boundary data for the 2010 Census obtained from the U.S. Census Bureau.
- Indicator Data Criteria: Data must be available statewide at the census tract level geographical unit or translatable to the census tract level; must be of sufficient quality; and must be complete, accurate, and current.
- Score Calculation Method for Pollution Burden and Population Characteristics Groups:
  - First, the percentiles for all the individual indicators in a group are averaged. Within the Pollution Burden Group, indicators from the environmental effects component are weighted half as much as indicators from the exposures component.[2] Thus, the score for the Pollution Burden category is a weighted average, with exposure indicators receiving twice the weight as environmental effects indicators.
  - Second, Pollution Burden and Population Characteristics percentile averages are scaled so that they have a maximum value of 10 and a possible range of 0 to 10. Each average is divided by the maximum value observed in the state and then multiplied by 10. The scaling ensures that the pollution component and population component contribute equally to the overall CalEnviroScreen score.

2. Disadvantaged Communities Identified

2.1 CalEnviroScreen Score and Maps

Using CalEnviroScreen, the disadvantaged census tracts within California have been identified. Because this tool is California-specific, it provides the following advantages for an in-state analysis:

- Use of census tracts[3] as the geographic scale allows for a reasonably precise screening of pollution burdens and vulnerabilities in specific communities.
- The tool reflects CalEPA's continued effort to enhance the current indicators by incorporating the most up-to-date information, as available.

[2] The contribution to possible pollutant burden from the environmental effects indicators is considered to be less than those from sources in the exposures indicators, and therefore a weighted average is used to calculate the total Pollution Burden.

[3] Census tracts generally have a population size between 1,200 and 8,000 people, with an optimum size of 4,000 people (approximately 1,500 housing units) (USCB, 2015).

Disadvantaged Communities Identified Statewide

Once CalEnviroScreen scores are calculated for each census tract, these tracts are ordered from highest to lowest, based on their overall score. After taking into consideration legislative direction, comparative markers of being disadvantaged and basic principles of fairness, CalEPA has decided on the use of a 25 percent threshold to identify disadvantaged communities (CalEPA, 2014). All census tracts (and population within) ranked within the top 25 percentile are considered disadvantaged within a statewide context.

CalEPA developed maps that show the percentiles for all the state's census tracts and that highlight the census tracts that are within the top 25 percent of communities. CalEnviroScreen scores within the top 25 percent, which are defined as disadvantaged communities, correspond to percentile as follows:

- Score of 7.51 to 8 represents 75 to 80%;
- Score of 8.1 to 9 represents 81 to 90% (population within this ranking is considered more sensitive than that ranked 75 to 80%); and
- Score of 9.1 to 10 represents 91 to 100% (population within this ranking is considered more sensitive than that ranked 75 to 90%).

Disadvantaged Communities Overlay Boundaries for SB 350 Study

In the maps and tables presented with this methodology overview, the locations of disadvantaged communities within the State of California appear, along with an overlay of the following three boundaries for comparison purposes:

- County boundaries.
- Air Basin boundaries. California is divided geographically into air basins for the purpose of managing the air resources of the state on a regional basis. An air basin generally has similar meteorological and geographic conditions throughout. California is currently divided into 15 air basins.
- Competitive Renewable Energy Zone (CREZ) boundaries. CREZ boundaries are established under the Renewable Energy Transmission Initiative (RETI) process and identify the best renewable resource locations to prioritize future transmission infrastructure development. An Aggregated CREZ is a coarsely-defined geography that can span multiple counties or substantial portions of counties.

Information is provided for the 25% highest-scoring census tracts within California, as these census tracts contain the population considered to be disadvantaged that could bear disproportionate impacts from energy infrastructure siting. Because the overlay boundaries encompass complete census tracts and portions of census tracts, to avoid double-counting population in partial tracts, the counted population and number of tracts considers the census tracts that are primarily within each of the boundaries. Accordingly, population data presented here includes some portion outside each overlay boundary.

Note that the scores for each area identified by CalEnviroScreen are the same underlay for each map in this overview, only the overlay of the different boundary types change here (i.e., County, Air Basin, and CREZ).

2.2 Disadvantaged Communities for the Environmental Analysis

Disadvantaged Communities in California by County

Figure 1 shows the distribution of the top 25% highest CalEnviroScreen scores across the counties in California. Table 3 (at the end of this section) provides data corresponding to the map, and shows the population levels in disadvantaged communities by county. As shown in Table 3, the counties with the highest percentages of population in disadvantaged communities are: Merced, Tulare, Fresno, Kings, Madera, Kern, Imperial, San Joaquin, Stanislaus, Los Angeles, and San Bernardino.

Disadvantaged Communities in California Air Basins

Figure 2 shows the distribution of the top 25% highest CalEnviroScreen scores across air basins in California. Table 4 (at the end of this section) provides data corresponding to the map, and shows the population levels in disadvantaged communities by air basin. As shown in Table 4, the San Joaquin Valley, South Coast, and Salton Sea air basins contain the highest percentages of population in disadvantaged communities.

Disadvantaged Communities in CREZs

Figure 3 shows the distribution of the top 25% highest CalEnviroScreen scores across the Aggregated CREZs in this overview. Table 5 (at the end of this section) provides data corresponding to the map, and shows the population levels in disadvantaged communities by CREZ. As shown in Table 5, the Westlands, Central Valley North & Los Banos, Mountain Pass & El Dorado, Kramer & Inyokern, and Greater Imperial CREZs contain the highest percentages of population in disadvantaged communities.

Figure 1. CalEnviroScreen 2.0 Scores by County

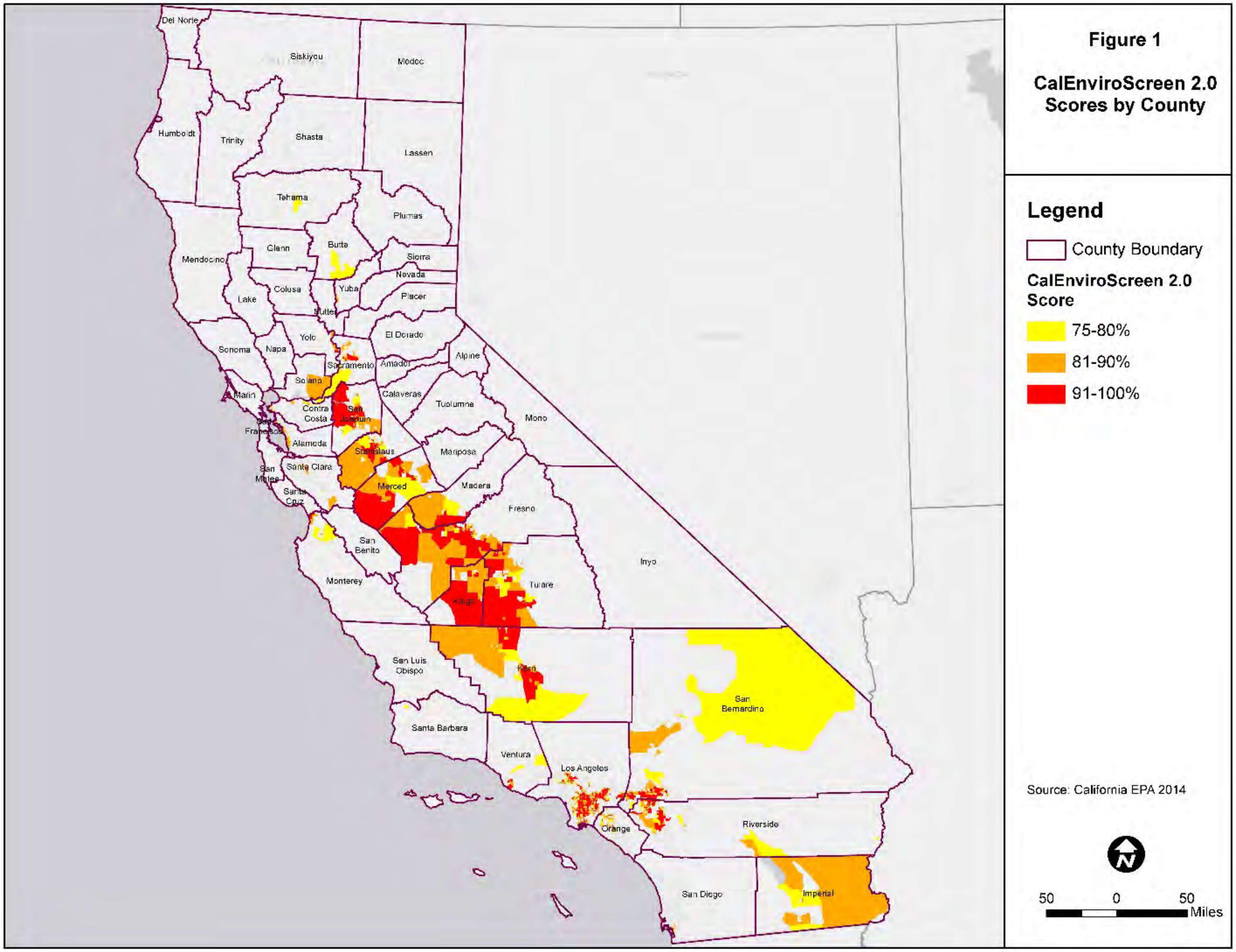


Figure 2. CalEnviroScreen 2.0 Scores by Air Basin

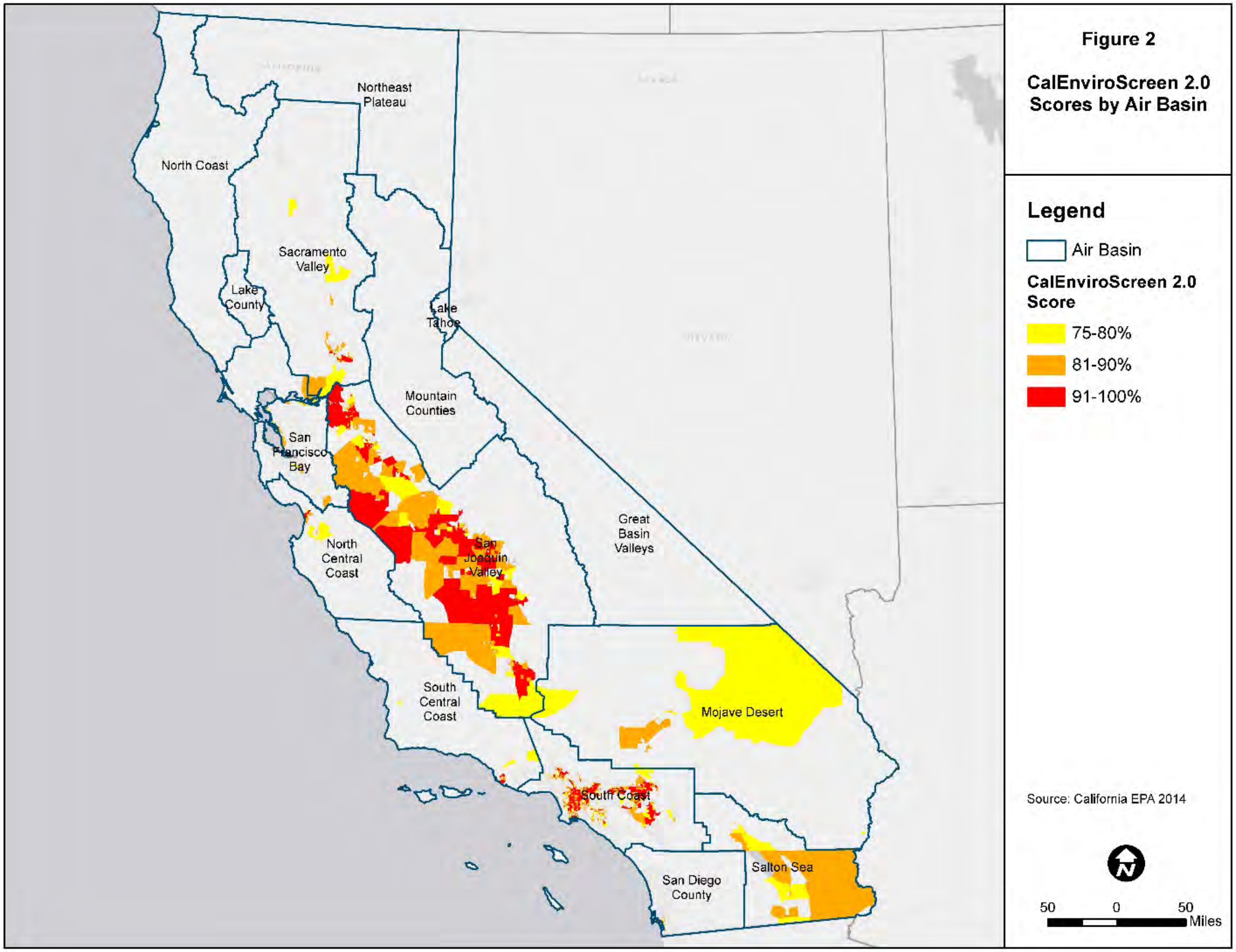


Figure 3. CalEnviroScreen 2.0 Scores by Aggregated CREZ

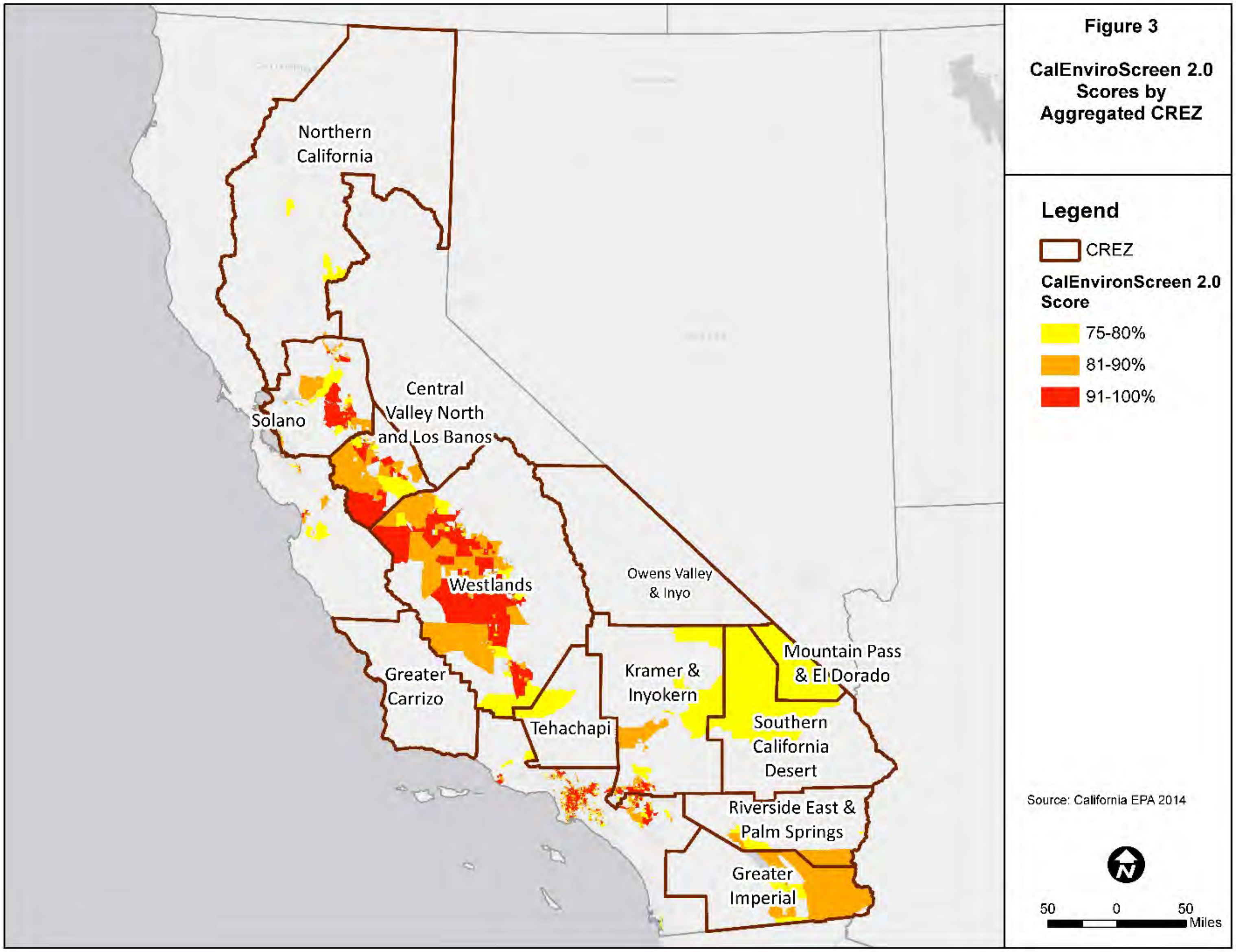


Table 3. CalEnviroScreen Scores by County

County	76-80% Highest Scores		81-90% Highest Scores		91-100% Highest Scores		County Totals (top 25% highest scoring areas)		Percentage of County Population within Disadvantaged Communities
	No. of Tracts	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*Percentage*
Merced	5	27,944	17	97,544	14	62,152	36	187,640	73%
Fresno	14	70,293	36	172,204	81	386,223	131	628,720	68%
Tulare	7	43,448	26	123,002	17	110,769	50	277,219	63%
Madera	2	17,424	6	36,584	5	38,016	13	92,024	61%
Kern	18	97,718	24	128,416	31	202,271	73	428,405	51%
Stanislaus	10	51,793	20	92,520	20	98,543	50	242,856	47%
Los Angeles	163	674,588	408	1,762,569	447	1,910,843	1018	4,348,000	44%
San Joaquin	10	42,512	26	134,429	28	120,939	64	297,880	43%
San Bernardino	23	119,125	61	343,508	76	400,063	160	862,696	42%
Kings	2	8,795	7	28,136	5	25,887	14	62,818	41%
Imperial	6	33,152	7	36,482	—	—	13	69,634	40%
Riverside	30	145,317	32	175,004	42	207,530	104	527,851	24%
Orange	33	213,508	43	249,509	10	63,840	86	526,857	18%
Yuba	—	—	3	12,296	—	—	3	12,296	17%
Sacramento	15	67,461	19	92,340	9	36,788	43	196,589	14%
Contra Costa	13	68,018	10	53,186	—	—	23	121,204	12%
Yolo	1	4,922	1	7,702	1	5,397	3	18,021	9%
Monterey	3	15,783	3	15,139	1	4,518	7	35,440	9%
Alameda	15	55,909	16	62,896	1	5,547	32	124,352	8%
Tehama	1	4,112	—	—	—	—	1	4,112	6%
Santa Clara	7	29,476	13	67,357	3	8,771	23	105,604	6%
Butte	3	12,313	—	—	—	—	3	12,313	6%
Ventura	3	9,076	2	9,002	3	15,390	8	33,468	4%

Table 3. CalEnviroScreen Scores by County

County	76-80% Highest Scores		81-90% Highest Scores		91-100% Highest Scores		County Totals (top 25% highest scoring areas)		Percentage of County Population within Disadvantaged Communities
	No. of Tracts	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*Percentage*
San Diego	8	40,549	14	60,614	4	15,432	26	116,595	4%
Santa Cruz	1	7,976	—	—	—	—	1	7,976	3%
Solano	1	2,962	1	8,423	—	—	2	11,385	3%
Santa Barbara	1	11,406	—	—	—	—	1	11,406	3%
San Mateo	1	7,510	1	7,327	—	—	2	14,837	2%
San Francisco	2	7,546	1	3,499	—	—	3	11,045	1%

Note: The counted population and number of tracts include the census tracts that are primarily within each boundary and may not include the population of the partial tracts in each overlay boundary.

Table 4. CalEnviroScreen Scores by Air Basin

Air Basin	76-80% Highest Scores		81-90% Highest Scores		91-100% Highest Scores		Air Basin Totals (top 25% highest scoring areas)		Percentage of Air Basin Population within Disadvantaged Communities
	No. of Tracts	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*Percentage*
San Joaquin Valley	67	354,453	162	812,835	201	1,044,800	430	2,212,088	58%
South Coast	242	1,112,097	534	2,469,914	575	2,582,276	1,351	6,164,287	39%
Salton Sea	9	57,547	9	50,060	—	—	18	107,607	18%
Sacramento Valley	20	88,808	24	120,761	10	42,185	54	251,754	9%
Mojave Desert	5	21,520	8	47,098	—	—	13	68,618	7%
North Central Coast	4	23,759	3	15,139	1	4,518	8	43,416	6%
San Francisco Bay	39	171,421	40	190,815	4	14,318	83	376,554	5%
San Diego County	8	40,549	14	60,614	4	15,432	26	116,595	4%
South Central Coast	4	20,482	2	9,002	3	15,390	9	44,874	3%
Great Basin Valleys	—	—	—	—	—	—	0	0	0%

Note: The counted population and number of tracts include the census tracts that are primarily within each boundary and may not include the population of the partial tracts in each overlay boundary.

Table 5. CalEnviroScreen Scores by Aggregated CREZ

Aggregated CREZ	76-80% Highest Scores		81-90% Highest Scores		91-100% Highest Scores		CREZ Totals (top 25% highest scoring areas)		Percentage of Population within CREZ within Disadvantaged Communities
	No. of Tracts	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*No. of Tracts*	*Population*	*Percentage*
Westlands	42	232,204	99	488,342	139	763,166	280	1,483,712	62%
Central Valley N & Los Banos	15	79,737	37	190,064	34	160,695	86	430,496	56%
Kramer & Inyokern	22	115,279	61	343,508	76	400,063	159	858,850	42%
Greater Imperial	6	33,152	7	36,482	—	—	13	69,634	22%
Solano	55	241,784	72	355,526	39	168,671	166	765,981	15%
Riverside East & Palm Springs	4	27,736	2	13,578	—	—	6	41,314	9%
Southern California Desert	1	3,846	—	—	—	—	1	3,846	8%
Tehachapi	2	8,407	2	10,900	—	—	4	19,307	2%
Northern California	4	16,425	—	—	—	—	4	16,425	2%
Greater Carrizo	1	11,406	—	—	—	—	1	11,406	2%
Owens Valley & Inyo	—	—	—	—	—	—	0	0	0%

Note: The counted population and number of tracts include the census tracts that are primarily within each boundary and may not include the population of the partial tracts in each overlay boundary.

2.3 Disadvantaged Communities for the Economic Analysis

The economic and environmental analyses use the same criteria for identifying disadvantaged communities; however, the economic analysis uses an alternative aggregation methodology for reporting results. Disadvantaged communities are aggregated to nine multi-county economic regions (Table 6). 91% of California's disadvantaged communities fall within three economic regions: Los Angeles (56%), Central Valley (22%), and Inland Valley (13%).

Table 6. Disadvantaged Community Aggregation Used for Economic Analysis

Regions	Counties within Region	Percent of Disadvantaged Communities
Los Angeles	Los Angeles, Ventura, Orange	56%
Central Valley	San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, Kern, Mariposa, Tuolumne, Calaveras, Amador	22%
Inland Valley	San Bernardino, Riverside	13%
Bay Area	San Francisco, Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo	4%
Sacramento	El Dorado, Placer, Sacramento, Yolo, Sutter, Yuba	2.5%
San Diego and Imperial	San Diego, Imperial	2%
Central Coast	Monterey, San Luis Obispo, Santa Barbara, Santa Cruz, San Benito	<1%
North State	Del Norte, Siskiyou, Modoc, Humboldt, Trinity, Shasta, Lassen, Tehama, Plumas, Sierra, Nevada, Butte, Glenn, Colusa, Lake, Mendocino	<1%
Southern Sierra	Alpine, Mono, Inyo	None

Note: The nine economic region aggregation is taken from the following report by the California EPA Office of Environmental Health Hazard Assessment: Approaches to Identifying Disadvantaged Communities (2014).

3. Ranking of Disadvantaged Communities

Areas that have the greatest numbers of highest-scoring tracts according to CalEnviroScreen results are considered in this study to be the areas of greatest concern. The areas of greatest concern in this study are likely to have many census tracts in the highest-scoring decile, and the highest percentage of population in disadvantaged communities, as shown previously for the air basins (Table 4), the CREZs (Table 5), and Economic Regions (Table 6).

The geographic resolution of the environmental study is at the scale of air basins and CREZs, some of which include hundreds of census tracts defined as disadvantaged communities The number of census tracts that are disadvantaged communities, meaning those in the highest quartile of CalEnviroScreen scores (7.6-10), and the number of census tracts with the highest decile of CalEnviroScreen Scores (9.1-10) are used here to further focus the study on areas where highest-scoring tracts are most likely to occur. Any area that has more than 40% of census tracts the top quartile also in the top decile (i.e., more than 10 tracts in the top decile per every 25 tracts in the top quartile) is an area characterized with the highest-scoring tracts.

Table 7 lists the air basins with the number of tracts in the highest-scoring decile and fraction of disadvantaged communities that are the highest-scoring. Table 7 shows that the San Joaquin Valley and South Coast air basins have the greatest numbers of the highest-scoring disadvantaged communities.

On the basis of having a relatively high percentage of population in disadvantaged communities (Table 4), the top three air basins of greatest concern also include the Salton Sea air basin.

Table 7. Air Basins with the Highest-Scoring Disadvantaged Communities

Air Basin	Percentage of Air Basin Population within Disadvantaged Communities	CalEnviroScreen Scores between 7.6 and 10 (No. of Tracts in Top Quartile)	CalEnviroScreen Scores between 9.1 and 10 (No. of Tracts in Top Decile)	Highest-Scoring Areas (Top Decile divided by Top Quartile)
San Joaquin Valley	58%	430	201	47%
South Coast	39%	1,351	575	43%
South Central Coast	3%	9	3	33%
Sacramento Valley	9%	54	10	19%
San Diego County	4%	26	4	15%
North Central Coast	6%	8	1	13%
San Francisco Bay	5%	83	4	5%
Salton Sea	18%	18	0	0%
Mojave Desert	7%	13	0	0%

Note: The counted number of tracts considers the census tracts that are primarily within each boundary, shown also in Table 4.

Table 8 lists the CREZs with number of tracts in the highest-scoring decile and fraction of disadvantaged communities that are the highest-scoring. The top five CREZs of greatest concern include the Central Valley North & Los Banos and Greater Imperial CREZs, due to a relatively high percentage of population in disadvantaged communities; the Solano CREZ has a lower percentage of population in disadvantaged communities (Table 5). Table 8 shows that the Westlands and Kramer & Inyokern CREZs also have the greatest numbers of highest-scoring disadvantaged communities.

Table 8. CREZs with the Highest-Scoring Disadvantaged Communities

Aggregated CREZ	Percentage of Population within CREZ within Disadvantaged Communities	CalEnviroScreen Scores between 7.6 and 10 (No. of Tracts in Top Quartile)	CalEnviroScreen Scores between 9.1 and 10 (No. of Tracts in Top Decile)	Highest-Scoring Areas (Top Decile divided by Top Quartile)
Westlands	62%	280	139	50%
Kramer & Inyokern	42%	159	76	48%
Central Valley N & Los Banos	56%	86	34	40%
Solano	15%	166	39	23%
Greater Imperial	22%	13	0	0%
Riverside East & Palm Springs	9%	6	0	0%
Southern California Desert	8%	1	0	0%
Northern California	2%	4	0	0%
Tehachapi	2%	4	0	0%
Greater Carrizo	2%	1	0	0%

Note: The counted number of tracts considers the census tracts that are primarily within each boundary, shown also in Table 5.

Table 9 lists the nine economic regions with the number of disadvantaged communities the top decile and quartile of CalEnviroScreen scores; 91% of the disadvantaged communities are in Central Valley, Inland Valley, and Los Angeles. These are also the three economic regions with the greatest number of high-scoring disadvantaged communities.

Table 9. Economic Regions with the Highest-Scoring Disadvantaged Communities

Aggregated Economic Region	CalEnviroScreen Scores between 9.1 and 10 (No. of Tracts in Top Decile)	CalEnviroScreen Scores between 7.6 and 10 (No. of Tracts in Top Quartile)	Highest-Scoring Areas (Top Decile divided by Top Quartile)
Central Valley	201	431	47%
Inland Valley	118	264	45%
Los Angeles	460	1,112	41%
Sacramento	10	49	20%
Central Coast	1	9	11%
San Diego and Imperial	4	39	10%
Bay Area	4	85	5%
North State	0	4	0%
Southern Sierra	0	0	NA

In summary, the areas having the highest percentages of population in disadvantaged communities and the highest-scoring disadvantaged communities are:

- **Air Basins:** the San Joaquin Valley, South Coast, and Salton Sea air basins.
- **CREZs:** the Westlands, Central Valley North & Los Banos, Kramer & Inyokern, and Greater Imperial CREZs.
- **Economic Regions:** the Central Valley, Inland Valley, and Los Angeles economic regions.

4. Environmental Impacts in Disadvantaged Communities

For our environmental study of impacts in disadvantaged communities, we focus on whether the action of changing the California ISO into a regional market operator is likely to increase the environmental pollution burden on any disadvantaged community. Two criteria are used here to describe how the different regionalization scenarios can affect disadvantaged communities:

- First, because regionalization is likely to influence the preferred locations for the incremental renewable energy buildout to meet California's 50% Renewable Portfolio Standard (RPS), construction of the buildout and long-term operation of renewable energy facilities may create adverse community-scale effects depending on whether the buildout is located in a setting of disadvantaged communities. The impacts common to all portfolios and the incremental buildout to meet the RPS by 2030 are discussed in Section 4.1.
- Second, because regionalization is likely to cause changes in the operation of the existing system of generation, and because power production may consume water and create emissions of air pollutants, the regional differences in power production are reviewed for adverse effects in areas of disadvantaged communities. The operational impacts are summarized in Section 4.2.

The potential to increase the pollution burden in disadvantaged communities could occur:

- If the locations of the incremental renewable energy buildout shift to identified disadvantaged communities under regionalization.
- If the location of an adverse environmental impact shifts to an area that predominately includes disadvantaged communities under regionalization.

Because the specific locations of community-scale impacts depend on the locations of actual individual future projects, these impacts cannot be determined with certainty at this time. However, the discussion below presents the typical localized environmental impacts resulting from renewable energy and utility-scale transmission project construction and operation that could affect areas of disadvantaged communities.

Figures 4, 5, and 6 illustrate the relative capacity that would be added by each buildout and the locations of disadvantaged communities in their resource zones.

