Contra Costa County Renewable Resource Potential Study

December 18, 2018

Prepared for:

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Department of Conservation
and Development

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CADMUS

Acknowledgements

The work upon which this publication is based was funded in whole or in part through a grant awarded by the California Strategic Growth Council. The Contra Costa County Department of Conservation and Development was the recipient of Grant Number 3017-502, of the 2017 Sustainable Communities Planning Grant & Incentives Program Best Practices Pilot. The research was informed by conversations with numerous County staff members and dozens of committed external stakeholders including utility and community choice energy representatives, environmental organizations, city staff, Contra Costa County Sustainability Commission members, solar developers, solid waste disposal companies, wastewater districts, and other interested parties.

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1. Executive Summary

The Contra Costa Renewable Resource Technical Potential Study, funded by a grant from the California Strategic Growth Council, is being conducted to identify opportunities that Contra Costa County can use to expand its leadership in local clean energy production and to bring clean energy's benefits broadly to County constituents, with attention on how these benefits can be shared with "disadvantaged" communities. The study includes four energy types: solar photovoltaic, wind, biomass combustion, and biogas generation.[1]

The study has two primary purposes:

1. Quantify the magnitude of available renewable energy resources, identifying where resources could be located within the County, exploring typical cost levels associated with each type and subtype of resource, and identifying constraints and tradeoffs associated with developing resources in each location.
2. Evaluate existing options for updating policy and zoning to facilitate development of renewable resources in the County, while remaining mindful of long-term planning considerations and potential tradeoffs.

This study uses resource quality estimates (e.g., annual solar irradiance, wind speeds, energy value of bioenergy feedstocks) and evaluates specific locations for the amount of energy they could generate. Sites assessed were selected by examining system performance, topographic limitations, and environmental and land-use constraints to find the maximum electrical power possible to produce given these technical constraints. The study places a strong emphasis on identifying renewable resources within the Urban Limit Line (ULL), established in 1990 to direct growth to where infrastructure exists and to preserve farmland and open space.[2] Nevertheless, the study evaluates certain property types outside of the ULL, including areas that might be suitable for large-scale wind and agricultural lands with the fewest constraints to renewable development (e.g., solar or wind).

In addition to the two primary purposes of quantifying the magnitude of available renewable energy resources and exploring policy options to reduce zoning barriers, the project team has worked with seven cities within the County that asked to be included and contributed funding. For these cities, the team has assessed the solar resources that could be sited on City-owned facilities (and in some cases on properties owned by other parties). The cities are Concord, Lafayette, Martinez, Oakley, Pinole, Pleasant Hill, and Walnut Creek. This includes a site-by-site assessment of shading, roof orientation, parking lot

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[1] Biomass is distinguished from biogas for this study in that biomass resources would be feedstocks that are combusted directly, while biogas is generated from a feedstock (typically by anaerobic digestion), and later combusted for energy.

[2] Such resources inside the ULL include solar on rooftops, parking lots, and "urban land unlikely to be developed" (a category defined for this study that includes brownfields, industrial buffer land, surplus land along freeways, and other lands that probably will not be developed for any other purpose and present few, if any, tradeoffs.

geometry and size, and other factors that provide a high-level understanding of which of their facilities have the most solar resource. The level of detail is limited to the technical potential and does not address questions of economics or feasibility. This additional work has been facilitated by the coordination between the County and its cities and was entirely separately funded, outside of the Strategic Growth Council grant that funded the majority of the study.

The study has benefited from the input of numerous stakeholders, both within County government and external stakeholders from cities within the County, community organizations operating in the County, environmental groups, local renewable energy project developers, utility stakeholders and energy supply stakeholders (both PG&E and MCE), the Contra Costa County Sustainability Commission, and citizens at large. Four meetings have been held throughout 2018 to solicit input from stakeholders on all components of the project, from methodology to resource potential to zoning and policy options. The County thanks these stakeholders for contributing their time and insights throughout the process.

1.1. Quantification of Technical Potential

As a technical potential study, this task focuses on the quantification of available resources in the County, considering environmental and land-use constraints, system performance, and site and topographic constraints. Economic constraints are also incorporated at a high level to account for project types that do not tend to be economically feasible (e.g., not including north-facing roof tops for solar, not including large wind farms below a certain size threshold).[3] Site-specific attributes are extremely important to any given project's economic viability, and accordingly, the technical potential estimates should not be viewed as predictions of how much resource would be developed, nor should the estimate be viewed as an endorsement that all of these resources should be developed. Rather the technical potential estimate sets an upper bound to inform how much energy could be developed subject to these constraints with existing technology efficiencies.

Subject to these caveats, Table 1 provides a sum of all the possible resources, both in the unincorporated portions of the County and in the cities. At a high level, this table estimates that between 4,674,000 and 7,990,000 megawatt hours (MWh) could be generated within the County by new renewable resources. For reference, total electricity consumption in the County in 2017 was 9,644,000 MWh.[4]

Of the resource types, rooftop solar by far offers the highest potential, both in terms of capacity and annual generation. Rooftop solar is followed in magnitude by non-urban, ground-mounted solar, on agricultural land with the least constraints. However, such areas have strong competing uses and priorities, such as agriculture, open space, aesthetics, and habitat. Parking lots could serve as a

[3] More detail is provided in the methodology section for each of the renewable resource types.

[4] It should be noted that new electricity loads have the potential to significantly increase county-wide electricity consumption, including the adoption of electric vehicles and heat pumps. Usage statistic sourced from California Energy Commission: http://ecdms.energy.ca.gov/elecbycounty.aspx.

significant solar resource and have the added benefit of providing shade as well as minimal tradeoffs associated with their development. The magnitude of new large wind resources available is significantly lower than the solar resource, and while significant siting challenges make the development of this potential far from certain, it is worth noting that newer turbine technology has made sites with lower average wind speeds potentially viable. Of all the bioenergy resources, the largest single component is landfill waste to energy, but this resource would only be realized if the County diverted all landfilled waste to incinerators, a policy change that appears unlikely for multiple reasons, including the current economics of the biomass combustion industry in California, as will be explained in the section on biomass. The other resource types offer less annual generation potential, but, taken together, could yield a significant amount of generation.

Table 1. Renewable Resource Technical Potential in Contra Costa County[a]

Type		MW Capacity			Annual MWh	
		Low	High		Low	High
Solar	Rooftops	1450	2600		2,290,000	4,100,000
	Parking Lots	180	530		280,000	840,000
	Urban Land Unlikely to be Developed	120	310		190,000	490,000
	Agricultural Land with Relatively Low Constraints	760	970		1,200,000	1,530,000
	Total Solar	2,510	4,410		3,960,000	6,960,000
Wind	Total Wind	35	35		76,700	76,700
Biomass	Agricultural	3	6		24,100	48,200
	Wood Waste	6	26		48,000	192,000
	Landfill	62	78		459,000	580,500
	Total Biomass	71	110		531,000	820,700
Biogas	Food Waste	1.5	1.8		10,800	13,200
	Waste Water	1.7	2.0		12,400	15,200
	Landfill Gas:	11	14		83,400	104,200
	Total Biogas	14	18		106,600	132,600
Grand Total		**2,600**	**4,600**		**4,674,000**	**7,990,000**

[a] Includes resources located in both the unincorporated areas of the County and the cities in the County. Estimates reflect future potential and do not include current renewable generation in the County.

The findings of Table 1 must be interpreted cautiously. While rooftop solar presents the largest opportunity, it is distributed over hundreds of thousands of roofs. The County would need to dramatically scale up from its current rate of rooftop solar installations in order to fully capture the rooftop potential on these roofs in a reasonable time frame, and significant action has already been taken by installers and County and city governments to streamline the process, leaving fewer options to further accelerate the rate of rooftop deployment. Even if all building owners who could install solar decided to install it, the importance of having a relatively new roof for cost effectiveness means that it would take at least 25 years before this potential could be realized.

