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DRAFT STAFF PAPER

Calculating Parcelization for Electric System Planning

An Overview of Geographic Information System Methods for Assessing the Average Number of Unique Parcels in an Area for Long-Term Solar Resource Planning

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ABSTRACT

Parcelization is a measure of the average number of unique parcels in an area and is a new proposed factor to help inform long-term electricity system planning. This report describes in detail the data processing procedure to create a statewide map of parcelization levels. Parcelization can inform planning assumptions for utility-scale solar photovoltaic technology in electricity system planning.

Keywords: Parcel density, parcelization, land use, energy planning, clean energy resources, solar energy, GIS

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EXECUTIVE SUMMARY

The California electrical grid is transitioning from fossil-fuel energy resources to renewable and zero-carbon energy generation. This electricity system transition is being driven by state policies, including the state policy of economy-wide carbon neutrality by 2045, and the state's target of 100 percent clean electricity. The 100 Percent Clean Energy Act of 2018 (Senate Bill 100, De León, Chapter 312, Statutes of 2018) sets a 2045 target of supplying all retail electricity sold in California and state agency electricity needs with renewable and zero-carbon energy resources.

The electricity system transition requires multiyear planning and forecasting along with extensive analysis and system modeling from the California Energy Commission (CEC), California Public Utilities Commission (CPUC) and California Independent System Operator (California ISO). Since 2008, the CEC, CPUC, and California ISO have used spatial land-use data to inform electricity system planning and help system planners focus on areas that have a greater potential for successful deployment of new utility-scale renewable energy capacity. Over time, the methods and data used have evolved, reflecting the availability of new information, new planning initiatives, and new factors influencing the deployment of renewable energy capacity. The *Calculating Parcelization for Electric System Planning* report describes a new metric, parcelization, for use in assessing solar photovoltaic resource potential for electricity system planning.

Parcelization is defined as a measure of the average number of unique land parcels in an area. Parcelization has been cited by the utility-scale solar industry as one of the most important factors in influencing the ability to develop large solar projects. Highly parcelized areas require aggregating, or collecting, numerous small parcels, often from disparate ownership, to assemble a land area of sufficient size for a large solar project. Therefore, high parcelization is a potential constraint to the successful deployment of new utility-scale solar photovoltaic capacity. In this staff paper, the CEC staff describe the methods used to produce a statewide map of parcelization to evaluate land-use in terms of opportunities and constraints for the deployment of new solar utility-scale photovoltaic capacity in electricity system planning.

Parcel data, collected and maintained by each county for tax and legal purposes, delineate the boundaries of how the land is partitioned. From this starting point, a series of geospatial data processing steps can transform the individual parcels into a continuous gridded surface where the average number of unique parcels within 0.5 miles from every point can be determined. The results show varying levels of parcelization throughout the state. The results can be used to highlight areas with significantly low or high parcelization to help system planners focus on areas that have a greater potential for the successful deployment of new utility-scale solar photovoltaic capacity. Further, this report explores the parcelization levels of developed large solar projects in California, using a recent solar footprint dataset created by CEC staff.

The assessment of parcelization in this staff paper is intended to inform high-level evaluations of solar resource potential for electric system planning and should not be used, on their own, to guide the siting of generation projects nor assess project-level impacts.

CHAPTER 1: Background

The Resource Build to Achieve Senate Bill 100

The 100 Percent Clean Energy Act of 2018 (Senate Bill 100, De León, Chapter 312, Statutes of 2018) sets a 2045 target of supplying all retail electricity sold in California and state agency electricity needs with renewable and zero-carbon resources.[1] The 2021 Joint Agency SB 100 Report assessed various pathways to achieve the SB 100 targets. One key finding from the report is that the next two decades will require an unprecedented amount of new generation and energy storage capacity to supply clean, reliable power. The need for record-setting buildout of new utility-scale clean energy resources and energy storage is driven by increased customer demand for clean energy and the continuing electrification of transportation and other industries.[2] This increase in new renewable generation and storage capacity will increase the land area required for successful implementation of SB 100. Recognizing the potential land-use impacts from the resource build necessary to achieve the SB 100 target, the report included several recommendations related to developing new methods to include land-use factors in electric system modeling.[3] Comprehensive energy and land-use planning approaches are needed to keep the two important channels of development — generation and transmission — aligned to produce clean, reliable electricity in a manner compatible with other planning and land-use priorities.

The Role of Land-Use Screens in Electric System Planning

Since 2008, the CEC, CPUC, and California ISO have used spatial land-use data to inform electricity system planning and help system planners focus on areas that have a greater potential for successful deployment of new utility-scale renewable energy capacity. This geospatial analysis is commonly known as *land-use screening*. The geospatial datasets in a land-use screen may include technical, environmental, and other land-use priorities and considerations.

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1 Senate Bill 100 (De León, Chapter 312, Statutes of 2018). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100.

2 CEC, CPUC, and CARB. 2021. *2021 SB 100 Joint Agency Report Achieving 100 Percent Clean Electricity in California: An Initial Assessment.* Publication Number: CEC-200-2021. https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349.

3 Ibid., page 18.

The CEC staff has recently completed an update to the land-use screens used in California's electricity planning. The updated land-use screens bring to light the land access limitations or competing land-use priorities that can be experienced in renewable energy project development. These land-use screens thereby help electric system planners focus on areas that have a greater potential for successful deployment of new solar photovoltaic, wind, or geothermal capacity. Competing land-use priorities may include military lands, agriculture, biological conservation, large-scale infrastructure, and housing, to identify a few.

The updated land-use screens include explicit spatial information identifying regions of the state with:

1. technical, economic, or physical barriers to energy development.
2. protected areas that prohibit renewable energy or transmission development by law, policy, or regulation.
3. land-use planning considerations related to biodiversity, lands used to grow crops (cropland), and landscape intactness.[4]

The results of applying the land-use screens yield an estimate of the renewable resource technical potential, or technical resource potential, for onshore wind, solar photovoltaic, and geothermal technologies for electric system planning. The renewable resource technical potential of a technology is its achievable energy generation capacity (in megawatts [MW] or gigawatts [GW]) given techno-economic, topographic, environmental, and land-use constraints.

The updated land-use screens will be used in modeling for the 2025 Joint Agency SB 100 Report, as well as the CPUC's Integrated Resource Planning (IRP),[5] to inform the renewable resource technical potential available for selecting new solar PV and onshore wind energy capacity. Further, the land-use screens are used to inform the CPUC's busbar mapping[6]

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4 *Landscape intactness* describes the extent to which human impacts such as agriculture, urban development, natural resource extraction, and invasive species have disrupted the landscape.

5 The CPUC's IRP process seeks to reduce the cost of achieving greenhouse gas emission (GHG) reductions and other policy goals by looking across load-serving entity (LSE) boundaries and resource types to identify solutions to reliability, cost, or other concerns that might not otherwise be identified without an integrated planning process. The IRP process includes capacity expansion modeling, using the RESOLVE model, of the electric system, providing the analytical foundation for the CPUC to require LSEs to procure new energy resources, such as renewable generation and storage resources to achieve California's goals. RESOLVE co-optimizes investment and dispatch to identify least-cost resource portfolios that meet policy and reliability targets. The CPUC's IRP process includes land-use screens as part of the RESOLVE model.

6 Busbar mapping is the process of refining the energy resource portfolios produced in the CPUC's IRP process, which are at a geographic scale too broad for transmission planning to specific interconnection locations (that is, substations) for analysis in California ISO's Transmission Planning Process.

process. In busbar mapping, CEC staff create geographic information system (GIS) layers to identify the potential environmental and land-use implications around select substations to inform assumptions related to the feasibility of deploying future renewable energy capacity.

Recent enhancements to the land-use screens focused on updating geospatial data related to protected areas, biodiversity, habitat, and agricultural criteria in electricity system planning. Public comments received during the process to update the land-use screens recommended incorporating development feasibility factors, such as parcelization.

CEC staff recognizes the importance of enhancing the state's land-use evaluation methods for electricity system planning to improve and keep pace with the changing dynamics of the energy sector. As such, there is an opportunity to update the land-use evaluation methods to integrate parcelization as a new metric for use in assessing solar photovoltaic resource potential for electricity system planning. The CEC staff, in coordination with CPUC staff, proposes to pilot this new method in the land-use evaluation for busbar mapping.

Parcelization as a New Metric in Electric System Planning

Parcelization is a measure of the average number of unique land parcels in an area. Parcelization has been cited by the utility-scale solar industry as one of the most important factors in influencing the ability to develop large solar projects.[7] Highly parcelized areas require aggregating, or collecting, numerous small parcels, often from disparate ownership, to assemble a land area of sufficient size for a large solar project. Therefore, high parcelization is a potential constraint to the successful deployment of new utility-scale solar photovoltaic capacity.

One way of incorporating parcelization into electric system planning is to use digitized cadastral[8] data to indicate the spatial variability of owners and parcel size throughout an area that has technical resource potential. Parcel datasets are a type of cadastral data containing ownership boundaries of the land and are readily available from many county assessor offices. Parcel data can be used as a basis to estimate parcel density, or level of parcelization, of a region. In the case of utility-scale solar development, the minimum size needed to develop a

7 Comments of the Large-Scale Solar Association. November 1, 2022. https://efiling.energy.ca.gov/GetDocument.aspx?tn=247227

8 Cadastral data give legal information about land ownership, including the boundaries and ownership of parcels of land that is contained in land records. Digitized cadastral data are often maintained by the county for taxation purposes and store the geographic extent of property lines, parcel numbers, market values and details on the management or zoning definitions the parcel of land falls within.

project is roughly 120 acres.[9] Thus, several adjacent parcels would likely need to be bought or leased by a developer to secure the success of a project, especially in areas with private land ownership, which tend to be more heavily parcelized than public land.[10]

In this draft staff paper, CEC staff describes the methods used to produce a statewide map of parcelization to evaluate land-use in terms of opportunities and constraints for the deployment of new solar utility-scale photovoltaic capacity in electricity system planning. Parcelization, as represented in this staff report, is defined as the average number of unique parcels within 0.5 miles of any point (using a 90-meter resolution grid) within a given parcel boundary. It represents an important factor of development feasibility to inform how much new solar resource generation a region can support.