Figure 4. Disadvantaged Communities Focus Map 1

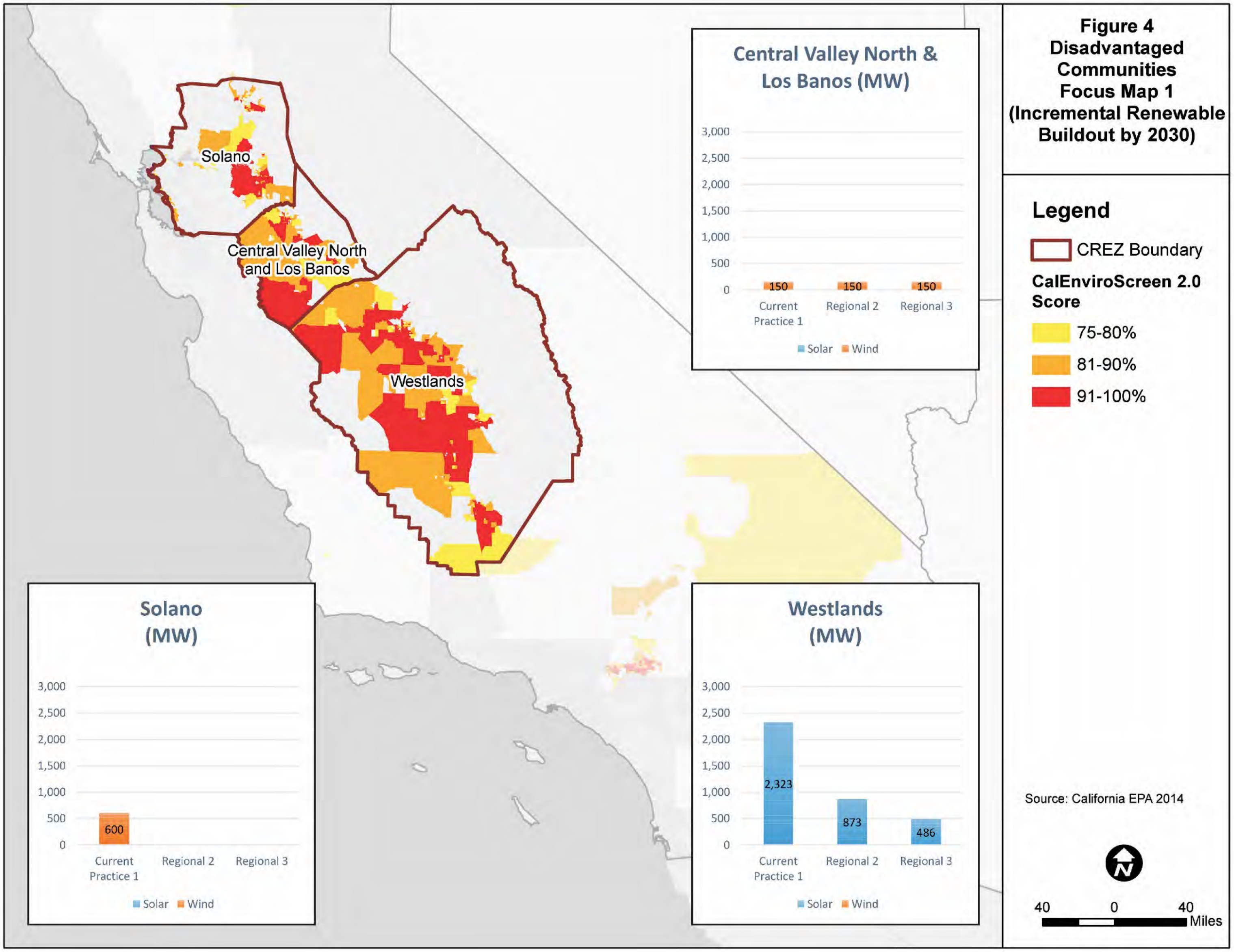


Figure 5. Disadvantaged Communities Focus Map 2

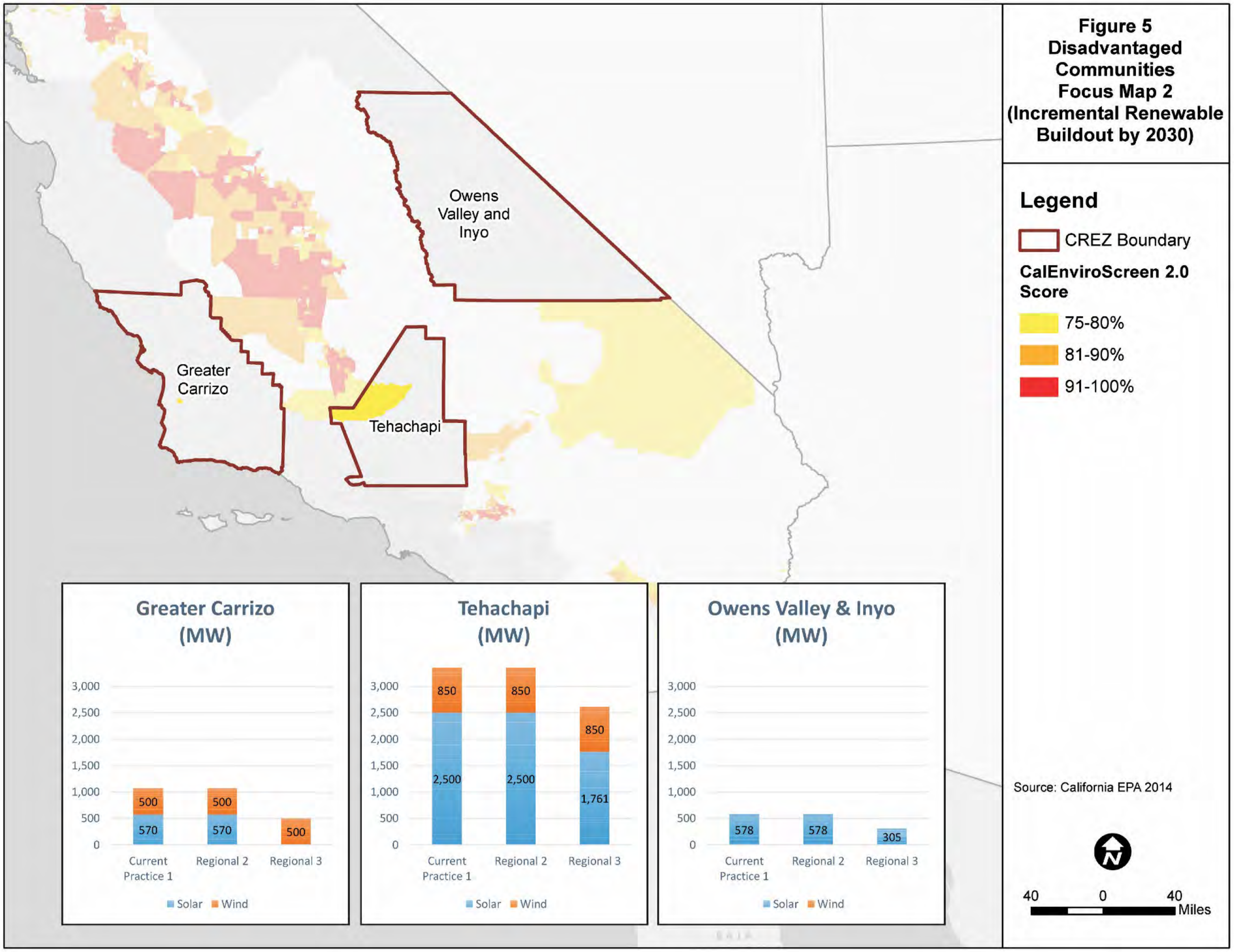
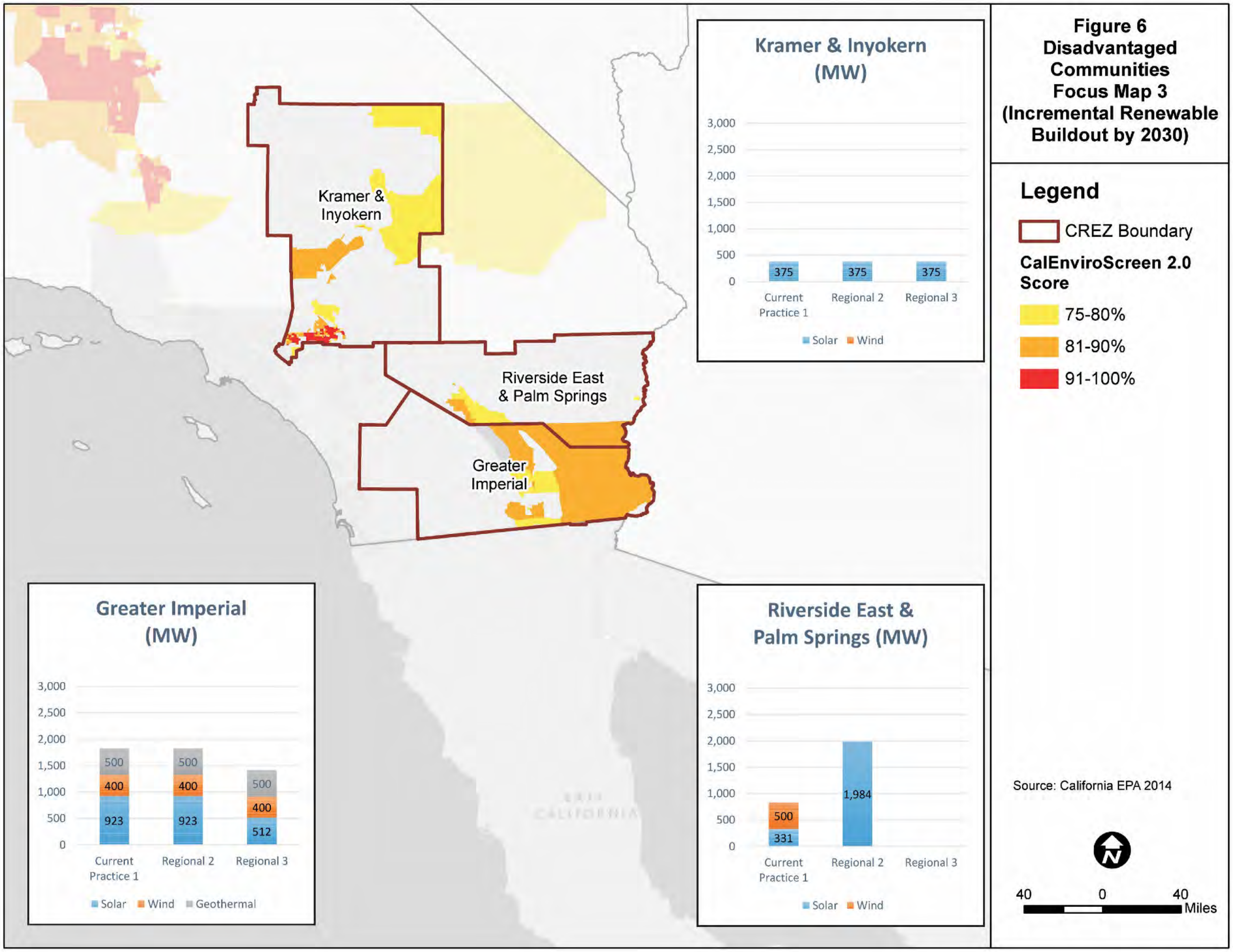


Figure 6. Disadvantaged Communities Focus Map 3



4.1 Typical Community-Scale Impacts of the Buildouts

This study of environmental impacts in disadvantaged communities considers how regionalization may influence the preferred locations for the incremental renewable energy buildout and how those locations may relate to disadvantaged communities. Because construction of the buildout and long-term operation of renewable energy facilities may create adverse community-scale effects depending on whether the buildout is located in a setting of disadvantaged communities, this section describes the environmental impacts that would be common across the scenarios as a result of the incremental buildout by 2030.

Note that the SB 350 environmental study is not site-specific and does not reflect or represent a siting study for any particular planned or conceptual construction project. Although environmental impacts are described in general, project-specific impacts can typically be managed through best management practices and mitigation, through the siting processes and with review by the siting authorities.

Construction Impacts in General

Common types of environmental impacts resulting from construction of large-scale renewable energy facilities or transmission infrastructure expansions could occur within disadvantaged communities depending on project-specific circumstances. These types of construction activities are similar for the incremental renewable energy buildouts in all scenarios. Therefore, the discussions below describe the types of impacts that could occur on a community-scale for construction of renewable energy facilities and associated transmission interconnections, with technology-specific unique or distinguishing aspects mentioned. Because construction is limited in duration, the potential to create construction-related environmental impacts essentially ends with the end of construction. These construction-phase impacts can typically be managed by siting authorities through best management practices and mitigation.

General types of construction impacts include:

- **Air Quality:** The typical construction-related air quality impacts are caused by fugitive dust from grading, vehicles driving on unpaved surfaces or roadways, and emissions from heavy-duty construction equipment and vehicles carrying construction materials and workers. These emissions occur during site development and preparation, transmission line development, and from building and roadway construction. The types of emissions would be the same for each renewable energy technology.

  Construction activities may include mobilization, land clearing, earth moving, road construction, ground excavation, drilling and blasting, foundation construction, and installation activities. Heavy equipment used during site preparation would also include bulldozers, scrapers, trucks, cranes, rock drills, and possibly blasting equipment. These activities and equipment use would temporarily increase the amounts of particulate matter, including PM2.5, and precursors to particulate matter. Similarly, increased amounts of ozone precursors (volatile organic compounds [VOCs] and nitrogen oxides [NOx]) would occur from engine exhaust emissions, further exacerbating ozone nonattainment conditions.

  Increased health risks would result for people exposed to excessive concentrations of dust, potentially including valley fever, and hazardous or toxic air pollutants routinely caused by gasoline and diesel-powered equipment. Diesel particulate matter is designated as a toxic air contaminant in California. High levels of construction-phase emissions can exacerbate regional nonattainment conditions or expose sensitive receptors to substantial concentrations of hazardous or toxic air pollutants during project construction. Assessing the air quality impacts from construction emissions usually involves project-specific quantification of air pollutants emitted by construction activities for each phase of site development for each project.

- **Noise:** Temporary construction noise typically occurs intermittently and varies depending on the nature or phase of construction (e.g., demolition and land clearing, grading and excavation, erection). Construction noise is localized and can create short term nuisances from the activities such as site preparation, trucks hauling material, concrete pouring, use of power tools, etc. Noise from heavy-duty equipment, including earthmovers, material handlers, and portable generators, can reach high levels for brief periods. Temporary noise impacts would be similar for all renewable energy types.
- **Traffic:** During construction of renewable energy and transmission facilities, workers commute to the project site over local roads, and shipments to and from the facilities are usually by truck. Rail transport to the closest intermodal facility for materials could also be used. The movement of persons, equipment, and materials to project sites during construction could cause a temporary decrease in the performance levels on local primary and secondary road networks.

  Wind turbine components are delivered in oversized or overweight loads, such as the rotor blades, which may be delivered as one piece, and nacelles, which contain massive drivetrain components and generators. Transporting these components typically requires permitting for movement of oversized loads and temporary road closures. In addition, the main cranes required for tower and turbine assembly typically also require a number of oversized or overweight shipments. The wind energy transportation requirements may cause temporary disruptions in surrounding communities.

Operational Impacts in General

General types of impacts that occur over the long-term operation of large-scale renewable energy facilities or transmission infrastructure expansions include:

- **Aesthetics:** The operation and maintenance of renewable energy facilities and associated transmission lines, roads, and rights-of-way would have long-term adverse visual effects due to visual intrusion of facilities introduced into landscapes. Among these are land scarring, introduction of structural contrast and industrial elements into natural settings, view blockage, and skylining (silhouetting of elements against the sky). Another impact common to renewable energy facilities is dust generated by vehicle movement within a site or along a right-of-way or access road. Without proper disturbed soil management strategies, wind can mobilize dust from project sites and create visible plumes or clouds of dust.

  Solar projects introduce geometric shapes and repeated linear elements into the visual environment. Utility-scale projects have a large footprint and are usually in open and relatively flat settings with little to no vegetative or other screening. Solar energy projects also vary in their visual impacts because of the different technologies employed. Furthermore, the level of impact can vary between urban and rural landscapes. While more viewers in urban areas see solar installations, the installations will typically create greater visual contrast in rural areas. Under certain viewing conditions, solar installations give rise to specular reflections (glint and glare) visible to stationary or moving observers from long distances, and can constitute a major source of visual impact. Glint and glare from photovoltaic facilities are typically lower than solar concentrating facilities using trough, power tower, and solar dish technologies that employ mirrors and lenses.

  Wind energy projects are usually highly visible because the vertical towers and rotating turbine blades need unobstructed access to the wind resource, usually best in areas where there are few, if any, comparable tall structures in strongly horizontal landscapes. Visual impacts associated with the operation and maintenance of geothermal energy projects largely derive from ground disturbance and the visibility of industrial power plants, wells, pipes, steam plumes, and transmission lines.

- **Air Quality:** Emissions are caused by operations and maintenance activities of the renewable energy buildout, through routine upkeep of the sites, security patrols, use of emergency generators, employee transportation, and vegetation removal. Dust emissions come from ground disturbance from access and spur road maintenance. Products of combustion are emitted by the use of natural gas, auxiliary heating of solar thermal technologies, and by the use of gasoline and diesel fuel for facility maintenance activities. Backup power supplies or fire water-pumping engines could also generate emissions if long-term operations and maintenance include diesel-powered emergency-use engines at substations and renewable energy facility sites.

  Geothermal well-venting emissions include hydrogen sulfide (H_2S), carbon dioxide (CO_2), mercury, arsenic, and boron (when these compounds are contained in geothermal steam). H_2S is generally the primary pollutant of concern, and typically an air monitoring system is installed during geothermal field development. People exposed to high concentrations of H_2S or other hazardous or toxic air pollutants could experience adverse health effects, including cancer and non-cancer health risks; even at very low concentrations.

- **Public Access:** The development of large undisturbed areas for renewable energy installations can result in long-term impacts by limiting the access to previously accessible public lands or limiting other development of these lands. Such limitations could both directly and indirectly affect local economies and populations, but effects depend on site-specific existing and potential use. Closures of open public lands may affect motorized access to historically available recreational destinations and areas and reduce new access to individual, commercial, and motor-dependent recreational destinations. Demand for motorized access, particularly in public backcountry areas on federal lands, may put additional pressure on the remaining backcountry areas to meet that demand. Such restrictions could also limit access to lands that could otherwise be used for farming or for other economic purposes, and lands with cultural, tribal, or religious significance.

- **Water Quality and Supply:** Operations and maintenance activities for the renewable energy buildout can introduce a small risk of groundwater contamination, interference with recharge, depletion of groundwater levels and storage, and other water quality impacts. Improper handling or containment of hazardous materials could disperse contaminants to soil and impact groundwater quality. Evaporation ponds may be required as part of cooling structures, and these may leak and possibly discharge brines and other contaminants to shallow groundwater. Groundwater consumption affects groundwater levels and storage volumes. Solar thermal and geothermal plant operations may require substantial amounts of water for steam generation, cooling, and other industrial processes; much less water is used for maintenance of photovoltaic facilities that may require cleaning. Similarly, the water used for operations and maintenance of wind energy systems would be limited to smaller volumes for operation, maintenance, cleaning activities, and possibly dust suppression.

- **Public Services:** Deployment of utility-scale renewable energy facilities can introduce new demands on the local public services of the host community and may also have implications in terms of local tax revenue. The need for new or expanded public services, including applicable performance objectives and service ratios, is strongly influenced by population levels. While development of renewable energy projects and transmission infrastructure could generate growth from new employment, in most areas, any population increase from new workers would likely be nominal compared to the existing population currently served by local public service providers, (e.g., fire, police, and schools). It should be noted that renewable projects sited on federal land may not generate property tax benefits to local communities when compared to those sited under a local jurisdiction.

Environmental Benefits

The construction and operation of large-scale renewable energy facilities may also provide environmental benefits, which can reduce preexisting burdens within disadvantaged communities. In general, the greatest beneficial impacts result from renewable energy facilities leading to a reduction or avoidance of the natural resources used by or emitted as a result of operating conventional power plants.

Regulatory precedent for identifying the environmental benefits of California's renewable energy buildout appears in SB X1-2, signed in 2011, that was reiterated in SB 350. According to SB X1-2 [specifically, in Pub. Util. Code § 399.13(a)(7)], procurement of renewable energy should give preference "to renewable energy projects that provide environmental and economic benefits to communities afflicted with poverty or high unemployment, or that suffer from high emission levels of toxic air contaminants, criteria air pollutants, and greenhouse gases."

General types of beneficial impacts that could occur from the incremental renewable energy buildout include:

- **Air Quality:** Producing electricity from the renewable energy resources displaces the need to produce electricity and the associated air contaminants from conventional fossil fuel-fired power generation facilities. While such benefits would be felt at a regional or statewide level, disadvantaged communities would be among those realizing reduced burden at the local level due to decreased emissions when compared to conventional power generation facilities.
- **Land Use:** While the deployment of large-scale renewable energy development is presumed to occur on land that is vacant or largely undeveloped, open land may be used that is previously disturbed. Rangeland and certain types of agriculture can be collocated with the wind buildout, and suitable solar buildout locations may include brownfield sites, where other development options are limited. In some instances, solar photovoltaic energy installations may be sited on degraded lands (landfills, brownfield sites, etc.), or co-located with other industrial uses. While these projects may introduce land scarring and some structural contrast and industrial elements, in developed areas, they can often be visually screened due to their relatively low profile (compared to wind energy or conventional power facilities). The siting of solar photovoltaic facilities on degraded lands could be considered a community benefit, as installations may: improve the value and aesthetics of underused sites; provide a buffer against land use incompatibilities in densely developed areas; and/or allow a fuller realization of value of other undisturbed or open lands with resource potential. Using degraded lands to site renewable energy can allow other lands with higher land use, resource, and visual potential to be preserved.
- **Water Supply:** The renewable energy buildout requires little water for operation. The buildout scenarios help to reduce the need for new conventional power plants. This could lead to a decrease in the amount of future water needed for electrical generation, resulting in reduced groundwater consumption, reclaimed water use (that could be utilized for agricultural use or groundwater recharge), and potable water use. While such benefits would be felt at a regional or statewide level, local disadvantaged communities would be among those benefiting from decreased water use by conventional power generation facilities because the water would remain available for agricultural and customer uses.
- **Socioeconomics:** The beneficial economic and tax base impacts in disadvantaged communities that occur during construction and operation of the renewable energy buildout are identified in Section 5, prepared by Berkeley Economic Advising and Research (BEAR).

4.2 Environmental Impacts of Regionalization in Disadvantaged Communities

The Environmental Study (Volume IX) describes the baseline environmental conditions and potential impacts across the entire study region including areas outside of disadvantaged communities. The study includes in-depth analysis of the setting and impacts to land use, biological resources, water, and air emissions. Our findings in the SB 350 environmental study reflect inherent tradeoffs to in-state versus out-of-state renewable development. From the methodologies and assumptions of the environmental study, this section describes the impacts on California's disadvantaged communities.

Our study methodology includes an estimate how power plants operate on a generating unit-specific basis, for all units in the WECC-wide fleet, but our presentation shows aggregated results for each geographical location. The presentation of operational impacts relies directly on the on the Production Cost Analysis (Volume V). However, there are some limitations to interpreting absolute levels of unit-specific operations and the subsequent air emissions from the production cost model, since the model does not mimic the precise accounting of emissions rates or air pollutant control equipment use.

Other important limitations and considerations relevant to the air emissions analysis include:

- The SB 350 study does not include an ambient air quality impact analysis of ambient ozone or PM2.5 levels or other air pollutant concentrations.
- The production cost analysis conducted for the SB 350 study was employed at a regional scale, with assumptions about how power may be traded between California and the rest of the WECC under different market configurations.
- The production cost analysis provides a potential dispatch profile for the generators in the region with a given set of assumptions about the power plants.
- The SB 350 study involves an analysis of greenhouse gases and other air pollutant emissions changes of the power sector. The study does not make any assumptions or analyze emissions from other categories of sources in California, and it does not analyze the potential reactions from other sectors of the economy when emissions from the power sector change.
- For the purposes of the Disadvantaged Communities (DAC) analysis, the regional modeling output for generators in specific communities was examined at the air basin level. Emissions are summed up by air basins. The DAC results are based on these basin-wide totals, not emissions from specific power plants in or near DACs.
- The regional modeling utilizes general characteristics of each generator type in the state, not actual generator specific data, which most of the time are proprietary to the owner of the generator. Thus, there are limits to how well a regional model can discern specific activities at specific generators when general characteristics about the generators are used in the simulations.
- Emissions are presented for the annual periods of the two study years: the near-term (2020), and the longer-term (2030), with separate presentation of average emissions rates within the three months of the summer season, for consideration of the effects on ozone levels.
- The results do not use any generator specific permit limits, as those are specific to each source in each air district. Note that emissions changes from the fleet of existing stationary sources are required to be well within the limits allowed by the permitting authorities, depending on the permitted terms that apply to each generating unit. This study assumes that no existing source would need to change its permitted terms of operation. New fossil-fueled stationary sources are not contemplated by this study.

Environmental Impacts in Disadvantaged Communities in 2020

Of the five primary scenarios of the SB 350 studies, the near-term 2020 scenarios include no incremental buildout of California's renewable energy portfolio beyond what is already planned to meet the state's 33% RPS by 2020. As a result, limited regionalization in 2020 (CAISO + PAC) involves no incremental construction activities and no construction-related impacts to the environment. The 2020 scenarios may cause changes in the operation of the existing system of generation; the impacts associated with those changes are described in the following paragraphs and tables.

Operational Impacts of Limited Regionalization in 2020

The modeling and production cost simulation of limited regionalization scenarios reveal how operation of the existing system of generation may change. Changes in power production will result in changes in the consumption of water and creation of emissions of air pollutants. The production cost simulation for 2020 Current Practice versus the CAISO + PAC scenario shows that the operational changes in California's existing system of generation and primarily the fleet of natural gas fired power plants would be negligible in a limited regional market as compared with the 2020 Current Practice scenario. On average, power plants across California would operate slightly less, and power plants outside of California would operate slightly more (Production Cost Analysis, Volume V).

Some components of the existing system of generation are located in disadvantaged communities, and reducing the use of fossil fuel burned at these facilities will slightly reduce the baseline pollution burden of disadvantaged communities. The 2020 results for water use and emissions are summarized as follows:

- By achieving a small decrease in fossil fuel use for electricity production in California, regionalization results in a small but beneficial decrease in the electric power sector's use of water resources (water used by electricity generation decreases by 1.5% statewide). This may reduce the baseline stress on water bodies and water systems in disadvantaged communities.
- Limited regionalization in 2020 reduces emissions of air pollutant emissions in California on average (decrease 0.5% to 1.2% statewide, depending on pollutant), depending on the dispatch of the fleet of natural gas-fired power plants. Certain air basins that are of the greatest concern for disadvantaged communities would experience slight increases in PM2.5 and SO_2 emissions (increase 0.4% in San Joaquin Valley and South Coast air basins and increase 0.7% in Mojave Desert air basin), but the San Joaquin Valley and South Coast air basins would experience greater benefits through decreases in NOx, which is a precursor to both ozone and PM2.5.

The Environmental Study (Volume IX) shows these benefits of a limited regionalization in 2020 in greater detail. In conclusion, the limited regionalization causes no adverse environmental impact in California's disadvantaged communities and may result in small but beneficial environmental effects by generally reducing water use and NOx emissions. Modeling of the 2020 CAISO + PAC scenario indicates that the San Joaquin Valley and South Coast air basins could slightly increase PM2.5 and SO_2 emissions due to natural gas-fired power plants, but these changes would occur in conjunction with a NOx decrease.

Environmental Impacts in Disadvantaged Communities in 2030

Each scenario of regionalization in 2030 requires an incremental buildout of new solar, wind, geothermal and other energy facilities that will create environmental impacts in the vicinity of the renewable energy buildout. The locations of the incremental buildout in all scenarios are illustrated in Figures 4, 5, and 6. Incremental Buildout for Current Practice 1 by 2030

The buildout for Current Practice 1 by 2030 emphasizes incrementally more new solar generation in the Tehachapi, Westlands, and Greater Imperial CREZs. New wind power would predominately occur in Tehachapi and Solano, and new geothermal would be in Greater Imperial (in all scenarios). The Westlands CREZ in the San Joaquin Valley is one area of greatest concern for impacts to disadvantaged communities due to the high baseline level of pollution burden (e.g., poor air quality) and concentrations of sensitive populations (i.e., people with low incomes and high unemployment). The Central Valley North & Los Banos, Kramer & Inyokern, and Greater Imperial CREZs also contain high percentages of population in disadvantaged communities.

The environmental impacts of the incremental renewable energy buildout in disadvantaged communities include: the construction-related dust and equipment exhaust emissions, along with noise and traffic; the general impacts of long-term operation of renewable energy facilities, including the changes in aesthetics; and benefits that depend on site-specific circumstances. These are impacts common to all portfolios (Section 4.1).

The Current Practice 1 buildout by 2030 involves seven different solar resource areas and six different wind resource areas in California, including four areas that have a high level of concern for impacts to disadvantaged communities (Westlands; Central Valley North & Los Banos; Kramer & Inyokern; Greater Imperial). The disadvantaged communities in these areas are the most likely to experience some construction-related community-scale environmental impacts. Although the Tehachapi, Westlands, and Greater Imperial CREZs are emphasized in the renewable energy buildout in Current Practice 1, the Tehachapi CREZ does not contain high percentages of population in disadvantaged communities.

The Regional 2 buildout by 2030 emphasizes solar in the Riverside East & Palm Springs, Tehachapi, and Greater Imperial CREZs. These areas have lower fractions of population within disadvantaged communities than the Westlands CREZ, which would not be emphasized in this buildout. The environmental impacts of the incremental renewable energy buildout in disadvantaged communities include the impacts common to all portfolios (Section 4.1).

The Regional 2 buildout by 2030 occurs across a smaller number of resource areas in California, when compared with Current Practice 1, although two buildout areas have a high level of concern for impacts to disadvantaged communities (Kramer & Inyokern; Greater Imperial). In contrast with scenario Current Practice 1, which includes an emphasis on Westlands, the Tehachapi and Riverside East & Palm Springs CREZs emphasized in Regional 2 do not contain high percentages of population in disadvantaged communities. Accordingly, Regional 2 would be likely to avoid some construction-related community-scale environmental impacts in disadvantaged communities.
Incremental Buildout for Regional 3 by 2030

The Regional 3 buildout by 2030 includes the lowest level of development overall among all of the scenarios, and it has the lowest incremental capacity of additional renewable energy resources inside California. The environmental impacts of the incremental renewable energy buildout in disadvantaged communities include the impacts common to all portfolios (Section 4.1).

The Regional 3 buildout by 2030 occurs at a much lower intensity in California than in other scenarios, and only five different solar resource areas and four different wind resource areas in California are included. As with other scenarios, two buildout areas have a high level of concern for impacts to disadvantaged communities (Kramer & Inyokern; Greater Imperial). By emphasizing renewable energy resources outside of California, Regional 3 would be most likely to avoid construction-related community-scale environmental impacts in the state's disadvantaged communities.

Operational Impacts of Regionalization in 2030

The 2030 scenarios reveal that regionalization generally reduces the need to operate power plants inside California, and this reduces the consumption of water and emissions of air pollutants. The production cost simulation for 2030 Current Practice 1 versus the two regionalization scenarios shows that greater levels of reductions in use of California's existing system of generation and primarily the fleet of natural gas fired power plants occur with increasing regionalization. On average, power plants across California and also outside California would operate slightly less as regionalization decreases the use of fossil fuels (Production Cost Analysis, Volume V).

Portions of the existing system of generation are located in disadvantaged communities, and reducing the use of fossil fuel burned at these facilities will slightly reduce the baseline pollution burden of disadvantaged communities. The 2030 results for water use and emissions are summarized as follows:

- Scenarios Regional 2 and Regional 3 decrease the amount of water used by power plants statewide, when compared with Current Practice 1. By decreasing fossil fuel use for electricity production in California, regionalization results in a beneficial decrease in the electric power sector's use of water resources (decrease by 4.0% to 9.7% statewide). This may reduce the baseline stress on water bodies and water systems in disadvantaged communities.
- Scenarios Regional 2 and Regional 3 decrease the emissions of NOx, PM2.5, and SO_2 from power plants statewide and in the air basins of greatest concern for disadvantaged communities, depending on the dispatch of the fleet of natural gas-fired power plants. The San Joaquin Valley, South Coast, Mojave Desert, and Salton Sea air basins experience decreased emissions of all pollutants when compared with Current Practice 1. Certain other locations that are not the areas of greatest concern for disadvantaged communities would experience slight increases in PM2.5 and SO_2 emissions, although these other locations would experience greater benefits through decreases in NOx.

The Environmental Study (Volume IX) shows these benefits of 2030 regionalization in greater detail. In conclusion, the 2030 regionalization causes no adverse environmental impact in California's disadvantaged communities. The expanded scenario of Regional 3 shows the most beneficial environmental effects by achieving the greatest reductions in water use and emissions.

Review of Operational Water Use Impacts and Emissions Changes

This section reviews the results of the SB 350 Environmental Study to illustrate the operational changes in the existing system of generation. Because power production may consume water and create emissions of air pollutants, these results are summarized here based on the Environmental Study (Volume IX).

Table 10 summarizes how regionalization changes statewide water use for electricity production. [See Environmental Study (Volume IX)]

Table 10. Water Use for Electricity Production in California

Statewide	2020 CAISO + PAC Relative to Current Practice (% water use)	2030 Regional 2 Relative to Current Practice Scenario 1 (% water use)	2030 Regional 3 Relative to Current Practice Scenario 1 (% water use)
Difference Statewide Water Consumption (all generating technologies, excluding geothermal)	–1.5%	–4.0%	–9.7%

Source: Environmental Study (Volume IX).

Tables 11, 12, and 13 summarize the relative changes in criteria air pollutant emissions from the existing system of natural gas fired generating units in California's air basins, listed in the order of highest to lowest percentage of population in disadvantaged communities. [See Environmental Study (Volume IX)].

Table 11. NOx Emissions Changes, California Natural Gas Fleet by Air Basin

Air Basin	2020 CAISO + PAC Relative to Current Practice (% NOx)	2030 Regional 2 Relative to Current Practice Scenario 1 (% NOx)	2030 Regional 3 Relative to Current Practice Scenario 1 (% NOx)
San Joaquin Valley	**–0.5%**	**–3.3%**	**–5.8%**
South Coast	**–1.4%**	**–9.2%**	**–12.8%**
Salton Sea	**–5.1%**	**–99.4%**	**–99.4%**
North Central Coast	–0.6%	–2.5%	–2.1%
Mojave Desert	0.2%	–15.6%	–26.8%
Sacramento Valley	–2.6%	–9.7%	–16.2%
San Francisco Bay	–1.7%	–3.0%	–8.7%
South Central Coast	–0.1%	–0.3%	–0.3%
San Diego County	–6.8%	–24.6%	–26.9%
North Coast	–0.3%	0.3%	–1.0%
Difference Statewide NOx (California natural gas fleet)	**–1.2%**	**–6.5%**	**–10.2%**

Note: Bold indicates an air basin of greatest concern for disadvantaged communities.
Source: Environmental Study (Volume IX).

Table 12. PM2.5 Emissions Changes, California Natural Gas Fleet by Air Basin

Air Basin	2020 CAISO + PAC Relative to Current Practice (% PM2.5)	2030 Regional 2 Relative to Current Practice Scenario 1 (% PM2.5)	2030 Regional 3 Relative to Current Practice Scenario 1 (% PM2.5)
San Joaquin Valley	**0.4%**	**–2.0%**	**–3.8%**
South Coast	**0.4%**	**–9.7%**	**–12.2%**
Salton Sea	**–1.4%**	**–99.2%**	**–98.8%**
North Central Coast	–0.7%	0.3%	2.9%
Mojave Desert	0.7%	–14.2%	–23.3%
Sacramento Valley	–1.3%	–8.5%	–12.6%
San Francisco Bay	–1.4%	4.4%	0.1%
South Central Coast	0.0%	0.0%	0.0%
San Diego County	–6.4%	–17.3%	–18.9%
North Coast	10.0%	–0.9%	–2.6%
Difference Statewide PM2.5 (California natural gas fleet)	**–0.5%**	**–4.0%**	**–6.8%**

Note: Bold indicates an air basin of greatest concern for disadvantaged communities.
Source: Environmental Study (Volume IX).

Table 13. SO_2 Emissions Changes, California Natural Gas Fleet by Air Basin

Air Basin	2020 CAISO + PAC Relative to Current Practice (% SO_2)	2030 Regional 2 Relative to Current Practice Scenario 1 (% SO_2)	2030 Regional 3 Relative to Current Practice Scenario 1 (% SO_2)
San Joaquin Valley	**0.3%**	**–1.9%**	**–3.8%**
South Coast	**0.4%**	**–9.7%**	**–12.2%**
Salton Sea	**–1.4%**	**–99.2%**	**–98.8%**
North Central Coast	–0.7%	0.3%	2.9%
Mojave Desert	0.7%	–14.2%	–23.3%
Sacramento Valley	–1.3%	–8.6%	–12.7%
San Francisco Bay	–1.4%	4.5%	0.1%
South Central Coast	0.0%	0.0%	0.0%
San Diego County	–6.4%	–17.3%	–18.9%
North Coast	10.0%	–0.9%	–2.6%
Difference Statewide SO_2 (California natural gas fleet)	**–0.5%**	**–4.0%**	**–6.8%**

Note: **Bold** indicates an air basin of greatest concern for disadvantaged communities.
Source: Environmental Study (Volume IX).

Sensitivity Analysis

As with Current Practice Scenario 1, the Sensitivity 1B buildout by 2030 emphasizes a renewable energy procurement strategy that is in-state focused. The primary CREZs are Riverside East & Palm Springs, Tehachapi, and Greater Imperial CREZs, along with the Westlands CREZ to a lesser extent than Current Practice 1. The environmental impacts of the incremental renewable energy buildout in disadvantaged communities include the impacts common to all portfolios (Section 4.1).