Another notable caveat is that utility rate structures and incentives are likely to be adjusted in the medium and long term due to the increasing importance of addressing the solar “duck curve,” the phenomenon in which peak daytime solar production results in the risk of over-generation of electricity and strains the grid's capacity to ramp generation up and down to respond to changes in solar output (for more details, refer to the context section of the introduction). As a result, a renewable portfolio that better balances resource types and energy storage will be an important consideration in future years. However, the scale of potential new wind and bioenergy resources is limited compared to the scale of potential new solar resources, and current economics make the transition to increased biomass generation less likely in the near and medium term.

When reviewing the technical potential presented above, it should also be noted that the UC Berkeley and UCLA Schools of Law have estimated that it would require only about 10,000 additional MW of solar statewide to achieve 50% renewables, which was until recently the renewable portfolio standard (RPS) target for 2030.[5] Given that Contra Costa County encompasses a very small percentage of the total land in California (~0.5%), the fact that 4,600 MW of renewables could come from the County alone underscores the importance of viewing this estimate as a technical potential estimate, rather than guidance for policy. The 4,600 MW identified could comprise 46% of additional statewide renewables needed to achieve 50% renewables statewide. Other counties that have fewer land use tradeoffs could also contribute significant amounts of land and renewable energy that could bring California not only toward its 2030 RPS goal, but also toward its new 100% greenhouse gas-free electricity goal by 2045. In particular, high-sun counties in southern California with significant undeveloped land will likely play an outsized role.[6] On the other hand, several factors increase the importance of developing renewable resources where they are available and suitable, including 1) the fact that many constraints will slow the development of renewables both within and outside the County, including transmission constraints, local approval and buy-in, environmental review, and evaluation of tradeoffs and policy goals in other jurisdictions, and 2) increased load from population growth, electric vehicles, and the electrification of the heating sector will increase the need for more renewable generation.

It is also important to look at the renewable resources identified with a perspective on their relative costs. Typical costs for different types of solar projects are shown in Table 2.

[5] https://www.law.berkeley.edu/wp-content/uploads/2018/11/New-Solar-Landscape-November-2018.pdf. It should be noted that more acreage would be required to reach the new Senate Bill 100 RPS target of 60% by 2030, but the point remains the technical potential for solar in Contra Costa County far exceeds a proportional contribution to statewide goals.

[6] Ibid.

Table 2. Solar Project Costs

Type	Approximate Average Cost per Watt of Labor and Parts
Rooftop Solar	High ($3.23/W,[a] $0.17/kWh)
Parking Lot Solar	Highest ($3.53/W, $0.15/kWh)
Solar on Urban Land Unlikely to be Developed	Lowest ($1.66/W, $0.10/kWh) (excluding any mitigation that may be required, and pending interconnection costs relative to project size)[b]
Solar on Agricultural Land With Least Constraints	Lowest ($1.66/W, $0.10/kWh) (excluding any mitigation that may be required, and pending interconnection costs relative to project size)[b]

[a] Costs in this table are cited as the cost per installed watt of direct current (DC) power, but are converted to an expected "levelized cost of electricity" (LCOE) per kilowatt hour. Sources for costs: Residential: Energy sage and Vivint.com | Ground mount: NREL's System Advisor Model

[b] It must be noted that land acquisition costs are highly variable, as are interconnection costs. Furthermore, the scale of the project matters, so the range of costs for ground-mounted systems will be quite variable from one project to the next. For ground-mounted solar on a valuable parcel/site, the costs are likely to be higher than those reported in this table. For more detail on ground-mounted solar costs versus residential solar costs, refer to Berkeley Lab's Tracking the Sun report, which presents significant detail on cost ranges obtained with many different methodologies.

From a financial perspective, the large amount of technically available rooftop and parking lot solar comes at a higher cost per watt than large-scale solar. Rooftop solar costs tend to exceed $3/W, and parking lot solar costs are closer to $3.50/W, while solar on agricultural lands or on urban lands unlikely to be developed could be as low as $1.60/W. This significant cost differential suggests that a cost-effective strategy would be to evaluate opportunities for the appropriate development of ground-mounted solar.

Given these caveats on the rate of development and the relative cost of the rooftop and parking lot solar available in the County, commercial-scale solar remains a critical component of a comprehensive renewable resource development strategy. At the same time, the development of ground-mounted commercial-scale resources must be balanced with the increasing scarcity and value of land in the County. At present, most commercial-scale solar is land-intensive and does not allow for multiple uses of the same land, although technologies that enable the co-location of ground-mounted solar with agriculture hold future promise that should not be overlooked. Therefore, County strategy should continue to encourage and facilitate solar in low or no tradeoff settings such as rooftops and parking lots, while concurrently defining parameters for the appropriate development of ground-mounted solar, now and in the future.

1.2. Extending the Benefits of Renewables to All

Of identified technical potential, significant opportunities exist in siting solar in or near to "disadvantaged" census tracts in the unincorporated County, as defined by the State of California. This includes technical potential for up to 22 MW of wind that could be sited in hills of Bay Point immediately east of Clyde, and up to 519 MW of solar in disadvantaged tracts throughout the County. Biomass and biogas resources were not considered as potential community energy resources due to potential nuisances (i.e., odors and pollution) and equity concerns about siting incineration or biogas facilities near disadvantaged communities.

The County is planning to work with three communities in unincorporated County areas on opportunities for residents of communities benefitting from these identified renewable resources, as part of the same grant from the Strategic Growth Council that funded this study.

Table 3. Resource Potential in Disadvantaged Tracts

Type	MW Capacity	
	Low	High
Rooftop Solar	233	339
Parking Lot Solar	40	80
Solar on Urban Land Unlikely to be Developed	30	100
Solar on Agricultural Land With Least Constraints	0	0
Large Wind	22	22
Total Solar and Wind	**325**	**541**

1.3. Leading by Example

The County owns or leases approximately 350 buildings that may be suitable for solar. The County already has taken great strides to install solar on its facilities, with a total of 19 arrays totaling 4,128 kW. The County could expand its leadership by continuing to identify opportunities to install solar. Table 4 shows an estimate of the power that could be generated annually if solar was placed on each of these buildings.

Table 4. Additional Solar Capacity on County-Owned and Leased Buildings

Type	MW Capacity		Annual MWh	
	Low	High	Low	High
Owned	7	11	11,100	16,700
Leased	4	5	5,600	8,400
Total	**11**	**16**	**16,700**	**25,100**

As shown in the table, the 16,700 to 25,100 MWh/year that could be generated by solar on County-owned or leased rooftops could generate between 40% and 60% of the County's annual electricity consumption for its own operations, which is 42,000 MWh/year. Given that the County spends approximately $7 million per year on electricity, investments in additional solar over time could help defray some of these costs.

1.4. Planning and Zoning Options

Given the significant amount of resource availability within the County, this study reviewed policy best practices to facilitate renewable development and to reduce zoning barriers, while remaining mindful of long-term planning considerations and potential tradeoffs. As a relatively urban county with a significant population, significant commercial activity, and significant land constraints, developing local, large-scale renewables that serve a large proportion of the County's load is inherently more difficult task than doing so in a more rural, less populous county. Therefore, policy best practices that facilitate development of the more limited resources available are of heightened importance, presuming the County seeks to contribute substantially towards realization of California's and its own renewable and climate goals. Summaries follow of some options uncovered in this study.