9 CEC staff assumes that 20 MW is a minimum size for a utility-scale solar power plant. A typical project size can be calculated using a power density range of 5.8-9.0 acres/MW. See *Land-Use Requirements for Solar Power Plants in the United States*, available at https://www.nrel.gov/docs/fy13osti/56290.pdf.

10 Cameron, Richard D., Scott A. Morrison, and Brian S. Cohen. 2012. "An Approach to Enhance the Conservation-Compatibility of Solar Energy Development." *PLoS ONE* 7(6): e38437. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0038437

CHAPTER 2: Methods

The current configuration and size of parcels are the result of many influences — historical, economic, proximity to basic development and infrastructure types such as roads, and proximity to natural resource amenities such as water bodies.[11] Population growth and development are also strong driving forces behind increasing fragmentation of land ownership boundaries.[12] The increasing fragmentation of land ownership boundaries can be seen in a typical pattern of urban areas having small dense parcels while rural areas typically have larger, less dense parcelization.[13] Utility-scale solar development requires large land areas to benefit from economies of scale and, thus, optimum locations for solar development should exhibit relatively low levels of parcelization. To incorporate this fundamental development feasibility factor into busbar mapping, CEC estimates a current snapshot of parcelization using statewide digitized parcel data.

As parcels are irregularly shaped and vary in size spatially, addressing the level of parcelization or the degree of fragmented land ownership in a region can vary. Parcel density, mean parcel size, the ratio of rights of way acreage to lot acreage, or a combination of metrics describing the physical size, shape, and frequency of parcels in a study area are a few possible approaches to calculating parcel density.[14] With the aid of geographic information systems or

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11 Three References: [1] Salinas, Eva R. "Mapping Rural Land Parcelization: A Methodology to Analyze the Intensity of Parcelization using Real Property Data." (Master of Science Thesis, SUNY College of Environmental Science and Forestry, 2016), 67, https://suny-esf-researchportal.esploro.exlibrisgroup.com/esploro/outputs/graduate/Mapping-Rural-Land-Parcelization-A-Methodology/99872705904826. [2] Haines, Anna L. and Dan McFarlane. 2012. "Factors Influencing Parcelization in Amenity-Rich Rural Areas." Journal of Planning Education and Research 32: 81. [3] Haines, Anna L., Timothy T. Kennedy, and Daniel L. McFarlane. 2011. "Parcelization: Forest Change Agent in Northern Wisconsin." *Journal of Forestry*.

12 Haines, Anna L. and Dan McFarlane. 2012. "Factors Influencing Parcelization in Amenity-Rich Rural Areas." *Journal of Planning Education and Research* 32: 81. https://journals.sagepub.com/doi/pdf/10.1177/0739456x11426781

13 Donnelly, Shannon and Tom P. Evans. 2008. "Characterizing spatial patterns of land ownership at the parcel level in south-central Indiana, 1928-1997." *Landscape and Urban Planning* 84, no. 3-4, 230-240. https://www.sciencedirect.com/science/article/abs/pii/S0169204607002125.

14 Two References: [1] Thomas, Niel, Greg Dobson, Paul Dezendorf, Mark Cantrell, and David Abernathy. 2009. "Development of a Parcel-based Density Analysis Tool to Evaluate Growth Patterns in Western North Carolina." *Journal of Conservation Planning* 5, 38-53. https://www.academia.edu/5790754/Development_of_a_Parcel_based_Density_Analysis_Tool_to_Evaluate_Grow

other software to process digitized cadastral data, a recently established method called the Parcel-based Density Analysis (PDAP) was developed.[15] This method begins by converting parcel polygons to the associated centroids, or the mathematical center of the parcel shape. The resulting map of points could then be converted into a point density map using a geoprocessing tool that calculates the number of points within a search radius from a given grid cell. Dividing the number of points by the area of the circle defined by the search radius gives the point density at that grid cell. Moving onto the next grid cell, the same density calculation is made, and the process is repeated for all grid cells in the study domain. The search radius and the size of the grid cell used in this calculation will affect the computed parcel density. The search radius depends on the size of development that the parcel density will be informing, and the grid cell controls the spatial resolution of the parcel density map. By varying these two parameters, a range of spatial patterns and a range of densities can emerge.

Evaluating parcelization for the use-case of utility-scale solar project development, CEC staff adopts a fundamentally similar approach to the PDAP method described above. However, instead of converting the parcel polygons to points, their irregular shape is kept intact (as much as possible while converting to a gridded raster[16] of the parcel polygons) and the level of parcelization is determined by the number of unique assessor parcel numbers (APNs)[17] within a defined search radius. Then, the average number of unique properties across all grid cells representing the entire parcel is averaged and applied back onto the parcel polygon. This

th_Patterns_in_Western_North_Carolina. [2] Kennedy, Timothy and Daniel McFarlane. 2009. *Identifying Parcelization and Land Use Patterns in Three Rural Northern Wisconsin Towns: Bayfield County Project Summary,* https://www3.uwsp.edu/cnr-ap/clue/documents/parcelizationstudy/Bayfield_final_report.pdf

15 Thomas, Niel, Greg Dobson, Paul Dezendorf, Mark Cantrell, and David Abernathy. 2009. "Development of a Parcel-based Density Analysis Tool to Evaluate Growth Patterns in Western North Carolina." *Journal of Conservation Planning* 5, 38-53. https://www.academia.edu/5790754/Development_of_a_Parcel_based_Density_Analysis_Tool_to_Evaluate_Growth_Patterns_in_Western_North_Carolina.

16 A raster is a type of spatial data organization consisting of a matrix of grid cells that store a value. For more information, see "Introduction to image and raster data," available at https://pro.arcgis.com/en/pro-app/latest/help/data/imagery/introduction-to-raster-data.htm

17 Ideally, the number of unique owners would be used to identify the number individual property owners that a developer would have to engage to develop a site. However, tax APN numbers readily accompany parcel boundaries in most datasets from the county assessor's office and provide an approximate measure of unique owners. Moreover, the ownership information available in parcel datasets can be easily obscured to seem as if multiple owners exist when, in fact, a single entity may be the true owner. For these reasons and the statewide scale of analysis used here, APN numbers were used as a proxy for unique owners.

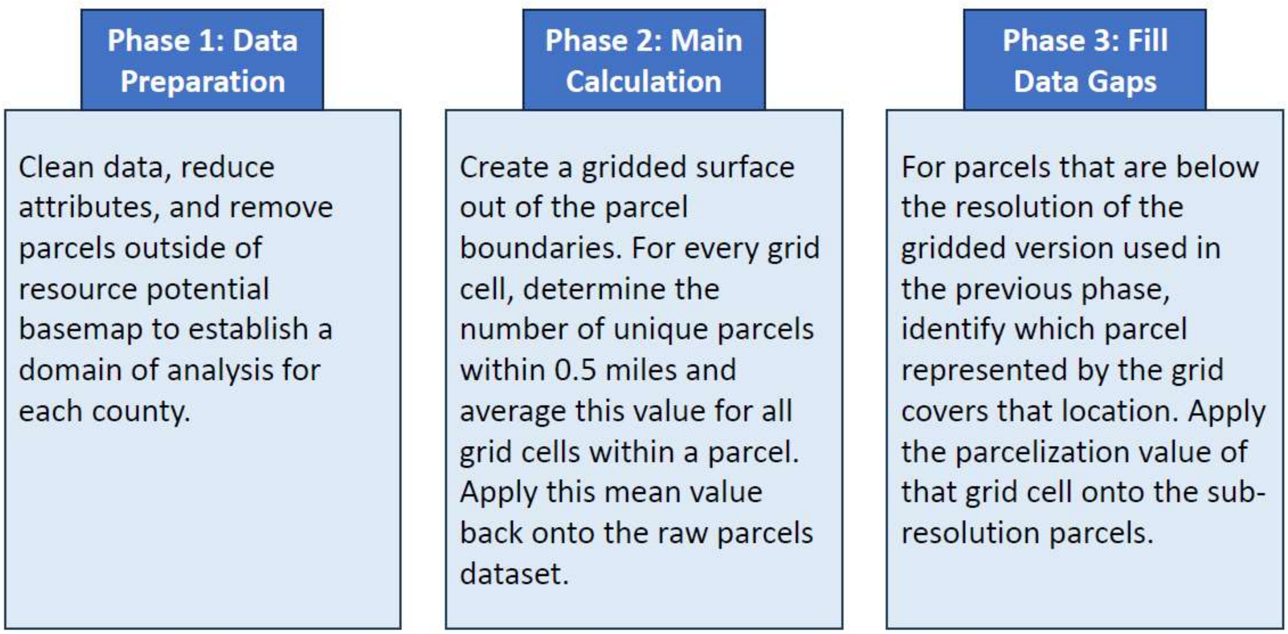
method was provided to CEC staff by ICF[18] and has been used in the solar development industry. The next section describes the data processing steps used to estimate parcelization.