The buildout for Sensitivity 1B, like Current Practice 1, involves seven different solar resource areas and six different wind resource areas in California, including four areas that have a high level of concern for impacts to disadvantaged communities (Westlands; Central Valley North & Los Banos; Kramer & Inyokern; Greater Imperial). However, the portfolio distribution of renewable energy buildout in Sensitivity 1B emphasizes the Tehachapi and Riverside East & Palm Springs CREZs more than Westlands. In contrast with scenario Current Practice 1, which includes an emphasis on Westlands, the Tehachapi and Riverside East & Palm Springs CREZs emphasized in Sensitivity 1B do not contain high percentages of population in disadvantaged communities.

Emissions of criteria air pollutants from California's natural gas-fired fleet of power plants are quantified in the Environmental Study (Volume IX) for two sensitivities analyses. Under the sensitivity analyses in comparison with Current Practice Scenario 1, the following would occur inside California:

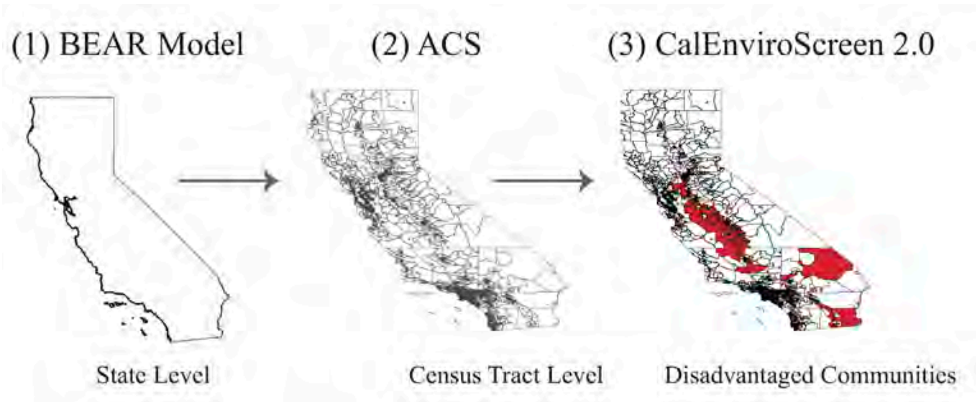
- Emissions in California would increase slightly (1% to 2%) in Sensitivity 1B, as operation of California's natural gas fleet would slightly increase, and this would slightly increase the emissions occurring within the air basins of greatest concern to disadvantaged communities, as illustrated in the Environmental Study (Volume IX).
- 2030 Scenario 3 without renewables beyond RPS similarly results in a slight increase in operation of California's natural gas–fired fleet, but this scenario would avoid some of the excess startup emissions of NOx that would occur under the 2030 Current Practice Scenario 1.

5. Economic Impact in Disadvantaged Communities

5.1 Methodology for Determining Economic Impacts in Disadvantaged Communities

The process of estimating economic impacts on disadvantaged communities is carried out in several steps. This assessment technique leverages available data to downscale state level estimates to the census tract level conforming to disadvantaged community definitions. Detailed descriptions of each step are presented below.

Figure 7. Downscaling Results to Identify Impacts in Disadvantaged Communities



Step 1 – Census Tracts

State-wide results produced by the BEAR model are first disaggregated across individual census tracts. Complete data on economic activities are not available at the census tract level, so it is not possible to build Social Accounting Matrices (SAMs) for individual census tracts. Instead, we construct census tract shares of state level economic activity for select variables of interest, i.e. income by decile, sector of employment, and occupation. Census tract estimates of these values are derived from the American Communities Survey (ACS)[4] using the 5-year averages covering the period 2008-2013.[5]

The ACS reports income by tax bracket, however, the BEAR model estimates impacts on income by decile. Consequently, tax brackets were converted to income deciles according to the share of overlap in each category. The number of households in each income decile was calculated for each census tract. State level income estimates were then shared out across census tracts according to the number of households in each income decile in each census tract.

The income estimates are presented as community income per household in 2030. Department of Finance estimates of population growth by county were used to estimate the *number of households* in each census tract to 2030. Population growth within counties is assumed to be constant across census tracts and household size is assumed to remain constant, so population growth is equivalent to growth in number of households. With these assumptions, household growth rates are calculated for each census tract and applied to the current number of households in order to forecast the number of households in each census tract in 2030.

[4] http://factfinder.census.gov/

[5] Base year economic accounts for the BEAR model are calibrated to 2013, the latest year for which complete California official economic statistics are currently available.

Job estimates from the BEAR model measure total Full Time Equivalent (FTE) employment by occupation. Indirect jobs at the state level are calculated by netting out statewide total estimated direct (investment target sector) jobs. Indirect jobs by occupation are then downscaled from state to census tract level according to the number of employees in each occupational category within each census tract. Direct jobs are downscaled from counties to census tracts according to the number of employees in construction-based occupations within each census tract. Direct and indirect jobs are then summed to estimate total jobs in each census tract. This allocation of jobs assumes local recruitment for investments in buildout, as well as local employment in activities responding to increased local demand.

Step 2 – Disadvantaged Community Level

In the final step, CalEnviroScreen 2.0 is used to identify census tracts designated as disadvantaged communities. Disadvantaged communities are defined as census tracts in the top 25th percentile of CES scores. By this definition, there are 2,009 disadvantaged communities (census tracts) in California. Income and job estimates for the subset of census tracts meeting this condition are presented in the results section.

5.2 Economic Impact Results

The economic results begin by decomposing our findings between disadvantaged and non-disadvantaged communities. Given that disadvantaged communities represent a quarter of all census tracts in California, it should be no surprise that the macroeconomic trends previously described also apply for disadvantaged communities. That being said, there are some small differences between impacts on disadvantaged and non- disadvantaged communities and these merit further discussion.

The first such results are illustrated in Figure 8, where we see that comparable job creation trends by type hold for disadvantaged communities versus non-disadvantaged communities. That is, Regional 2 and Regional 3 both produce more jobs in 2030 in disadvantaged communities than Current Practice 1. More robust job growth in the regional scenarios is driven primarily by ratepayer savings. The effect if this induced employment is more readily seen in Figure 9, which illustrates direct comparison between Current Practice 1, Regional 2, and Regional 3. Disadvantaged communities will experience relatively fewer direct jobs from renewable energy projects in either regionalization scenario compared to Current Practice 1, but the more widely distributed household benefits of ratepayer savings induce new job creation across occupations that more than offset this.[6] Similar effects are observed for non-disadvantaged communities, although the effects are less pronounced. This difference in jobs between disadvantaged and non-disadvantaged communities resulting from the renewable buildout depends upon the precise counties in which certain renewable development is expected to occur across the various scenarios. The key takeaway here is that, like the rest of the state, regionalization will not benefit the disadvantaged communities in terms of direct job creation as much as Current Practice, but instead disadvantaged communities will see benefits from the indirect effects from the supply chain or induced effects from lower energy rates.

The distinction can be quite important depending on the nature of jobs created by the renewable energy buildout. While the BEAR assessment identifies employment impacts spatially and in different occupations, we are looking at economic stimulus only in the time period considered (2015-2030). Direct

[6] The Regional 2 scenario actually calls for the largest solar build of all three scenarios and generates the greatest number of solar jobs (29,300 compared to 28,800 in Current Practice 1). However, the total number of additional jobs from the renewable buildout is less in Regional 2 compared to Current Practice 1 since there is considerably less wind energy development in Regional 2.

job stimulus will last as long as the renewable capacity buildout investments, while ratepayer savings can be expected to continue. Many of the investment-driven buildout jobs may be temporary, while those fueled by ratepayer savings will be sustained and support higher long term community income and expenditure. Moreover, the latter are widely dispersed across service sector employment, providing more diverse training and income earning opportunities.

Figure 8.
Job Creation Across Scenarios in Disadvantaged Communities and Non-Disadvantaged Communities

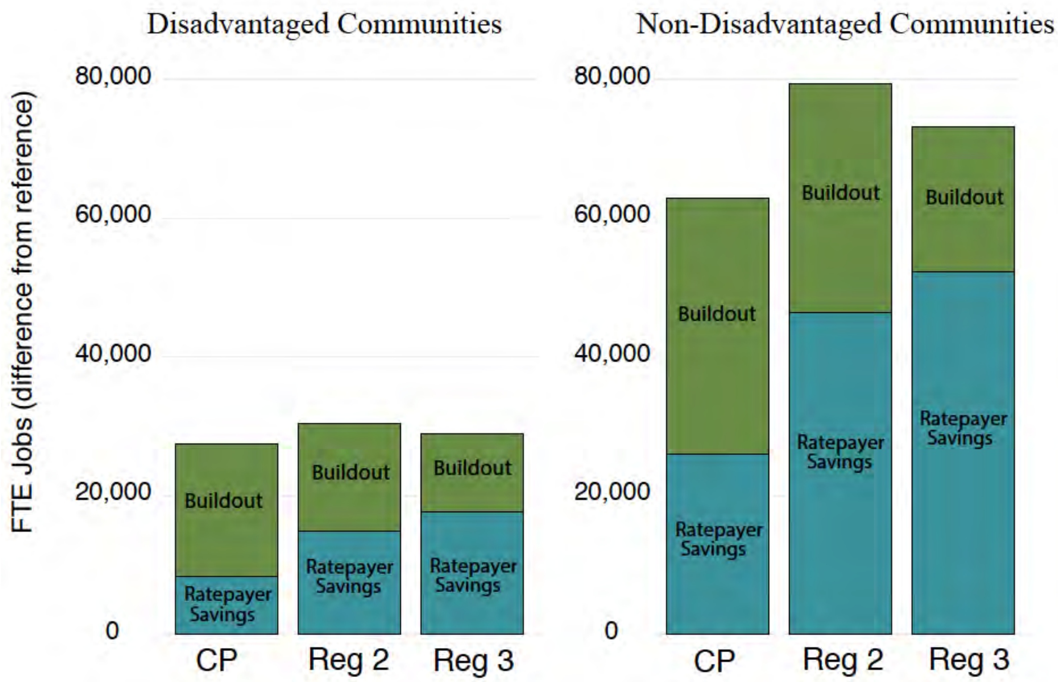
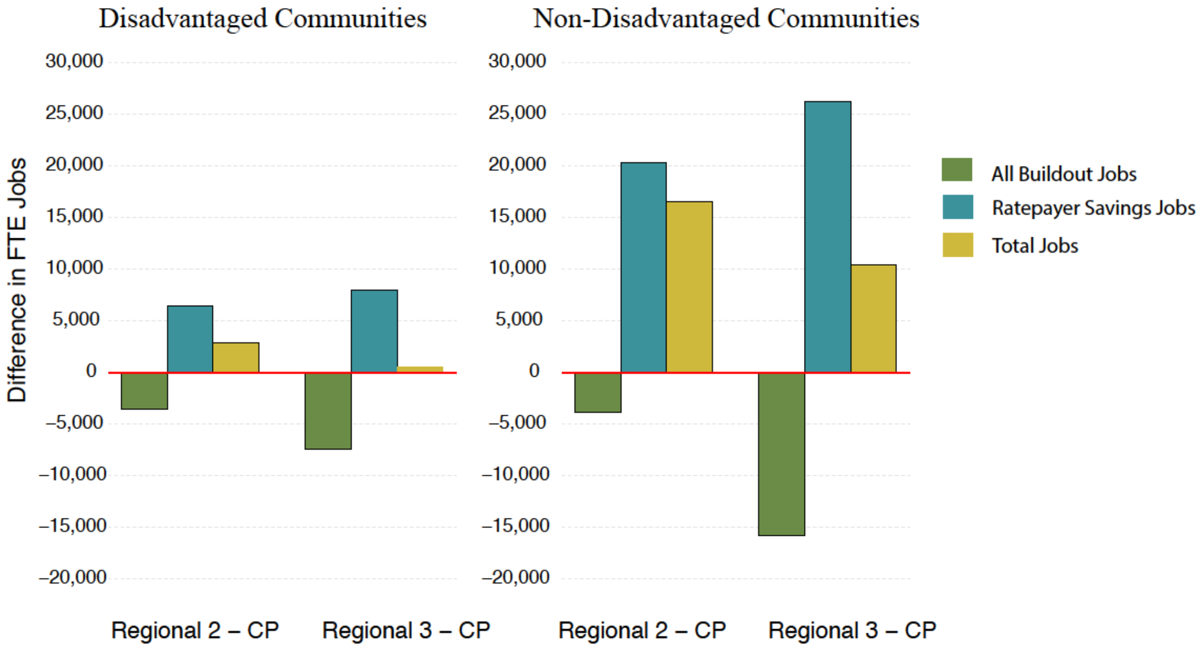
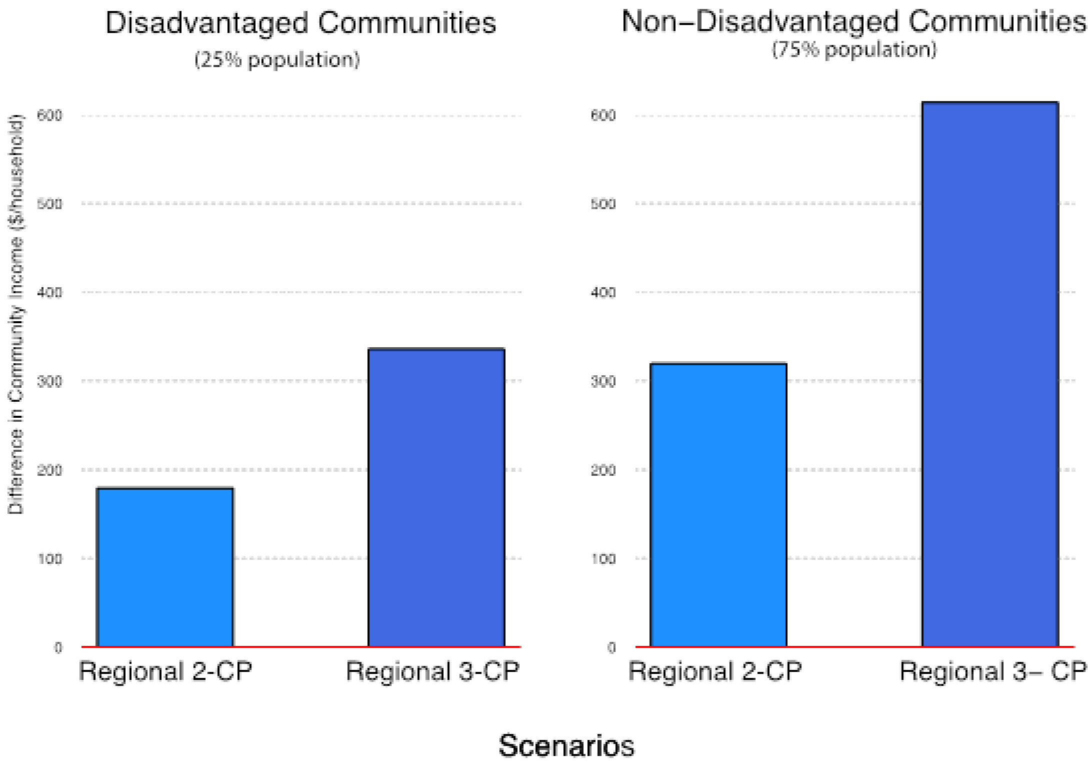


Figure 9.
Difference in Job Creation Across Scenarios in Disadvantaged Communities and Non-Disadvantaged Communities



Income effects also differ between disadvantaged communities and non-disadvantaged communities across scenarios, as shown in Figure 10. Once again the state trend remains the same with Regional 3 posting the largest increase in incomes across both disadvantaged communities and non-disadvantaged communities. Average income gains for disadvantaged communities are lower than non-disadvantaged communities, which is to be expected given that disadvantaged communities have lower average incomes in general. However, disadvantaged communities, which account for 25% of the State's census tracts, receive 31% and 35% of the total income benefits for Regional 2 and Regional 3, respectively. This result suggests that the income benefits accrue to disadvantaged communities in higher proportion than their population share.

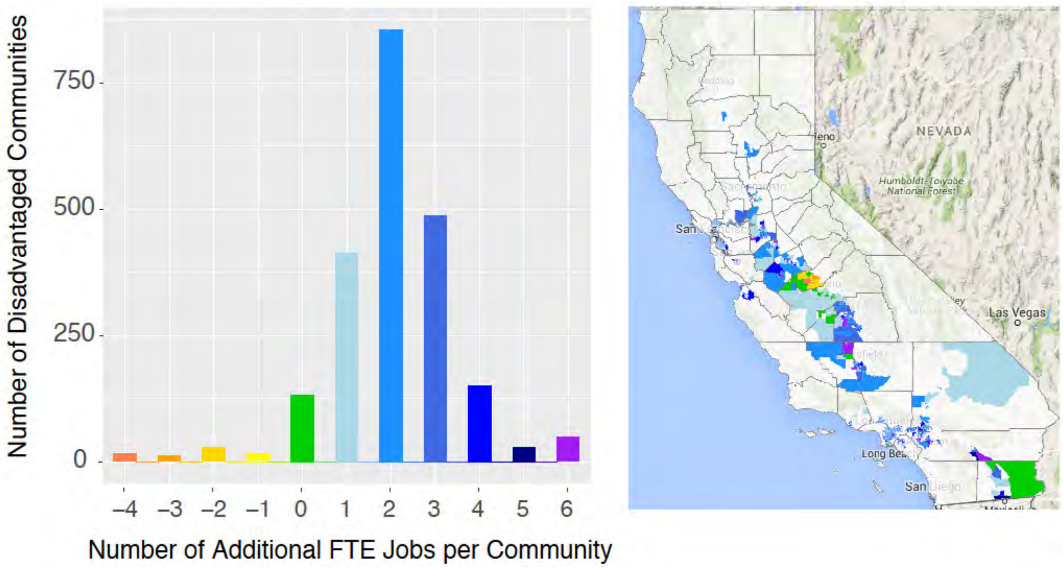
Figure 10.
Difference in Community Income Across Scenarios in Disadvantaged Communities and Non-Disadvantaged Communities



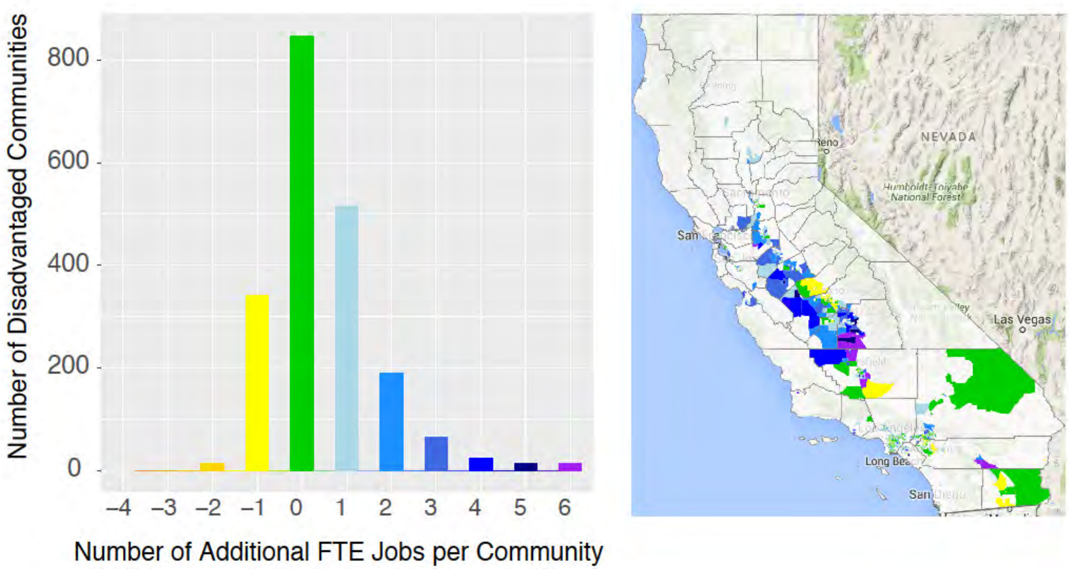
The disadvantaged communities results can also be represented with spatial detail, and the following figures represent the employment and income results for specific disadvantaged community regions. Figure 11 shows job creation results for all disadvantaged communities across California in 2030. The left panels show a count of the number of disadvantaged communities that are expected to have more or less jobs compared to Current Practice, and the right panels show the spatial distribution of employment effects.[7] This figure shows how majority of job creation will be concentrated in communities in the Central Valley and Los Angeles. Comparing Current Practice 1 to Regional 2 and Regional 3, we find that jobs across Regional 2 are more evenly dispersed among disadvantaged communities, while Regional 3 sees a higher concentration in specific disadvantaged communities. Moderately lower job growth is observed in several disadvantaged communities (primarily in the Central Valley) in both regional scenarios, compared to Current Practice 1, although the net employment impact for disadvantaged communities is positive.

[7] The term *community* refers to an individual disadvantaged community census tract.

Figure 11. Difference in FTE Jobs in Disadvantaged Communities
Scenario 2 vs. Current Practice



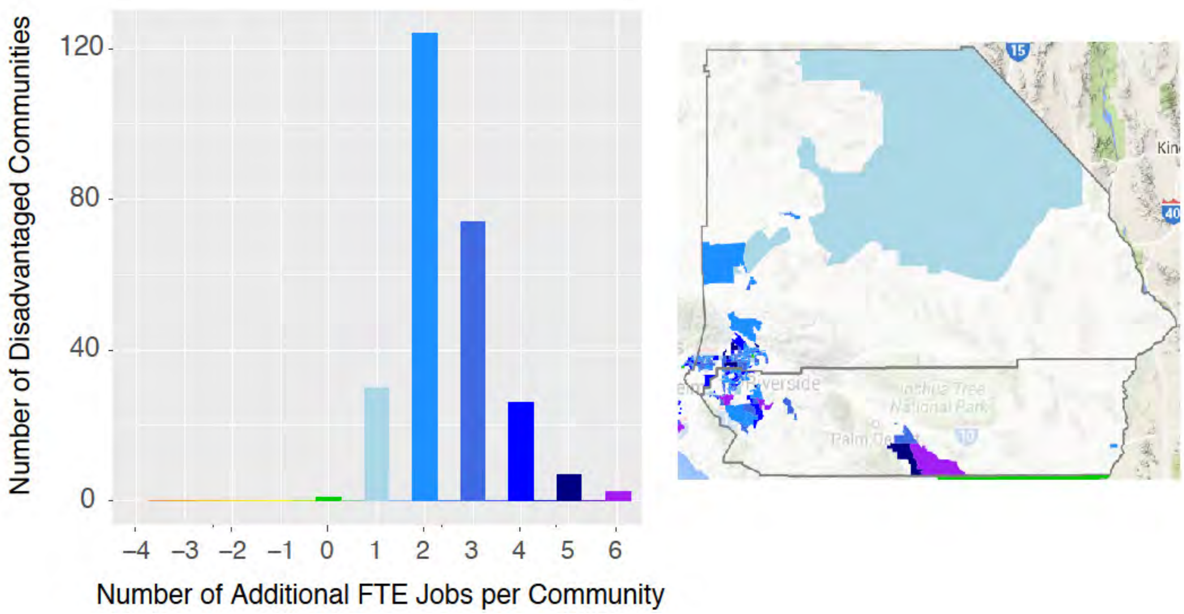
Scenario 3 vs. Current Practice



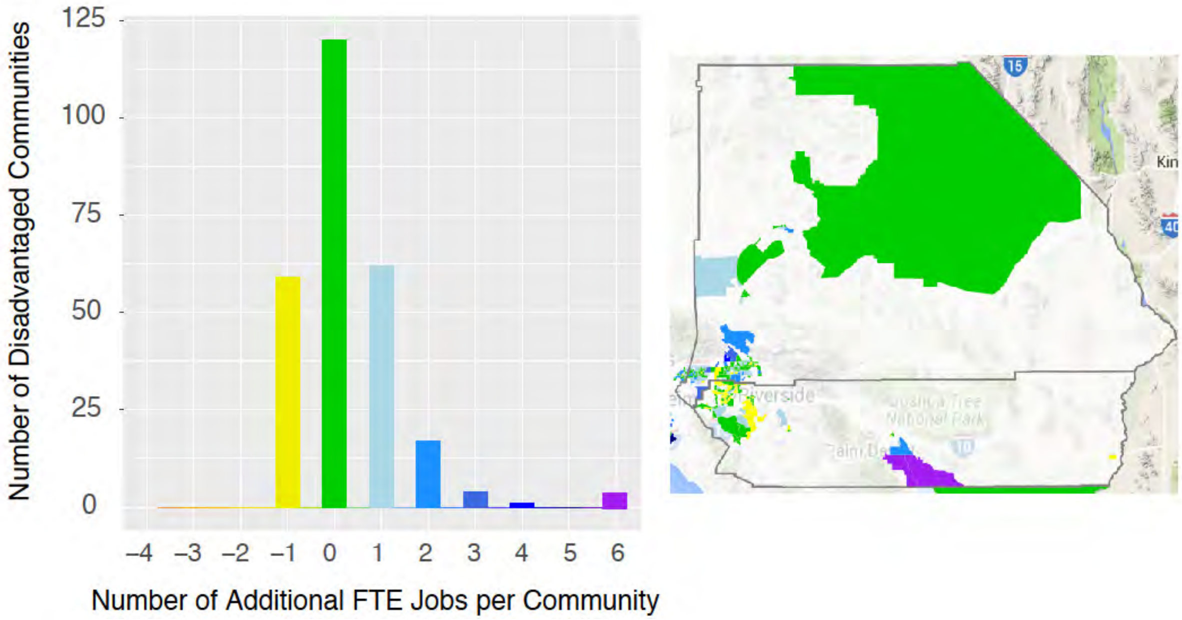
Employment and income results are presented below for three economic regions with the majority of disadvantaged communities: The Inland Valley, the Greater Los Angeles Area, and the Central Valley. Starting with the Inland Valley, Figure 12 shows that a regional market would have a positive impact on job creation. Regional 2 yields a greater number of jobs created from the renewable buildout than Current Practice (8,800 FTEs in Regional 2 vs. 6,200 FTEs in Current Practice), while also retaining the employment generated by considerable ratepayer savings. The net employment effect in Regional 2, compared to Current Practice, is positive job creation in all of Inland Valley's disadvantaged communities. Regional 3 shows more modest net jobs creation due to the fact that the total jobs created through ratepayer savings are only slightly greater than the fewer number of jobs created from the renewable buildout. In the Inland Valley renewable buildout, the Regional 3 scenario results in approximately 1,300 FTEs vs. the 6,200 FTEs created in the Current Practice Scenario. Approximately half of the disadvantaged communities in Regional 3, compared to Current Practice, received no additional jobs created. Approximately 60 disadvantaged communities are projected to have 1 less job in Regional 3 compared to Current Practice.

Figure 12. Difference in FTE Jobs in Disadvantaged Communities (Inland Valley)

Regional 2 – Current Practice



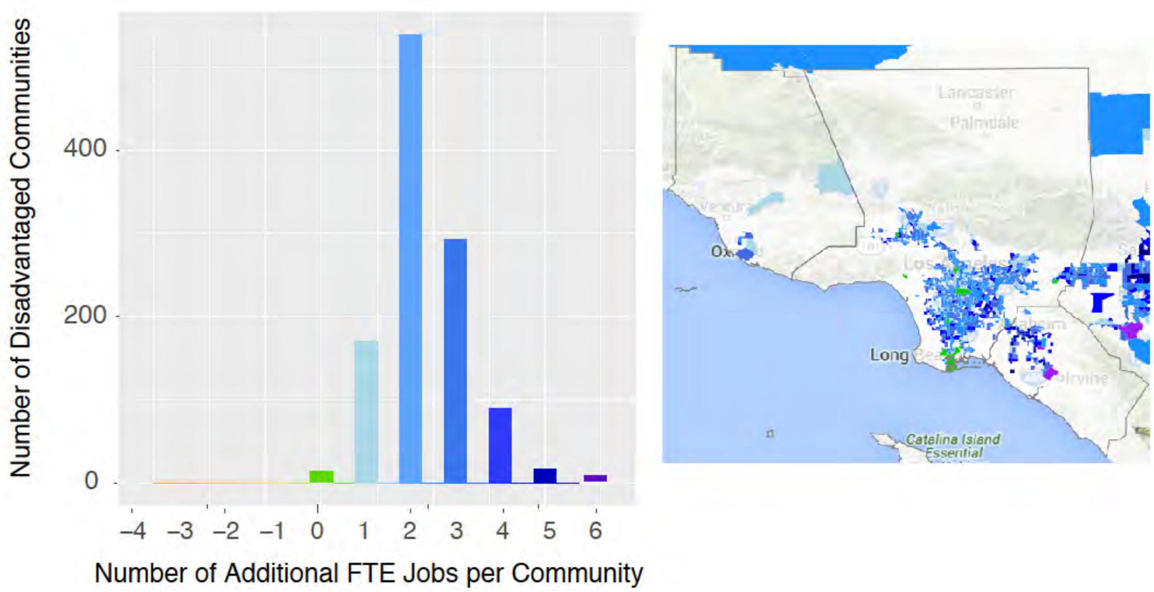
Regional 3 – Current Practice



Moving next to the Greater Los Angeles Area, Figure 13 shows positive employment impacts across for the vast majority of the region's 1,112 disadvantaged communities in Regional 2 and Regional 3. The region, which accounts for 56% of the state's disadvantaged communities, also accounts for most of the jobs creation resulting from regionalization. The job creation driven by a regional market is due primarily to the effect of ratepayer savings on economic activity in the region. Job creation is highest in the Regional 2 scenario, where disadvantaged communities receive both significant ratepayer savings and all of the buildout jobs attributed to Los Angeles and Ventura counties in the Current Practice scenarios. A small fraction of the disadvantaged communities that might benefit slightly more from the employment generated from the renewable buildout are projected to have one less job in Regional 3 compared to Current Practice.

Figure 13. Difference in FTE Jobs in Disadvantaged Communities (Greater Los Angeles)

Regional 2 – Current Practice



Regional 3 – Current Practice

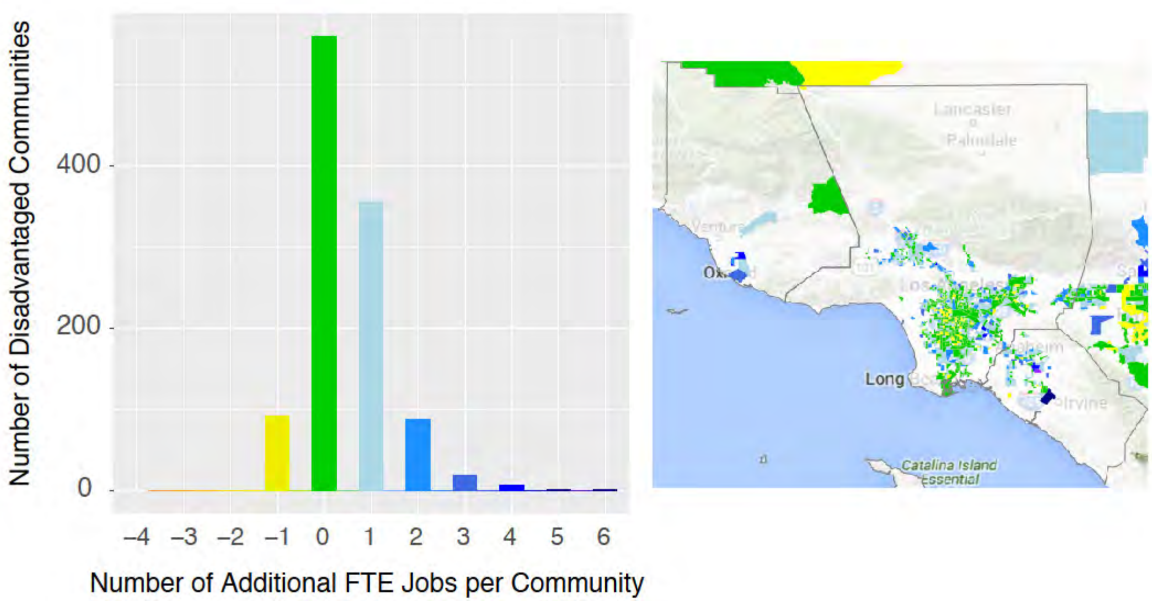
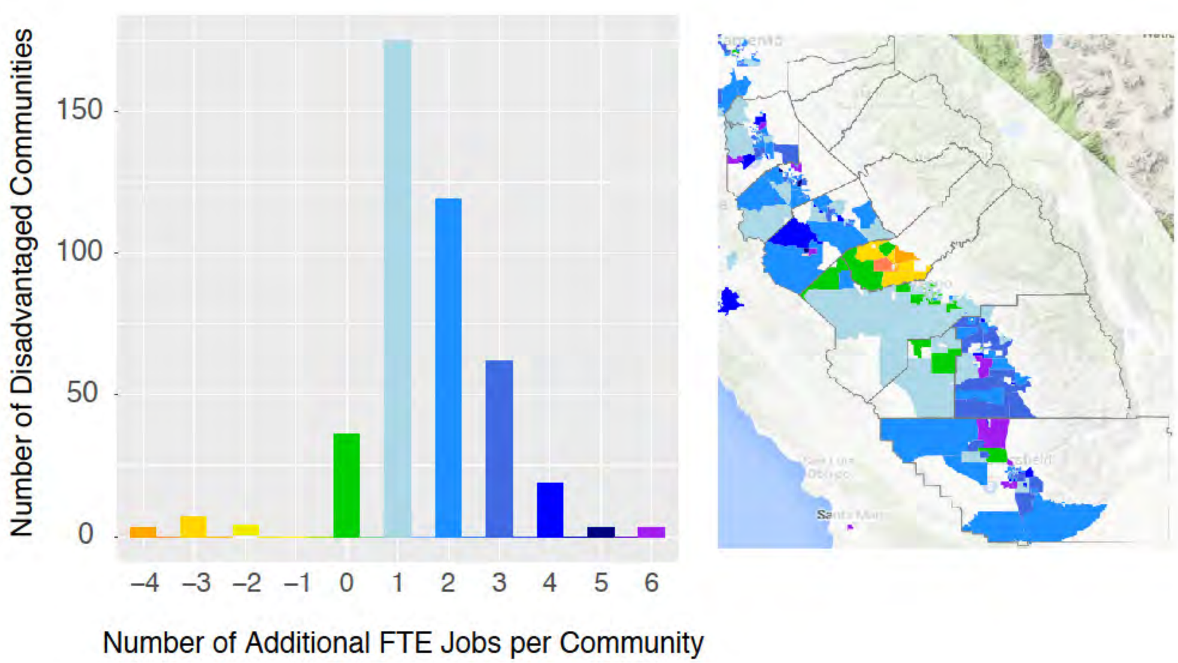


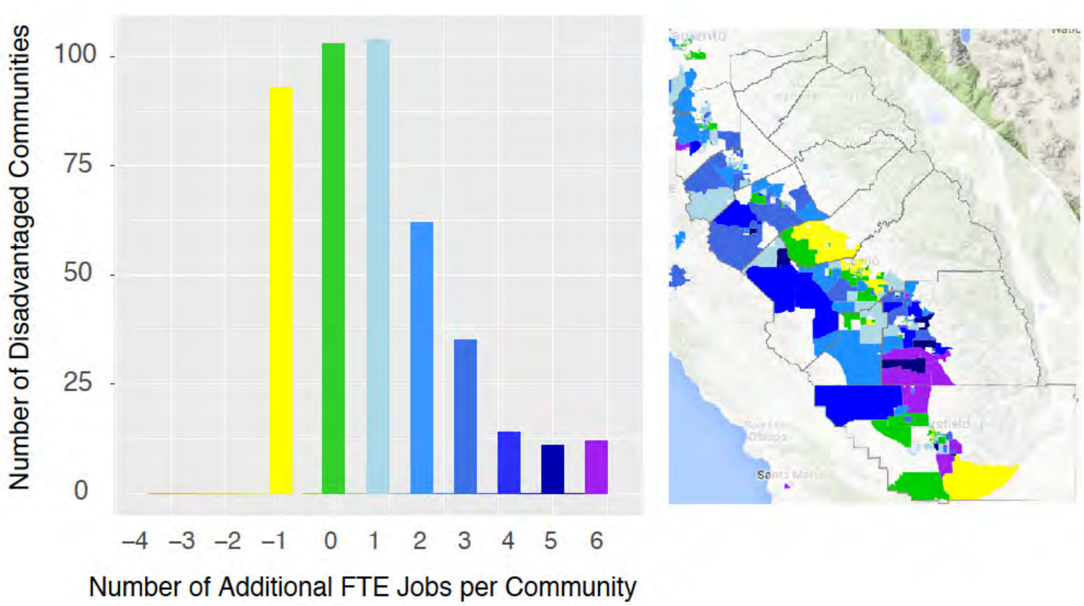
Figure 14 shows the employment impacts in the Central Valley's 431 disadvantaged communities. Both regional scenarios show positive employment effects in all disadvantaged communities, despite the fact that there are fewer jobs from the renewable buildout compared to Current Practice. There are 7,000 and 10,500 fewer renewable buildout jobs in the Central Valley for Regional 2 and Regional 3, respectively, compared to Current Practice. However, fewer additional renewable buildout jobs are more than offset by the employment generated through greater ratepayer savings. As shown in Figure 14 (left panel), the vast majority of the disadvantaged communities receive an additional 1-3 jobs.