1.4.1. Rooftop Solar

Solar soft costs are a well-documented inhibitor to rapid rooftop solar development. The County has already taken significant strides to reduce these soft costs by streamlining its processes for rooftop solar zoning, permitting, and inspections, as required by California legislation (Assembly Bill (AB) 2188). Having taken these actions, the County has addressed most of the barriers that are under its direct control. Nonetheless, the County can expand on current efforts by seeking to further coordination with cities in the County to harmonize policies and undertake planning and market development efforts that could accelerate residential and commercial rooftop installations across jurisdictions. There are also several types of development incentives that could be employed, as will be described in more detail in the section on planning and zoning actions for rooftop solar. Additionally, the County could demonstrate expanded leadership by installing solar on more of its most publicly visible buildings (such as is occurring at the County's new administration building complex), and use these installations as an educational opportunity to encourage more constituents to install their own.

1.4.2. Ground Mounted Solar

Contra Costa County has already taken action to enable commercial-scale solar in commercial and industrial zoning districts. However, there exist additional options to encourage the development of such solar resources as parking lot canopies or on "urban land unlikely to be developed" (as defined above). Furthermore, additional large scale solar potential exists in other parts of the County, namely rural lands. Large scale solar farms on lands that have competing values (e.g., open space, habitat preservation, economic development, agricultural productivity) must be evaluated carefully.

Some notable options available to the County for accelerating the development of solar on parking lots and "urban land unlikely to be developed" include:

- **Mandates** (for instance a solar requirement for new parking lots),
- **Tax policy** (for instance incentives for specific parcels where the County deems solar would be desirable, or exempting the value of battery storage systems associated with solar from assessment),
- **Offering County-owned land and parking lots** and/or signing up for power purchase agreements,
- **Facilitating coordinated studies of grid constraints**, working with PG&E and the local electricity aggregator, MCE,

- **Collaborating with MCE and other potential partners to explore incentives** to facilitated infill solar development, and,
- **Considering expedited permitting approaches** in certain cases such as certain industrial areas where job-rich alternative uses are not feasible.

Notable options available to steer the appropriate development of ground mounted solar in rural locations include:

- **Zoning and general plan revisions**, to enable project developers to apply for land use permits in locations that are appropriate and have the least constraints,
- **Encouraging pilot projects** of emerging technologies that could vet the possibility of "agrophotovoltaics" (which can be installed in greenhouse settings and above crops without reducing yield),
- **Requiring monetary reserves** to be held for end-of-useful-life decommissioning, and
- **Developing a programmatic environmental impact study** upon which future solar development projects could rely to speed California Environmental Quality Act (CEQA) approval.[7]
- **Considering sales tax and/or community benefit approaches** to securing revenue and/or power that supports affected local communities in order to maintain public support

For **both** urban commercial-scale solar (including parking lots and land unlikely to be developed) and rural commercial-scale solar, the County could engage in additional activities to streamline the approval and project development process in appropriate locations, such as convening potential solar developers, MCE, and PG&E to conduct area-wide interconnection studies that would reduce the timeline and cost for prospective developers while helping utilities keep integration costs low. More information on all of these options is included in Section 4 of this report.

1.4.3. Wind

Similar to large scale solar, large scale wind power requires careful consideration due to the large amount of land required and potential conflict with other priorities such as open space, habitat preservation, and economic development. Contra Costa County's current ordinance allows large-scale wind power in agricultural lands, but not elsewhere. Given the wind power potential maps of the County, it may be useful to revisit the possibility of allowing wind power on other types of land, aligned with where the wind resource is most viable. This includes the industrial buffer lands east of Rodeo (some of which is classified as heavy industrial buffer and open space). The County could also consider reducing its setback requirements, in line with recent California Energy Commission guidelines. Small scale wind is emerging as increasingly viable in specific settings and has numerous benefits, including

[7] Building on the analysis performed in this study to identify least conflict rural solar locations, the County could define certain least conflict locations as compatible with commercial scale solar, incorporate this analysis into its upcoming General Plan update, and develop a zoning permit process for these locations. This process could then establish discretion for County planners to evaluate the merits of applications to build solar resources in certain types of agricultural lands on a case by case basis, subject to a land use permit.

very low potential for bird and bat deaths from Vertical Axis Wind Turbines in particular. For small wind, the County could convene industry participants to obtain further information on technology development, cost curves, and new opportunities for applications of these technologies as pilots and early deployments. It could also participate in pilot projects to prove the value and develop lessons learned. Finally, the County could proactively prepare to address planning and zoning barriers as these technologies become more prevalent.

1.4.4. Bioenergy

Bioenergy in this study is divided into biomass and biogas. The former refers to the combustion of biological feedstocks directly in order to generate electricity through a combustion turbine. The latter refers to the production of combustible gas from biological feedstocks through anaerobic digestion, which could later be used to generate electricity. Due to project economics, developers have not been contacting the County for biomass project approval; this comports with the overall industry trend in California. On the biogas side, some waste management operators in the County (solid waste and waste water) have been exploring increased opportunities to collect biogas on site, but because these are existing land uses (landfills and waste water treatment plants), zoning may be less of a consideration than air, water, and disposal permits. Accordingly, County planning actions could include actions to convene local refuse haulers, waste generators, and operators of biomass plants nearby. If economics become favorable for any class of waste, the County could help them negotiate and plan with the biomass plants for transport of feedstocks to the plant.

1.5. Conclusion

This study finds that a significant quantity of renewable resources could be developed within County boundaries. While a significant fraction of the energy output from these resources could be produced by technologies that have minimal land use implications (e.g., rooftop and parking lot solar), an important challenge for the County will be to facilitate the appropriate development of larger scale commercial renewables as well, and these commercial resources often pose land use tradeoffs that require careful policy-making. As a relatively urban county with a significant population, significant commercial activity, and significant land constraints, developing local large-scale renewables that can serve a large proportion of the County’s load is inherently a more difficult task than it would be in a more rural and less populous county. Therefore, policy best practices that facilitate the development of the more limited resources that *are* available are of heightened importance, presuming the County desires to contribute what it can towards the realization of California’s renewable energy and climate goals.

Depending on the assumptions used, local renewable generation could produce between 4,674,000 and 7,990,000 megawatt hours per year. However, this amount of resource development will take considerable time to develop and significant challenges must be overcome before development can reach this level. For instance, the intermittent generation profiles of renewables pose challenges for the grid, and a high level of penetration of these resources will require the State to take action to prioritize markets for energy storage, flexible load, and faster ramping resources to maintain a balance of generation and consumption. Utilities will also need to invest in transmission and distribution upgrades and adapt to a more distributed model of energy provision if these local resources are developed at this scale. Nonetheless, an understanding of the magnitude of the total available resource and how much comes from each technology is an important foundational step to help the County set appropriate goals for the medium and long term.

All the resource types that were evaluated for this study can contribute meaningfully to the overall level of renewable generation, and a strategy that enables each of these markets to grow may help avoid the challenges of over-investing in a single resource type (e.g., the generation profile of wind daily and seasonally will be different from solar). Biomass and biogas have the potential to provide steady and dispatchable output. This study finds that the magnitude of the solar resource is the highest of all the technologies considered. In order of declining magnitude, large amounts of solar could be installed on rooftops, on the Delta islands, on parking lots, on urban land unlikely to be developed for other uses, and on select agricultural lands. Several locations along the Northern Waterfront and in the Altamont Pass region have significant wind resources. It should be noted that the Altamont Pass is already developed for wind (and is being repowered with more modern turbines), and it is far from certain that the resources in the northern part of the County would be seen as desirable by the surrounding communities and stakeholders. It is also unclear whether potential projects in these locations could be sited and permitted successfully. The largest contribution to potential renewable capacity outside of wind and solar is the incineration of waste that would otherwise have been landfilled, though it appears unlikely that this option would occur in the current energy and policy environment in California.