Geoprocessing Steps

To calculate the average number of unique properties within a given distance of a location, CEC staff relies on a July 2022 statewide dataset of parcel boundaries purchased through the California Department of Technology from LightBox. Although county assessor offices throughout California keep records of ownership and the ways that their land is parsed for property rights, taxes, and laws, LightBox has compiled these data into a single GIS database, divided into datasets (feature classes) that are partitioned by county. In addition to the geometries of the parcel boundary, the data contain more than 300 attribute fields for each parcel, including an APN number, which is used as a unique identifier for each property.

The parcel datasets for each county are the basis for a series of geoprocessing steps that are executed through a Jupyter Python Notebook using mainly the Arcpy Python package. A diagram summarizing the steps used in this calculation is provided in Figure 1 below. The steps described in each phase is completed for each county in an automated process.

Figure 1: Overview of Parcelization Calculation



The main data processing steps to calculate the level of parcelization for solar development

18 ICF, personal communication, January 24, 2023.

has been outlined in three phases which are applied to each county.

Source: CEC staff

In the first phase of the method, the domain of the parcel density surface that is needed for study of solar photovoltaic project development is established. Because the search radius used to calculate parcelization is 0.5 mile, each county is buffered by that distance, and the neighboring parcels from other counties are merged to each central county. This buffering and merging are to ensure that all necessary parcels on which the calculation depends are available for each county, even those from outside the county. The parcelization calculation is limited to the resource potential basemap for solar[19] (buffered by 0.5 mile). This analysis domain is used because past busbar mapping cycles concentrates the evaluation of the land-use and environmental impacts assessment in this subset of the area around each substation. Since the most fundamental exclusions for renewable energy development are incorporated into the techno-economic and protected area layer exclusions, the areas remaining outside of them are considered as the broadest area that could have technical resource potential. In other words, calculating parcel density for areas outside of the resource potential basemap would have little meaning for resource potential for generation purposes. Figure 2 below shows the outlines of a sample region, centering around Yuba County, clipped to the 0.5-mile buffered resource potential basemap. As shown in this figure, the parcels data within the 0.5-mile ring of each of the five neighboring counties to Yuba would be merged to Yuba County, as is indicated by the bright blue outline around Yuba County.

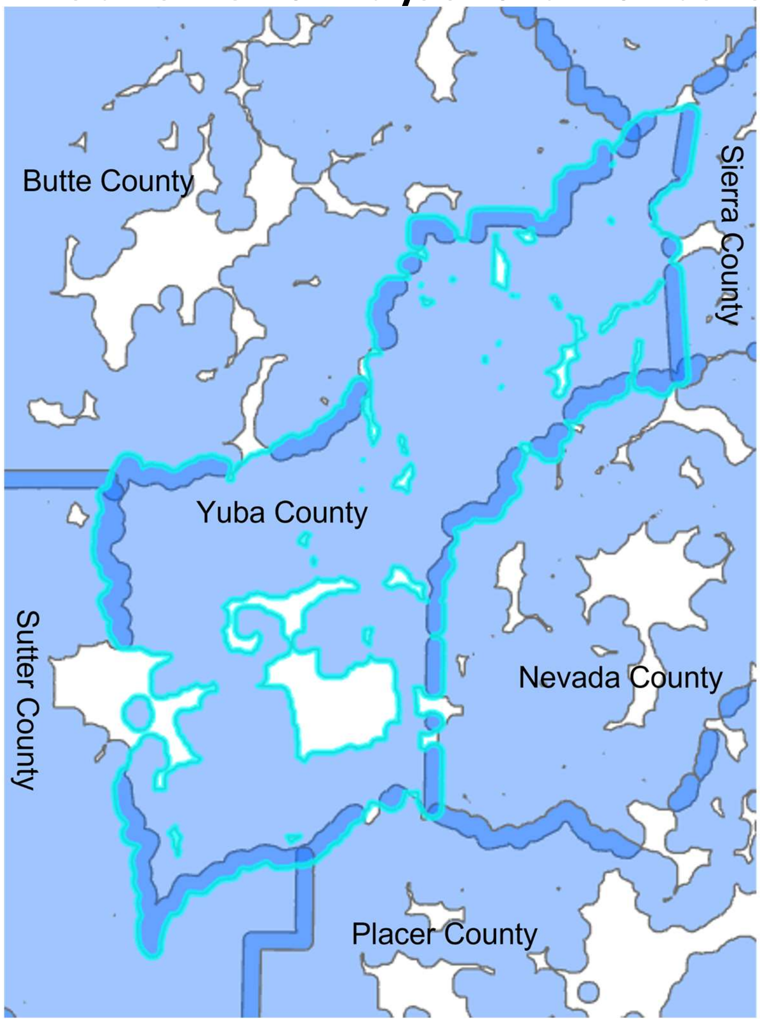
Other data cleaning steps are made during this phase of the methodology. For each county, the parcels data are dissolved by APN. In addition, some parcels with unique APNs were found to be overlapping. Sometimes identical geometries contain hundreds of unique APNs, and in other cases, the vertices of a parcel overlapped with neighboring parcels. The CEC staff chose to remove parcels with more than five overlaps, thus removing a negligible total footprint of parcels statewide.

At the completion of this initial phase, by limiting the domain of analysis to the resource potential basemap (which excludes densely parcelized urban areas), removing overlapping

19 The resource potential basemap is the area of the state remaining outside the base exclusions, or the techno-economic exclusion layer and the protected area layer for solar. The base exclusions are geospatial datasets used to refine the amount of land available for resource potential in electric system planning processes such as Integrated Resource Planning and SB 100 capacity expansion modeling. The techno-economic exclusion layer is compiled by the California Public Utilities Commission and captures technical (for example, competitive wind resource locations), physical (for example, slope, water bodies), socioeconomic or hazardous criteria (for example, densely populated areas, railways, airports, highways, mines), and military lands. The protected area layer is a single composite geospatial layer designed to encompass areas where utility-scale solar or transmission development is precluded by state or federal law, policy, or regulation.

features greater than five, and reducing the number of attributes, the 20 gigabyte (GB) statewide parcels data have been reduced to about 5 GB.

Figure 2: Establishment of Analysis Domain for Each County



Each county boundary is buffered by 0.5 miles. The parcels data from all neighboring counties are merged to the central county, as shown here for Yuba County. The resource potential basemap limits the domain of evaluation as well, and each county has been limited to the areas of the resource potential basemap, buffered by 0.5 miles.

Source: CEC staff

The second phase of the method provides the main steps of the parcelization calculation. Starting with the parcels data limited to the areas of the resource potential basemap (and buffered by 0.5 miles), the following geoprocessing steps are performed for each county:

1. The parcel polygons are rasterized to 90-meter resolution grid using the Parcel APN field as in the value field parameter in the "Polygon to Raster" conversion tool.[20] See Figure 3 below.
2. The "Nibble" tool[21] is applied to replace null cells with the nearest neighbor raster cell with a real value.
3. Using the "Focal Statistics" tool,[22] the number of unique values within 0.5 miles of every cell in the raster is calculated. This tool uses the Variety statistics type parameter value. See Figure 4 below.
4. Run the "Zonal Statistics as Table" tool.[23] For each group of unique IDs or Parcel APNs stored in the nibbled raster (the zone), the mean of the focal statistics output is calculated to provide the average number of unique parcel APNs within 0.5 mile of every parcel.
5. Join this *mean* parcelization value for every APN to the original parcels polygon data.

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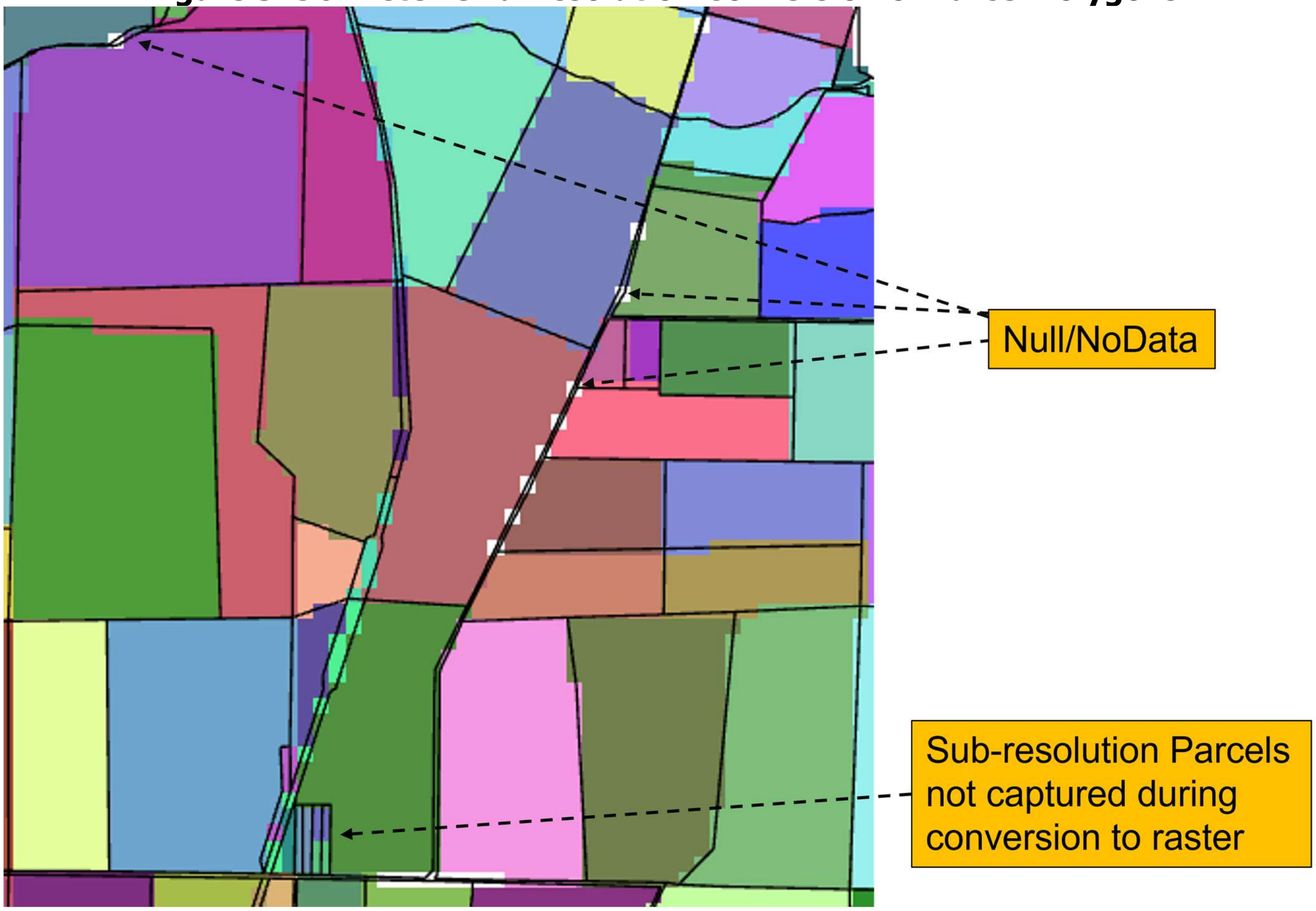
20 See "Raster to Polygon (Conversion)," available at https://pro.arcgis.com/en/pro-app/latest/tool-reference/conversion/raster-to-polygon.htm.