Figure 14. Difference in FTE Jobs in Disadvantaged Communities (Central Valley)

Regional 2 – Current Practice

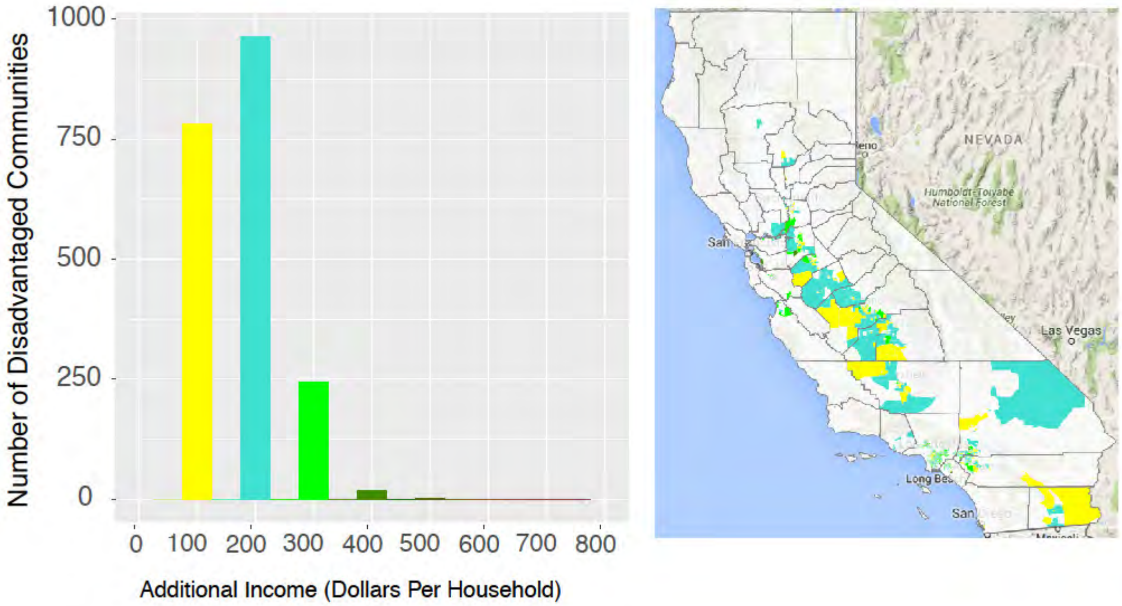


Regional 3 – Current Practice

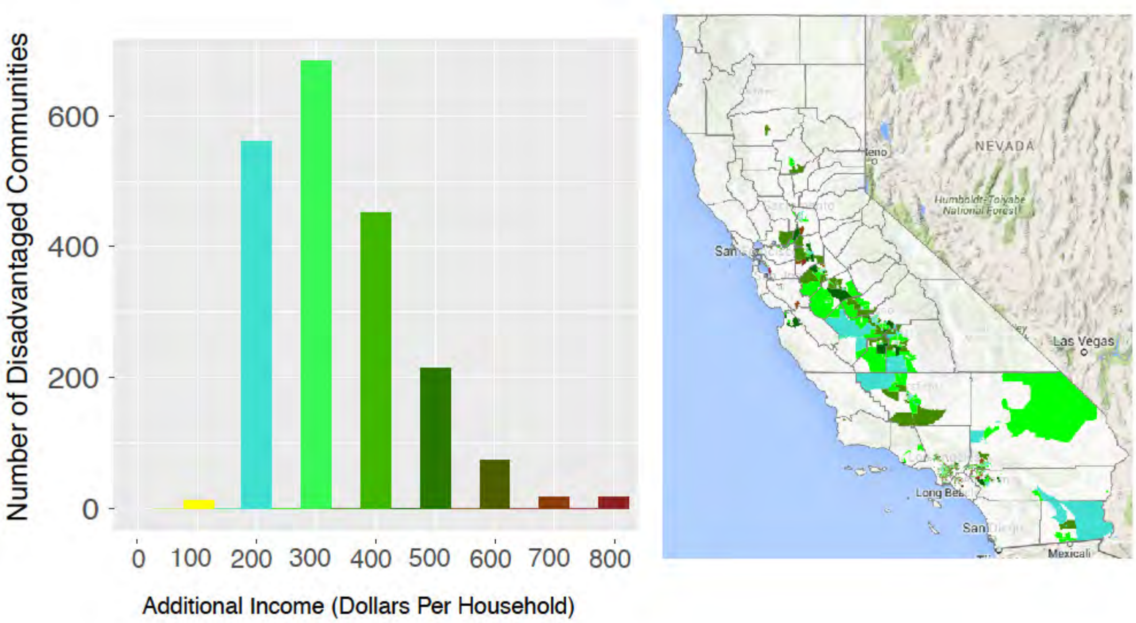


Turning next to differences in real income across the state level results show similar trends across comparison groups in Figure 15. The income effects are generally consistent with the employment effects described above in terms of the regional allocation of benefits from a regional market. The Central Valley region experiences the largest amounts of income benefits, although Inland Valley shows strong growth. Comparing Current Practice 1 to Regional 2 and Regional 3, we find that Regional 2 has a more even dispersion of income benefits, while Regional 3 sees a higher concentration in specific disadvantaged communities.

Figure 15. Differences in Disadvantaged Community Income
Scenario 2 vs. Current Practice



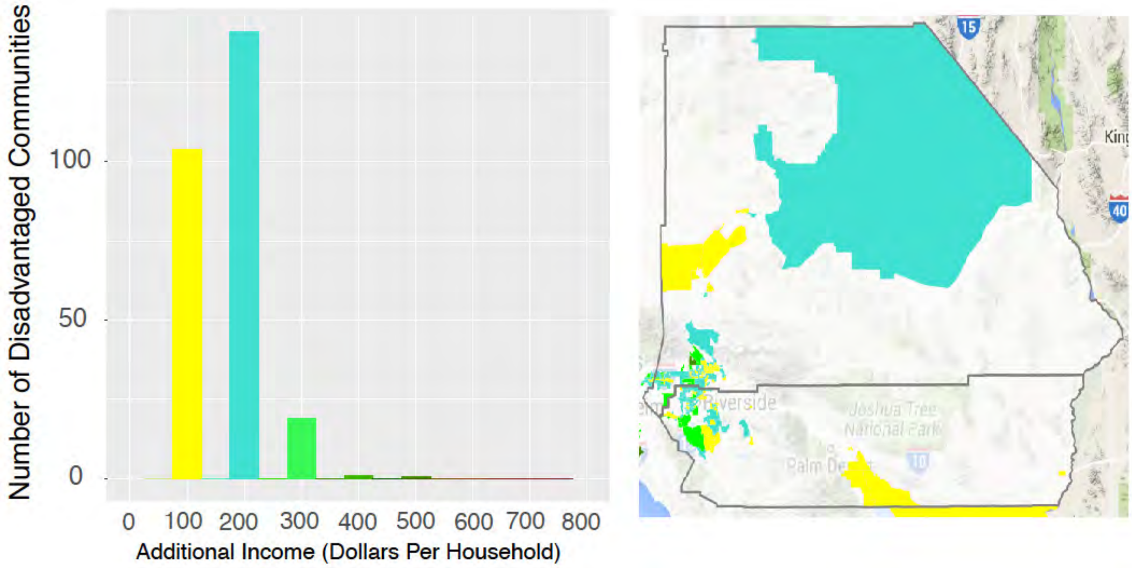
Scenario 3 vs. Current Practice



Similar to the employment results, the income results are also presented in a more disaggregated regional analysis. In Figure 16 we find the largest gains in income are expected in the communities around Riverside and San Bernardino, with the largest income effects in Regional 3. Figure 17 shows that the most concentrated income effects are in the communities near Long Beach. There are also large effects in the areas around the Orange County communities of Irving and Anaheim. Finally, both Oxnard and communities in western San Bernardino show significant income increases as well. Comparing scenarios, results show the largest income gains expected in Regional 3. Figure 18 shows results for the Central Valley, where a fairly even distribution of income effects are observed, with Regional 3 having the largest gains. The largest gains are in the communities near Los Banos, Merced, and south of Fresno. Jobs and income results for the remaining 5 economic regions with disadvantaged communities are shown in Annex A.

Figure 16. Differences in Disadvantaged Community Income – Inland Valley

Regional 2 – Current Practice



Regional 3 – Current Practice

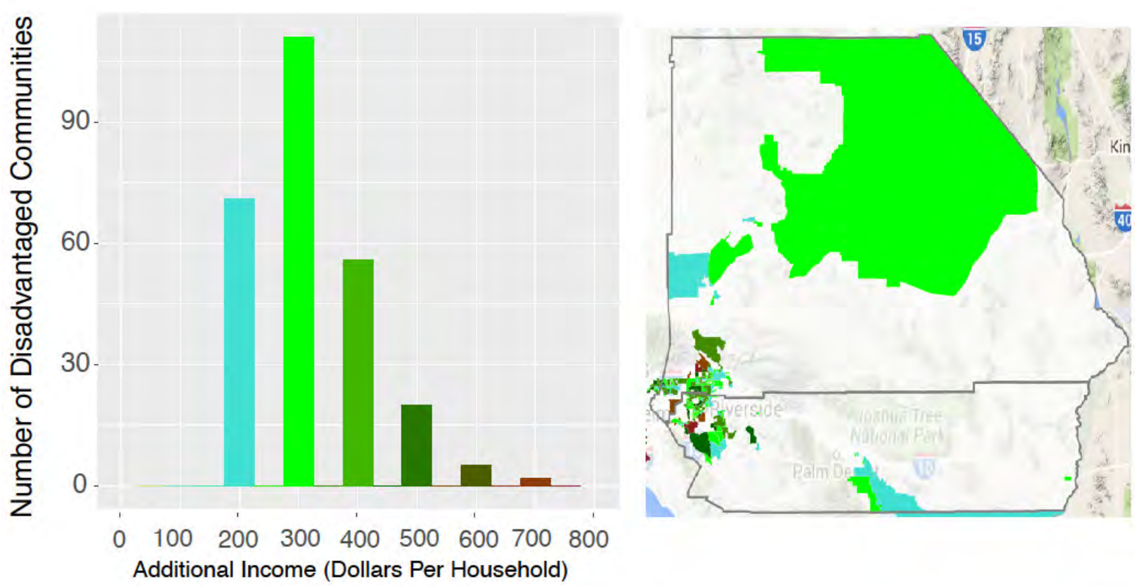
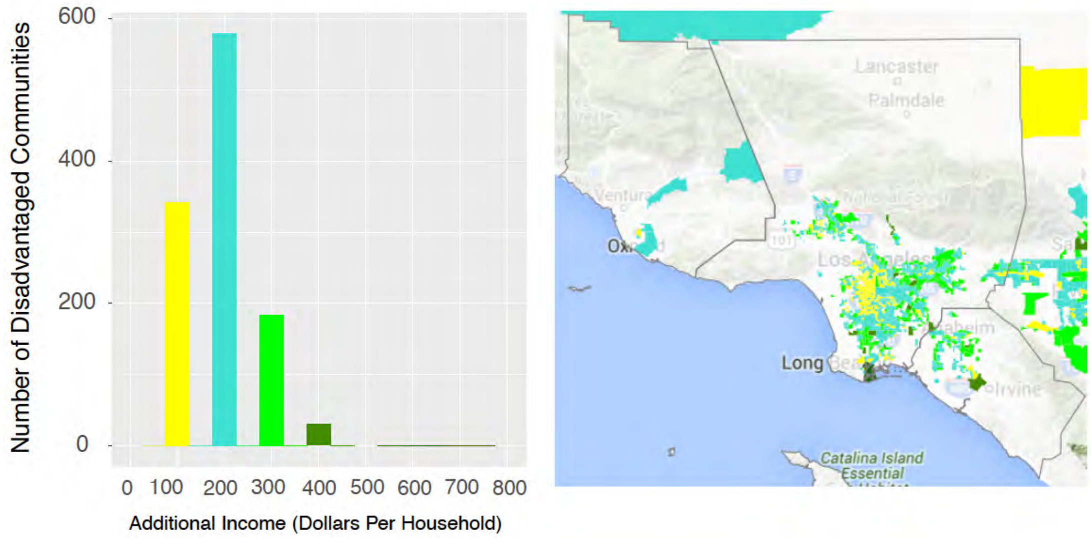


Figure 17. Differences in Disadvantaged Community Income – Greater Los Angeles

Regional 2 – Current Practice



Regional 3 – Current Practice

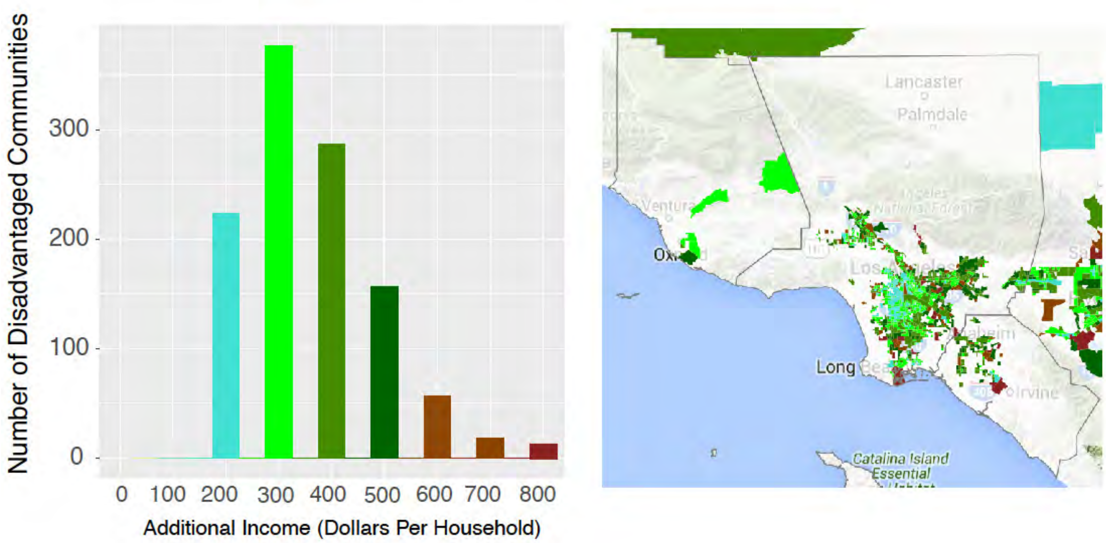
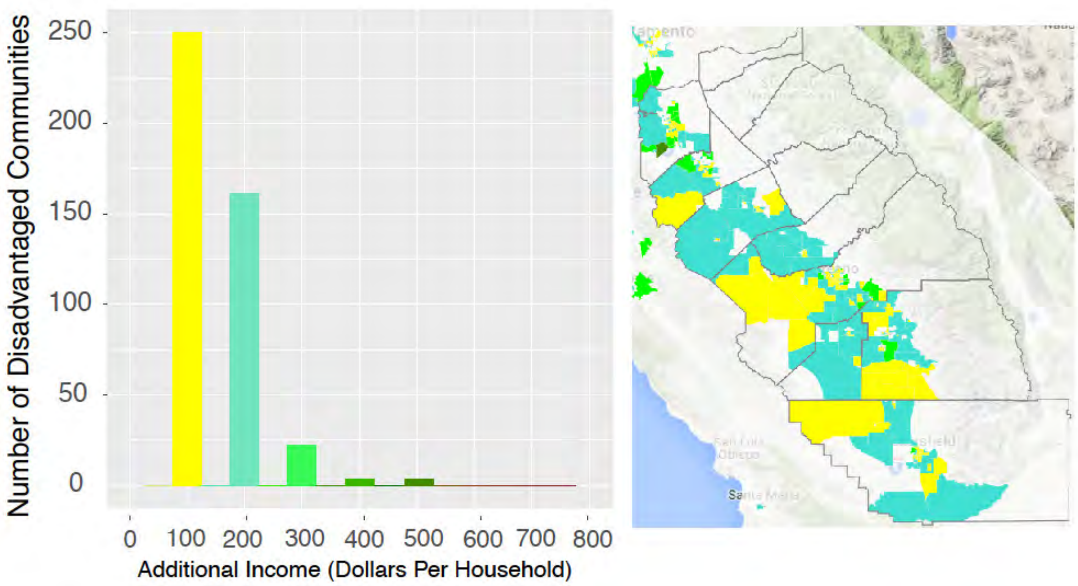
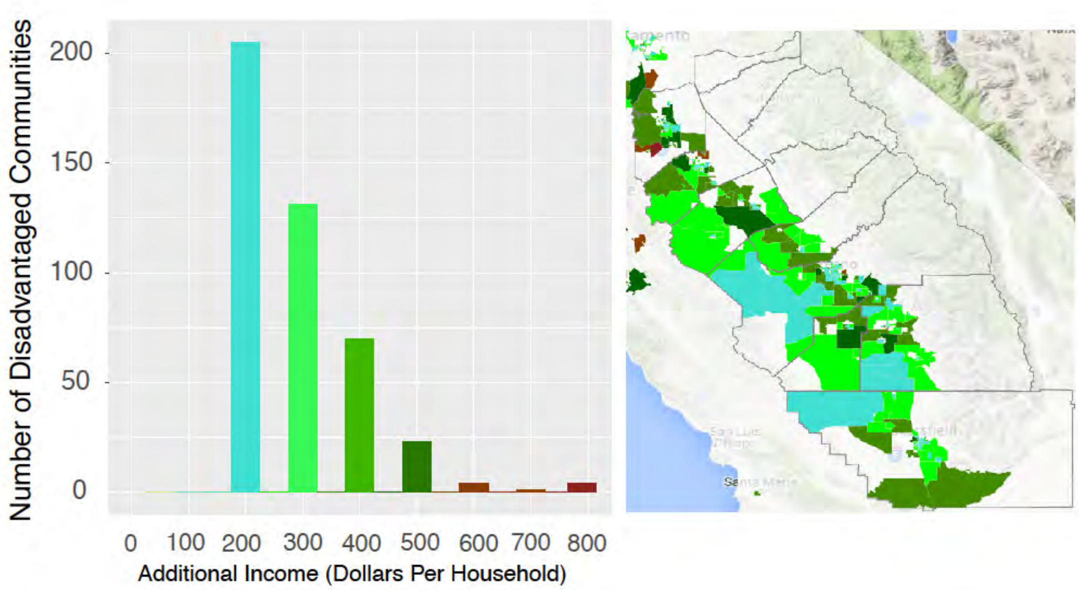


Figure 18. Differences in Disadvantaged Community Income – Central Valley

Regional 2 – Current Practice



Regional 3 – Current Practice



Sensitivity Analysis

The economic impact study for disadvantaged communities considered one sensitivity case. Scenario 1B is identical to the Current Practice scenario except with a higher export limit (8,000 MW vs 2,000 MW). As noted in Volume 8 of the study report, this sensitivity is considered to be a bookend for identifying the benefits attributable to a regional market. It is highly unlikely that achieving the export capability in Sensitivity 1B would be feasible in the absence of a regional market. However, these results are presented below for completeness.

Comparing the two regional scenarios to this alternative (1B) scenario suggests show that more disadvantaged community jobs would be created than in either regional scenario. Regional 2 results in 117 fewer jobs (0.01 jobs per thousand people) than Sensitivity 1B, and Regional 3 results in 2,100 fewer jobs (0.35 jobs per thousand people) than scenario 1B. These small net effects are due to the fact that the jobs created in disadvantaged communities from the greater ratepayer savings are slightly more than offset by lower job creation from renewable buildout in those communities.

Similar to the employment effects, income gains for Regional 2 are also less than the sensitivity 1B scenario ($15/HH lower income in Regional 2). Regional 3 income is actually higher than 1B by $140/HH. This result suggests that the income effects generated from ratepayer savings (which is greatest in Regional 3) are greater than the income effects generated by the renewable buildout. In other words, ratepayer savings, which is more dispersed across the economy, yields more salient multiplier effects than the localized impact of renewable capacity development. Indeed, the sensitivity comparison reminds us of the importance of distinguishing between sources of demand and job creation. Current Practice and 1B scenarios are largely investment driven, while household consumption is the primary demand driver when regionalization confers higher purchasing power on California households. The longevity of buildout or investment-driven employment is very uncertain, while ratepayer benefits are likely to be enduring. The latter, consumption expenditure by households across the state, is also likely to create more diverse and inclusive employment, with about 70% distributed across tertiary activities.

6. Summary of Key Conclusions

6.1 Environmental Analysis Conclusions

Regional 2 Relative to Current Practice Scenario 1

For California's disadvantaged communities, and generally inside California, Regional 2 results in:

- Fewer community-scale impacts from construction of the renewable buildout in California by emphasizing the Tehachapi and Riverside East & Palm Springs CREZs that do not contain high percentages of population in disadvantaged communities.
- Less water used in California because the fleet of natural gas fired power plants would operate less than in the Current Practice (Scenario 1), and this may reduce the baseline stress on water bodies and water systems in disadvantaged communities.
- Lower emissions from California power plants in air basins of greatest concern because the fleet of natural gas fired power plants would operate less than in the Current Practice (Scenario 1), and this decreases the emissions of NOx, PM2.5, and SO_2 in the air basins of greatest concern for disadvantaged communities.

Regional 3 Relative to Current Practice Scenario 1

For California's disadvantaged communities, and generally inside California, Regional 3 provides:

- Fewest community-scale impacts from construction of the renewable buildout in California by emphasizing renewable energy resources outside of California.
- Least amount of water used in California because the fleet of natural gas fired power plants would operate less than other scenarios, and this may reduce the baseline stress on water bodies and water systems in disadvantaged communities.

- Lowest emissions from California power plants in air basins of greatest concern because the fleet of natural gas fired power plants would operate less than other scenarios, and this decreases the emissions of NOx, PM2.5, and SO_2 in the air basins of greatest concern for disadvantaged communities.

6.2 Economic Analysis Conclusions

- Disadvantaged communities primarily benefit from a regional market and job creation induced by ratepayer savings, generating greater employment and income than the Current Practice.
- Employment effects: There is a tradeoff between the types of jobs in disadvantaged communities across the scenarios. Current Practice yields the greatest number of direct jobs from the renewable buildout, while induced employment from ratepayer savings in the regional scenarios is a more potent stimulus to these local economies. Regional 3 yields the fewest jobs from the renewable buildout, but more than offsets this with the greatest number of jobs created through ratepayer savings. Regional 2 creates the greatest number of jobs in disadvantaged communities by combining the employment benefits of in-state renewable capacity generation and high levels of induced employment from ratepayer savings.
- Income effects: The income effects in disadvantaged communities from a regional market largely mirror the net employment effects. Driven by a combination of more modest renewable development and the potent growth catalyst of ratepayer savings, regional markets deliver higher real incomes to disadvantaged communities. This is driven by the economic stimulus delivered by ratepayer savings, which more than offsets lower levels of direct job creation due to less ambitious in-state renewable energy development.
- The employment and income benefits accrue primarily to disadvantaged communities in three economic regions: Inland Valley, Los Angeles Area, and the Central Valley. These regions account for 91% of the State's disadvantaged communities. Economic benefits from ratepayer savings are estimated to be distributed across all disadvantaged communities. The employment gains and losses attributable to renewable buildout vary considerably across the State's disadvantaged communities, based on scenario and precise location of future renewable capacity development.

7. References

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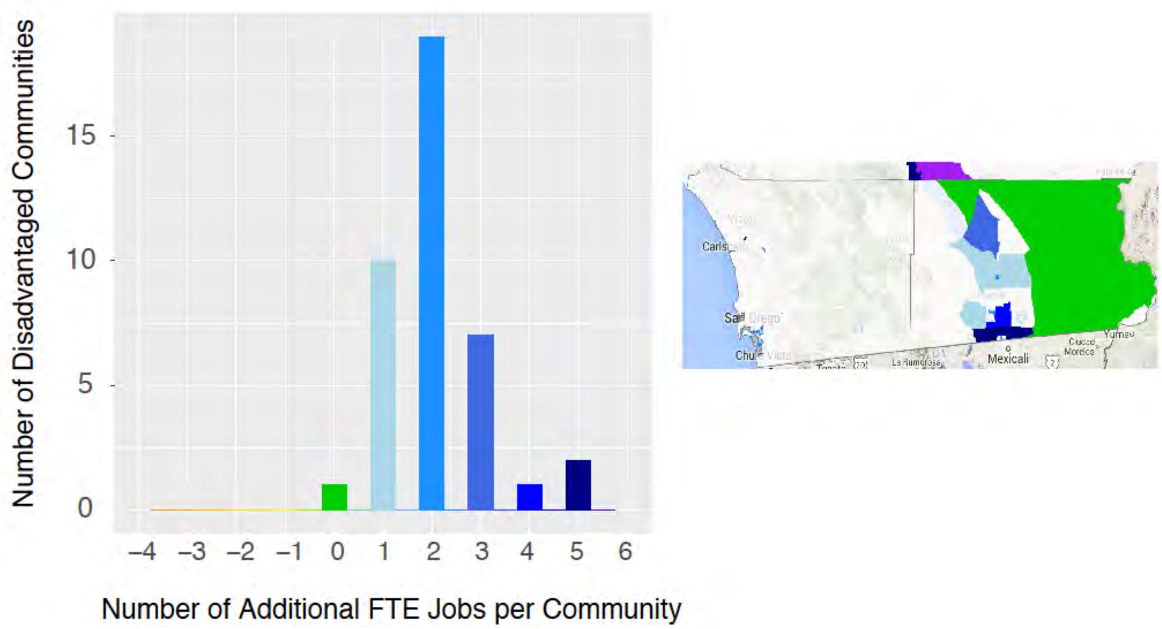
8. Annex A: Disadvantaged Community Figures for Additional Economic Regions

Figure A.1: Difference in Disadvantaged Community FTE Jobs (San Diego and Imperial)

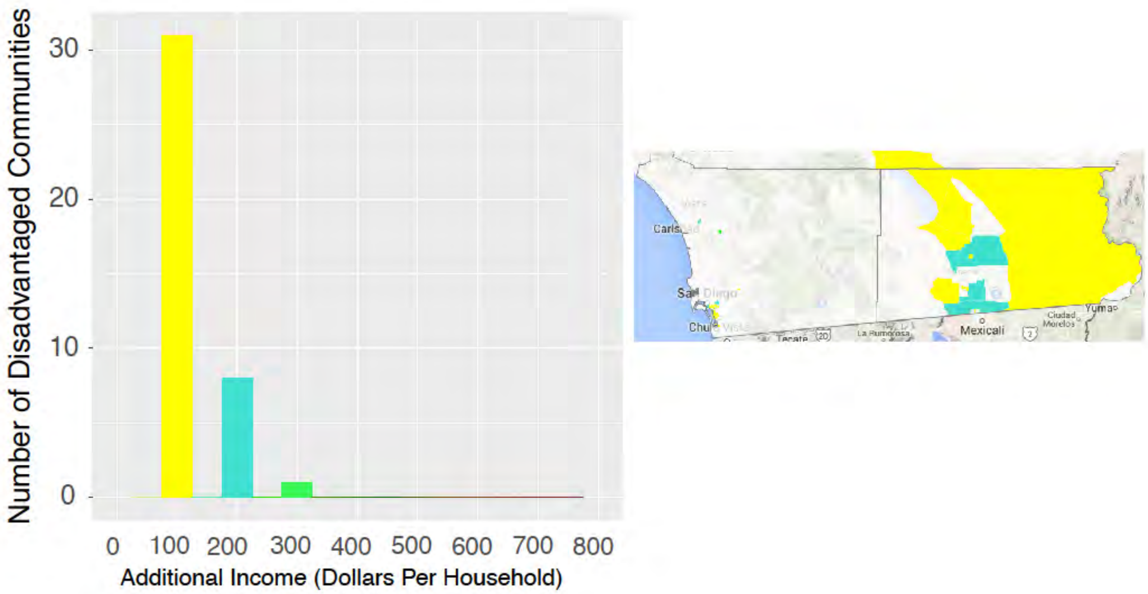
Regional 2 – Current Practice



Regional 3 – Current Practice

Figure A.2: Differences in Disadvantaged Community Income – San Diego and Imperial ($/hh)

Regional 2 – Current Practice



Regional 3 – Current Practice

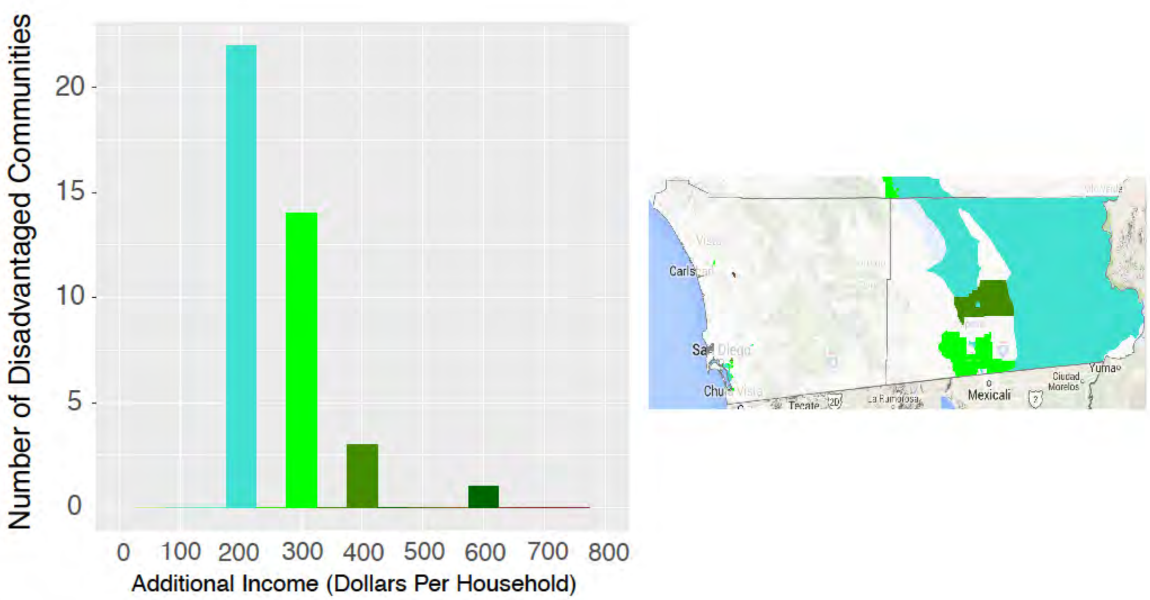
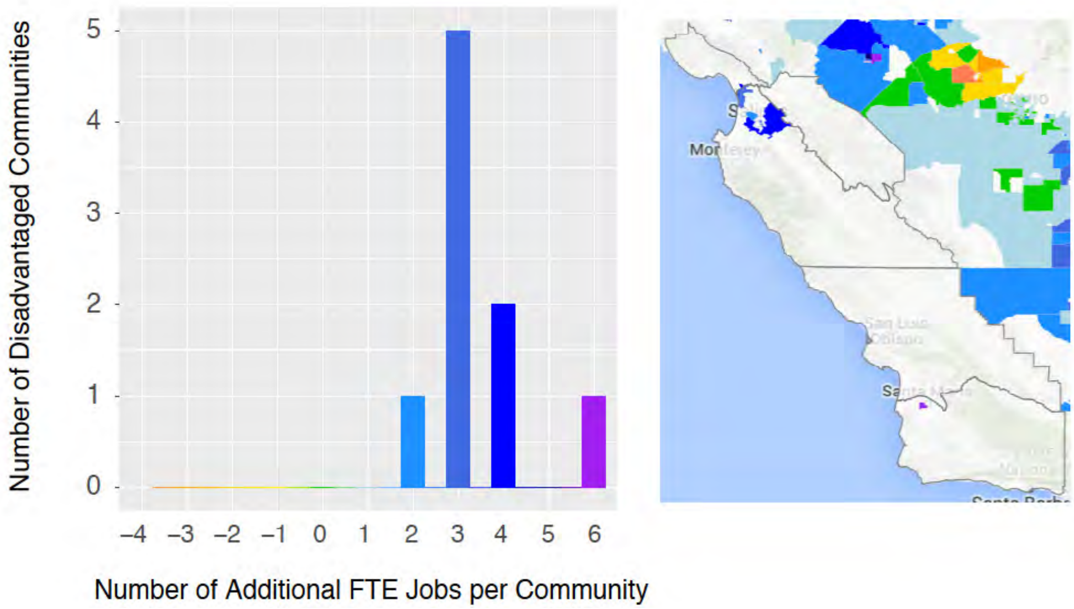