Together, solar and wind make up the vast majority of the resources identified in this study (>95% of the total estimate). As a result, policy to advance the development of the solar and wind markets in particular can have a significant effect on the overall success of developing renewable resources. Given the timeline for the planned phase out of the federal Investment Tax Credit (ITC), which currently provides a 30% tax credit for qualified renewable energy projects, prompt action by the County to facilitate the appropriate development of these resources will likely have significantly more impact than delayed action. After 2021, the ITC is scheduled to be eliminated for residential installations, and reduced to 10% for commercial projects, which will make solar investments less financially appealing for property owners in the near future.[8]

The County has already taken significant steps and achieved significant successes, resulting in a substantial amount of commercial-scale renewables (both wind and solar), and a dramatic increase in rooftop solar development in recent years. Notable examples of the County's actions include the streamlining of rooftop solar permit application process, the creation of a commercial-solar permit process for commercial and industrial areas, installation of on-site renewables at County facilities, and the development of a wind ordinance. Judicious local development of renewables can save constituents money and support local installers and industry. The County can continue to benefit from the growth of

[8] For more details on the phase out timeline of the ITC and its potential impacts visit https://www.seia.org/initiatives/solar-investment-tax-credit-itc and https://www.energy.gov/savings/residential-renewable-energy-tax-credit

renewable energy generation by taking action to guide and facilitate the appropriate development of these resources. From the perspective of building overall statewide public buy-in, it may be important to demonstrate that every county is "doing their part"[9] while still acknowledging that certain counties and regions possess greater total resources and have fewer constraints than counties like Contra Costa with its significant urban and suburban development.

Some promising ideas that the County can investigate to continue to "do its part" toward achieving statewide goals include the following. These options are all described in more detail in this report.

- Working with MCE and other partners to explore incentives that preferentially target development of renewables in locations with the least tradeoffs. This is a particularly important action to explore because a key element of Contra Costa County's decision to join MCE was MCE's promise to assist with the development of *local* renewable resources.
- Developing job training programs to enable local workers to benefit from local development of renewable technologies.
- Continuing to support rooftop solar development, including maintaining the streamlined process that already exists, and offering new incentives to encourage incorporation of solar PV in any new buildings not subject to California's 2019 solar requirement.
- Monitoring emerging and improving small wind technologies and proactively updating zoning to address any technological changes.
- Continuing to install solar on County-owned buildings, where appropriate.
- Mandating solar for large new parking lots, as done by Alameda County[10]
- Creating an expedited permit process for development of commercial-scale solar in industrial and commercial areas that have little other potential use (e.g., industrial buffer lands, parking lots).
- Defining specific additional areas where commercial ground-mounted solar may apply for a land use permit (based on analysis developed for this study and additional refinement). Notwithstanding the land use permit process for commercial solar in commercial and industrial zones, the majority of the County's unincorporated land acreage falls in zones where commercial-scale solar is not a permitted use.
- Exploring opportunities to develop a programmatic Environmental Impact Report that could enable specific solar projects that were compatible with the General Plan to shorten their California Environmental Quality Act (CEQA) approval timelines and risks.
- For all renewable technologies, conducting anticipatory planning to guide developers to certain more viable locations and project proposals (e.g., by convening PG&E, MCE, and other stakeholders).

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[9] https://www.law.berkeley.edu/wp-content/uploads/2018/11/New-Solar-Landscape-November-2018.pdf

[10] Alameda County's regulation will be described in more detail below, and solar is one of several options for parking lots to fulfill the requirement, which is focused on mitigating heat island effects.

The County is positioned well to expand its leadership in renewable energy by building on the outcomes of this study, including the estimate of the technical resource potential, the constraint mapping process for large ground-mounted solar, and the stakeholder dialogue that has accompanied this study. Strong stakeholder support exists for the development of additional renewable resources in ways that appropriately balance competing land values with the environmental benefits of clean energy. The upcoming General Plan update provides an opportunity to judiciously take action to advance clean energy in the County. Future collaborations with MCE, PG&E, project developers, landowners, and other local stakeholders hold significant promise to realize these opportunities.

2. Introduction

In response to the ambition presented in Contra Costa County's December 2015 Climate Action Plan (CAP), Contra Costa County has embarked on a series of initiatives to study pathways to achieve greenhouse gas (GHG) reductions, consistent with California AB 32 GHG emissions targets.

In the recent past, the County has fully implemented the solar permit streamlining processes of California's AB 2188, and rooftop solar permits have now become the most frequently issued construction permit issued by the County. The County has also evaluated the potential for forming its own community-choice aggregation to provide clean electricity by default to residential and commercial electricity customers within the County. In 2017, the County joined MCE to accomplish these objectives, along with thirteen of its incorporated jurisdictions (five of which had already joined MCE between 2012 and 2015). Also in 2017, the County amended its zoning to allow commercial-scale renewable projects in commercial and industrial zones, a first step toward helping MCE fulfill its promise to help the County develop local renewable resources. The County also has started the process of updating its Climate Action Plan (CAP), in conjunction with an update to the General Plan.

Finally, the County has successfully won a variety of sustainability grants and funding resources from the State and other sources, and the current effort — this renewable resource potential study — is funded by a grant from the Governor's Office of Planning and Research and the Strategic Growth Council. While Contra Costa County has been taking these actions, the State of California has also increased its renewable energy ambition, notably with the increase of the renewable portfolio standard (RPS) target via SB 100, which led to a goal of 60% renewables by 2030 and 100% carbon-free electricity by 2045. Thus, the County's incremental and tangible steps to date are well-aligned with California policy direction, and there is likely to be impetus to continue to expand efforts supporting appropriate development of renewables in the County.

In alignment with the direction provided by the Board of Supervisors in the adoption of the CAP, this report identifies opportunities for the County to expand its leadership in local clean energy production and bring the benefits of clean energy broadly to County constituents, with attention to how these benefits can be shared with communities considered by the State as "disadvantaged." This report gives the County the opportunity to translate the aspirations of the CAP into specific next steps.

2.1. Purpose

This report assesses the potential for renewable energy resource deployment, primarily within the unincorporated areas of Contra Costa County, but also in incorporated areas, where data existed. The report is divided into two sections: a renewable resource technical potential assessment; and a zoning best practices assessment and recommendations.

The resource potential assessment addresses several key priorities: quantifying the magnitude of available resources; identifying where the resources could be located; exploring typical cost levels associated with each type and subtype of resource; and identifying constraints and tradeoffs associated with developing resources in each location. Additional purposes include: 1) identifying renewable resources on County-owned and leased facilities; 2) quantifying the amount of resources within MCE's service territory (and eligible for MCE's feed-in tariff); and 3) identifying candidate locations for community renewable projects that could serve disadvantaged populations, as defined by CalEnviroScreen 3.0's top 25% most disadvantaged census tracts, with a particular focus on North Richmond, Bay Point, and Rodeo. Constraints and tradeoffs incorporated into the analysis include technical limitations associated with a site's physical attributes (e.g., slope), incompatible land uses with large-scale, standalone renewables (e.g., residential areas and certain classes of farmland particularly for solar), and biological resources incompatible with large-scale renewables (e.g., wetlands and other areas of natural land cover, critical habitat according to U.S. Fish and Wildlife Service, priority areas in the East County Habitat Conservation Plan). The study's goal is to develop an understanding of priority locations and regions for renewable development.

What is a Feed-In-Tariff (FiT)?