21 See "Nibble (Spatial Analyst)," available at https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/nibble.htm.

22 See "Focal Statistics (Spatial Analyst)," available at https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/focal-statistics.htm.

23 See "Zonal Statistics as Table (Spatial Analyst)," available at https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/zonal-statistics-as-table.htm.

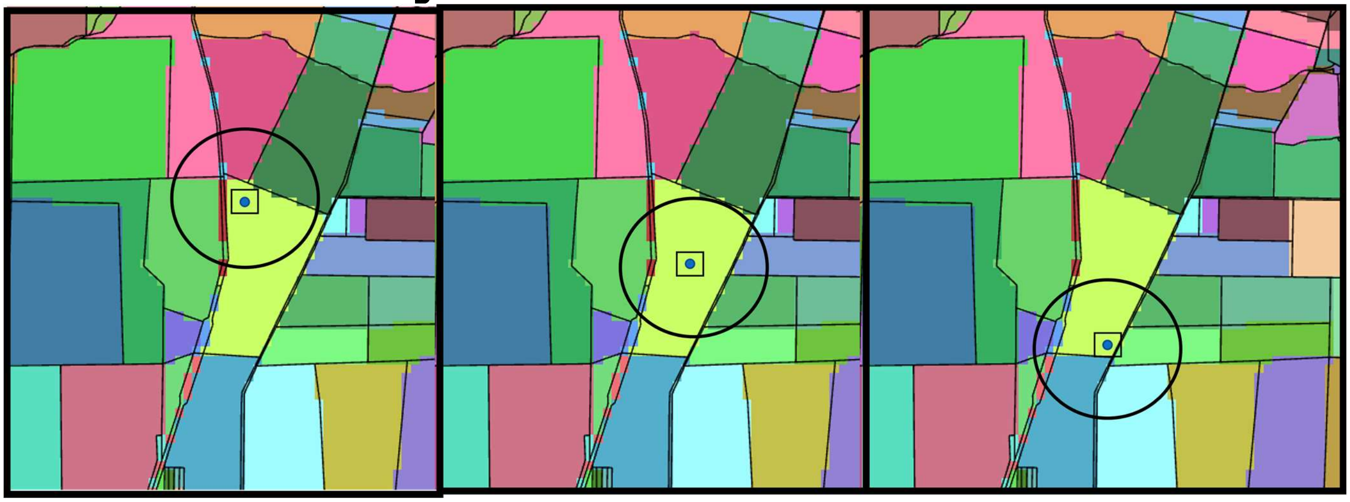
Figure 3: 90-Meter Grid Resolution Conversion of Parcel Polygons



Parcel polygons are rasterized at 90-meter resolution. Each color denotes a unique ID following the Parcel APN value for each polygon. The actual parcel geometries are delineated by the black line. Parcels that are below the 90-meter resolution may not be captured in conversion to raster format.

Source: CEC staff

Figure 4: Focal Statistics Calculation



This illustrates the data processing procedure that occurs when the focal statistics tool is applied. A calculation of the number of unique parcels within a 0.5 mile search radius from a single grid cell is determined before moving on to the next grid cell. This calculation occurs for every grid cell in the raster dataset and that unique value is stored as the value for each grid cell in the raster.

Source: CEC staff

The steps described above produce a mean parcelization value for most of the area used in the analysis domain of parcel polygons. However, parcels that had dimensions below or straddled the resolution of the 90-meter resolution may not get represented during the rasterization step above (which captures Parcel APN values at the cell center of the raster grid). This omission of parcelization values for sub-resolution parcels is illustrated in Figure 5 below. These Parcel APNs will not have a value that the result of Step 4 above can join to. So, CEC staff applies an approximation of the parcelization values for those small polygons. Starting with the result of Step 5 above, the data gaps are filled by the following method:

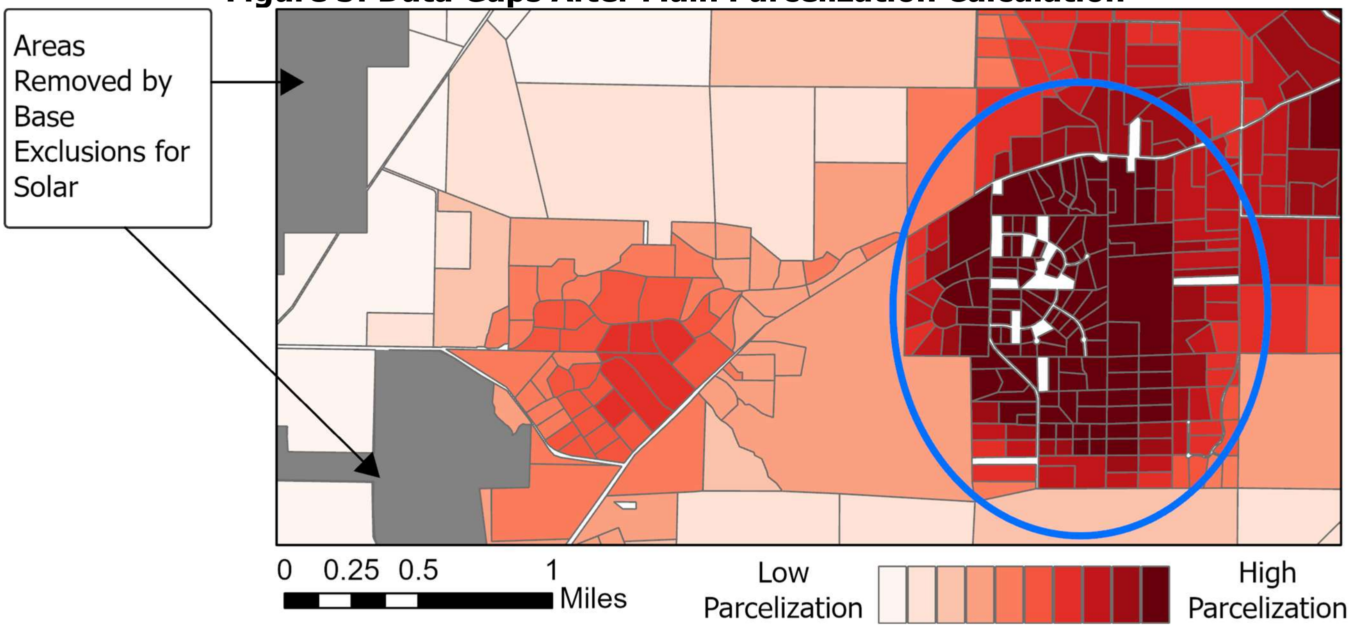
1. Select parcels that have a null mean parcelization value.
2. Convert the polygons to points using the parcel's centroid.
3. Use the "Extract Values to Points" tool[24] to bring the unique ID/APN values from the nibbled raster to those points.
4. Join the "Zonal Statistics as Table" output to this dataset. Now, these points that had a null parcelization value are associated with a unique ID that contain a mean

24 See "Extract Values to Points (Spatial Analyst)," available at https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/extract-values-to-points.htm.

parcelization value. This table can be used to identify that value that the null point overlays.

5. Join this *mean* parcelization value back to the original parcels dataset.

Figure 5: Data Gaps After Main Parcelization Calculation



Intermediate result after the first main pass of calculating parcelization values for parcel polygons is shown here. The area circled in blue contains many parcels with APNs that did not get represented in the first rasterization step, so a third phase of geoprocessing will fill these holes with the surrounding values. Areas colored in grey are outside of the domain of the parcelization calculation as they are part of the base exclusions for solar.