Figure A.3: Difference in Disadvantaged Community FTE Jobs (Central Coast)

Regional 2 – Current Practice



Regional 3 – Current Practice

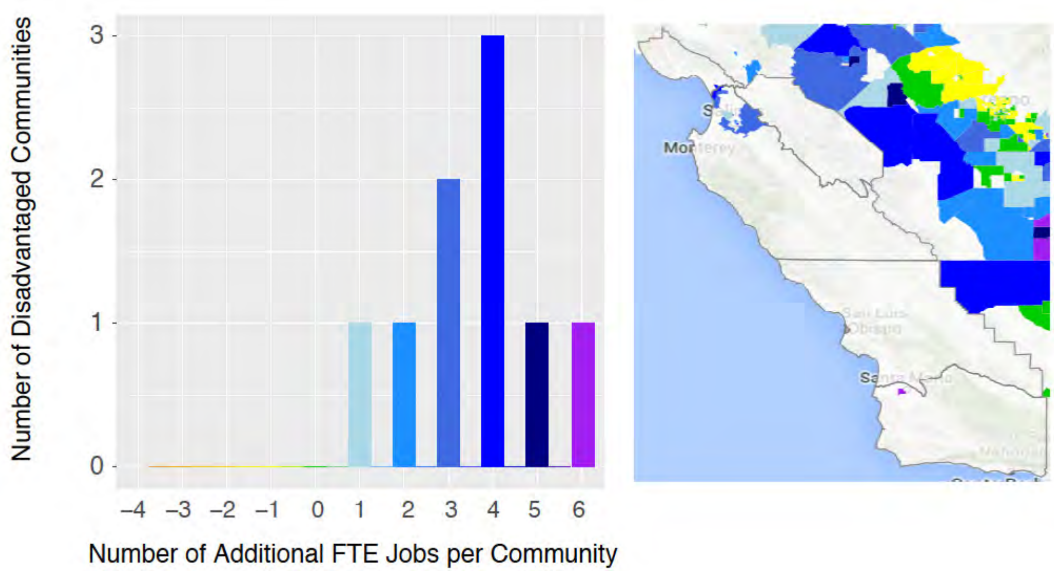
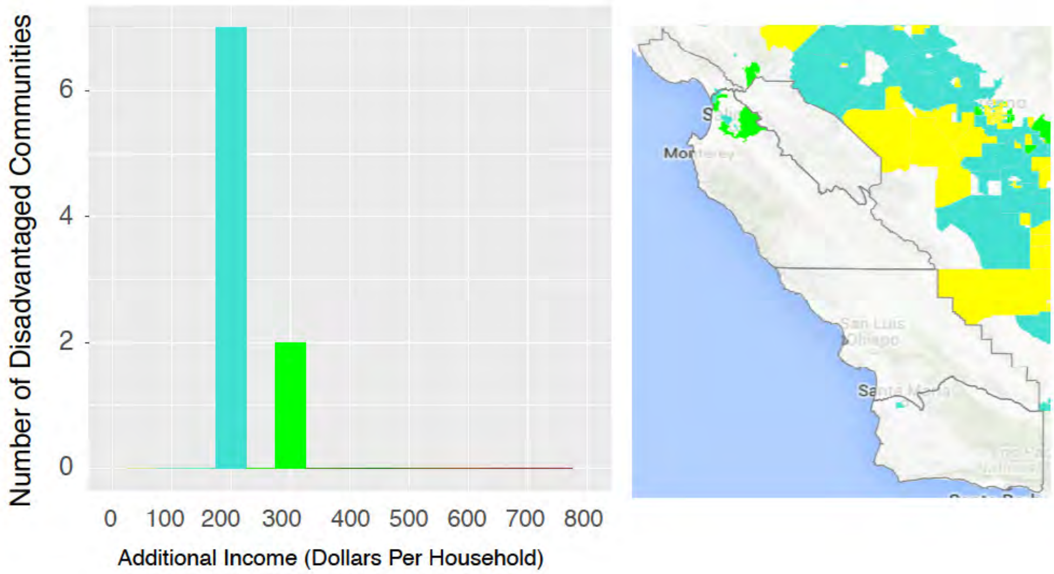


Figure A.4: Differences in Disadvantaged Community Income – Central Coast ($/hh)

Regional 2 – Current Practice



Regional 3 – Current Practice

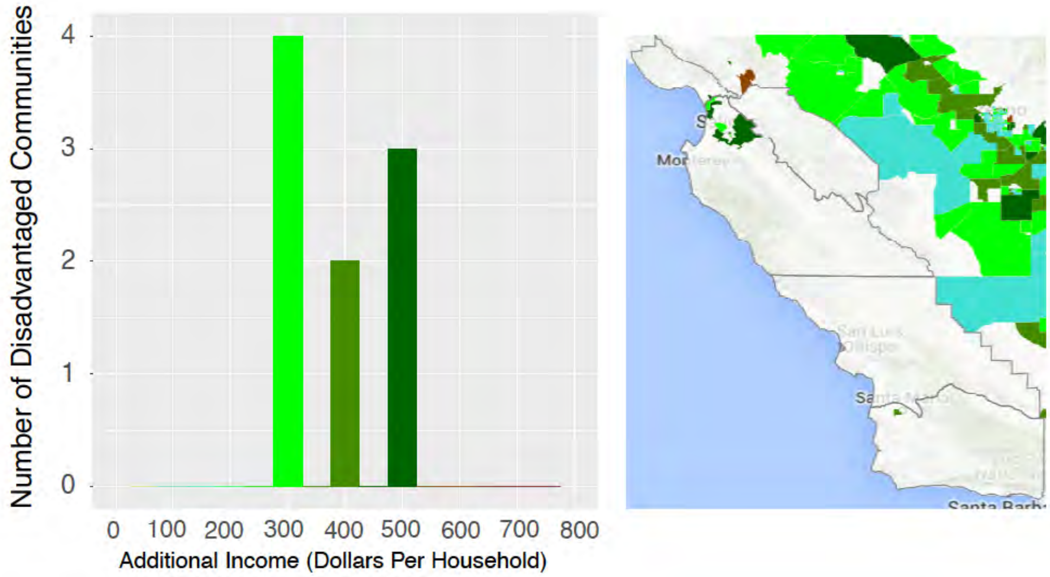
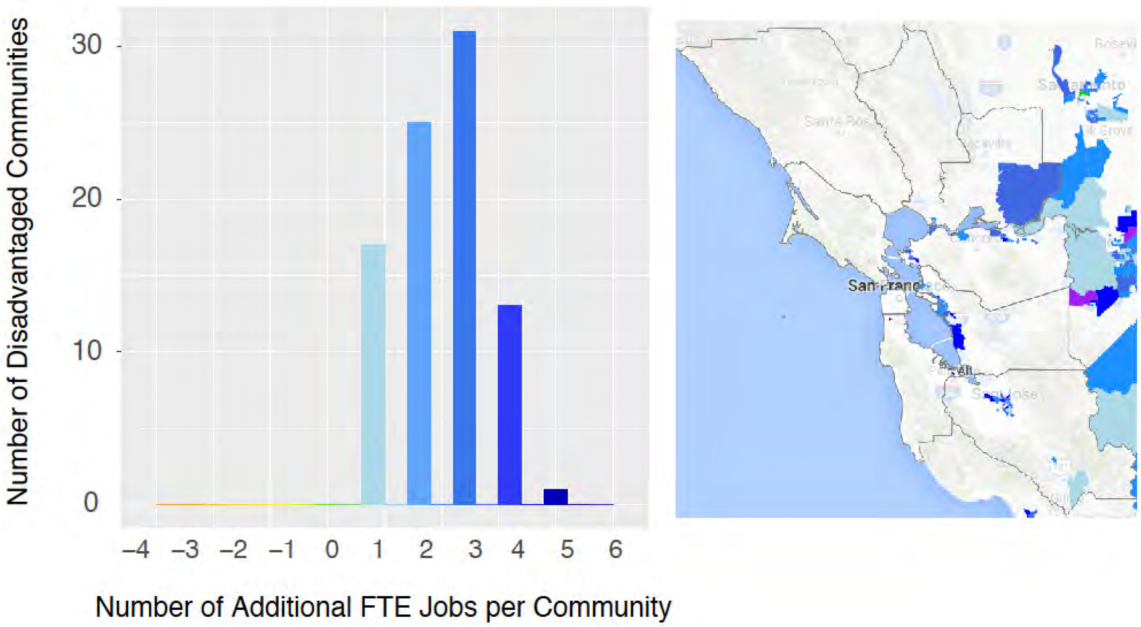


Figure A.5: Difference in Disadvantaged Community FTE Jobs (San Francisco Bay Area)

Regional 2 – Current Practice



Regional 3 – Current Practice

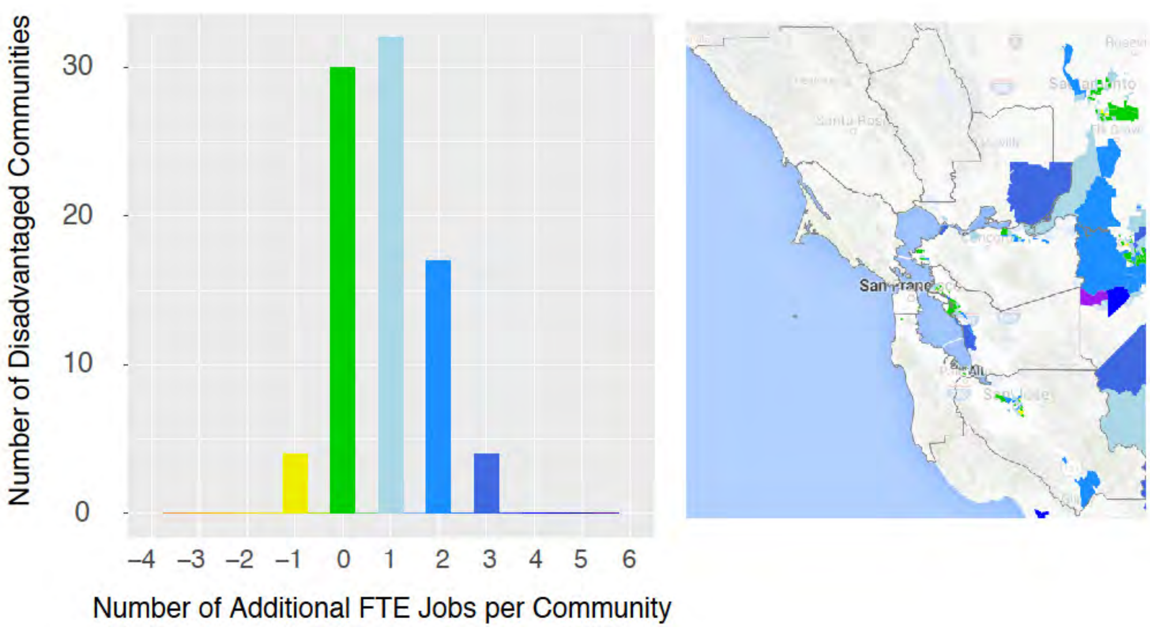
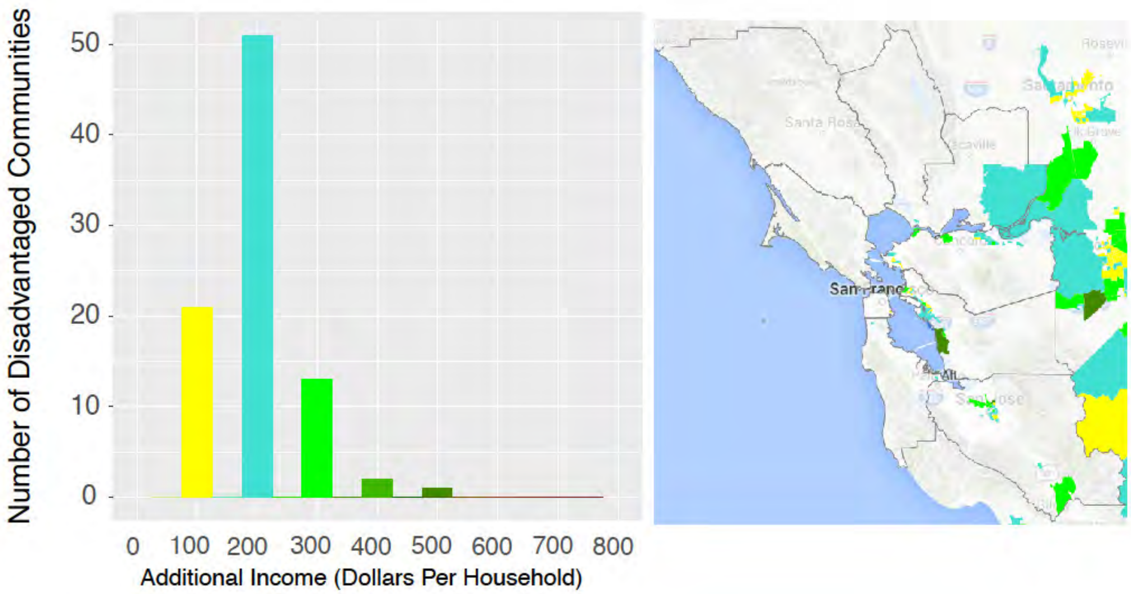


Figure A.6: Differences in Disadvantaged Community Income – San Francisco Bay Area ($/hh)

Regional 2 – Current Practice



Regional 3 – Current Practice

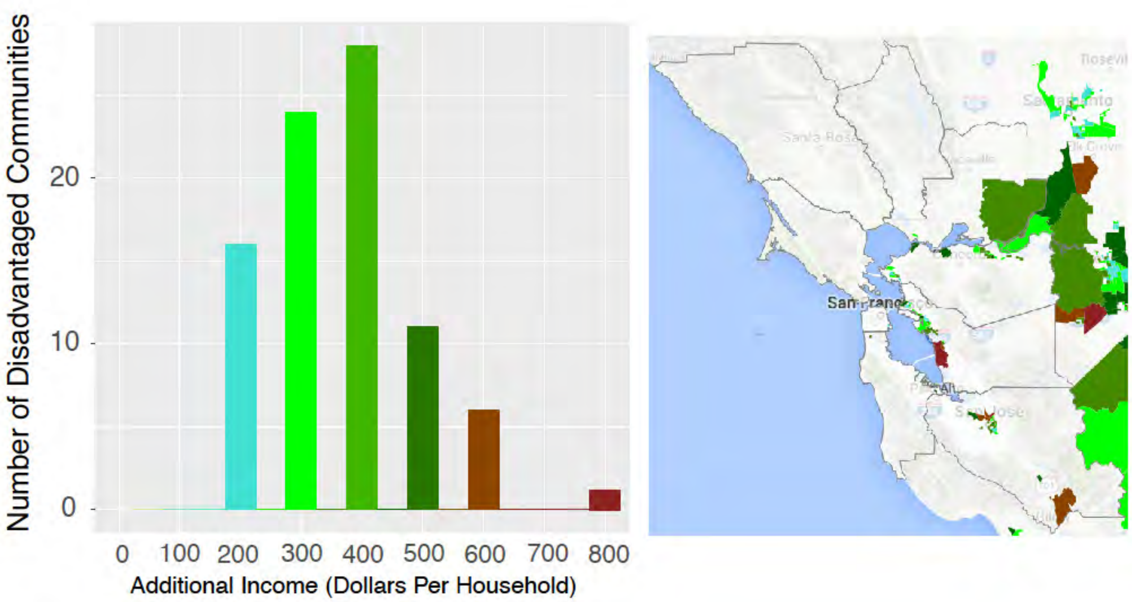
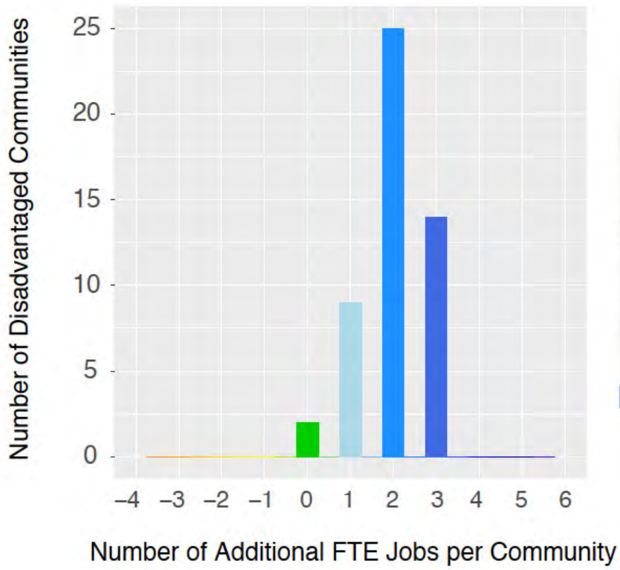
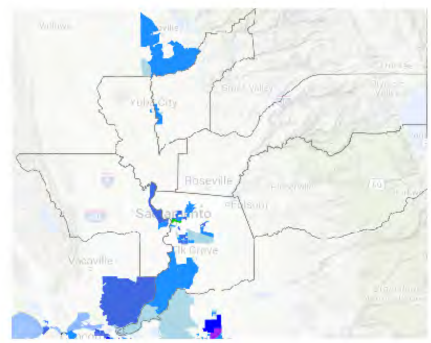


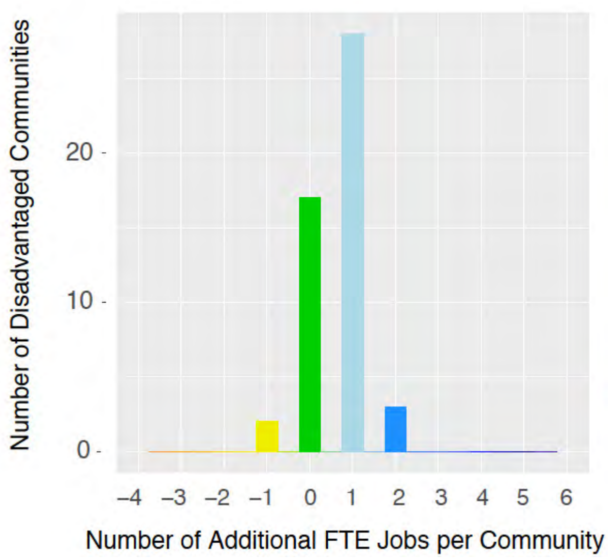
Figure A.7: Difference in Disadvantaged Community FTE Jobs (Sacramento Area)

Regional 2 – Current Practice





Regional 3 – Current Practice



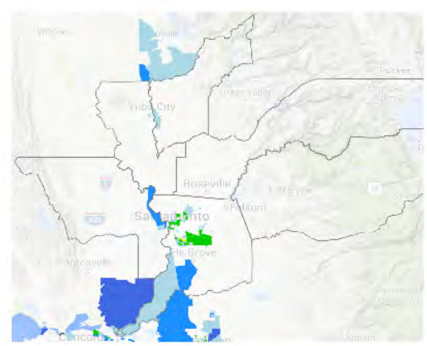
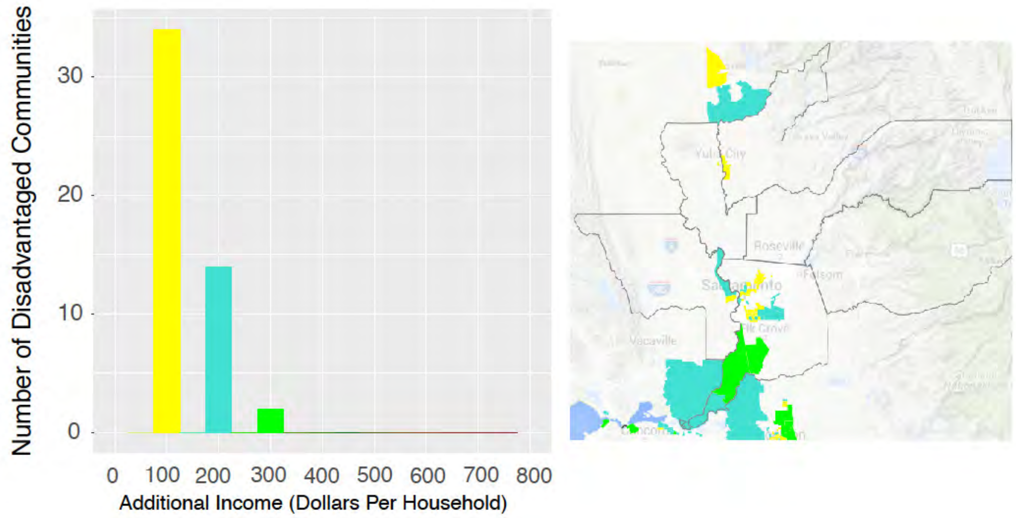


Figure A.8: Differences in Disadvantaged Community Income – Sacramento Area ($/hh)

Regional 2 – Current Practice



Regional 3 – Current Practice

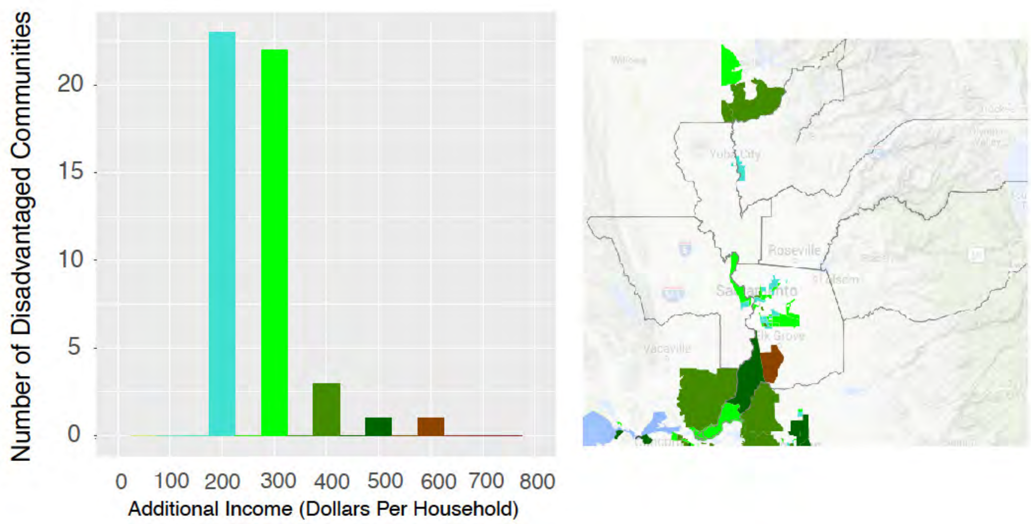
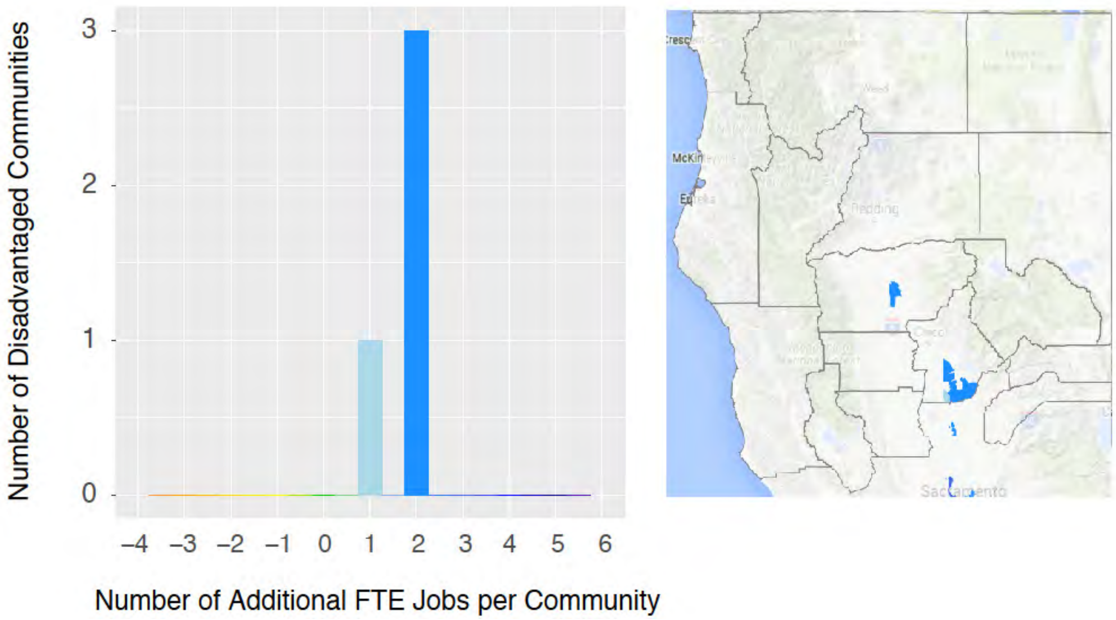


Figure A.9: Difference in Disadvantaged Community FTE Jobs (North State)

Regional 2 – Current Practice



Regional 3 – Current Practice

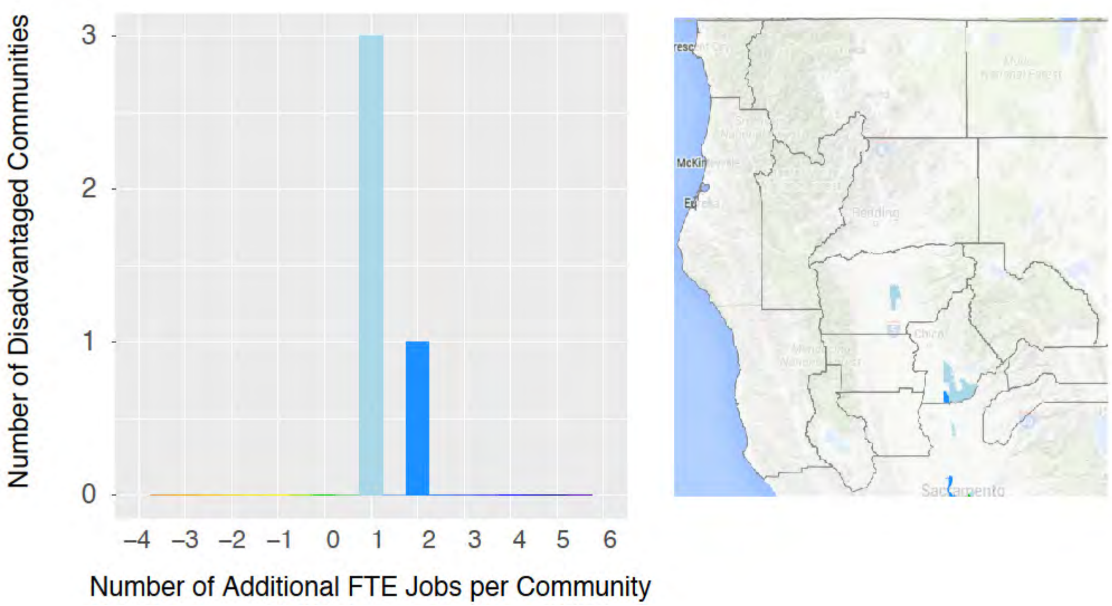
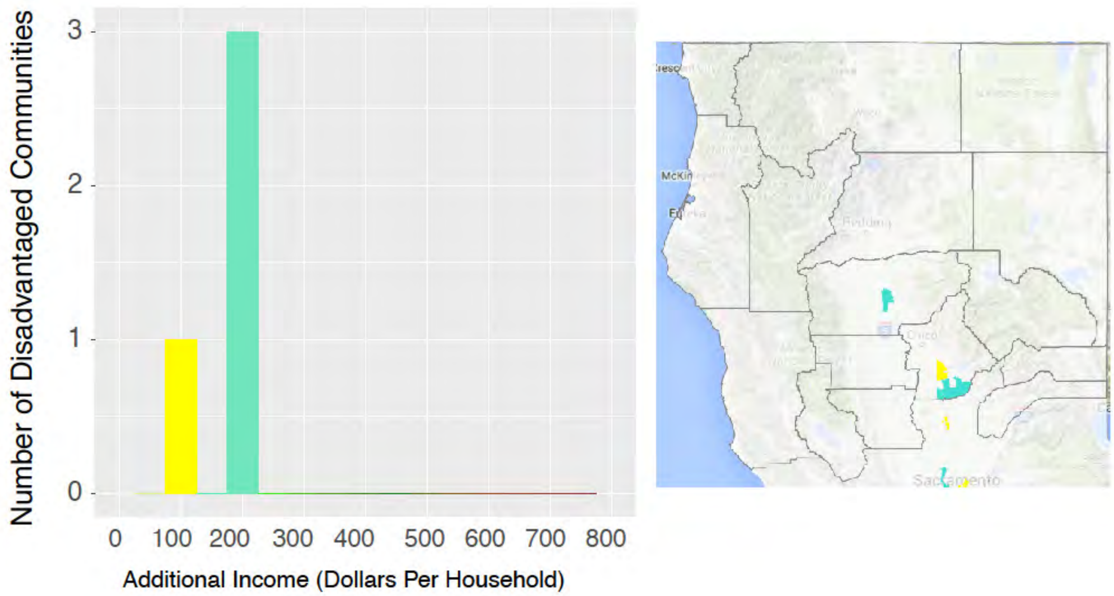
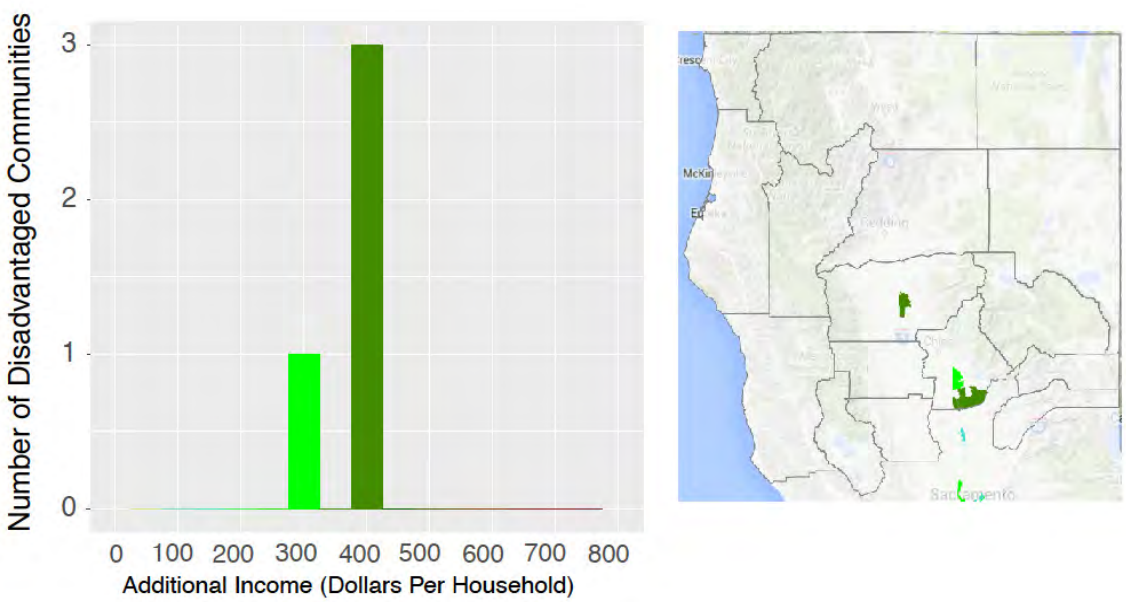


Figure A.10: Differences in Disadvantaged Community Income – North State ($/hh)

Regional 2 – Current Practice



Regional 3 – Current Practice



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Senate Bill 350 Study

Volume XI: Renewable Integration and Reliability Impacts

PREPARED FOR

California ISO

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July 8, 2016

THE Brattle GROUP

Senate Bill 350 Study

The Impacts of a Regional ISO-Operated Power Market on California

List of Report Volumes

Executive Summary	
Volume I.	Purpose, Approach, and Findings of the SB 350 Regional Market Study
Volume II.	The Stakeholder Process
Volume III.	Description of Scenarios and Sensitivities
Volume IV.	Renewable Energy Portfolio Analysis
Volume V.	Production Cost Analysis
Volume VI.	Load Diversity Analysis
Volume VII.	Ratepayer Impact Analysis
Volume VIII.	Economic Impact Analysis
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Volume XI. Renewable Integration and Reliability Impacts

A. INTRODUCTION

As documented by industry experience and in a wide range of industry studies, regional market operations and planning will allow for the more cost effective and more reliable integration and balancing of intermittent renewable resources.[1] The benefits of operational efficiency, increased renewable integration and reliability associated with closer regional coordination across the many existing Balancing Areas in the WECC has been documented and recognized in the context of the Energy Imbalance Market ("EIM").[2]

A full "Day 2" regional market will magnify these EIM-related benefits by adding substantial additional regional market operations, which consist of: (1) a day-ahead energy market; (2) day-ahead and intra-day system-wide forecasting of intermittent renewable generation levels; (3) optimal economic and reliability-based commitment of conventional generating units on both a day-ahead and intra-day basis; and (4) region-wide, co-optimized ancillary services markets for procurement of regulation reserves, procurement and deployment of operating reserves, and flexible capacity for load-following reserves. In addition to these operational benefits, an ISO-based regional market will also benefit from the integrated, region-wide operational, reliability, resource adequacy management, and transmission planning functions performed by an independent system operator ("ISO").

Covered in other parts of this report, key aspects of reliability and renewable integration benefits of a larger ISO-operated regional market already have been quantified in terms: (1) the load diversity analysis, which assesses how resource adequacy requirements can be met with less

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1 See discussion of existing studies in Volume XII of this report.