MCE, California's first Community Choice Aggregation program, offers 20-year contracts to Contra Costa County renewable energy project developers at a guaranteed price level to encourage local development of wind, solar, biopower, and all resources that comply with California's Renewable Portfolio Standard (RPS). This is an example of a "Feed-In-Tariff".

MCE's current compensation for solar is:

FiT, 0-1 MW - $0.085/kWh
FiT Plus, 1-5 MW – $0.08/kWh

These compensation rates will be reduced as the program becomes more fully subscribed, and as industry costs decline.

For further information, see www.mcecleanenergy.org/feed-in-tariff/

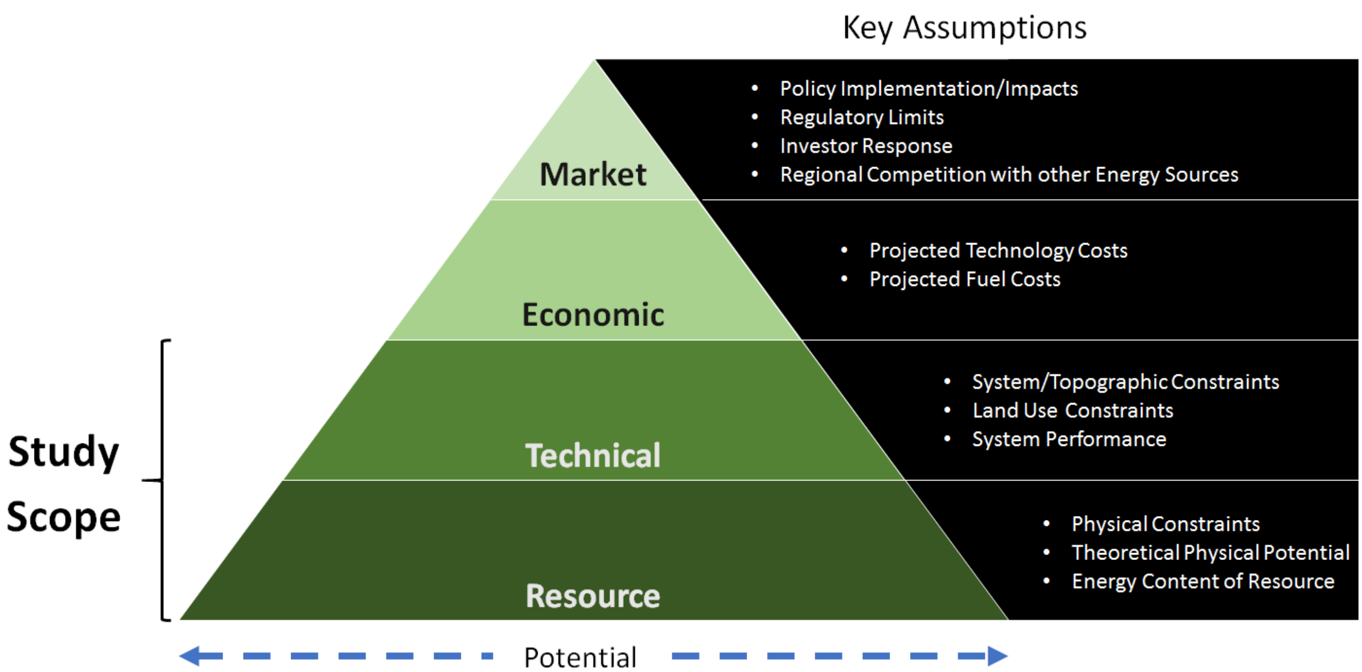
Given the resources identified in the technical potential assessment, the zoning best practices assessment's key priority is to evaluate options to update zoning to facilitate appropriate development of renewable resources in the County, while remaining mindful of long-term planning considerations and potential tradeoffs. For solar, wind, biomass, and biogas, the zoning best practices assessment examines and considers possible policy actions not strictly related to zoning that could help with development of these resources. For each resource type, this assessment briefly discusses the degree to which zoning may present a critical barrier to development, what planning considerations are associated with each resource type, options to update zoning, and other actions to consider.

2.2. Scope

This technical potential study covers the County broadly, emphasizing the potential on unincorporated land within the ULL. Technical potential, as defined by the National Renewable Energy Laboratory (NREL), is "achievable energy generation given system performance, topographic, environmental, and land-use constraints."[11]

As shown in Figure 1, technical potential can be seen as an upper-limit estimate of the potential for renewable development in the County. Economic potential and market potential estimates fall outside of this project's scope; and, as such, this report does not provide or account for estimates of site-specific technology costs, regulatory limits, financing, or overall economic competitiveness. However, this report does examine overall market trends affecting how the County's technical potential may be fulfilled.[12]

Figure 1. Renewable Resource Potential Study Framework



Source: National Renewable Energy Laboratory

The scope focuses on four renewable resource types, as defined in the County's grant from the Strategic Growth Council, specifically: solar photovoltaic, wind, biomass combustion, and biogas digestion. It does

11 https://www.nrel.gov/gis/re-potential.html

12 This study provides a high-level assessment of relative costs for various renewable energy sources in the County, serving as an input into determination of policy options and recommendations.

not include other renewable sources, such as offshore wind, tidal, concentrating solar power, solar thermal, hydropower, or geothermal.

2.3. Context

2.3.1. California Renewables—Goals, Timelines, and Progress

California has long been a leader in setting ambitious climate change and renewable energy goals, and its goals continue to strengthen. On September 10, 2018, Governor Brown signed SB100 into law. This law increases California's already ambitious 2030 renewable portfolio target from 50% to 60%, while also setting a goal to meet 100% of California's retail electricity needs by 2045 without using any carbon resources.[13] The bill aims to accomplish the goal through increased efficiency programs, demand response technology, and a regionalized energy grid.

On top of this, Brown signed an Executive Order, instructing the California Air Resources Board (CARB) to develop a framework to achieve carbon neutrality by 2045.[14] While this order could be reversed by the following administration, it stipulates that the State should remove as much carbon dioxide from the atmosphere as it emits, doing so through policies such as carbon capture and storage and restoration of natural carbon sinks (e.g., wetlands).

The recent passage of SB100 builds on California's decades of established bipartisan policy direction. In 2002, when the State derived 11% of its electricity from renewable sources,[15] California established its Renewable Portfolio Standard (RPS) program with the support of Governor Schwarzenegger, setting a goal of deriving 33% of its energy from renewable sources by 2020. In April 2011, the program was codified into law. As of December 2017, the State remains on track to meet this goal, with 32% of its retail energy coming from renewable sources—a 3% increase from the previous year, as shown in Figure 2.[16]