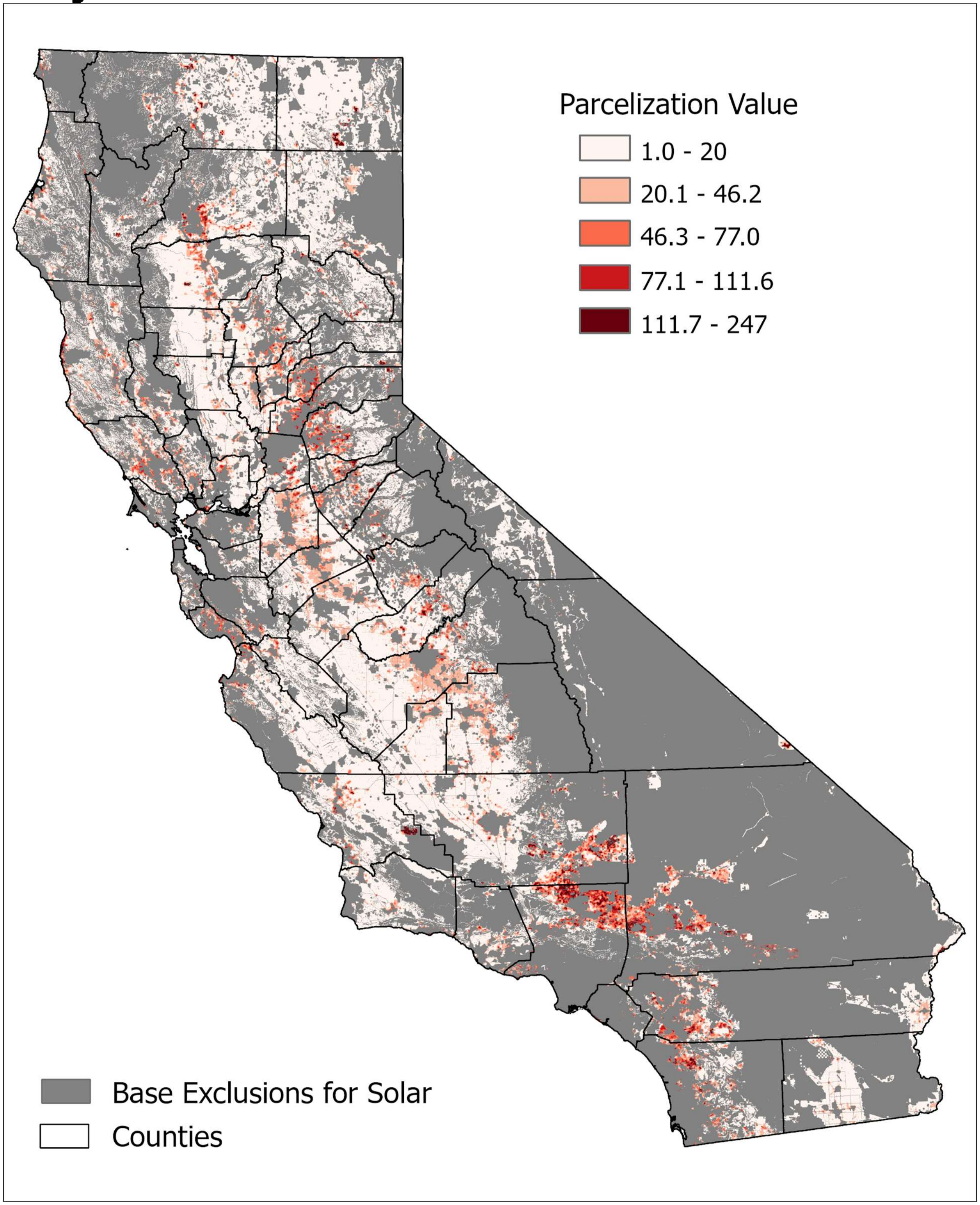
Source: CEC staff

The highest parcel density regions with parcels that are below 90-meter resolution are not explicitly incorporated into the calculation for parcelization. This creates parcelization value results that are lower than they should be. This is a shortcoming of the resolution of the grid cell resolution in the rasterization step of the method, but it is most pronounced in areas that have small and highly parcelized boundaries. Since utility-scale solar project developers are focusing on very low parcelization values, these characteristics are typically well beyond the range of feasible parcelization values. In addition, since this error and limit of the method happens statewide, it is not obscuring the relative values of low and high parcelization, except in the most high-density areas containing sub-90-meter parcels. The third phase of the parcelization calculation that fills the data gaps created by the 90-meter resolution completes the approach used by the CEC staff.

Evaluation of Results

The result of the geoprocessing steps described in the preceding section is a statewide distribution of the mean number of unique parcels, up to 0.5 miles away, from anywhere within each parcel for the entire domain of the solar resource potential basemap. Figure 6 below shows this result. Parcelization ranges from a minimum of 1.04 to a maximum of 247. Although there is a large variation throughout the state, there is a dominance of relatively low parcelization. From an estimated 34 million acres within the parcelization domain, about 44 percent of that area has a parcelization value of less than fifteen, whereas only twelve percent has a parcelization greater than thirty. There is also a common spatial pattern of high parcelization surrounding the excluded urban areas (urban areas that have been excluded as part of the techno-economic component of the base exclusions). However, areas like the Tehachapi region also host high parcelization levels.

Figure 6: Parcelization Results Within the Solar Resource Potential Basemap



Parcelization results from the three phases of geoprocessing steps described above. The Tehachapi region has the largest area of elevated parcelization, while many areas surrounding urban areas throughout the central valley have medium level parcelization values. The vast majority of the area of the analysis domain has a low parcelization level of less than thirty.

Source: CEC staff

Parcelization matters most in areas near the electric grid that are preferable locations for interconnection. The CEC staff explores parcelization levels throughout several subsets of the domain to understand what level of parcelization can be accommodated in proximity to transmission lines and substations. Table 1 below indicates the mean, median, tenth percentile value and the total acreage less than the tenth percentile of the entire parcelization surface domain (the resource potential basemap), fifteen-mile buffers around the 500 kilovolt (kV) and 220/230 kV transmission lines, and the region within ten miles of the California ISO preferred substations. The California ISO preferred substations are determined by the 2021 white paper on transmission constraints[25] and interconnection points listed in the California ISO interconnection queue.[26]

25 See *Transmission Capability Estimates for use in the CPUC's Resource Planning Process*, available at http://www.caiso.com/Documents/WhitePaper-2021TransmissionCapabilityEstimates-CPUCResourcePlanningProcess.pdf

26 See the "Reporting" tab of the *California ISO Resource Interconnection Management System*, and click on the link to download the *Formatted Generator Interconnection Queue Report* in either PDF or Excel format available at https://rimspub.caiso.com/rimsui/logon.do.

The preferred substation list also includes five substations in Imperial Irrigation District because California ISO often interties with this system.

Table 1: Parcelization Values Summarized by Region

Region	Mean	Median	10th Percentile	Total Acres (Millions) Less than 10th Percentile Value
Resource Potential Basemap	68.1	61.0	10.5	21.3
15 Mile Buffer of Transmission Lines ≥ 500kV	69.1	62.3	10.6	9.6
15 Mile Buffer of Transmission Lines > 200kV	69.8	63.0	12.0	16.0
10-Mile Buffer of Preferred Substations*	67.6	61.6	12.8	7.2

***All but two of the California ISO preferred substations have been identified in this analysis. Also, four substations in the Imperial Irrigation District have also been included in this footprint. Finally, existing solar projects have been removed from the parcelization statistics in this subset region.**

Source: CEC staff

The mean and median parcelization values of these regions are all relatively high and unvarying. These values are likely due to most of these regions spanning the entire state and are large enough to capture the same variability that exists in the entire study domain, the resource potential basemap. The median value is slightly less than the mean, indicating that there are outliers with very high parcelization value among the data. This finding is supported by the actual distribution of parcels where many small parcels can fit in a small area, resulting in a larger number of parcels with high parcelization levels.

The tenth percentile value also shows very little variability between the regions listed in Table 1, but the values are lower than the mean or median. These values are indicative of target levels of parcelization conditions for large solar project development.[27] The buffered regions around each subset of transmission lines and the buffered regions around the substations produce a higher tenth percentile value than the resource potential basemap. This means that these regions tend to be less rural and contain some of the more developed areas of the state,