2 For example, for renewable integration benefits of the EIM refer to http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=5180B3C9-2B88-4678-B6AD-2A6B55CE8DEB for actual benefits and http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=7DF86332-C71D-44B7-836B-56181A694C8C for pre-operational benefit assessments.

For reliability benefits of the EIM see FERC's Staff Report, "Qualitative Assessment of Potential Reliability Benefits from a Western Energy Imbalance Market," February 26, 2013, Available http://www.caiso.com/Documents/QualitativeAssessment-PotentialReliabilityBenefits-WesternEnergyImbalanceMarket.pdf generating capacity (Volume VI of this report); (2) the nodal market simulations, which simulate more optimized power flows on the transmission grid, reduced curtailments, and reduced need for ramping, load following, and operating reserves at high levels of renewable resource development (Volume V); and (3) the renewable investment optimization, which recognizes integration benefits when selecting the renewable portfolios that can meet California's 50% RPS (Volume IV).

However, the estimation of the benefits associated with reliability and renewable integration benefits captured in California ratepayer savings does not reflect other value of achieving more reliable region-wide system operations. For example, expanding ISO operations to a larger regional footprint will offer significant reliability benefits to both California and the larger regional market area. Regional ISO operations and practices will offer various reliability benefits over the standard operational practices of Balancing Authorities in the WECC footprint. Because the WECC is a single interconnected power system, reliability events in neighboring WECC areas affect California as well.[3] Expanding CAISO operational practices consequently offer reliability benefits to (a) the expanded regional footprint that, in turn, (b) increases reliability in the ISO's current California footprint. Reliability-related benefits will be particularly pronounced during stressed system conditions, such as extreme weather, drought, and unexpected outages.

B. Integration and Balancing of Renewable Generation

CAISO has undertaken a number of initiatives to improve the current market structure and improve renewable integration. Our future scenarios assume these measures are in place, even in the Current Practice scenarios, including:

- The creation and regional expansion of the Energy Imbalance Market;
- Ensuring sufficient flexible generation is made available in the CAISO market;
- Refining the markets for ancillary service needed to balance intermittent generation;
- Expanding the transmission system;

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3 Examples of WECC-wide reliability events that affected California include the October 6, 2014 Northwest RAS Event; the September 8, 2011 Arizona–Southern California Outage; and the August 10, 1996 Western Interconnection (WSCC) System Disturbance.

- Introducing 15-minute scheduling on transmission interties with neighboring regions; and
- Facilitating the wholesale market integration of demand-side resource and storage.

In addition, all scenarios assume that a number of additional measures are in place by 2030:

- Time-of-use rates that encourage daytime use;
- 5 million electric vehicles by 2030 with near-universal access to workplace charging;
- 500 MW of pumped storage are developed in California;
- 500 MW of geothermal resources are manually added to California's renewable portfolio in all cases, which reduces renewable curtailment relative to a case with an equivalent quantity of solar;
- 5,000 MW of out-of-state renewable resources available to be selected on a least-cost basis;
- Unlimited storage available to be selected on a least-cost basis;
- Renewable resources are assumed to be fully dispatchable and capable of providing grid services such as operating reserves;
- Storage and hydro are assumed to be fully dispatchable and capable of providing grid services such as operating reserves and frequency response.

A larger regional ISO-operated wholesale power market will improve the integration and balancing of renewable resources by enabling:

- A single intra-hourly energy market for selling intermittent output that is integrated with optimal day-ahead commitment and pre-dispatch of the entire region's generating plants;
- Coordinated and centralized region-wide day-ahead and intra-day forecasting of renewable output to reduce balancing costs, improve congestion management, and reduce curtailments;
- Reduced system-wide operating and load following reserve requirements in a regional market because of larger-regional diversification of renewable generation variances and a more cost-effective combination of renewable resources and transmission;
- Lower-cost provision and deployment of regional operating and load following reserves through optimized security-constrained unit commitment and dispatch; and

- Lower integration-related investment needs through improved region-wide generation interconnection and transmission planning processes.

For example, SPP has recently announced that within its larger, consolidated balancing area it can now manage wind generation of up to 60% of its load. As noted by SPP's CEO, due to the larger footprint, SPP can "forecast the wind rise and decline such that we can bring other resources to bear against the variability of wind…[y]ou just couldn't have done that when we were operating as 20-plus different balancing authorities."[4]

Compared to EIM, the broader regional market design further lowers the integration and balancing costs currently faced by many developers of renewable generation projects by additionally providing:

- A system-wide generation day-ahead unit commitment and dispatch over a broader region with a more diverse set of renewable and conventional resources
- 5-minute real-time pricing for all energy generated by both intermittent resources and the entire fleet of conventional resources in the regional market's footprint (which exceeds the scope of EIM dispatch);
- Availability of market-based ancillary services with lower-cost balancing options;
- Fewer renewable curtailments through improved region-wide forecasting, optimized unit commitment, and utilization of transmission infrastructure;
- Streamlined access to existing and new transmission to deliver low-cost renewables and one-stop shopping for generator interconnection requests and transmission planning service; in the entire region; Improved regional transmission planning to provide access to low-cost renewable areas within the regional footprint;
- Easier contracting for load-serving entities (including public power companies, cooperative utilities, municipal electric companies) as well as with commercial and industrial customers who do not currently have transmission access to the low-cost renewable generation areas within the region; and
- Improved financial hedging options through day-ahead markets, optimized congestion management, and congestion revenue rights, more transparent energy pricing, more

4 Gavin Blade, "SPP CEO: Regionalization, transmission help push renewables penetration near 50%," UtilityDive, May 26, 2016.

competitive access to a larger regional market, and improved access to more liquid trading hubs that offer longer-term forward contracting.

As discussed in more detail below, this reduction of integration and balancing costs faced by renewable generation developers or their contractual off-takers offered by regional ISO-operated markets reduces investment costs, thereby contributing to a more rapid development and growth of renewable generation in the regional footprint.

C. Facilitating The Development of Renewable Generation

Numerous existing studies show that ISO-operated regional markets facilitate renewable generation investment and, thus, a more rapid development and growth of renewable generating resources. Nationally, ISO-operated regional markets account for a disproportionate share of the nation-wide investment in renewables, which has been attributed to the improved integration of renewable resources in ISO-operated regional markets.[5]

For example, as of 2014 over 77% of wind generation capacity was installed in areas with regional electricity markets.[6] As shown in Figure 1, the seven states with the highest installed wind generating capacity are Texas, Iowa, California, Oklahoma, Illinois, Kansas, and Minnesota; they are all located in areas with ISO-operated wholesale power markets.[7]

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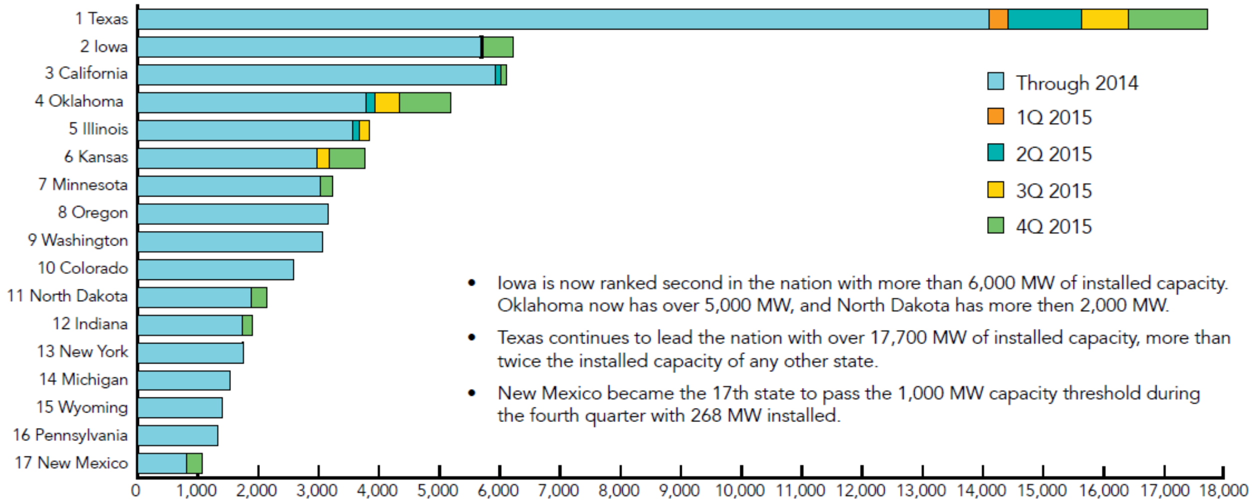
5 Hogan, W., "Electricity Wholesale Market Design in a Low Carbon Future", volume in Padilla, J. and Schmalensee, R., Harnessing Renewable Energy, p. 10, Available: https://www.hks.harvard.edu/fs/whogan/Hogan_Market_Design_012310.pdf

6 COMPETE, "RTO and ISO Markets are Essential to Meeting Our Nation's Economic, Energy and Environmental Challenges", 2014, pp. 3-4, Available: http://www.competecoalition.com/files/COMPETE%20RTO%20White%20Paper_December%202%202014%20FINAL.pdf

7 AWEA, "U.S. Wind Industry Fourth Quarter 2015 Market Report", American Wind Energy Association, January 2015, p. 14, Available: http://awea.files.cms-plus.com/FileDownloads/pdfs/4Q2015%20AWEA%20Market%20Report%20Public%20Version.pdf

Figure 1: Installed Wind Generation Capacity, End of 2015



* Source: http://awea.files.cms-plus.com/FileDownloads/pdfs/4Q2015%20AWEA%20Market%20Report%20Public%20Version.pdf

The fact that regional markets facilitate renewables integration has specifically been emphasized by developers and utilities. For example, MidAmerican stated when joining MISO that it was motivated in part by the ability of the market to provide ancillary services and facilitate integrating renewables.[8] Since joining MISO, MidAmerican has been able to greatly expand its (mostly voluntary) purchase and development of renewable resources, which are now expected to supply 58% of the utility's Iowa load by the end of 2016.[9]

As shown in Figure 2, in 2015, most of the country's wind generation additions were focused in the wind-rich areas of the Great Plains with regional wholesale power markets operated by ERCOT, SPP, and MISO. As also shown in Figure 2, significantly less development activity occurred in the similarly wind-rich areas of Wyoming, Colorado, and New Mexico without ISO-operated wholesale markets.

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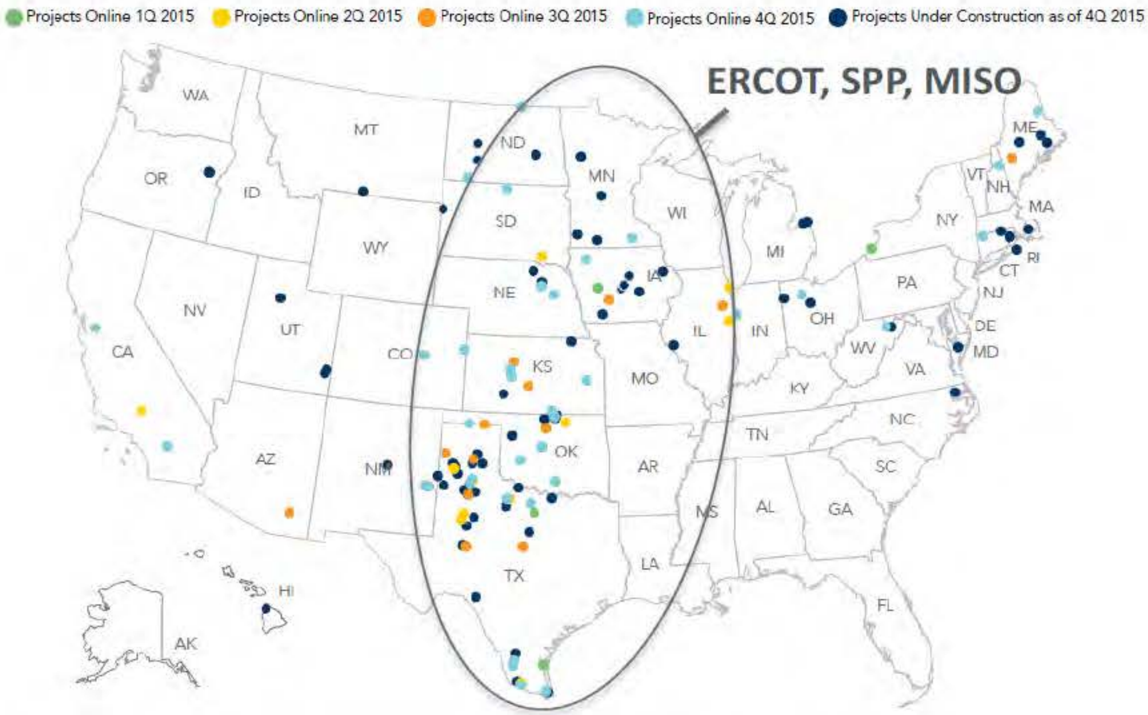
8 COMPETE, "RTO and ISO Markets are Essential to Meeting Our Nation's Economic, Energy and Environmental Challenges," 2014, pp. 3–4

9 These renewable energy purchases also allowed MidAmercian to retire 2,000 MW of coal plants. See Matyi and McGuirk, "2,000 MW of coal retired in the Midwest," *Mega Watt Daily*, April 15, 2016.

Figure 2: 2015 Wind Generation Additions and Projects under Construction



* Source: http://awea.files.cms-plus.com/FileDownloads/pdfs/4Q2015%20AWEA%20Market%20Report%20Public%20Version.pdf

The industry reports we reviewed summarize a range of factors by which ISO/RTO markets facilitate renewable development. These factors are summarized in Figure 3 and Figure 4 below. ISO/RTO markets improve transmission planning processes, allowing previously inaccessible renewable sites to be developed.[10,11] Features of ISO/RTO markets, such as 5-minute pricing, nodal pricing, and financial congestion hedging, enable further savings.[12] The larger geographic scale of ISO/RTO market footprints allows the development of renewable resources in lower-cost

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10 AWEA, "Green Power Superhighways: Building a Path to America's Clean Energy Future," American Wind Energy Association, 2009, Available: http://www.tresamigasllc.com/docs/2016_02_19_US_FOSG_GreenPowerSuperhighways.pdf

11 FERC-Regulated ISO/RTOs, "2010 ISO/RTO Metrics Report," 2010, Available: https://www.ferc.gov/industries/electric/indus-act/rto/metrics/summary-rto-metrics-report.pdf

12 FERC-Regulated ISO/RTOs, "2015 ISO/RTO Metrics Report," 2015, Available: http://www.pjm.com/%5CMedia%5Cdocuments%5Cferc%5Cfilings%5C2015%5C20151030-ad14-15-000-package.pdf

locations and reduces both the variability of renewable output due to geographic diversity and improves access to low-cost balancing resources.[13]

Figure 3: Summary of Studies Discussing How Regional Markets Facilitate Renewable Generation Development

Study	Finding
Brookings Clean Economy Study (2011)	• ISO/RTOs facilitate renewables through geographic diversity • ISO/RTOs also reduce barriers to expanding transmission capacity to allow additional renewables
AWEA Green Power Superhighways (2009)	• Markets that incentivize flexibility minimize the cost of integrating renewables • RTOs have been more effective in administering large balancing areas, using short scheduling intervals, and operating sophisticated energy markets
Hogan Markets In a Low Carbon Future (2010)	• Wind installations are disproportionately in RTO markets • Markets facilitate integration of low-carbon technology through improved granularity of pricing and dispatch
COMPETE Markets and Environmental Challenges (2014)	• Renewables developers are attracted to ISO/RTO markets due to transparency, fairness of rules, and geographic diversity
ISO/RTO Metrics Report (2015)	• ISO/RTOs facilitate renewables by establishing simple interconnection processes for new resources, providing access to spot markets, and allowing resources to take advantage of geographic diversity
IRC Increasing Renewables (2007)	• ISO/RTO markets facilitate renewables by having transparent pricing, highly granular dispatch, and geographic diversity

13 Muro, et al., "Sizing the Clean Economy: A National and Regional Green Jobs Assessment," The Brookings Institution, 2011, Available: http://www.brookings.edu/~/media/series/resources/0713_clean_economy.pdf

Figure 4: Summary of Factors by Which Regional Markets Facilitate Renewable Generation Development

Factor	Description
Improved Market Designs	Increased granularity in time (5-minute) and location (nodal) improves price signals and stimulates efficient transmission and generation investment Increased granularity increases the ability of prices to reflect avoided cost and improves dispatch of low carbon resources ISO/RTO markets provide a mechanisms for non-transmission owners (such as most renewables developers) to hedge against congestion RTO/ISO markets allow market participation by renewable resources by offering provide bid-based curtailments and providing ancillary services
Larger Markets	The larger geographic reach of ISO/RTO markets allows the development of renewable resources in lower-cost locations Allows a larger set of low-cost resources to provide balancing services for renewables Large footprints of ISO/RTO markets reduce balancing costs by taking advantage of the diversity of renewables output Liquidity of RTO spot markets further reduces the cost of addressing wind's variability and uncertainty compared to illiquid markets
Transparency, Open Access, and Fairness	Fair, transparent pricing rules give confidence to investors Markets reduce the potential for conflicts of interest in selecting new transmission projects and allocating the costs of these projects ISO/RTOs help promote Open Access to transmission, which is particularly important to the largely independent producers who develop renewables ISO/RTOs allow for market participation by all resources, including intermittent renewable resources

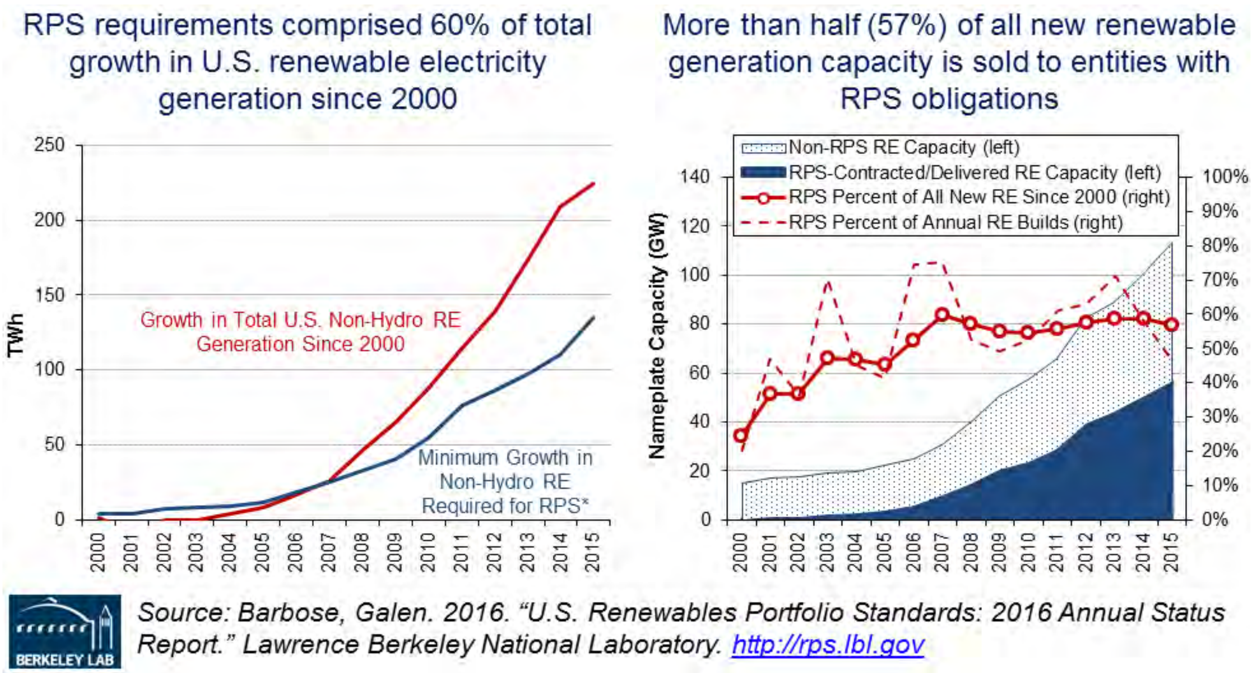
Finally, as summarized in the above tables, the transparency, fully open access to transmission, and fairness offered by independently operated RTOs provide increased confidence to investors in renewable generating plants. While ISO/RTOs support renewables penetration beyond the requirements of Renewable Portfolio Standards, they facilitate the implementation of the RPS itself. This observation is supported by the fact that most states with RPS are in regions with RTOs. Several U.S. ISO/RTOs support implementation of RPS by tracking generation and Renewable Energy Credits. This tracking is useful to market participants in meeting their RPS obligations and to states in monitoring compliance.[14]

[14] IRC, "Increasing Renewable Resources," ISO/RTO Council, 2007, p. 11, Available: http://www.consultkirby.com/files/IRC_Renewables_Report_101607_final.pdf

D. DEVELOPMENT OF RENEWABLE GENERATION BEYOND RPS REQUIREMENTS

In areas with access to low-cost renewable generation, regional markets have supported the development of renewable generating plants at levels well <u>beyond</u> RPS mandates. In fact, as shown in Figure 5, since 2000, RPS mandates have been responsible for only about 60% of the total development of non-hydro renewable generation nation-wide.[15]

Figure 5: Renewable Generation Investments for and beyond RPS Requirements



Based on data provided by Dr. Galen Barbose of the Laurence Berkeley National Laboratory (LBNL), most of the development of renewables beyond RPS requirements has occurred in ISO/RTO regions with low-cost wind resources. For example, since 2000, wind generation accounted for 80% of 44,000 MW of non-RPS-related renewable generation additions nationwide, and 80% of these non-RPS-related wind generation investments (over 28,000 MW) took place in six states (Texas, Iowa, Oklahoma, Kansas, Illinois, and Indiana), all of which are in ISO-operated market areas. In 2015 alone, 6,100 MW or 95% of all non-RPS-related wind

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15 Barbose, G., "U.S. Renewables Portfolio Standards: Overview of Status and Key Trends," Lawrence Berkeley National Laboratory, January 2016, p. 7, Available: https://emp.lbl.gov/sites/all/files/2016%20CESA%20Webinar%20Barbose.pdf

generation additions were located in just these six states with low-cost wind resources and ISO-operated regional markets.[16]

Particularly in Texas and the Great Plains portion of the Midwest—with regional power markets operated by ERCOT, SPP, and MISO—the penetration of wind generation has far exceeded RPS mandates. As shown in Figure 6, 72% of Texas' total 17,800 MW of wind generating capacity installed by the end of 2015 was unrelated to RPS mandates and 7,690 MW of these "beyond-RPS" wind plants have been added in the last five years. The output of these 7690 MW is equivalent to 6.9% of Texas retail load. Similarly, the LBNL data summarized in Figure 6 shows that more than 9,200 MW of wind generation were added in the Midwest (mostly western SPP and MISO) unrelated to RPS requirements over the last five years.[17] These 9,200 MW of wind generation additions are equivalent to serving more than 3% of total Midwestern retail load beyond RPS requirements.

Figure 6: Wind Generation Investments beyond RPS Requirements in Texas and the Midwest

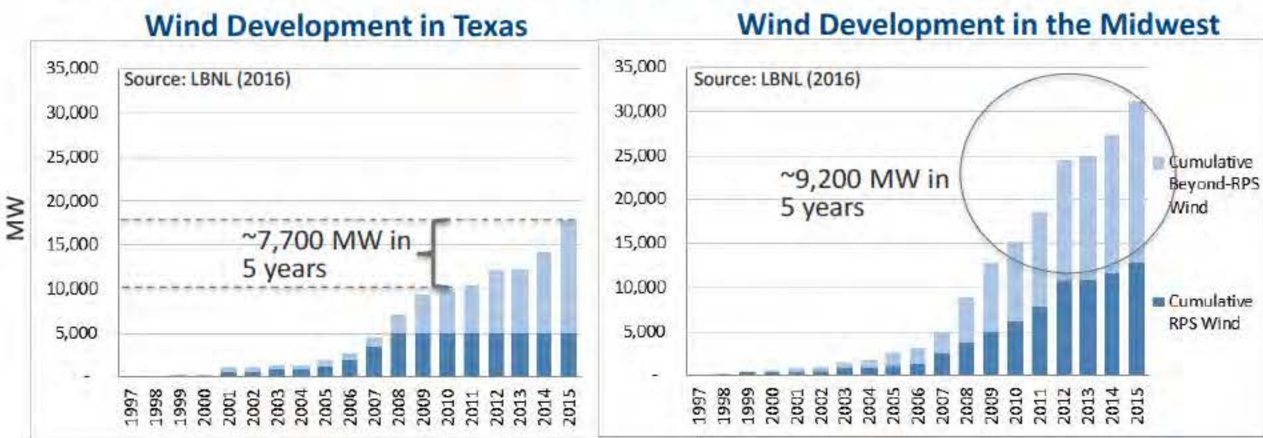

Figure 7 shows the amount of beyond-RPS wind added in Texas and the Midwest as a share of total retail load in these regions. As mentioned above, the 7,690 MW of wind unrelated to RPS that has been installed in Texas over the last five years represents 6.9% of Texas retail load. Similarly, the 9,200 MW of beyond-RPS wind installed in the Midwest over the same period represents 3% of retail load. Figure 7 also provides a benchmark for the 5,000 MW of additional beyond-RPS wind assumed to be developed between 2020 and 2030 in regional market scenarios of the SB350 study. This 5,000 MW of additional wind generation represents only 2.6% of the

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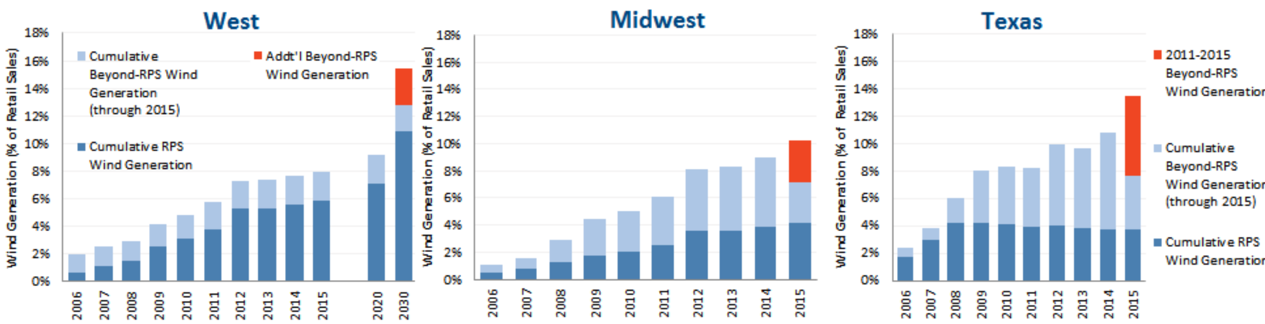
16 Based on data provided by Dr. Galen Barbose of LBNL.

17 Based on data provided by Dr. Galen Barbose of LBNL.

regional market's 2030 retail load, a smaller share than the amount of beyond-RPS wind that has already been developed in Texas and the Midwest. This assumption is also discussed in more detail in Volume I of this report.

Figure 7: Wind Generation Development to meet RPS Requirements and Beyond

Historical (and simulated WECC future) in Regions with ISO-markets and Low-Cost Resources



Historical RPS and beyond-RPS wind installations data and retail load data provided by Dr. Galen Barbose of LBNL. We used average 2012 wind capacity factors by region to estimate wind generation based on installed capacity. We assumed a 10% loss factor when comparing wind generation and retail load.

Most of these wind generation investments beyond RPS mandates are supported by power purchase agreements ("PPAs") voluntarily signed by utilities, public power companies, and large commercial or industrial customers. However, the combination of transmission access, an improved wholesale market design, and liquid forward markets even allowed ERCOT to attract over 1,400 MW of pure "merchant" wind projects in 2014. Expanded transmission and the improved wholesale market design allowed ERCOT to reduce wind curtailments from 17% of generation in 2009 to 0.5% of generation in 2013, thereby increasing renewable energy generation without the need for new construction of renewable resources.[18]

The industry studies reviewed show that the drivers behind renewable generation development beyond RPS mandates fall into four distinct categories:

- **Voluntary PPAs by Investor-Owned Utilities in Excess of RPS Requirements.** While Investor Owned Utilities are often subject to RPS requirements, many utilities in areas

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18 Wiser, R. and Bolinger, M., "2014 Wind Technologies Market Report," Lawrence Berkeley National Laboratory, August 2015, pp. 38, 66, Available: http://energy.gov/sites/prod/files/2015/08/f25/2014-Wind-Technologies-Market-Report-8.7.pdf

"Merchant" projects are those whose electricity sales revenue is tied to short-term contracted and/or wholesale spot electricity market prices (with the resulting price risk commonly hedged over a 10- to 12-year period) rather than being locked in through a long-term PPA. (*Id.*, at 27) with access to low-cost wind generation have procured additional renewables for economic reasons. For example, because of MidAmerican's voluntary purchases and development of low cost wind resources, wind generation is projected to supply 58% of the utility's Iowa load by the end of 2016.[19]

- **Purchases by Public Power and Municipal Utilities Not Subject to RPS.** Public Power and Municipal Utilities, who are generally not subject to RPS requirements, have voluntarily contracted for significant amounts of renewable generation. For example, publicly-owned utilities were responsible for 15% of the renewable generation purchases in 2014.[20]
- **PPAs by Commercial and Industrial Customers.** Commercial and industrial electricity customers are increasingly opting to purchase renewable power through PPAs with renewable power developers. As discussed further below, in regional markets that can readily accept the energy produced by renewable generating resources, such PPAs with retail electricity customers are possible even in states without retail access. According to Renewable Choice Energy, 3,420 MW of voluntary PPAs for renewable energy were signed by commercial and industrial customers in 2015 (up from 1,615 MW in 2014 and 559 MW in 2013).[21,22]
- **Merchant Renewable Generation Development.** Merchant wind generation projects have been developed without a long term PPA. They often sell power into spot energy markets and may use multi-year financial hedges to support the financing of the generation investments. While utilities remain the largest purchaser of renewables, merchant wind installations reached 33% of the total renewable generation development in 2014.[23]

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[19] These renewable energy purchases also allowed MidAmercian to retire 2,000 MW of coal plants. See Matyi and McGuirk, "2,000 MW of coal retired in the Midwest," MegaWatt Daily, April 15, 2016.

[20] Wiser, R. and Bolinger, M., "2014 Wind Technologies Market Report," Lawrence Berkeley National Laboratory, August, 2015, p. 27

[21] O'Shaughnessy, E. *et al.*, "Status and Trends in the U.S. Voluntary Green Power Market (2014 Data)," NREL, October, 2015, p. v., Available: http://www.nrel.gov/docs/fy16osti/65252.pdf

[22] Powers, J. "The Rise of the Corporate Energy Buyer," Renewable Choice Energy, 2016, Available: http://www.renewablechoice.com/blog-corporate-energy-buyer/

[23] Wiser, R. and Bolinger, M., "2014 Wind Technologies Market Report", Lawrence Berkeley National Laboratory, August 2015, p. 27, Available: http://energy.gov/sites/prod/files/2015/08/f25/2014-Wind-Technologies-Market-Report-8.7.pdf

Recently, several new mechanisms have emerged to enable voluntary purchases of renewable electricity. In some states, community choice aggregation programs allow municipalities to purchase renewable electricity on behalf of some or all of the customers in their jurisdictions. Community solar programs allow customers to directly support the construction of a solar facility while continuing to receive power from their local utility. Of particular interest, large commercial and industrial customers have increasingly been signing PPAs to procure renewable energy directly. Such PPAs are facilitated by organized markets.

According to NREL, "voluntary" renewable purchases by retail customers accounted for 26% of U.S. non-hydro renewables generation in 2014 (74 million MWh), an increase of 10% over 2013.[24] Such voluntary purchases could be executed in several ways. First in de-regulated states, customers may purchase renewable electricity from competitive suppliers. Second, in regulated states where no retail choice exists, utilities may procure renewable electricity and then sell it to their customers using green pricing programs or tariffs. Third, customers in any region can purchase "unbundled" Renewable Energy Credits (RECs) that are sold independently of the underlying renewable energy. And finally, customers can sign PPAs that financially support renewable generation investments whose energy is injected into the regional wholesale power market while customers continue to be served by their local utility through the utility's standard regulated retail service.

Commercial and industrial purchasers account for an increasingly large share of renewable PPAs and such retail purchases are increasing over time. Non-utility entities have been reported to account for over 50% of all wind PPAs in 2015.[25] The recently formed Renewable Energy Buyers Alliance (REBA), a collection of more than sixty companies interested in increasing purchases of renewable energy, set a goal of procuring 60,000 MW of new renewable generation in the U.S. by 2025.[26,27] Figure 8 shows aggregate commercial and industrial (C&I) PPA deals over time by counter-party.