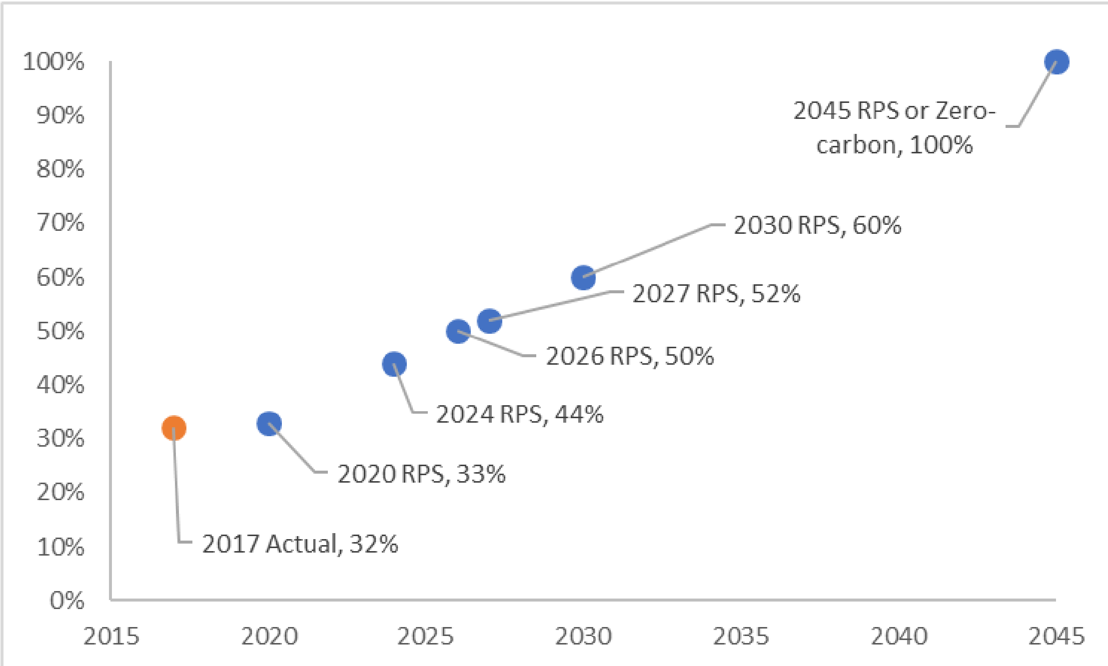
13 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

14 https://www.sacbee.com/news/politics-government/capitol-alert/article218128485.html

15 https://www.energy.ca.gov/almanac/electricity_data/system_power/2002_gross_system_power.html

16 http://listserver.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

Figure 2. California's Progress Towards its SB100 Renewable Energy Targets (most recent actual in orange)



Source: Ibid and https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

Achieving these policy goals requires developing a diverse portfolio of energy sources to leverage regional resource availability and to ensure a steadily available amount of electricity. Energy sources such as wind and solar are intermittently available throughout the day. Therefore, to ensure a reliable supply, more constant generation sources, such as hydroelectric, biomass, and geothermal—must be used as well as resource types that can quickly be scaled up or back to adjust for a real-time balance of energy supply and demand. Currently, natural gas provides much of this "peaking" power, although energy storage may contribute more substantially over the long term.

California has some of the highest solar potential in the country, with the state's southern region receiving an average insolation of 8.5 kWh per square meter in a day; the state's central valley and northwest regions receive closer to 5 kWh/m^2/day.[17]

State wind resources are more varied. Offshore winds, at 110 meters above sea level, average 9-10.5 meters per second in the northwest, but only a few areas have strong wind resources on land—one of which is in Contra Costa County.[18] Geothermal and hydroelectric energy provide more consistent

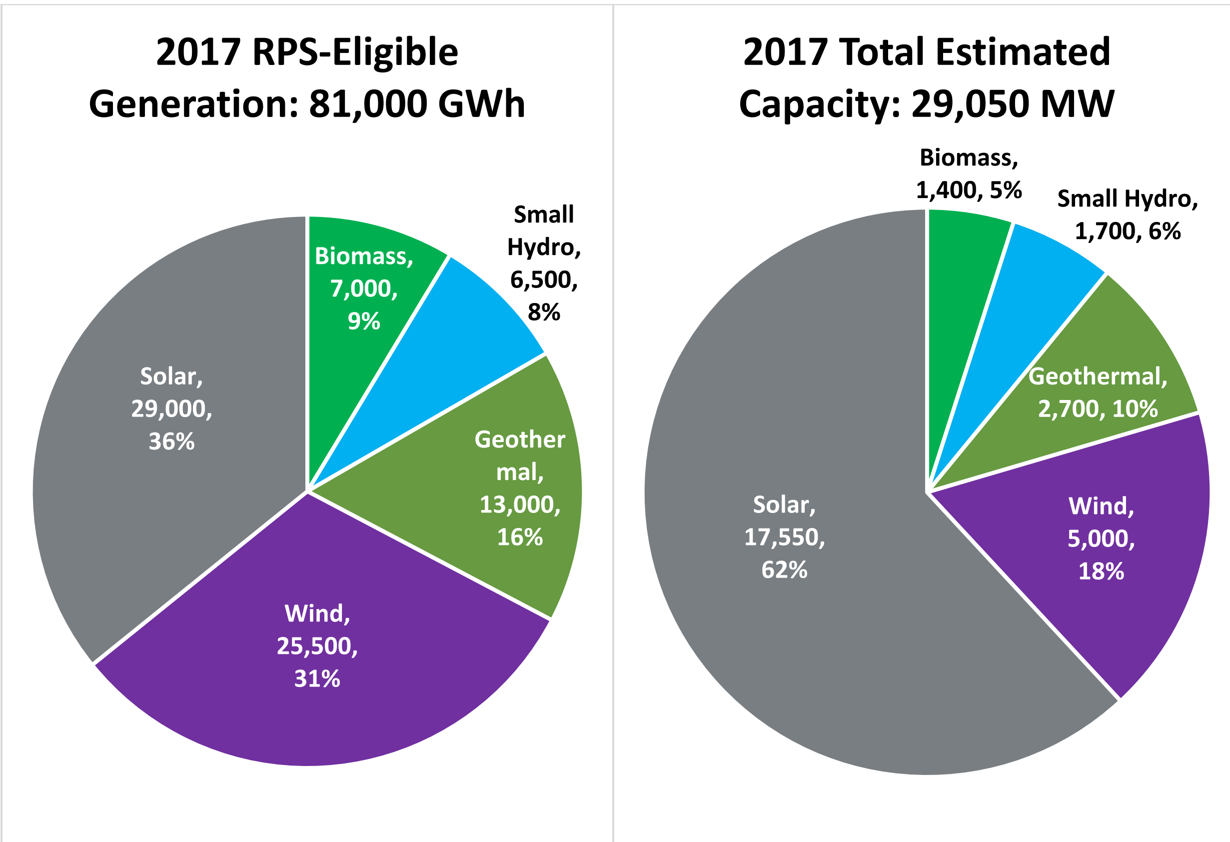
17 https://www.nrel.gov/gis/solar.html

18 https://maps.nrel.gov/wind-prospector/

generation capacities, but they are limited by the geographic scope of underground hot-springs and sufficient hydro stream flows.[19]

Currently, solar offers the most prevalent RPS-eligible renewable source in the state. Of 81,000 GWh generated annually by RPS-eligible renewables, 36% comes from solar,[20] followed closely by wind, with 31% of the capacity, despite recent slowdowns in growth of the state's wind generation capacity.[21] Figure 3 shows profiles for total state portfolio generation.