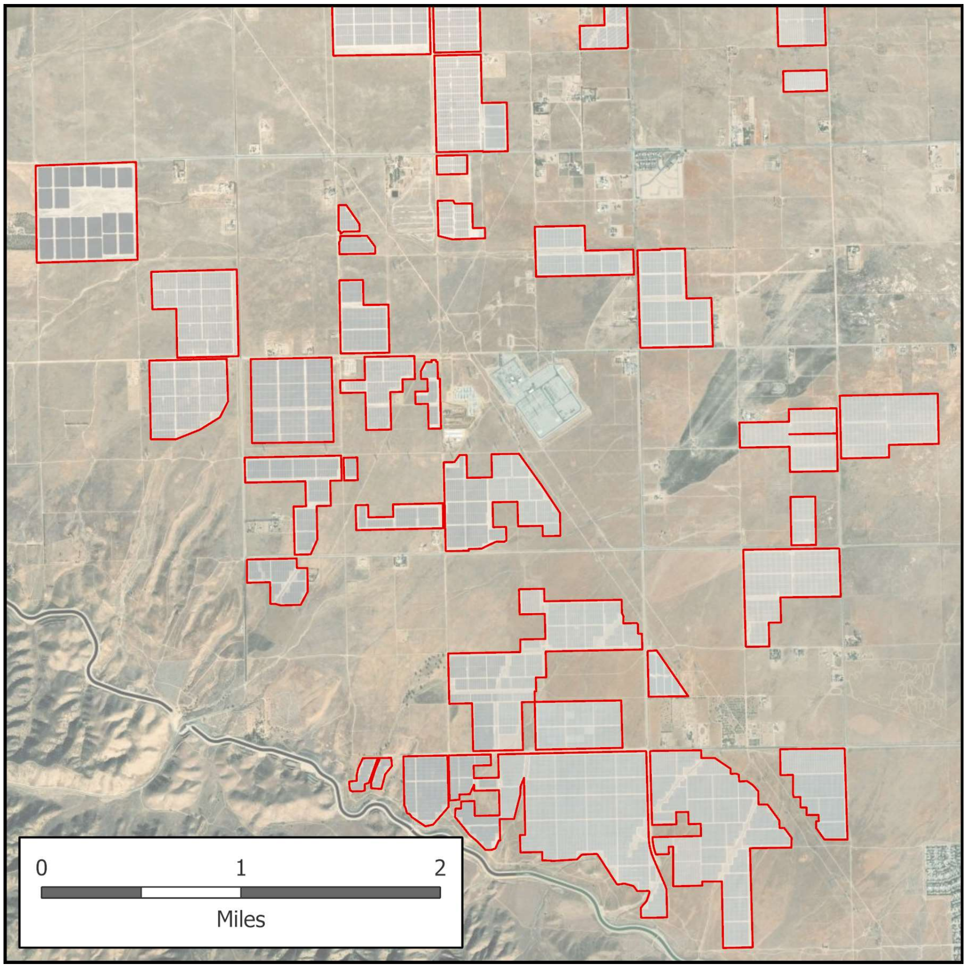
27 Comments of the Large-Scale Solar Association. November 1, 2022. https://efiling.energy.ca.gov/GetDocument.aspx?tn=247227

compared with the regions outside of these areas, which are the very lowest, most rural areas of the map. The subset of the parcelization domain that is within ten miles of substations has the highest tenth percentile value, indicating that these substations are in relatively more developed areas, compared to the buffered transmission system as a whole. The smaller buffer distance also accounts for the higher tenth percentile value because more parcelized conditions tend to exist closer to this infrastructure rather than further out. Finally, the total area of the lowest tenth percentile values of parcelization in these regions range from about 21 million acres to almost seven million acres. This implies that if parcelization were the only land-use factor to consider, there is ample opportunity for solar development in California.

Parcelization of Existing Solar Footprints

As more solar projects are built, especially around substations, an understanding of the level of existing development in these areas is important to improving future utility-scale solar capacity deployment assumptions in electricity system planning. In areas of high renewable energy project buildout, there may be increasing land or infrastructure access limitations. A new GIS dataset of solar footprints evaluated from recent imagery acquired mostly between 2021 and 2022 has been developed by CEC staff. By bringing these solar footprints together with the parcelization dataset, CEC staff can characterize the levels of parcelization at existing solar projects, which informs acceptable parcelization level assumptions for future electricity system planning.

Figure 7: Example Area Showing Solar Footprints



The figure above shows an area near Lancaster, California, with many commercial scale solar electric generating facilities. Areas outlined in red are polygons in the Solar Footprints dataset.

Source: CEC staff

CEC staff manually identified and digitized solar footprints based on imagery with recent acquisition dates to provide an up-to-date statewide inventory of large solar arrays. CEC staff relied on previously published datasets that identify locations of large solar projects to guide where staff focus their visual search of the imagery. If solar panels were visible in the imagery, the boundaries were digitized as polygons to match the visual extent of the arrays of solar panels. These previous datasets include:

1. California Solar Footprints[28]
2. UC Berkeley Solar Points[29]
3. Kruitwagen et al. 2021[30]
4. BLM Renewable Project Facilities[31]
5. Quarterly Fuel and Energy Report (QFER)[32]

Datasets that hold recent imagery that are used to confirm the existence of the solar projects and determine the associated boundaries include:

1. Esri World Imagery Basemap, 2021-2022.[33]
2. USGS National Agriculture Imagery Program (NAIP), 2020.[34]
3. Sentinel-2 Satellite Imagery, 2023.[35]

January 2023 Sentinel-2 imagery was applied in a few areas where the two other imagery sources did not show any indication of solar development even though the location was identified in one of the previously published datasets used to guide the CEC staff search. Most of these solar projects without a corresponding visual identification in the imagery came from QFER. Areas along Interstate-10 in Riverside County and near Colorado River Substation were also scrutinized by CEC staff with January 2023 Sentinel-2 data. These areas were known from

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28 2017. "California Solar Footprints (2017)." Conservation Biology Institute, https://databasin.org/datasets/f5c2c15925b74fc4bbd2a8a22fbf4ad0/.

29 See "Utility-Scale Solar 2022 Edition Data File (XLSM)," a downloadable file available at https://emp.lbl.gov/utility-scale-solar. The sheet name called "Individual_Projects_Data" contains the point locations of solar projects used in methods described above.

30 Kruitwagen, L., K. T. Story, J. Friedrich, L. Byers, S. Skillman, and C. Hepburn. 2021. "A Global Inventory of Photovoltaic Solar Energy Generating Units." *Nature* 598, 604-610, https://doi.org/10.1038/s41586-021-03957-7.

31 See "BLM CA Renewable Energy Projects," available at https://gbp-blm-egis.hub.arcgis.com/maps/BLM-EGIS::blm-ca-renewable-energy-projects/about.

32 See "California Power Plants," available at https://cecgis-caenergy.opendata.arcgis.com/datasets/california-power-plants/explore.

33 See "World Imagery," available at https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9.

34 See "USA NAIP Imagery: Natural Color," available at https://www.arcgis.com/home/item.html?id=3f8d2d3828f24c00ae279db4af26d566. USDA National Agriculture Imagery Program information available at https://naip-usdaonline.hub.arcgis.com.

35 Copernicus Sentinel-2. 2023. Retrieved from Google Earth Engine.

the California ISO Public Interconnection Queue to contain very recently developed solar projects.[36]

In this way, CEC staff created the new GIS dataset called Solar Footprints in California.[37] It consists of polygons that represent the footprints of solar arrays larger than about 0.5 acres placed on rooftops, parking lots, and the ground. Small-scale solar (less than 0.5 acre) and residential footprints were not included. No other data was used in the production of these shapes.

Once all footprints identified by the above criteria were digitized for all California counties, the features were visually classified into ground, parking, and rooftop categories. Definitions for the solar projects identified via imagery are subjective and described as follows:

- Rooftop solar: Solar panels located on rooftops of large buildings.
- Parking lot solar: Solar panels on parking lots roughly larger than one acre or clusters of solar panels in adjacent parking lots.
- Ground solar: Solar panels located on ground roughly larger than one acre, or large clusters of smaller scale footprints.

The features were also classified into rural and urban types using the 42 U.S. Code § 1490 definition for rural.[38] The coverage provided by this dataset should not be assumed to be a complete accounting of solar footprints in California. Rather, this dataset represents an attempt to improve upon previously published solar project datasets in California and to update the inventory of large solar footprints via more recent imagery.

This procedure produced a total solar project footprint of 129,742 acres. Attempts to classify these footprints and isolate the large solar projects from the smaller solar projects identified in the dataset is difficult. The data was gathered based on imagery, and project information that could link adjacent solar footprints under one larger project is not known. However, partitioning all solar footprints that are at least partly outside the techno-economic exclusions and greater than seven acres yields a total footprint size of 114,470 acres. These acres and footprints can be identified as part of large solar projects. As described above, the term large

36 See the "Reporting" tab of the California ISO Resource Interconnection Management System, and click on the link to download the Formatted Generator Interconnection Queue Report in either PDF or Excel format available at https://rimspub.caiso.com/rimsui/logon.do.

37 See "Solar Footprints in California," available at https://cecgis-caenergy.opendata.arcgis.com/maps/CAEnergy::solar-footprints-in-california.

38 See " 'Rural' and 'rural area' defined," available at https://uscode.house.gov/view.xhtml?req=(title:42%20section:1490%20edition:prelim).

solar project does not have a formal definition given the approach and limitations of the analysis.

The Conservation Biology Institute (CBI) Solar Footprints dataset,[39] which also focused on large, mostly utility-scale, solar footprints, produced a total footprint of 64,528 acres determined by imagery through 2016. Comparing this estimate and the total size of the large solar projects determined by CEC described here (based on imagery mostly through 2022), indicates a 49,942-acre (75 percent) increase in the six years since the CBI data was completed. The QFER database, which tracks all electric generation in California of 1 MW or greater, indicates the same rate of growth over the same period for solar PV. Specifically, the total capacity from the QFER database increased from 8,740 MW at the end of 2016 to 15,221 MW in 2022, an about 74 percent increase.[40] This shows that the 114,470 acres of large-scale solar determined by CEC staff are in agreement with the recent rate of growth in California. The CEC dataset has captured an accurate number of solar arrays developed since 2016 using the GIS method described above.