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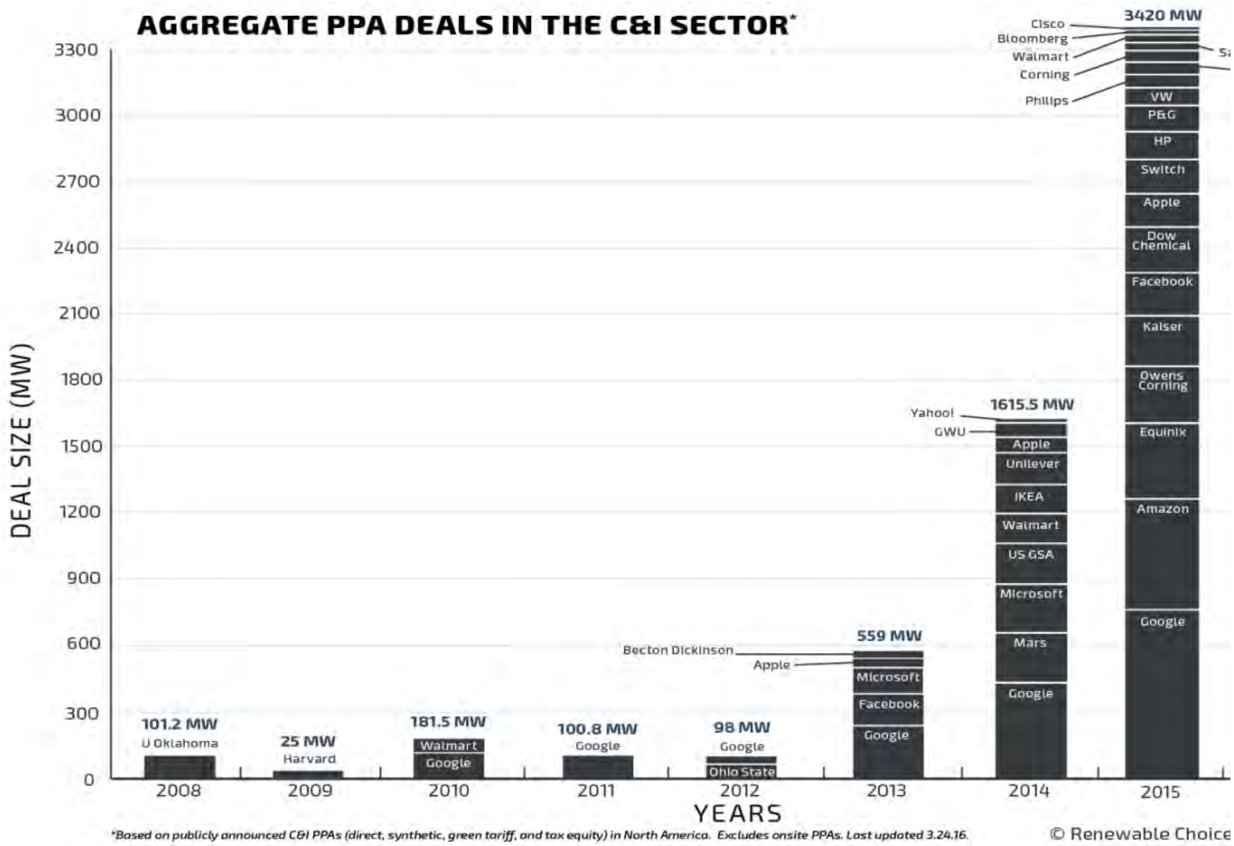
24 O'Shaughnessy, E. *et al.*, "Status and Trends in the U.S. Voluntary Green Power Market (2014 Data)," NREL, October, 2015, Available: http://www.nrel.gov/docs/fy16osti/65252.pdf

25 Copley, M. "Business coalition doubles down on corporate demand for renewables," SNL, May 13, 2016, Available: https://www.snl.com/InteractiveX/article.aspx?id=36493637&KPLT=2

26 WRI, "RELEASE: Renewable Energy Buyers Alliance Forms to Power the Corporate Movement to Renewable Energy," WRI Press Release, May 12, 2016, Available:

Continued on next page

Figure 8: Aggregate PPA deals with Commercial & Industrial Customers
(Reproduced from renewableenergychoice.com)



Source: http://www.renewablechoice.com/blog-corporate-energy-buyer/

See also: http://www.renewablechoice.com/blog-electricity-corporate-ppa-buyers/

Based on the authors of Figure 8, all PPAs shown on the chart involve long-term PPAs, for bundled off-site resource (not unbundled RECs), involve new construction, are mostly for wind generation (with some solar), and are generally (but not always) located in the same ISO market as the retail customers.

Continued from previous page

http://www.wri.org/news/2016/05/release-renewable-energy-buyers-alliance-forms-power-corporate-movement-renewable

27 WRI, "Corporate Renewable Energy Buyers' Principles: Increasing Access To Renewable Energy," December 2015, Available: http://www.wri.org/sites/default/files/Corporate_Renewable_Energy_Buyers_Principles.pdf

Google, one of the most active companies in this regard, states the following about its renewable power purchases:[28]

> Google's goal is 100% renewable power, and to date we've signed 16 contracts to purchase over 2.2 Gigawatts of clean energy…To achieve our goal, we're buying clean electricity directly from wind and solar farms around the world through Power Purchase Agreements (or PPAs), and we're additionally working with our utility partners to make more renewable energy available to us and others through renewable energy tariffs and bilateral contracts.
>
> We hold ourselves to the highest standards when purchasing clean power. First, our contracts must create new sources of green power on the grid. Second, we purchase renewable energy in the same grid regions from which we're withdrawing power. And third, we purchase "bundled" energy and RECs, meaning the same quantity of energy and RECs at the same time.

More recently, organized wholesale markets have been facilitating the development of renewable generating facilities through PPAs with commercial and industrial customers in the form of so-called Contracts for Differences ("CfD")—a novel mechanism allowing non-utility purchasers to access both the environmental and economic benefits of new renewables in states with or without retail access. In a CfD arrangement, customers obtain bundled RECs directly from the renewable generator, but leave their existing retail arrangement unchanged. Meanwhile, the renewable generator sells the PPA-related energy output into the local wholesale market at market rates. The customer and renewable generator then settle for the difference between the wholesale market price and the contract price. If the wholesale price is less than the contract price, the customer pays the renewable generator. If the wholesale price is higher than the contract price, the renewable generator pays the customer. The CfD arrangement provides a steady revenue stream for the renewable generator and allows the customer to hedge against electricity price risk while obtaining the environmental benefits of purchasing renewable generation in the wholesale power region in which they are located.

Figure 9 illustrates the concept. While such contracts have recently been used by Apple, Google, and Kaiser Permanente to execute renewable PPAs in California,[29] they are particularly

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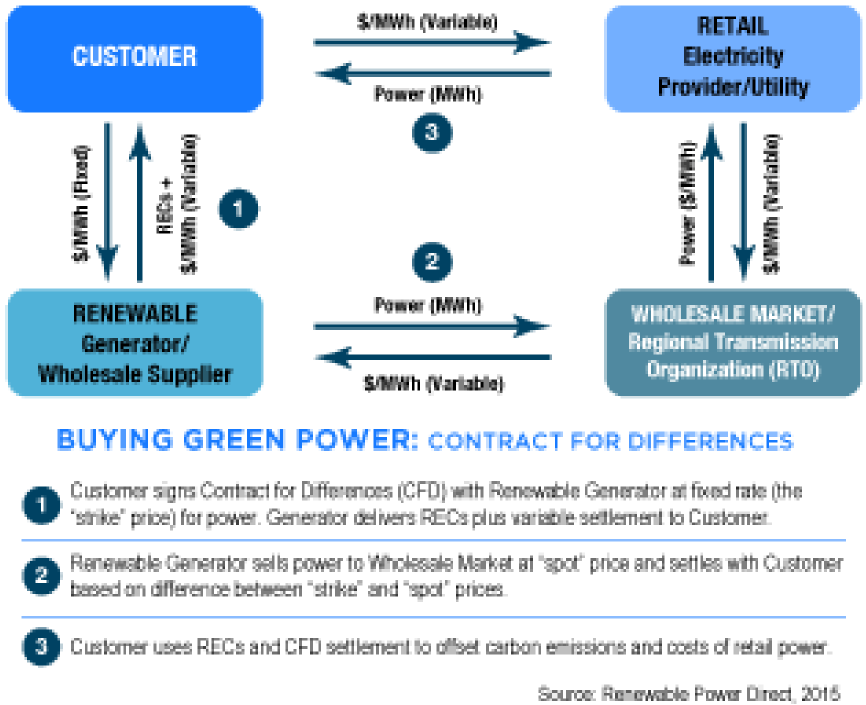
[28] See https://www.google.com/green/energy/use/#purchasing. Amazon's goals and approach are very similar: http://aws.amazon.com/about-aws/sustainability/

[29] Catasein, J. "A New Way for Companies to Go Green," Renewable Power Direct, February 27, 2015, Available: http://renewablepowerdirect.com/a-new-way-for-companies-to-go-green/

attractive in regional wholesale markets that provide access to the lower-cost renewable resources.

Figure 9: Renewable Purchases Using Contracts for Differences
(Reproduced from renewablepowerdirect.com)



Reproduced from: http://renewablepowerdirect.com/a-new-way-for-companies-to-go-green/

As the industry data discussed earlier shows, the majority of renewable generation developed beyond RPS requirements occurred in areas that offer both (1) low-cost renewable generating resources that make contracts economically attractive; and (2) ISO-operated regional wholesale power markets. Regional markets without access to low-cost renewable resources (such as CAISO, ISO-NE, NYISO, and PJM) show significantly less renewable development beyond RPS requirements.

E. Reliability Impacts

The quantitative analyses of ratepayer savings and environmental and economic impacts presented in this report focus on maintaining the existing level of reliability in a more cost-effective fashion. The estimated ratepayer impacts include only the following cost savings associated with meeting applicable planning and operational reliability standards:

- Lower generation investment costs from load diversity based on estimated market price for capacity. This does not capture the additional reliability value of any achieved higher reserve margins.
- Production cost savings associated with lower operating, regulation, and load-following reserve requirements and the reduced cost of providing these operating reserves due to reserve sharing and net load diversity.

This quantification of ratepayer benefits does not reflect the value of achieving more reliable region-wide system operations.

Expanding ISO operations to a larger regional footprint additionally offers significant reliability benefits to both California and the larger regional market area for several reasons. Regional ISO operations and practices will offer various reliability benefits over the standard operational practices of Balancing Authorities in the WECC footprint. Because the WECC is a single interconnected power system, reliability events in neighboring WECC areas affect California as well.[30] Expanding regional market operational practices consequently offers reliability benefits to (a) the expanded regional footprint which, in turn, (b) increases reliability in the ISO's current California footprint. Reliability-related benefits will be particularly pronounced during stressed system conditions, such as extreme weather, drought, and unexpected outages.

As presented in Figure 10 (prepared by CAISO), even relative to the enhanced reliability benefits achieved by EIM, an ISO-operated, consolidated regional market and balancing area offers important additional reliability benefits.

As the table shows in significantly more detail, these enhanced regional reliability-related benefits include:

- Improved real-time awareness of system conditions[31];

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30 Examples of WECC-wide reliability events that affected California include the October 6, 2014 Northwest RAS Event; the September 8, 2011 Arizona–Southern California Outage; and the August 10, 1996 Western Interconnection (WSCC) System Disturbance.

31 This would be complementary to the role of the reliability coordinator for the Western Interconnection (Peak Reliability) – a NERC registered entity responsible for providing provide situational awareness and real-time monitoring of the Reliability Coordinator (RC) Area within the Western Interconnection.

- More timely, more efficient, and lower-cost congestion management and adjustments for unscheduled flows;
- Regionally-optimized, multi-stage unit commitment;
- Enhanced systems and software for monitoring system stability and security;
- Enhanced system backup;
- Coordinated operator training that exceeds NERC requirements;
- More frequent review of operator performance and procedures;
- Consolidated standards development and NERC standards compliance;
- More unified regional transmission planning to address long-term reliability challenges;
- Broader fuel diversity to more effectively respond to reliability challenges associated with changes in fuel availability or costs and hydro/wind/solar conditions; and
- Better price signals for investment in new resources of the right type and in the right geographic locations
- More effective deployment and dispatch of resources and reserves that will enhance reliability and recognizes system conditions across the entire regional foot print.

Figure 10: Reliability Benefits of Regional Market Operation, Compliance, and Planning

	Reliability Benefits of Regional Market Operation, Compliance, and Planning			Extent Achievable	
	Function	**Western Interconnection Operations/Standard Practice**	**Regional Operations/ISO Practice**	**EIM**	**Full Day-2 Market**
1	Locational 5-minute Real-Time (and Hourly Day-Ahead) Price Signals	Bilateral markets achieve reliability based on contractual rights and industry standards with little guidance from locational prices or focus on economic impacts	• ISO enhances reliability by informing all market participants on the state of grid conditions and market operations through locational electricity prices and the day-ahead and real-time posting of other key system information • As a reflection of actual real-time (and projected day-ahead) system conditions, market prices in the ISO energy market provides specific locational signals where more (or less) generation is needed to maintain reliabilty	Limited to real-time prices and conditions	Provides Day-Ahead and opportunity to converge prices reflective system conditions between markets and thus providing
2	Congestion Management	• Performed using WECC Unscheduled Flow Mitigation Procedure or internally developed operating procedure based on congestion management system • 30 – 60 minute response time	• Market-based congestion management that relies on a five minute security constrained economic dispatch to mitigate transmission congestion on a least-cost basis allows for more timely and efficient congestion management • Look Ahead Commitment Tool provides unit commitments, de-commitments, online extension recommendations for congestion management, and models near-real-time conditions to utilize resource capabilities • Simultaneous feasibility tests performed to capture transmission security constraints in DA market processes, while Real-time contingency analysis of Energy Management System provides real-time security constraints for real-time clearing and pricing	Limited to real-time condtions	Day-Ahead can anticipate and position system to avoid congestion in real-time based on the greater situtational awareness.
3	Unscheduled Flow Management	• Unscheduled flows are managed sub-optimally on a limited set of qualified paths	• A regional integration allows congestion management to more effectively manage unscheduled flows in the entire grid and also solve the related congestion	Limited to real-time condtions	Day-Ahead can anticipate and position system to avoid unscheduled flow. A broad region would elminate unscheduled flow because all flow would be managed by congestion management
4	Regional Unit Commitment	Decentralized unit commitment decisions without region-wide perspective and differing granularity can lead to inconsitencies and unintended reliability	Regional unit commitment to address footprint-wide reliability needs: • Advisory 2-day ahead process • Multi-day residual unit commitment (RUC) • Regional Reserve Requirements Calculation • Day-Ahead RUC • Intra-Day RUC • Ensure availability of flexible capacity	Limited to short-start resources	Incorporates all periods of unit commitment and can ensure commitment aligns with flexibility needs

	Reliability Benefits of Regional Market Operation, Compliance, and Planning			Extent Achievable	
	Function	**Western Interconnection Operations/Standard Practice**	**Regional Operations/ISO Practice**	**EIM**	**Full Day-2 Market**
5	Sytem Monitoring and Visualization	• Real-time monitoring using SCADA on a local area basis (Some has limited Real Time Contingency Analysis) • Use of standard vendor supplied displays • Operator interface of standard monitor display screen augmented with static map board (some has digital dynamic map board) • Ad-hoc and off-line voltage security analysis review	• Regional view/monitoring of the power system including: – A State Estimator - runs every 60 seconds – Contingency analysis of over 2000 contingencies every five minutes that is scallable to higher number of contingencies – 24-hour shift engineer coverage responsible for maintaining security application performance - Advanced real-time voltage stability and security application • Extended use of custom tools and displays to allow for faster analysis and better situational awareness • Large video wallboard (80 feet) that provides operators with live data reflecting the state of the power system and real-time market results • Real-time Voltage Stability Analysis Tool (VSAT) and Transmission Security Assessment Tool (TSAT), which allow comprehensive analyses of system operating conditions for predicting and preventing voltage insecurity and transient instability	Limited to real-time conditions and EIM footprint	Can monitor and visualize prior to real-time and thus respond to security conditons prior to real-time expanding solution options for secure operation over entier region.
6	Backup Capabilities	• Offline and/or scaled down backup facility • Significant time to bring backup facility up in the event a failover or failback is needed • Testing of failover process performed annually	• 24 x 7 staffed back-up control center • On-line back-up facility with full coverage of power system and market applications immediately available • Less than 30 minutes required for failover or failback for critical applications • Testing of failover process is performed quarterly for critical applications	Not covered because BA maintains its role	Consolidated back-up capablity
7	Operator Training	• Classroom training only (some has limited simulators) • Train to meet minimum NERC requirements • Five-person rotation (no training rotation) and some has six person rotation • Offline power system restoration procedure review	• Training methods include extensive use of full-dispatch training simulator • Training exceeds NERC requirements • Six-person rotation at key operator positions (allowing a training week during each cycle) • Annually conduct a regional "live" power system restoration drill that includes dozens of companies in the region	Not covered because BA maintains its role	Consolidated, consistency across region
8	Performance Monitoring	• Performance reviewed on a "post-event" basis • Operator call review on a "post-event" basis	• Daily review of operational performance including: – Frequent near-term performance feedback to operators and support personnel – Routine review of upcoming operational events • Standardized operator call review process • Feedback provided to each operator	Not covered because BA maintains its role	Consolidated, consistency across region
9	Procedure Updates	• Procedures updated on an ad-hoc, as-needed basis	• Annual procedure review conducted on all control room procedures • Routine drills including member participation conducted on capacity emergency procedures • Annual Emergency Operating Procedures training session with members, neigboring entities, and reliability coordinator	Not covered because BA maintains its role	Consolidated, consistency across region

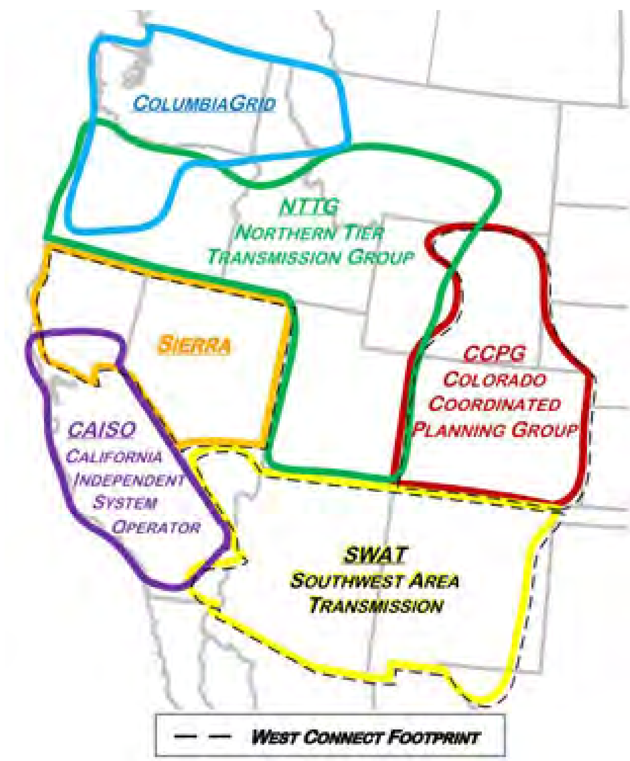
	Reliability Benefits of Regional Market Operation, Compliance, and Planning			Extent Achievable	
	Function	**Western Interconnection Operations/Standard Practice**	**Regional Operations/ISO Practice**	**EIM**	**Full Day-2 Market**
10	Standards Development	• Utilities are varied in their approach to standards engagement. • Many are “standards takers,” relying on the good judgment of others in the industry to develop standards.	• By collaborating and participating in the standards creation, the ISO and its members can better manage the ultimate compliance responsibilities • ISO engages in several WECC/NERC drafting teams to actively manage the scope of standards development and to limit the number of changes required to MISO and stakeholders • ISO’s integrated efforts lighten the workload on all members for a given level of input and control of the process	Not covered because BA maintains its role	Consolidated, consistency across region
11	NERC Compliance	• Many parties in the WECC region are responsible for managing NERC compliance • 30+ Interchange Authorities, Transmission Service Providers, Balancing Authorities (BA) • Several Planning Authorities • Individual Reserve Sharing Groups	• With ISO as a regional balancing authority, many compliance responsibilities are consolidated (and member responsibilities decreased) • Single regional Transmission Service Provider • Significantly fewer BAs and related compliance requirements • Fewer Planning Authorities • Consolidated Reserve Sharing Administrator • Centralization of some Transmission Operator Requirements • Allows members to avoid hiring compliance-dedicated staff or reduce existing compliance-driven staff to track these compliance-related issues	Not covered because BA maintains its role	Conssolidated, consistency across region
12	Regional Planning	• Planning by many individual utilities focused on local needs • Regional and interregional planning require complex coordination amont many utilities and planning groups	• Single regional view and planning can address reliability needs more accurately and consistently • Offers opportunities to find most efficient solutions across multiple transmission owners	Not covered because BA maintains its role	Consolidated, consistency across region
13	Fuel Diversity	• 38 WECC Balancing Areas with limited fuel diversity within many of the areas	• Regional market can mitigiate reliability risks associated with fuel supply risks (Gas, Hydro/Drought, Renewable Intermittency)	Limited to real-time and voluntary	More fully leverages diverstiy across region and market time frames
14	Long-term Investment Signals	Bilateral markets provide less granular price signals which can result in less efficient investment and placement of generation resources and transmission infrastructure	Price signals sent by the ISO’s market provides investors in generation assets with more economic signals upon which they can anchor their forecasts for future wholesale prices and provide the basis for market driven investments	No real-time, too limited	Full leverages signals across regoin and market time frames leveraging regional resource adequacy opportunity

F. REGIONAL TRANSMISSION PLANNING

A larger ISO-operated regional market will offer improved regional transmission planning, from a reliability, economic congestion management, and renewable integration perspective. Transmission planning is currently undertaken in a coordinated but not integrated fashion by the CAISO and each of several sub-regional transmission planning groups in the West.

As shown in Figure 10, this planning process currently requires the coordination of utility planning efforts through four transmission planning groups: (1) CAISO; (2) WestConnect (and its three embedded sub-regions, Sierra, Southwest, and Colorado); (3) Northern Tier Transmission Group; and (4) Columbia Grid.

Figure 11: Western Sub-Regional Planning Groups



Source: http://www.westerngrid.net/western-sub-regional-planning/

Outside the CAISO, which employs a single integrated planning process, intra-regional planning within each of these planning sub-regions is conducted by aggregating individual transmission plans of the member utilities and conducting sub-regional studies to identify possible sub-regional transmission projects that are more effective than the projects proposed by the individual utilities. Planning of transmission projects that cross the boundaries of the individual sub-regions requires substantial and complex coordination across these individual planning groups, which employ their own (in many aspects unique) planning processes. This coordination is time consuming and challenging even under the coordination requirements under FERC Order No. 1000 on transmission planning and cost allocation.[32] The challenges of interregional planning are further magnified by the absence of a clear cost allocation framework for valuable interregional transmission projects.

In comparison, the more unified transmission planning process of an expanded regional ISO offers significant benefits and additional long-term value through the following features:

- A single, unified planning process and set of planning criteria that will apply to a larger regional footprint;
- ISO-market operations and price signals that allow for an enhanced focus on identifying valuable economic and public policy transmission projects (while maintaining reliability) that reduce overall system costs;
- Planning for a larger regional footprint that will facilitate regional access to and integration of renewable resources;
- Generator interconnection and repowering processes that are simplified because more power flows are internalized within the planning region and fewer individual planning will be affected by unscheduled loop flows;
- Fewer planning coordination challenges, enhanced regional planning visibility, and more consistent and unified regional planning tools in a regional footprint that includes a greater number of individual transmission owners;
- Streamlined cost allocation processes that facilitate development of valuable regional transmission projects; and
- Fewer interregional planning challenges related to "market seams" between small, individual planning areas.

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32 See http://www.ferc.gov/industries/electric/indus-act/trans-plan/filings.asp

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Senate Bill 350 Study

Volume XII: Review of Existing Regional Market Impact Studies

PREPARED FOR

California ISO

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July 8, 2016

THE Brattle GROUP

Senate Bill 350 Study

The Impacts of a Regional ISO-Operated Power Market on California

List of Report Volumes

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Volume XII. Review of Existing Regional Market Impact Studies

A. Introduction

We reviewed a number of other studies that have estimated the benefits of organized regional electricity markets. While most other studies analyzed markets different from those projected for California and the West, they offer relevant information and helpful reference points. Many of these studies employ analytical frameworks similar to those used in this SB 350 study. Taken together, the studies show that the magnitude of benefits from regionalizing markets is generally consistent across various regions, circumstances, and time periods.

Some of the studies we reviewed analyzed circumstances similar to those explored in this SB 350 study. For example, the SPP Retrospective Study (2015) estimated the benefits of moving from an imbalance market similar to California's Energy Imbalance Market to a full Day-2 Market. This study is particularly relevant for SB 350 because SPP resembles WECC in other ways, albeit on a smaller scale. Much like WECC, SPP has a mix of natural gas, coal, and renewable generation with major load centers in one portion of the footprint (the southeast) and distant areas with low-cost renewable generation (the Great Plains). Additionally, the Basin/WAPA Study (2013) explored the benefit of regional market participation to public power entities similar to those found in WECC. The Entergy-MISO Study (2011) analyzed the benefits of the expansion of a regional market.

A few of the reviewed studies specifically focused on WECC and explored the benefits of improved regional market design and renewable integration. For example, and as discussed further below, the Low Carbon Grid Study (2016) simulated the WECC for a 2030 study year with very similar study assumptions, yielding very similar results for both California and the broader WECC region.

B. Market Integration Studies Reviewed

Figure 1 below summarizes the types of studies reviewed to provide background and reference levels for the analysis of the impacts that regional market integration and region-wide independent system operations would likely have on California and the surrounding regions.

Figure 1: Studies Reviewed

Study Type	Examples of Studies
Day-2 Market Studies Evaluate benefits of moving from de-pancaked transmission and energy imbalance market to full Day-2 market	SPP Retrospective (2015), SPP Prospective (2009), Navigant Markets Study (2009), Chan Efficiency Study (2012), MISO Value Proposition Report (2015), MISO Retrospective Study (2009), Wolak Nodal Study (2011), NYISO Plant Efficiency Study (2009), ERCOT Nodal Study (2014)
RTO Participation Studies Evaluate benefits and costs to a utility of joining an existing RTO	E3 PAC Integration Study (2015), Basin/WAPA Study (2013), Entergy-MISO Study (2011), Entergy SPP/MISO Cost-Benefit Analysis (2010), Mansur PJM Efficiency Study (2012)
Post Order 2000 RTO Studies Benefit-cost studies of forming RTOs that followed issuance of FERC Order 2000 in late 1999	LBNL Review Study (2005), RTO West Study (2002), National RTO Study (2002)
EIM Studies Evaluate the benefits of the Western EIM, or the benefits of a utility joining the EIM	WECC-Wide EIM (2011), APS-EIM (2015), PGE-EIM (2015), NV Energy-EIM (2014), Puget Sound-EIM (2014), PacifiCorp-EIM (2013)
European Market Integration Studies Evaluate the benefits of market integration in the European context	EPRG Integrating European Markets (2015), DNV-GL European Renewable Integration Study (2014)
Renewables Studies Studying the challenges of higher penetration of renewable resources	NREL/DOE WWSIS 2 (2013), Low Carbon Grid Study (2016), WGA Integration Study (2012), SPP Wind Integration (2016)
Markets-Based Renewables Studies Discussing the function of markets in facilitating renewables development beyond RPS requirements	Brookings Clean Economy Study (2011), AWEA Green Power Superhighways (2009), Hogan Markets In a Low Carbon Future (2010), COMPETE Markets and Environmental Challenges (2014), ISO/RTO Metrics Report (2015), IRC Increasing Renewables Study (2007), LBNL Wind Technologies Market Report (2015), NREL Voluntary Green Power (2015)

While the scopes and objectives of some of these studies differ markedly from the requirements under SB 350, most of them estimate the cost savings and price impacts of regional market integration. This provides a useful reference point for the ratepayer impact analyses required under SB 350. Additional industry studies were reviewed in the context of regional markets' facilitation of renewable generation developments. These studies and the related industry data is discussed in Volume XI of this report.

C. Most Prospective Regional Market Integration Studies Show Production Cost Savings Ranging from 1% to 3%

The transition to regional markets impacts both investment-related (fixed) costs and production-related (variable) costs. The impact of regional markets on variable production costs has been studied extensively in many analyses from both a prospective (*ex ante*, before the fact) and retrospective (*ex post*, after the fact) basis. The prospective studies we reviewed generally report production cost savings associated with transitioning to a regional market in the range of 1% to 3% of the system's total production costs. Note, however, that the magnitude of intermittent renewable generation present in the regions analyzed in most of these studies is well below the magnitude of existing and projected future renewable generation in California and the WECC.

These studies typically use production cost models to simulate a "Without Regional Market" (or "Smaller Regional Market") case to compare with a "With Regional Market" case. Savings are then estimated based on the difference between the two cases' production costs. The market design features that are simulated to represent the "Without Regional Market" and "With Regional Market" cases differ across the studies. The most common market design feature used to represent a "With Regional Market" case is to have a full "Day-2" market (consisting of integrated day-ahead energy, real-time energy, and ancillary services markets) in which the transmission charges are fully de-pancaked within the study region. The de-pancaking of transmission charges means that, within the regional market, energy transactions between the individual areas of the regional market are not subject to any variable transmission charges.[1]

Most of the production cost simulations do not incorporate uncertainties in load or generation between the time when conventional generation is committed (mostly on a day-ahead basis) and the real-time dispatch of these resources against load. A few of the studies differentiate between the day-ahead commitment time frame and the real-time market to capture the potential impact caused by unanticipated changes in load and generation between the two time frames. Some of the studies analyze the potential impact of more efficient utilization of the existing transmission system due to automated, security-constrained economic dispatch for the entire region. Collectively, these prospective studies embody a representative range of analytical approaches used to estimate production cost savings from regional market integration.

Figure 2 summarizes the features of the Regional Markets that are analyzed across various prospective studies and thereby represent the benefits that the various studies are able to capture through the production cost simulations. The last row in the figure shows the estimated production cost savings (as a percentage share of total production costs) reported by the studies.

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1 In other words, while loads pay for transmission at the withdrawal point, they can be served from any resource within the region without incurring additional, transaction-specific transmission charges.

Figure 2: Market Features and Production Cost Savings Captured in Prospective Market Integration Studies (expressed as a % of system production costs)

Market Design Features Captured in Production Cost Savings	National RTO (2002) [1]	LBNL Review (2005) [2]	RTO West (2002) [3]	SPP Prospective (2009) [4]	Basin/ WAPA (2013) [5]	Entergy-MISO (2011) [6]	E3 PAC Integration (2015) [7]
Transmission Charge De-Pancaking	✓	✓	✓	✓	✓	✓	✓
Day-Ahead Market	no	✓	no	✓	✓	✓	✓
Full Real-Time Imbalance Market	✓	Varies	✓		✓	✓	Varies
Ancillary Services Market	no	Varies	✓	✓	no		Varies
Improved Transmission Utilization	✓	Varies	✓	no	no	✓	Varies
Generator Efficiency and Availability Improvements	✓	Varies	no	no	no	no	Varies
% Reduction in Total Production Costs	0.3%–5%	<1% to 8%	Not Reported	1.3%–2.0%	0.9%–2.1%	3.4%–3.8%	1.6%–3.6%

Sources and Notes:

[1]: The range represents savings in the “Transmission Only” scenario (de-pancaked transmission charges and increased transmission capacity) on the low end and “RTO Policy” scenario (includes 6% efficiency and 2.5% availability improvement for fossil units) on the high end. This study used a single-stage dispatch model to estimate benefits. It did not model unit commitment.

[2]: This was a study review report. Studies in the review modeled different market designs. Inter-quartile range of reported savings was 1%–3%. Some of the reviewed studies reported other savings in addition to production cost (*e.g.*, congestion revenues).

[3]: Study did not provide baseline production costs, so % savings could not be calculated.

[4]: Total production cost savings over 2009–2016 time horizon with low end of range from across case I (DA market-only) and high end from case IIB (DA + AS markets).

[5]: WAPA ‘Enhanced Adjusted Production Cost” savings of joining SPP as a percentage of “Standalone” LMP-based charges. Range reflects 2013–2020 savings.

[6]: Range reflects Entergy adjusted production cost savings of joining SPP and MISO as estimated using production cost simulation. Savings do not include spinning and regulation reserve savings estimated using MISO’s Value Proposition methodology.

[7]: This was a study review. Studies in the review modeled different market designs.

Of the studies summarized in Figure 2, two represented a review of several other analyses. Specifically, the LBNL Review Study (2005) reviewed 11 RTO studies from the early 2000s. From those studies reviewed, LBNL found that the reported production cost savings ranged from less than 1% to 8% of total production costs, though most of the reviewed studies reported estimated production cost savings between 1% and 3%.[2] Further, the E3 PAC Integration Study (2015) surveyed several prior market integration studies and found that estimated production cost savings ranged from 1.6% to 3.6%.[3] Overall, these results show that the production cost benefits of regional market integration tend to range from 1% to 3%.

D. Limitations in the Analytical Approaches Used for Prospective Studies Tend to Underestimate the Benefits of Regional Markets

The prospective studies of regional markets' production cost savings commonly acknowledge that their analytical methodologies omit some of the benefits provided by regional markets. These studies generally underestimate benefits because they (1) do not capture the full production cost benefits of market integration, and (2) do not capture non-production cost related benefits. We first discuss common set limitations related to the deterministic approaches of the analyses and the fact that production cost simulations capture only fuel and other variable generation cost savings.

Most of the prospective studies reviewed put the estimated benefits into perspective by either (1) discussing limitations of their analytical framework which tend to understate the estimated production cost savings; or (2) discuss benefits beyond production cost savings that have not been quantified. We first summarize the types of production cost benefits that are not typically captured due to the limitations generally found in market simulation analyses. We later discuss the second set of limitations—that studies rarely estimate investment cost benefits, such as reductions in generation investments needed as a result of greater load and resource diversity across larger footprints.

Most prospective production cost studies tend to understate production cost savings due to one or more of the following limitations: (1) they simulate only normal system conditions; (2) they do not analyze the extent to which regional markets optimize the use of the existing grid; (3) they do not capture the impact of stronger incentives to improve plant efficiencies; and (4) they do not capture increased competition and improved market monitoring and mitigation. Regional markets additionally (5) improve system reliability, and (6) improve regional operational and system planning, which offers benefits not fully captured in production cost savings.

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2 Eto and Hale (December 2005).

3 Energy + Environmental Economics (October 2015)

1. Production Cost Simulations Typically Do Not Capture Cost Savings Associated with Non-Normal System Conditions

Most studies that rely on production cost models estimate savings only by simulating normal system conditions. This means that the simulated load generally is weather normalized without any potential large swings and differences in regional loads due to different weather conditions. In addition, transmission outages are not typically considered in the analyses. Both of these omissions were discussed in the Basin/WAPA study (2013). That study states that the production cost simulations used in its analysis will yield a conservative estimate of benefits because it does not address important aspects of actual market operations such as transmission outages, actual weather patterns that deviate from normal weather, and any load and generation uncertainties between day-ahead and real-time operations. Due to these limitations, simulation results will tend to underestimate the level of transmission congestion and the extent to which improved congestion management through a regional market with security-constrained economic dispatch can reduce overall production costs.