Figure 3. California RPS-eligible generation and total estimated capacity



Source: http://listserver.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

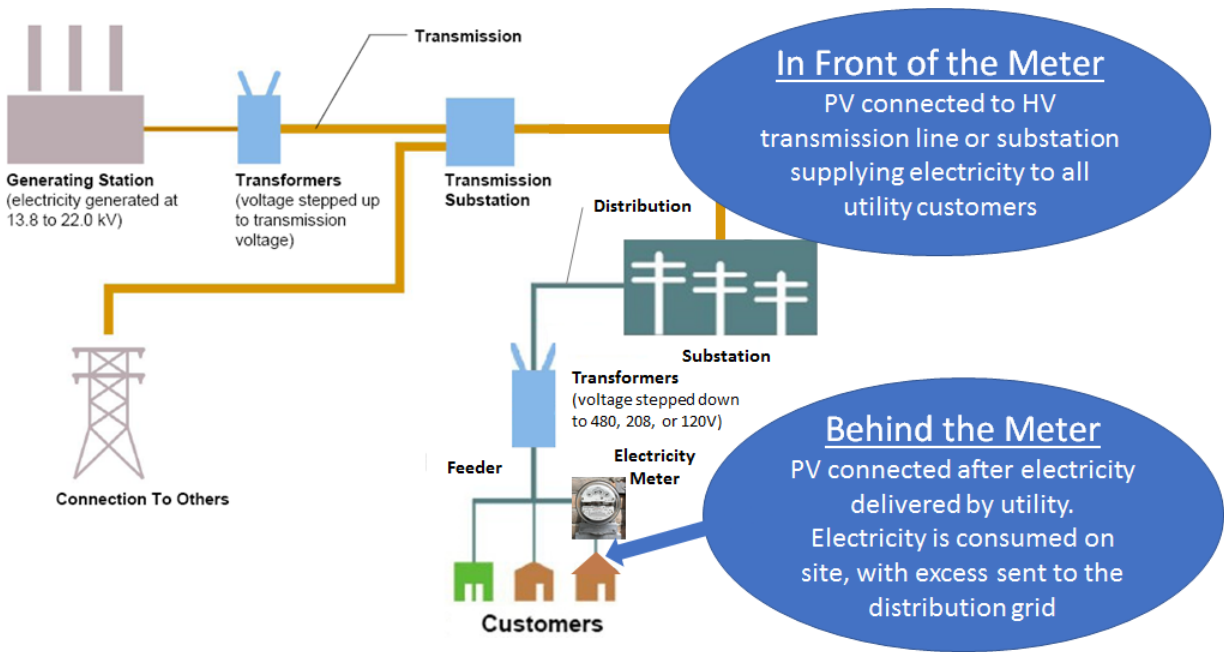
[19] Only hydroelectric resources with capacities lower than 30 MW capacity are considered renewable sources. https://www.energy.ca.gov/almanac/renewables_data/hydro/

[20] http://listserver.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

[21] https://www.energy.gov/sites/prod/files/2018/08/f54/2017_wind_technologies_market_report_8.15.18.v2.pdf

The percentage in RPS-eligible solar generation is undercounted as behind-the-meter renewables do not count towards the RPS compliance goals, and the vast majority of these systems are solar. Behind-the-meter systems, as the name suggests, are systems where energy is generated for consumption on site (such as a rooftop array of solar panels on a home or business) and are connected before the electricity meter. In California, these systems have grown rapidly, as shown in Figure 5. Of almost 6,700 MW of behind-the-meter solar, nearly 5,600 MW have been installed since 2011, accounted for by 780,000 systems installed on homes and businesses around the state.[22] Contra Costa County alone issues approximately 1,500 permits per year for residential rooftop solar in its unincorporated areas and in the five cities that partner with the County for building inspection services.[23]

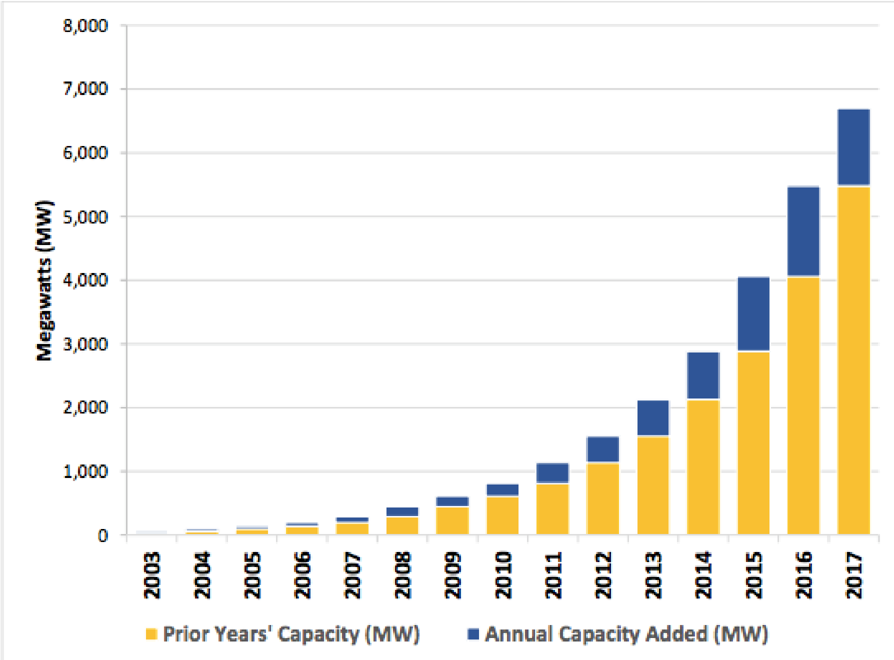
Figure 4. Depiction of "Behind the Meter"



22 http://listserver.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

23 https://www.wearestillin.com/organization/contra-costa-county-ca

Figure 5. Growth in Behind-the-Meter Solar Capacity in California



Source: http://listserver.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

2.3.2. MCE in Contra Costa County

MCE, California's first Community Choice Aggregation program, has been active in Contra Costa County since July 2012.[24] MCE allows communities to combine their purchasing power and provides an alternative to PG&E's default service with an increased percentage of renewables and clean energy. MCE currently offers three energy products: a "Light Green" option, composed of 55% renewable electricity; a "Deep Green" option, composed of 100% renewables; and a "local sol" program, composed of solar energy produced from the Novato Cooley Quarry solar farm (built through MCE's feed-in tariff program).[25]

MCE helps to stimulate **local** renewable generation growth in many ways. Notably, through its Feed-In Tariff (FIT) program and FIT Plus program, which provide local renewable energy producers with 20-year contracts that help secure construction financing by providing certainty in revenue streams. The program determines contract pricing on a schedule based on the number of confirmed participants and the position of any given project within the program's queue. Four facilities within MCE's service area

[24] The City of Richmond was the first Contra Costa city to join, followed by El Cerrito, San Pablo, Lafayette, and Walnut Creek from 2014 to 2015. In 2017, the program expanded to include eight more cities (Concord, Danville, Martinez, Moraga, Oakley, Pinole, Pittsburg, and San Ramon) and the County's unincorporated communities.

[25] https://www.mcecleanenergy.org/

have been built through the FIT program.[26] A significant driving factor behind the County joining MCE was that joining MCE would lead to more local renewable energy development.

MCE also expands renewables production by engaging in bilateral long term power purchase agreements (PPAs) with developers. For example, MCE completed construction of its Solar One facility in April 2018, a 10.5 MW, 60-acre production facility. Constructed in partnership with Chevron and RichmondBUILD—a public/private partnership that supports clean energy job training and placement, the project supported 341 jobs, at least 50% of which were unionized and within the City of Richmond.[27]

The County's decision to join MCE presents an opportunity for the County to expand renewable generation. Currently, another county owns one FIT program site (San Rafael Airport in Marin County). MCE's projected demand increase (paired with long-term purchasing contracts it offers through the FIT and other programs), means the County could negotiate to expand generation on County property. Richmond's experience demonstrates that the County can negotiate with MCE to provide workforce training partnerships and local employment, and to identify projects that benefit underserved communities. Currently, the MCE FIT and FIT plus programs have 30 MW remaining in their queues (10 MW & 20 MW respectively). However, as will be discussed later in this report, only a small percentage of unincorporated Contra Costa County is zoned in a way that allows commercial-scale solar. Should the County take action to increase opportunities for commercial-scale solar, MCE and the County could collaborate to accelerate the development of appropriate local solar.

Putting Renewables in Context

250 households can be served by 1MW of solar PV in California

It typically takes **7.5 acres** to create 1 MW of solar

It would take over **150** typical rooftop installations to produce the same output as a typical 1 MW (7.5 acre) wholesale solar project.