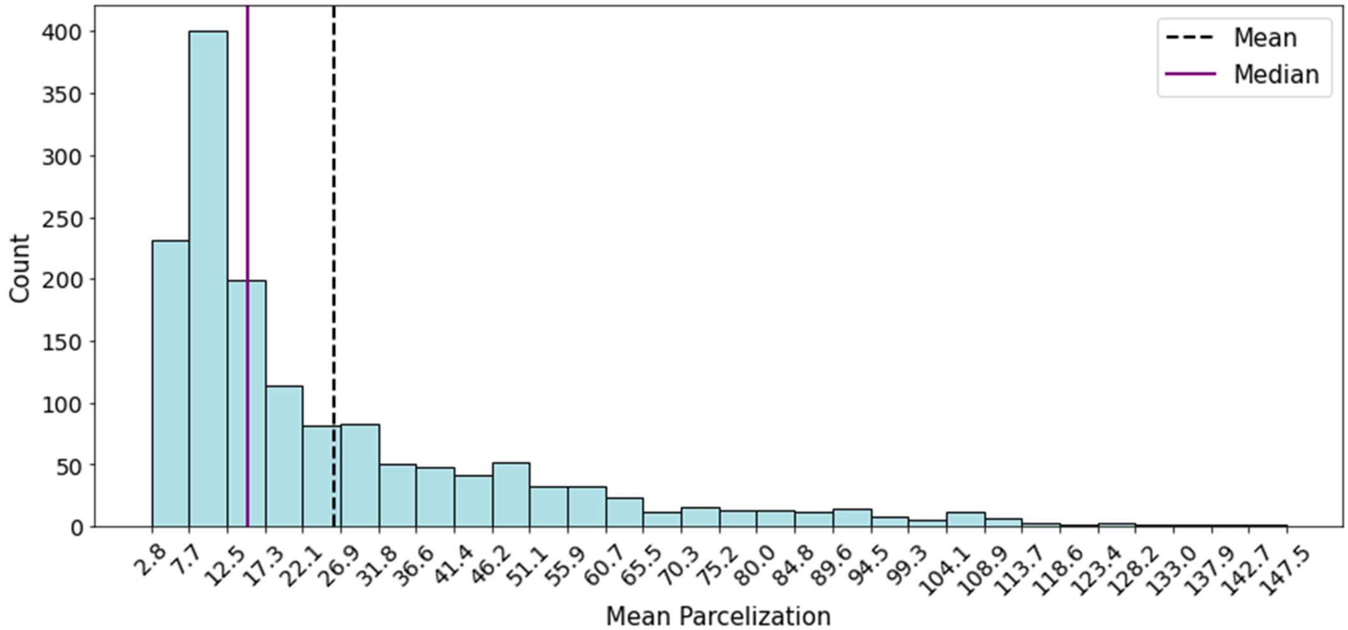
CEC staff evaluated the level of parcelization in existing solar footprints by intersecting the new Solar Footprints in California[41] dataset with the parcelization map. An average parcelization value is computed for every solar footprint that intersects more than one parcel. The distribution of mean parcelization value for solar footprints that are within the resource potential basemap is shown in Figure 8 below. Large counts of parcelization values are below about 30, with the largest peak (reaching a count of almost 400) capturing parcelization values of 7.7 to 12.5. The minimum value is 2.8. The histogram is right skewed with a long tail stretching out to a maximum parcelization value of more than 147.5. Existing solar footprints within the resource potential basemap exhibit a mean parcelizaiton value of 26.1 and a median of 15.2.

39 2017. "California Solar Footprints (2017)." Conservation Biology Institute, https://databasin.org/datasets/f5c2c15925b74fc4bbd2a8a22fbf4ad0/.

40 See *Installed In-State Electric Generation Capacity by Fuel Type (MW)*, available at https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/electric-generation-capacity-and-energy

41 See "Solar Footprints in California," available at https://cecgis-caenergy.opendata.arcgis.com/maps/CAEnergy::solar-footprints-in-california.

Figure 8: Parcelization of Existing Solar Footprints



The distribution of parcelization values that intersect existing solar footprints. The largest counts of parcelization values are below about 30, and the data exhibits a mean of 26.1 and a median value of 15.2. The histogram is right skewed with a long tail stretching out to a maximum parcelization value of 147.5.

Source: CEC staff

This analysis provides an assessment of what parcelization levels have been successfully developed for solar projects. Target parcelization levels for future solar projects may reach beyond sixty or eighty parcels, but most of the existing footprints have been developed in parcelization levels below thirty.

The CEC staff recognizes that for long-term electricity system planning, many factors can influence the level of parcel density developers are willing to engage in site development. However, incorporating parcelization as a factor representative of development feasibility is important to improving future solar capacity assumptions. The next chapter describes a potential method of quantifying parcelization levels to evaluate land use in terms of opportunities and constraints for the deployment of new solar utility-scale photovoltaic capacity in electricity system planning.

CHAPTER 3: Application of Parcelization Methods

CEC staff, in coordination with CPUC staff, proposes to pilot this new measure of parcelization in the land-use evaluation for busbar mapping. Busbar mapping is the refinement of the geographically coarse energy generation and storage resource portfolios produced in the CPUC's Integrated Resource Plan proceeding into plausible network modeling locations for transmission analysis in the California ISO's annual Transmission Planning Process (TPP). In January 2023, the CPUC released a document describing the busbar mapping methods.[42] In busbar mapping, the CEC staff conducts a geospatial analysis to identify the potential environmental and land-use implications around select substations to inform assumptions related to the feasibility of deploying future renewable energy and storage capacity. Details regarding data, methods, and implementation of the environmental and land-use evaluation for busbar mapping will be described in the CPUC's most current *Methodology for Resource-to-Busbar Mapping* document.[43]

In busbar mapping, there are several categories of criteria that help inform whether a substation can support a new allocation of renewable energy capacity, as described in the most recent busbar mapping method document. Most of these criteria assess the substation's physical characteristics in the transmission system, such as how much electricity it can accommodate with transmission constraints, but also include other factors such as commercial development interest and consistency with prior TPP portfolios. An additional set of criteria evaluates the characteristics of the land around a substation – the land-use and environmental implications. Renewable energy resources, such as solar, wind, and geothermal, have a larger land use intensity and this set of criteria helps determine the feasibility of the land to accommodate the projected growth of renewable generation that will be needed to support the modeled portfolios. Geospatial analysis is used to determine the land availability within the immediate area of a substation and characteristics of the land's environmental, ecological, and

42 See Methodology for Resource-to-Busbar Mapping & Assumptions for the Annual TPP, available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2022-irp-cycle-events-and-materials/2023-2024-tpp-portfolios-and-modeling-assumptions/busbarmethodologyfortppv20230109.pdf.

43 See *Draft Methodology for Resource-to-Busbar Mapping & Assumptions for the Annual TPP*, available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-irp-cycle-events-and-materials/assumptions-for-the-2024-2025-tpp/draft_mappingmethodology_07-17-23.pdf.

cropland value can be quantified. In prior busbar mapping cycles, the characteristics of the land area around a substation that were reported to the CPUC by CEC can be summarized as:

1. Total acreage of technical resource potential.[44]
2. Percentage of total resource potential.[45]
3. Percentage of total resource potential acreage with high environmental factors.
4. Percentage of total land area around the substation within a high fire threat tier or within an important bird area.

CEC staff recommends adding parcelization as a new metric of analysis for the land-use characteristics around a substation. Along with the other land-use metrics and other categories of compliance criteria, this will inform energy generation resource mapping decisions that are made by CPUC, CEC and California ISO during busbar mapping so that the California ISO can study the capability of the electric grid to receive and transmit these new inputs as part of the TPP. CEC staff will assist the busbar mapping working group by calculating parcelization metrics within the resource potential basemap, reduced by existing solar footprints,[46] around each substation. The general level of parcelization and total size of low-parcelization land will likely be captured by:

1. The tenth percentile value.
2. The total acreage with low and mid-level parcelization value.

The metrics will be reported for every substation in the California ISO preferred list.[47] The first metric gives a general indication of the parcelization value for the area surrounding a

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44 Technical resource potential in the last busbar mapping cycle was determined by a suitability model that evaluated the land outside of the techno-economic exclusions layer and the protected area layer in terms of its biodiversity, connectivity and landscape intactness characteristics. This area was partitioned into high and low implication areas based on the results of the suitability model. The low implication areas were considered as having technical resource potential, since these areas remain after applying the environmental screen of the suitability model. In the upcoming busbar mapping cycle for the 2024-2025 TPP, the technical resource potential corresponds to the area remaining after application of the 2023 CEC Core Land-Use Screen.

45 The total resource potential refers to the areas outside of the techno-economic exclusions and the protected areas layer. In the upcoming busbar mapping cycle for the 2024-2025 TPP, the total resource potential uses the updated techno-economic exclusion layer and the protected area layer from the final 2023 CEC Land-Use Screens.