2. Markets Can Improve the Utilization of the Existing Transmission Grid by More than is Reflected in Production Cost Simulations

The RTO West Study (2002) suggests, but does not quantify, that an RTO would increase the effectively Available Transmission Capacity (ATC) over major transmission lines. The benefits associated with increased ATC are incremental to the production cost savings that result from de-pancaked transmission charges and region-wide security-constrained dispatch.[4] The Basin/WAPA study (2013) makes the qualitative point that—because congestion management based on point-to-point transmission reservations and the curtailment of scheduled transactions[5] is less efficient than how congestion is managed in production cost simulations—the savings associated with participation in an RTO would be underestimated.[6] Similarly, the Entergy SPP/MISO Cost-Benefit Analysis (2010) notes that the inefficiencies at the seam between the Entergy and the SPP systems in the "Not-Joint-RTO" case, if they were fully simulated, would increase the value of integration compared to model results.[7]

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4 Zobian, *et al.* (March 2002), at p. 49

5 Such curtailments are undertaking through "flow mitigation events" in the WECC and Transmission Loading Relief or "TLR" in the Eastern Interconnection.

6 Celebi, M., *et al.* (March 8, 2013), at p. 6

7 Charles River Associates and Resero Consulting (September 30, 2010).

The extent to which markets can utilize the existing grid more fully has been documented by analyzing how much of the available transmission capability remains unutilized in traditional bilateral markets. For example, an analysis of RTO market benefits by the U.S. Department of Energy (DOE) assumed that improved congestion management and internalization of power flows by ISOs result in a 5–10% increase in the effective transfer capabilities on transmission interfaces.[8] Similarly, a study of congestion management in MISO's "Day-1" market found that, during 2003, available flowgate capacities were underutilized by between 7.7% to 16.4% on average within MISO sub-regions during curtailment (so-called "TLR") events.[9] Our own analysis of unused capacity on WECC transmission paths during flow mitigation events similarly shows that between 5% and 25% of available transmission capabilities is left unutilized in the current bilateral market structure even at times when existing transactions are being curtailed.[10]

3. Production Cost Simulations Typically Do Not Capture Cost Savings Associated with Stronger Incentives to Improve the Efficiency and Availability of Power Plants

The stronger exposure to market forces of a regional market can lead to improvements in generator efficiency and availability. A number of studies have examined such efficiency improvements. As pointed out by the 2005 LBNL Review Study, operating within RTOs can create incentives for generators to invest in "enhancements or improvements to the efficiency" of existing generators.[11] The LBNL review noted that prospective studies typically do not capture such generator efficiency improvements because of the challenges of making assumptions about those efficiency improvements and benchmarking them against actual experiences.

An indication of possible plant efficiency gains is provided by several industry studies. For example, the Chan Efficiency Study (2012) used an econometric analysis to estimate the efficiency improvements in coal plants operated by investor-owned utilities over the period from 1991 through 2005 when restructuring policies were implemented and several regional

8 U.S. Department of Energy, DOE/S-0138 (April 30, 2003), pp. 7–8 and 41–42.

9 McNamara, Ronald R., Docket ER04-691-000 (June 25, 2004), p. 14

10 See slide 167 of the CAISO stakeholder presentation, "Clean Energy and Pollution Reduction Act Senate Bill 350 Study: Preliminary Results," May 24, 2016, available at: https://www.caiso.com/Documents/Presentation-May24_2016-SenateBill350Study-PreliminaryResults.pdf

11 Eto and Hale (December, 2005), p. 40.

electricity markets were formed in the U.S. The study found that the efficiency of coal plants improved by 2%–3% in restructured states compared to non-restructured states.[12]

An increasing trend of power plant availability has been documented by various regional system operators as well. For example, the 2015 MISO Value Proposition report includes "Generator Availability Improvement" as a benefit of operating within the RTO and estimates its magnitude by using observed increases in availability since the start of market operations. The study found that availability improved by 1.5% from 2000 to 2014 and estimated associated annual savings of $210 million to $260 million per year. Other informal assessments, including ones conducted by the Electric Power Supply Association, NYISO, and Navigant, report increased power plant efficiency coincident with the introduction of markets.[13] The Navigant Markets Study (2009) reported that the availability of nuclear units operating in NYISO, MISO, and PJM had increased from 81% in 1996 (before regional markets were implemented) to 93% in 2007 (after Day-2 markets were established in all these regions.).

If these plant efficiency and availability gains materialize due to the increased transparency and competition of a regional market, the potential impacts on California and the rest of the WECC could be significant. While power plants in California are operating in such a market environment, the rest of the region is not. For example, the 2002 National RTO study evaluated a scenario featuring a 6% improvement in fossil generation efficiencies and a 2.5% increase in fossil unit availability. That study found that the assumed efficiency and availability improvements associated with market integration would reduce production cost by an additional 4.5%. While California generators are subject to strong market-based incentives, given California's dependence on imports, the state would benefit from the efficiency improvements across the WECC.

4. Organized Markets Can Increase Competition and Mitigate Uncompetitive Behavior, a Benefit Not Generally Captured by Market Simulations

Organized regional markets create price transparency in the wholesale market and thereby increase competition among generation and demand-side resources. The RTO West study (2002)

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12 Chan, *et al.* (August 2012).

13 Babcock, *et al.* (April 2009); EPSA (May, 2007).

notes that RTOs would reduce transaction costs, reduce overall production costs, and improve market liquidity.[14] Regional markets greatly facilitate the market monitoring of competitive behaviors and implementing mitigation practices. Anti-competitive practices tend to be less visible and more difficult to monitor and mitigate in a bilateral market construct.

Since production cost simulations typically represent existing systems as perfectly efficient systems without significant internal transactions costs (unless specifically added), the resulting comparisons commonly understate the potential competitive benefits of enlarging the regional markets. Production cost simulations generally assume fully competitive bidding behavior with bids reflecting true marginal costs. This does not capture the extent to which the additional competitive pressures and improved market monitoring that is present in larger-regional markets reduce bid-cost mark-ups and thus yield additional benefits.

5. Organized Markets Can Improve System Operating Reliability, a Benefit not Fully Captured by Production Cost Simulations

Region-wide coordinated outage planning, operations management, and real-time monitoring will improve system reliability. The value of such reliability improvements is not fully captured in the production cost simulations. Because of the challenges to fully reflect real-world conditions, the models typically simulate the region for normal system conditions, without transmission outages, and with perfect foresight of system conditions, generation outages, loads, and renewable generation levels. This will understate the benefits of a larger regional market and its ability to more efficiently and more quickly respond to forced outages, extreme events, and unexpected system conditions. The RTO West study (2002) notes that RTOs would improve reliability by allowing coordinated outage management, reducing failure propagation, improving outage restoration, voltage/frequency management, and loop/parallel path flow management,[15] but those benefits are above and beyond those captured by conventional analyses. Similarly, the LBNL Review study (2005) mentions that additional benefits (not usually quantified by prospective analyses) to forming RTOs include reliability benefits that stem from facilitating coordinated scheduling of maintenance outages, improving reserve procurement, and managing frequency and voltage in real time, and contingency response.[16]

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14 Zobian, *et al.* (March 2002), at p. 53

15 *Id.*, pp. 47-49.

16 Eto and Hale (December, 2005), p. 38.

6. Regional System Operations Improve System Planning

More coordinated regional planning and operations can increase the value of regional transmission investments and allow resources across larger footprints to be used more optimally. This can help the region meet its public policy goals at lower costs and simultaneously avoid redundant transmission projects that aim to meet similar needs in different areas within the large region. The RTO West study (2002) discusses that RTO-level transmission planning would "elevate the system planning process from a narrow focus on local or subregional needs to a broader focus on regional needs, thereby reducing the cost of transmission for the larger footprint."[17]

E. Retrospective Studies of Regional Market Integration Document Benefits Higher than those Estimated in Prospective Studies

Several studies evaluated the benefits of implementing a regional Day-2 market on an after-the-fact basis. Because the retrospective studies use actual market performance data, the analyses are more likely to capture impacts of market integration. By contrast, analyses conducted prospectively need to make assumptions about how the eventual operation of the market would perform relative to the status quo, which requires simulating complex bilateral markets or suboptimal coordination across operations and planning. Further, most prospective production cost studies do not or cannot estimate certain benefits (as discussed above), thus underestimating the overall production cost benefits of market integration (and before even considering any investment cost savings). Figure 3 describes the market features evaluated by each retrospective study as well as the savings reported by each one.

Three of the retrospective studies we reviewed focused on production cost savings. While one of these studies estimated only the incremental benefit of transitioning from a zonal to a nodal Day-2 market (Wolak Nodal Study 2011), the other two studies (MISO Retrospective Study 2009 and SPP Retrospective Study 2015) evaluated the benefits of transitioning from no centralized markets (*i.e.*, only bilateral transactions facing pancaked transmission charges), to full regional Day-2 markets (*i.e.*, de-pancaked transmission, nodal markets, and consolidated balancing areas). These latter two studies estimated the full production cost benefits of forming Day-2 markets and found notably larger production cost savings than the prospective studies we reviewed.

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17 Zobian, *et al.* (March 2002), at p. 52

The 2009 MISO Retrospective Study used econometric methods to estimate achieved generation cost savings based on actual market performance.[18] The study found that MISO's transition from "no centralized market" to a region-wide Day-2 market produced a 4% reduction in production costs. The study separately estimated the benefits of (1) moving from a bilateral market with pancaked transmission charges, to a regionally de-pancaked but still bilateral "Day-1" market; and (2) additionally consolidating balancing areas and implementing a nodal Day-2 market design with regional day-ahead, real-time, and ancillary services markets. The analysis showed that 'more than half of the overall benefits (2.6% out of 4%) were attributable to the transition from MISO's Day-1 market to its current Day-2 market design.

Similarly, a 2015 SPP Retrospective study of its Day-2 market performance used actual market bid offers and real-time load to estimate the savings during the first year of SPP's "Integrated Marketplace."[19] The results documented an 8% reduction in production costs attributable to SPP's transition from purely bilateral markets with pancaked transmission charges to its current Day-2 market design. SPP evaluated separately (1) the benefits captured by its initial energy imbalance services (EIS) market with fully de-pancaked transmission rates; and (2) those provided incrementally by the consolidation of balancing areas and its implementation of a nodal Day-2 market design with day-ahead, real-time, and ancillary service markets. The SPP study found that, out of the 8% in total production cost savings from regional market integration, more than half (4.8%) is attributable to the transition from SPP's EIS imbalance market to the full Day-2 market design.[20] SPP resembles WECC (on a smaller scale) with a mix of natural gas, coal, and renewable generation, major load centers in one portion of the footprint (the southeast), and distant areas with low-cost renewable generation (the Great Plains).

The authors of the LBNL Review Study (2005) made a similar observation when they reviewed 11 prospective and retrospective market integration studies conducted in the early 2000s. They observed that retrospective studies would more accurately capture the value of RTO formation and discussed that many potentially much larger benefits (and costs) of RTO formation were not

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18 Reitzes, *et al.* (October 1, 2009).

19 Davis (April, 2015).

20 In contrast to the EIM, SPP's Energy Imbalance Service (EIS) market was a fully de-pancaked market (including bilateral transactions) and made use of all available transmission.

captured by prospective production cost modeling. They recommended that retrospective studies "should become the standard for assessing the impacts of FERC's policies."[21]

Two other retrospective studies more narrowly focused on the benefits of changing from a zonal Day-2 market to a nodal market design. The Wolak Nodal Study (2011) estimated production cost savings for the CAISO footprint to transition from a de-pancaked zonal market (with a bilateral day-ahead market, a real-time imbalance market, and an intra-zonal congestion management process) to a full nodal market with integrated day-ahead, real-time, and ancillary services markets. The study used econometric techniques to estimate improvements in the efficiency of the 258 natural gas power plants in the California ISO associated with the new nodal market design and found that the efficiency of these units increased by 2.5%—leading to a 2.1% reduction in the variable cost of CAISO generation (after controlling for changes in gas prices).

Similarly, the ERCOT Nodal Study (2014) estimated the effect of ERCOT's transition from a zonal market (with a bilateral day-ahead market) to a nodal market structure with integrated day-ahead, real-time, and ancillary-services markets. Using a regression analysis to control for changes in load, price caps, natural gas prices, and the treatment of congestion costs, the authors estimated that implementing the nodal market resulted in a 2% reduction in real-time energy prices.

The MISO Value Proposition (2015) is an annual assessment of the overall benefits to MISO market participants. Taking advantage of data from the operation of its markets, the study estimates a number of different benefits ranging from improved reliability, dispatch of energy, regulation, spinning reserves, wind integration, compliance, footprint diversity, generator availability improvement, and demand response integration. The most recent 2015 study reported annual net benefits (net of MISO operating costs) to market participants ranging from $2.1 billion to $3.0 billion per year.

The Mansur PJM Efficiency Study (2012) examined the expansion of the PJM footprint to include the AEP and Dayton control areas that occurred in October 2004. Prior to the expansion of the footprint, these regions had traded electricity via bilateral arrangements. However, the study authors observed that the more effective matching of buyers and sellers facilitated by

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21 Eto and Hale (December, 2005), p. 37.

PJM's formal markets increased the volume of trade by a factor of three. Additionally, the authors found that the total gains from trade (*i.e.*, the total reduction in production costs compared to a scenario with no trading) were 48% ($163 million in the first year) higher under organized markets compared to bilateral markets.[22]

Figure 3 summarizes the results of the reviewed retrospective market integration studies. The studies report different savings metrics, although many focus on production cost savings. As shown, production cost savings range from 1.4% (for moving to a de-pancaked bilateral Day-1 market in MISO) to 8.0% (for moving from pancaked bilateral markets to consolidated balancing areas with nodal markets in SPP). Other retrospective studies reported decreased wholesale power prices, improved generating plant availability, and improved generating plant efficiencies (heat rates) associated with regional market integration.

22 Mansur and White (January, 2012).

Figure 3: Market Formation Benefits as Reported By Retrospective Studies

Study	Region	Metric	Savings
MISO Retrospective Study (2009)	MISO	Production Cost Savings	1.4% Implementing a regional, de-pancaked bilateral market + 2.6% Consolidating BAs and implementing nodal DA, RT, and AS markets = 4.0% Total
SPP IM Retrospective Study (2015)	SPP	Production Cost Savings	3.2% Implementing a de-pancaked regional imbalance energy market (EIS) + 4.8% Consolidating BAs and implementing nodal DA, RT, and AS markets Markets), = 8.0% Total
MISO Value Proposition Report (2015)	MISO	Reduced production costs, generation investment needs, wind integration cost; improved reliability; net of MISO costs	Total of $2.1–$3.0 Billion/year
Wolak Nodal Study (2011)	CAISO	Production cost savings	2.1% Moving from de-pancaked zonal Day-2 market to full nodal DA, RT, and AS markets
ERCOT Nodal Study (2014)	ERCOT	Wholesale power price reductions	2.0% Moving from de-pancaked zonal Day-2 market to full nodal DA, RT, and AS markets
Navigant Markets Study (2009)	PJM, MISO, and NYISO	Improved Availability of Nuclear Units and Heat Rates of Large Coal Units	Nuclear Unit Availability Increased from 81% to 93% and Large Coal Unit Heat Rates Improved by 9.4% from 1998 to 2007
Chan Efficiency Study (2012)	U.S.	Improved Heat Rates of Large Coal Units	2%–3% increase in restructured markets compared to non-restructured regions
NYISO Plant Efficiency Study (2009)	NYISO	Improved Heat Rates of Fossil Fueled Units	21% Improvement in market-wide heat rates from 1999 to 2008
Mansur PJM Efficiency Study (2012)	PJM	Gains from Trade	Gains from trade were 48% higher in an organized market compared to a bilateral market

F. In Addition to Reducing Production Costs, Regional Markets Can Reduce the Need for Generating Capacity and Associated Investment Costs

By diversifying load fluctuations across a larger region, market integration reduces the total generation capacity needed to meet regional peak demand and assure resource adequacy under adverse system conditions. This reduces the generation investment cost of ensuring resource adequacy. Several of the reviewed studies quantitatively estimated this benefit and several discuss the benefit in a qualitative manner. Figure 4 summarizes the capacity savings reported in three studies that made a detailed assessment of the load diversity capacity savings enabled by regional markets. The savings range from 0.6% of peak load (savings to CAISO of PacifiCorp joining a regional market) to 8% of peak load (savings to PacifiCorp of joining a regional market with CAISO). Several studies reported savings ranging from 6% to 8% of peak load.

Figure 4: Load Diversity Capacity Savings in Other Studies

Study	Reported Capacity Reduction (% of Peak Load)	Note
MISO 2015 Value Proposition[1]	**6%–7%**	Capacity savings to all MISO members of participating in the RTO market
Entergy-MISO(2011)[2]	**6%**	Capacity savings to Entergy of joining MISO
E3 PAC Integration (2015)[3]	**0.6% (ISO)** **8% (PAC)**	Capacity savings with an integrated market consisting of the California ISO (ISO) and PacifiCorp (PAC)

Sources and Notes:

1. MISO (January 21, 2016).
2. Entergy (May 12, 2011).
3. Energy + Environmental Economics (E3) (October, 2015).

In the MISO 2015 Value Proposition Report, a retrospective analysis, MISO estimates that the investment cost savings achieved by its members are equivalent to reducing the region's capacity requirements by 9,300 MW to 11,250 MW (6% to 7% of peak load), compared to balancing areas assuring resource adequacy individually in the absence of a regional market. The value of those savings is estimated at $1.2–$2.0 billion per year in the entire MISO market.[23]

The National RTO Study (2002) estimated the value of resource adequacy by assuming that RTO formation would reduce planning reserve margins across the country from 15% to 13%, with an associated reduction in generation capacity requirement of approximately 2%.[24] Translating these investment cost savings to annualized cost reductions, they are equivalent to an approximately 1.6%–2.5% additional decrease in total production costs.[25]

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[23] MISO (January 21, 2016).

[24] ICF (February, 2002), p. 37

[25] Because total investment costs are not available in most studies, we report investment cost savings as a percentage of total *production costs* in order to enable comparison across regions.

The Entergy-MISO Study (2011) applied the MISO resource adequacy framework to estimate the investment cost savings of joining the RTO. Entergy compared the reserve margin it required as a standalone entity (17%–20% over the study period) to the effective reserve margin of approximately 12% of its internal peak load that it would need to hold as a MISO member. The reduction in planning reserve margin reflects the load diversity benefit between the original MISO and Entergy systems. Entergy's estimated reduction in generating capacity needs was approximately 1,400 MW or 6% of Entergy's peak load.[26] Entergy estimated the value of such savings to be approximately $35/kW-year or $49 million per year, equivalent to an additional 1.3% reduction of total production costs. In 2015, after joining MISO, Entergy confirmed that the anticipated capacity savings had in fact been achieved.[27]

Similarly, the E3 PAC Integration study (2015) estimated the value of load diversity between PacifiCorp and CAISO by calculating coincidence factors between the loads of the two entities. The study determined that PacifiCorp's capacity needs would decrease by up to 900 MW (approximately 9.5% of PacifiCorp's peak load), but that the savings to PacifiCorp would be limited by the 776 MW of available transmission capacity from California when integrated with CAISO. The study estimated that PacifiCorp's' reduced generation capacity need of 776 MW represented approximately 8% of PacifiCorp's internal (non-coincident) peak load. Similarly, the estimated generation investment savings for the CAISO footprint are 284 MW, which represents approximately 0.6% of the CAISO's internal (non-coincident) peak.[28] The associated annual cost savings of $90 million/year are equivalent to approximately 0.5% of the total CAISO plus PacifiCorp annual production costs.

Load diversity benefits were discussed in the RTO West Study (2002) as well. While it did not estimate the value of generation-related investment cost savings, it recognized that "As the [participation in] RTO results in lower capacity requirements, benefits will be recognized in the long run through reduced need for additions to generating capacity."[29] Similarly, the

26 Entergy also performed a similar calculation for the case of joining SPP, which we do not report here.

27 Entergy (August, 2015).

28 Based on PacifiCorp and CAISO 2024 peak loads of 9,550 MW and 47,000 MW.

29 Zobian, *et al.* (March, 2002), p. 52.

Basin/WAPA Study (2013) noted that ISO-membership would have resource adequacy benefits in addition to the quantified production cost savings.[30]

G. MARKET INTEGRATION CAN IMPROVE ACCESS TO LOW-COST RENEWABLE RESOURCES AND REDUCE THE INVESTMENT COST OF MEETING RPS GOALS

In the context of ambitious renewable generation targets, gaining access to lower cost and higher-quality renewable resources through a regional market can significantly reduce the capital costs necessary to comply with those public policy goals. By enabling renewable generators to access a larger market, regional markets can reduce the need to curtail renewable generation output during times of high output, thus further reducing renewable capacity by avoiding the "over build" that would be necessary to offset the curtailed production.

Both MISO and SPP have shown that their larger footprints allow the regions to access lower-cost renewable energy resources to help meet various states' public policy goals. Specifically the high-capacity-factor wind resources in western MISO and SPP allowed the utilities and other buyers in the regions' footprint to access lower-cost renewable resources to meet their procurement preferences or requirements under the various states' RPS. In fact, the low cost and high quality of wind resources in the Great Plains means that these resources have (with the help of production tax credits) become competitive with conventional generation such that some utilities and other buyers are entering into renewable energy contracts well beyond those needed to comply with their states' RPS.

The LBNL Wind Technologies Market Report (2014) documents trends in wind installations and the cost of Power Purchase Agreements across the country and over time.[31] The report discusses that SPP's 2014 market integration and consolidation of its balancing areas helped the SPP states access the high-quality wind resources in the Great Plains. The report notes that the now completed Texas Competitive Renewable Energy Zones (CREZ) transmission projects will enable 18,500 MW of low-cost wind development in the state—much of which is constructed or under construction. Furthermore, the additional transmission and an improved regional market design helped to balance wind generation more effectively. ERCOT was able to reduce wind curtailments from 17% of total wind generation in 2009 to 1.2% in 2013. The reduced

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30 Celebi, *et al.* (March 8, 2013), p. 5.

31 Wiser and Bolinger (August, 2015).

curtailments mean that less renewable generating capacity is needed to produce a particular amount of renewable energy production.

Similarly, the E3 PAC Integration study (2015) included in its estimated market integration benefit the savings associated with California's ability to access lower-cost renewable resources in PacifiCorp's balancing areas. The authors found that the low-cost and high-quality Wyoming wind would allow California to reduce the cost of meeting its RPS requirements while providing resource diversification benefits. The study found that the annual value of accessing the lower-cost resource would be range from $150 to $750 million per year, the equivalent of 1%–4% of the combined region's total production costs.

Additionally, the E3 PAC Integration study (2015) estimated investment cost savings associated with reduced renewable generation curtailments. These investment cost savings are associated with avoiding the construction of renewable generation capacity that otherwise would be needed to make up for the curtailed renewable output. The study estimated the additional investment cost benefits of this "More Efficient Over-Generation Management" to range from $50 to $220 million/year, which is equivalent to approximately 0.3%–1.0% of the combined footprint's production costs.

The MISO Value Proposition (2015) likewise estimated the value of access to the higher-quality wind resource enabled by its regional market. MISO estimated the capacity cost savings of providing access to higher-quality resources by comparing the actual capital cost of developing wind in MISO to the cost of meeting state renewables mandates with lower-quality local wind resources. The value proposition deducts the incremental cost of transmission required to reach the low-cost wind resources from the estimated benefits, concluding that the regional market creates $316–$377 million/year in annual renewable capacity cost savings, a benefit the RTO labels "wind integration."

While the specific assumptions made in these analyses differ across the studies, they uniformly show that regional markets facilitate both the access to and integration of low-cost renewable resources, providing investment cost savings to the entire regional footprint. The studies find that is the case even after netting out the cost of transmission investments that may be associated with providing access to low-cost renewable resources in certain locations.

H. REGIONAL MARKETS REDUCE THE COST OF BALANCING VARIABLE RENEWABLE GENERATION OUTPUT

The geographic and resource diversity of renewables generation across large regional markets can significantly reduce the overall variability of generation and the quantity of flexible fossil generators and other resources needed to balance the system. In addition to this "quantity benefit," the ability to use the most economic flexible resources across the larger region to provide these balancing services reduces production costs even further.

Regional market integration increases the flexibility of the grid and its ability to "absorb" and "balance" renewable energy. Using this analogy, it is useful to examine how the CEERT/NREL Low Carbon Grid Study (2016) analyzed the value of a flexible grid for accommodating high renewable generation targets in western states. The CEERT/NREL study simulated increased flexibility by allowing WECC-wide resources to satisfy California's RPS, allowing the region's hydro facilities to provide ancillary services, and allowing California to meet more of its load with external resources. While the Low Carbon Grid Study did not specifically analyze the impacts of a regional market, the study's "increased flexibility" assumptions are fully consistent with the typo of increased flexibility that is provided by a regional ISO-operated market.

The Low Carbon Grid Study has many parallels with the SB 350 study. The CEERT/NREL study evaluated scenarios achieving a 50% reduction in carbon emission of the California electricity-sector by 2030. The study also evaluated scenarios with very high renewables penetrations (averaging 56% for supplying California loads) and additional energy efficiency. The CEERT/NREL study modeled the retirement of all California-contracted (out of state) coal plants in meeting the emissions reduction target. Additionally, the study considered additional sensitivity cases, for example, Dry Hydro, High Solar, and High WECC RPS.

Figure 5 shows annual electric sector CO_2 emissions in California and all of WECC in four of the scenarios presented in the Low Carbon Grid study: Baseline Enhanced (33% renewables with additional flexibility), Baseline Conventional (33% renewables with status quo flexibility), Target Enhanced (56% renewables with additional flexibility), and Target Conventional (56% renewables with status quo flexibility). In both the 33% Baseline and the 56% Target cases, enhanced flexibility reduced CO_2 emissions. Emissions assigned to imports actually increased with flexibility, but were offset by larger reductions in emissions from California gas generation. The emissions reductions due to enhanced flexibility were substantially larger in the 56% renewable scenarios.

Figure 5: Annual Carbon Accounting, in Million Metric Tons
Table 10 in the CEERT/NREL Low Carbon Grid Study (2016)

Scenario	CO_2 from CA gas generators	CO_2 assigned to imports and exports	CO_2 assigned to CA load	Change in assigned California CO_2 emissions compared to Baseline	Total WECC CO_2 emissions	Change in WECC CO_2 emissions compared to Baseline
Baseline Enhanced	67.7	6.7	74.4	-	380.9	-
Baseline Conventional	68.9	6.3	75.2	0.8	381.0	0.2
Target Enhanced	43.7	-2.5	41.1	-33.2	345.1	-35.8
Target Conventional	48.9	-3.9	45.0	-29.4	349.3	-32.4

Sources and Notes:

Brinkman, *et al* (January, 2016), Table 10.

Original notes:

Exports in this context include both net exports and specified imports that are not imported. This is zero-carbon energy that is sold out of state.

Total WECC emissions not only include the western United States but also parts of Mexico and Canada (Alberta and British Columbia).

Unspecified imports and exports are assumed to have a 0.432 MT/MWh carbon penalty (or credit). Unspecified imports from the Northwest have a penalty of 20% of 0.432 MT/MWh, which is consistent with the California Air Resources Board 2012 assumptions (CARB 2014) and the California ISO LTPP modeling (Liu 2014). CARB uses 0.022 MT/MWh for data year 2015.

In terms of costs, the study found that increasing grid flexibility through market integration reduced WECC-wide production costs by approximately $600 million/year (2.1% of total production costs) for the 56% California renewable requirement scenario, with $550 million in California savings related to the production, purchase, and sale of electricity for serving California loads. The WECC-wide production cost benefit of increased flexibility was $100 million/year for the 33% RPS scenario, demonstrating that savings are much higher in scenarios with high penetrations of renewables. The study found that increased flexibility reduced carbon emissions in California and in the rest of WECC. This shows that increasing system flexibility significantly reduces operating costs under a high renewables scenario while facilitating emissions reductions. Figure 6 summarizes the study's WECC-wide production cost savings and California emissions reductions of improved flexibility at renewables penetrations of 33% and 56%.

Figure 6: Production Cost Savings and Carbon Emissions Reductions of "Enhanced Flexibility" at 33% and 56% CA Renewables Penetrations

CEERT/NREL Low Carbon Grid Study (2016)

	Renewables Penetration	70% Import Requirement for CA RPS Resources	Limited Ancillary Services from Hydro	Minimum 25% Energy from Local Thermal and Hydro in CA BAs	Total WECC Production Cost ($ millions)	California CO_2 Emissions (million metric tons)
Baseline (33% CA RPS), Conventional Flexibility [1]	33%	✓	✓	✓	$33,760	75.2
Baseline (33% CA RPS), Enhanced Flexibility [2]	33%				$33,660	74.4
Estimated Production Cost Savings and CA emissions reductions of Regional Markets with 33% California Renewables as Difference between [1] Conventional Flexibility Case (as approximation of bilateral markets) and [2] Enhanced Flexibility Case (as approximation of an ISO-operated regional market)					***$100 0.3%***	***0.8 1%***
Target (56% CA renewables), Conventional Flexibility [3]	56%	✓	✓	✓	$29,430	45.0
Target (56% CA renewables), Partially Enhanced Flexibility [4]	*56%*		✓	✓	*$28,990*	*42.3*
Target (56% CA renewables), Enhanced Flexibility [5]	56%				$28,820	41.1
Estimated Production Cost Savings and CA emissions reductions of Regional Markets with 56% California Renewables as Difference between [3] Conventional Flexibility Case (as approximation of bilateral markets) and [5] Enhanced Flexibility Case (as approximation of an ISO-operated regional market)					***$610 2.1%***	***3.9 9%***

Sources and Notes: Results from selected scenarios in the CEERT/NREL Low Carbon Grid Study (2016). Renewables penetration for the non-California portion of WECC in the above scenarios was 16%. CO_2 emissions in the rest of the WECC (not shown in figure) also declined when flexibility improved in both the 33% and 56% renewables cases.

The Western Wind and Solar Integration Study No. 2 (NREL/DOE WWSIS-2 2013) similarly estimated the likely range of savings associated with a reduction in resource variability due to increased geographic diversity in wind and solar generation. The study quantified the resource variability before and after accounting for geographic diversity and found that diversity can dramatically decrease the collective resource variability thereby decreasing the amount of flexible resources needed to balance the system at high renewable deployment levels. The study found that aggregating distributed rooftop PV in southern California reduced variability (as measured by the coefficient of variation of hour-over-hour changes in output) from 4% to 3%

after approximately 3,000 MW were aggregated. The study found that wind variability dropped even faster—from 9% to 2% after approximately 2,000 MW were aggregated.

SPP's recent (2016) Wind Integration Study similarly evaluated the impacts of 30%–60% wind generation in the SPP footprint. The study did not attempt to quantify the wind integration value of its recently-implemented Day-2 market design, but highlighted several ways in which the market is already facilitating the integration of high levels of renewables. The study identified several enhancements that would allow very high penetrations to be achieved in the future and confirmed that the new transmission projects identified through the RTO's recent transmission planning process would be critical in providing access to the high-quality, low-cost wind resources located in the southwest portion of the footprint. It further determined that SPP has sufficient ramping capability to accommodate its projected growth in renewables generation (SPP experienced real-time wind generation equal to 40% of its system-wide load). SPP notes that, as more wind generation is added over the longer-term, the introduction of additional ancillary services may be necessary to provide added flexibility.

The Western Governors' Association's Renewable Integration Challenge study (WGA Integration Study 2012)[32] similarly discussed a number of options for facilitating the integration of renewables in the West. Several of the options include the operation of an integrated market across WECC. As explained in the study, a WECC-wide regional market would include the operation of sub-hourly dispatch and intra-hour scheduling, increased geographic diversity supported by new transmission, and increased reserve sharing—all of which would help to lower the cost of integrating renewable resources.

I. Benefits of Regional Market Integration are Confirmed by the European Experience with High Renewable Generation

The European experience is helpful in documenting the role of regional markets, particularly with respect to integrating increasing amounts of renewable generation. In Europe, the integration of renewable generation is seen as a key pillar to the region's broader energy and climate objectives in reducing emissions, improving security of supply, diversifying energy supplies, and improving Europe's industrial competitiveness. Many European countries have

32 Western Governors' Association (June, 2012).

high shares of renewable generation and ambitious goals to further increase renewable generation in the next decades.

Germany's share of renewable generation exceeds 30% on an annual basis and reached a high of 83% on August 23, 2015.[33] Because most of Germany's solar power generation is associated with distributed solar installations in southern Germany while most of Germany's wind generation is located in northern Germany and the North Sea, these locational differences create substantial north-south power flows through Germany and its neighboring countries[34] that require close coordination. Such issues are among the motivations for market-integration efforts, such as a European Union-wide "market coupling."[35]

The experience in Denmark serves as another illustration of managing high renewables penetration.[36] In January 2014, wind generation provided 62% of Denmark's monthly power demand, with that share reaching 105% on January 19, 2014. The ability to manage this level of renewable power generation operationally has been attributed primarily to Denmark's strong integration with the neighboring grids of Europe, including the well-developed region-wide Nord Pool markets (Nordic and Baltic day-ahead and intraday markets). Through Nord Pool, Denmark is part of a large market with significant resource diversity (including hydro resources in Sweden and Norway), which means Denmark can buy freely from, and sell power to, its neighbors in order to balance its high renewable generation levels.

The DNV-GL European Renewable Integration Study[37] (2014) finds that having a regional market has become increasingly important to support the integration of higher levels of renewable generation due to its ability to increase system flexibility and security of supply through the exchange of energy between the regional submarkets. This reduces the overall amount of conventional generation capacity required in the system—thereby reducing total system-wide costs.

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[33] Graichen, Kleiner, and Podewils (January 7, 2016).

[34] Weixin Zha, Marke Strzelecki (July, 2015).

[35] Baritaud and Volk (2014).

[36] Martinot and White (January, 2015).

[37] DNV-GL (June 12, 2014).

Similarly, the EPRG European Market Integration study (2015) evaluated potential savings from integrating the existing country-level electricity markets.[38] The proposed single European market platform, known as Euphemia, would lead to increased utilization of and price convergence across international transmission interties. The proposal would couple the country-level European markets at the day-ahead, intraday, and real-time horizons. (Day-ahead coupling has already been implemented.) The study estimated that the benefits of market coupling were approximately €3.3 billion per year, equivalent to 2% of the total value of wholesale electricity. Approximately one-third of these benefits were estimated to be achieved by day-ahead integration, intraday integration, and region-wide real-time balancing.

In addition to the direct economic impact of reducing price divergence across interties, the study qualitatively discussed some of the value of coordinated European markets. These included pressures to reduce costs and innovate, improved liquidity in markets, and potentially reduced environmental impact. Additionally, increased coordination should lead to increased reliability.

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38 Newbery, Strbac, and Viehoff (February, 2015J).

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