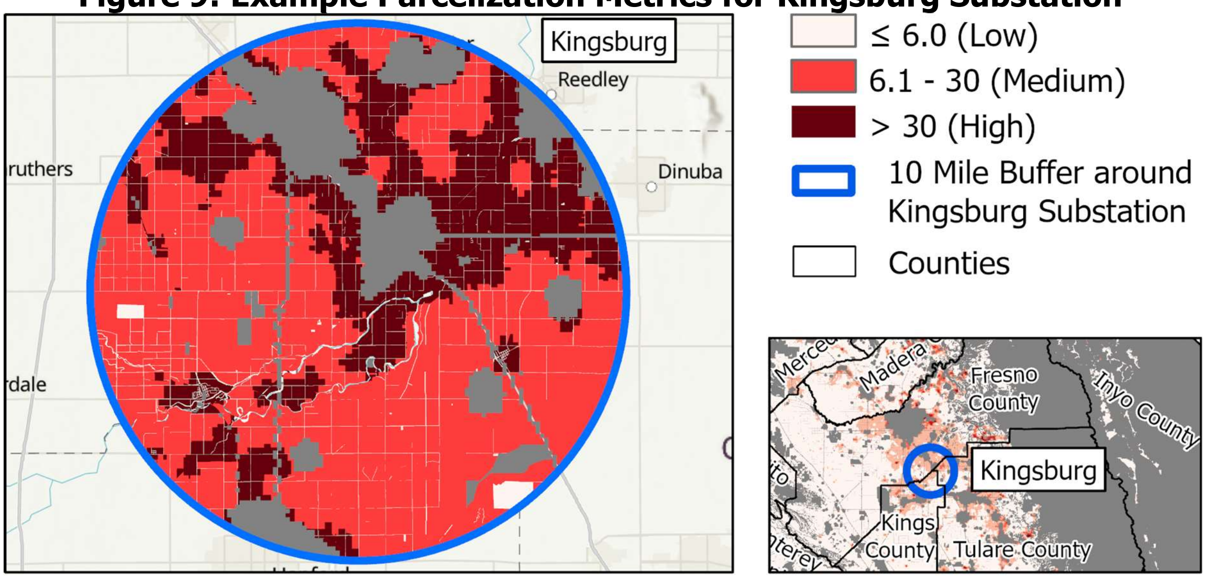
46 See "Solar Footprints in California," available at https://cecgis-caenergy.opendata.arcgis.com/datasets/CAEnergy::solar-footprints-in-california/explore

47 See *Transmission Capability Estimates for use in the CPUC's Resource Planning Process*, available at http://www.caiso.com/Documents/WhitePaper-2021TransmissionCapabilityEstimates-CPUCResourcePlanningProcess.pdf

substation. If the tenth percentile parcelization value is high, then the substation may possibly have a development feasibility constraint due to the level of parcelization. However, the second metric, which indicates how much area is available with low or medium levels of parcelization, provides corresponding information which, together with the tenth percentile value, can create a more complete picture of how much solar resource capacity can be allocated to a substation for study.

Example thresholds of low and mid-level parcelization values can be based on the analysis of parcelization values of existing solar footprints described in the last chapter. A low level of parcelization of six or less can be considered as an attractor factor for allocating resources to that substation. A midlevel parcelization value between six and thirty can be considered as having sufficient parcelization levels to support solar resource capacity allocation since the mean parcelization value of all existing solar footprints is close to thirty. An abundance of the land area around a substation that has a high level of parcelization would indicate that the substation may not be an optimum location for allocating large amounts of solar capacity. The partitioning of the resource potential basemap area using those example categories of low and midlevel parcelization as well as the tenth percentile value is shown in Figure 9 below for the Kingsburg Substation.

Figure 9: Example Parcelization Metrics for Kingsburg Substation



Substation	Resource Potential Total Acres	10th Percentile	Low Parcelization Acres (≤ 6)	Mid Parcelization Acres (<6 and ≤ 30)
Kingsburg	161,589	16.7	1,152	111,986

Parcelization values partitioned into three categories are displayed for the ten-mile buffer area around Kingsburg Substation. The total acreage within the low and medium categories along with the tenth percentile parcelization value is calculated and given in the corresponding table. This figure exhibits example metrics that would be used in the new parcelization component of the land-use evaluation for an example substation, Kingsburg.

Source: CEC staff

Existing solar footprints have been removed from the resource potential basemap and parcelization map. Within ten miles of Kingsburg Substation, there is a median parcelization value of 33.7 and a tenth percentile value of 16.7, which is well within the range of parcelization levels of most of the existing solar footprints. The total acreage of very low parcelization value, less than or equal to six, is just over 1,000 acres, but the midlevel category contains a much higher amount of acreage. This indicates that both the tenth percentile metric and the total acreage of feasible parcelization levels are aligned. Both indicate the land-use feasibility factor of parcelization would likely not limit the amount of resources that could be allocated to this substation. In some cases, the tenth percentile value may be very high, but this metric's importance may be reduced by considering the total acreage values in the low and medium parcelization categories. If there is ample acreage available in these categories, then that indicates that the area's development feasibility has sufficient parcelization levels to allocate resource to that substation.

The exact metrics describing the variability of parcelization around a substation, along with the precise boundaries of low vs. medium parcelization levels are described here as a possible use for the current 2024-2025 cycle of busbar mapping IRP portfolios for the TPP. These metrics are draft and subject to change based on public feedback and after use alongside the other compliance criteria. The CEC staff recommend adding parcelization to the list of metrics used to inform the land-use characteristics around a substation as it is an important representative factor of development feasibility and will improve future solar capacity mapping decisions.

APPENDIX A
Glossary

Table A-1: Glossary of Terms

Term	Definition
2021 Joint Agency SB 100 Report	The 2021 Joint Agency SB 100 Report includes a review of the policy to provide 100 percent of electricity retail sales and state loads from renewable and zero-carbon resources in California by 2045. The report assesses various pathways to achieve the target and an initial assessment of costs and benefits. The report includes results from capacity expansion modeling and makes recommendations for further analysis and actions by the joint agencies. Under SB 100, the joint agencies include the CEC, California Public Utilities Commission, and California Air Resources Board, and a new report is required to be published every four years. For more information see, the 2021 Joint Agency SB 100 Report.
Assessor Parcel Number (APN)	A unique identifying number for each parcel boundary used for taxation and legal purposes.
Base Exclusions	A foundational set of exclusion layers that CEC and CPUC updated in the recent 2023 land use screening effort for electric system planning. The exclusion set is composed of the protected area layer and the techno-economic exclusion layer, which delineate mapped boundaries of the state that exhibit (1) legal, administrative or policy-driven prohibitions against renewable energy development or (2) technical, economic, hazardous, or physical characteristics that are infeasible for renewable energy development. The base exclusions for solar used in this analysis is available at https://caenergy.maps.arcgis.com/home/item.html?id=5648df9222964820a2431ffc897da5a3. For more information, see the *Land-Use Screens for Electric System Planning* staff report and accompanying material, available at https://www.energy.ca.gov/publications/2022/land-use-screens-electric-system-planning-using-geographic-information-systems.
Busbar mapping	The process of refining the energy resource portfolios produced in the CPUC's Integrated Resource Planning process, which are at a geographic scale too broad for transmission planning to specific interconnection locations (that is, substations) for analysis in California ISO's Transmission Planning Process.

CPUC Integrated Resource Planning (IRP)	A planning proceeding to consider all the CPUC's electric procurement policies and programs and ensure California has a safe, reliable, and cost-effective electricity supply. The integrated resource planning process ensures that load-serving entities (LSEs) detail the procured and planned resources in their portfolios that allow the electricity sector to meet electricity demand while also contributing to meeting California's economywide greenhouse gas emissions reductions goals. For more information see, CPUC IRP.
Kilovolt (kv)	One-thousand volts (1,000). Distribution lines in residential areas usually are 12 kV (12,000 volts).
Land-use Screen	A geospatial dataset or map-based footprints that may include technical, environmental, and other land-use priorities and considerations. For example, a land-use screen may depict energy resource potential, terrestrial biodiversity, cultural resources, physical characteristics of the land, or agricultural value to list a few.
Load-serving Entity (LSE)	Any company that (a) sells or provides electricity to end users located in California, or (b) generates electricity at one site and consumes electricity at another site that is in California and that is owned or controlled by the company. LSE does not include the owner or operator of a cogenerator. LSEs include: investor-owned utilities, rural electric cooperatives, publicly owned utilities, community choice aggregators, and electric service providers.
Parcelization	The measure of average number of unique land parcels in the area. This measure represents an important factor of development feasibility to inform how much new solar resource generation a region can support.
Raster	A type of spatial data organization consisting of a matrix of grid cells that store a value.
Renewable Resource Technical Potential	Renewable resource technical potential, or technical resource potential, is the achievable energy generation capacity (in megawatts [MW] or gigawatts [GW]) of a renewable technology given techno-economic, topographic, environmental and land-use constraints.
RESOLVE	RESOLVE is an electricity resource planning model that identifies optimal long-term electric generation and transmission investments subject to reliability, policy, and technical constraints. RESOLVE identifies optimal portfolios of renewable and conventional energy resources through capacity expansion and production simulation modeling. The CPUC uses RESOLVE in

	the IRP process. For more information on modeling assumptions in the IRP process and RESOLVE data inputs see, CPUC Portfolio and Modeling Assumptions.
Resource Potential Basemap	The area of California remaining after removing base exclusions – techno-economic and protected area exclusions – for solar PV and onshore wind technologies. This footprint forms the basis of further land-use screening and evaluation for electric system planning efforts. This term was developed during the recent 2023 update to the land-use screens. For more information, see the *Land-Use Screens for Electric System Planning* staff report and accompanying material, available at https://www.energy.ca.gov/publications/2022/land-use-screens-electric-system-planning-using-geographic-information-systems.
Substation	A facility that steps up or steps down the voltage in utility power lines. Voltage is stepped up where power is sent through long-distance transmission lines. it is stepped down where the power is to enter local distribution lines.
Transmission Planning Process (TPP)	Annual transmission planning by the California Independent System Operator (ISO) that actively engages stakeholders and public input while using the best engineering analysis possible to determine short and long-term electric infrastructure needs. The transmission plan's primary purpose is to identify, using the best available information at the time the plan is prepared, needed transmission facilities based upon three main categories of transmission solutions: reliability, public policy, and economic needs. The ISO accounts for an array of considerations, with advancing the state's objectives of a cleaner future grid playing a major part in those considerations. For more information see, California ISO Transmission Planning.

Source: CEC staff