Solar costs dropped **60-80%** between 2009 and 2016, according to National Renewable Energy Labs.

The International Renewable Energy Agency forecasts that costs for solar and wind electricity will continue to fall by **59%** and **26%**, respectively between 2015 and 2025.

2.3.3. Market Status of Solar, Wind, Biomass, and Biogas in California

California leads the nation in renewable energy deployment, employing a geographically distributed variety of resources to reduce integration costs and improve reliability. Renewable energy resources reduce carbon emissions (and, for some technologies, electricity

[26] https://www.mcecleanenergy.org/feed-in-tariff/

[27] https://www.mcecleanenergy.org/news/press-releases/mce-solar-one-thinking-globally-building-locally/

costs), while increasing local economic development.[28] Solar and wind costs have decreased rapidly and present compelling economics for many customers.[29] As discussed, wind and solar renewable sources have variable generation profiles, necessitating the use of other sources when the sun does not shine or the wind does not blow.

California has passed several supporting policies that have enabled the rapid expansion of its renewables markets. As discussed, SB100 passed in August 2018, and commits the State to obtaining 100% of its power from clean sources by 2045. Steadily increasing renewable portfolio standards such as this represent but one tool that government has used. Other government efforts include passing community choice aggregation legislation, enacting policies surrounding energy procurement, setting mandates for rooftop solar in new construction, and offering support for community solar.

With 22 GW of capacity, California has the largest solar installation of any state in the United States.[30] In spring 2018, the California Independent System Operator (CAISO) met over 50% of demand with solar, setting a new peak record;[31] solar meets an average annual energy demand of 17%. California's three largest investor-owned utilities operate ahead of the 25% RPS requirements (33%, 28%, and 43%, respectively, for PG&E, SCE, and SDG&E). In fact, solar installation growth has been so strong that it has strained the technical capacity of California's grid to handle new variable resources.

In 2013, the CAISO observed the now infamous duck curve, which demonstrated that, on low-load spring and fall days, the grid is subject to significant increases in solar energy production and decreases in consumption at midday, risking overgeneration. Conversely, it showed that during the evening, energy demand peaks risked under-generation (assuming the grid relied on solar alone).[32] The State has addressed this challenge by employing multiple strategies, including energy storage, demand response, curtailment, and geographic dispersion of varying profile generation resources.[33]

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28 https://ase.tufts.edu/gdae/education_materials/modules/RenewableEnergyEcon.pdf

29 Statistics provided in inset box on the next page. Sources for these statistics include SEIA, IRENA, and NREL

30 https://www.seia.org/state-solar-policy/california-solar

31 http://www.caiso.com/TodaysOutlook/Pages/default.aspx, March 23rd, 2018

32 CASIO (2013). *What the Duck Curve Tells us about Managing a Green Grid*. https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

33 Chad Singleton. "Can California Conquer the Next Phase of Renewables Integration?" June 2017. Available online: www.greentechmedia.com

California also has been a long-time leader in wind installations, with Alameda/Contra Costa County's Altamont Pass wind farm serving as one of the nation's earliest large-scale solar installations. Altamont pass generated 13.5 GWh of wind electricity in 2016, meeting 7% of the state's demand.[34] The state ranks third nationally (after Texas and Iowa) for developed large-scale wind resources.

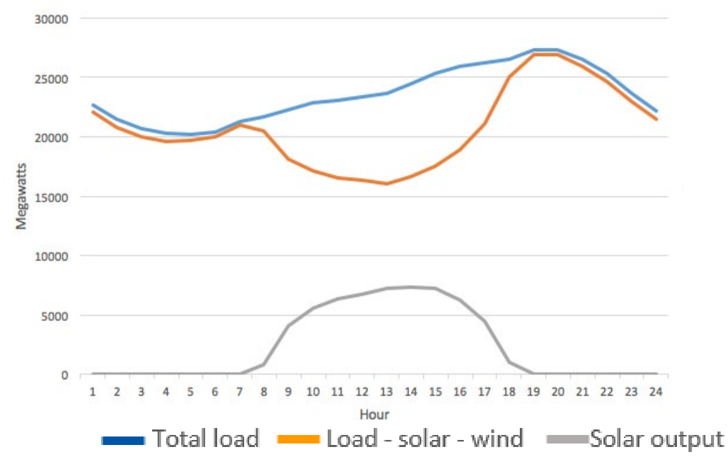
However, unrestricted land areas offering good wind resources and sited near available transmission are dwindling in California, stalling the development of new large-scale wind in the state. As older turbines reach their end of life, repowering these turbine sites is improving power generation per acre. Small-scale wind remains relatively uncompetitive, and exploitation of plentiful offshore wind resources face "technical, regulatory, environmental, infrastructure, and economic hurdles" that make their successful development uncertain.[35]

Duck Curve

When renewable production is subtracted from gross energy demand and plotted over the course of a typical day, it forms the shape of a duck, especially at low demand times of the year (spring and fall). As more solar is added to the grid, the bottom of this duck curve could eventually go to zero, and non-renewable sources will only be needed at night and during cloudy weather; any further solar added to the grid would not be cost-effective.

California is tackling this issue via energy storage, demand response load shifting, curtailment, and geographic dispersion of varying profile generation resources (using wind when the sun is not shining and vice versa).

Figure 6. California Hourly Electric Load Less Renewables, 10/22/16



Source: Jenkins and Schultz. Section 5.4.2, Jenkins and Schultz, "Renewable Energy Resource, Technology, and Economic Assessments.", Section 5.4.2. California Energy Commission., January 2017.

California's significant biomass resources offer an advantage in being dispatchable (i.e., they can operate at any time).[36] Wood, agricultural, food, forest, and landfill waste are plentiful, and can be burned to produce electricity. At present, however, economic conditions remain unfavorable for biomass-based

34 http://www.energy.ca.gov/wind/

35 Ibid.

36 Duck Curve graphic source: https://commons.wikimedia.org/wiki/File:Duck_Curve_CA-ISO_2016-10-22.agr.png

electricity, as the costs of fuel collection, pollution prevention, and electricity generation are higher than current electricity prices. As a result, utilities are phasing out their biomass purchase power agreement (PPA) contracts, and facilities are closing: only 22 of the state's 34 permitted facilities are active.

Biogas offers similarly extensive resources from animal manure, compost, food waste, wastewater sludge, industrial fats/oil/greases, and landfill methane off-gas waste. Each of these sources produces methane, which can be burned to produce electricity or be used to produce transportation fuels, offsetting California's transportation emissions rather than emissions in the electricity sector. Despite being a national leader for biogas resource development, California has biogas capacity of 350 MW[37] out of 79,000 MW[38] due to costs higher than competing fuels and electricity sources. Multiple recent California Senate Bills have reaffirmed support for expanding biogas and bioenergy projects, including SB 1122 and SB 1043.[39]

Table 5 compares current and projected wholesale electricity costs, comparing renewable and conventional sources, for electricity sources used by the County. While California costs cannot be directly compared to national costs due to differing labor costs and timeframes for estimates, the table's third, fourth, and fifth columns show declining costs. In California, solar and wind levelized costs are competitive with natural gas generation.

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37 https://www.energy.ca.gov/biomass/

38 https://www.energy.ca.gov/almanac/electricity_data/electric_generation_capacity.html

39 Senate Bill 1122, enacted in 2012, requires utilities to acquire 250 MW of biogas and bioenergy projects. Senate Bill 1043, enacted in 2015–2016, describes further State support for biogas and biomethane.

Table 5. Wholesale Electricity Cost Comparison

Generation Source	PG&E 2016 Actual Power Mix[a]	CA-Specific	National	
		2013 LCOE (CEC Mid-Case)[b] $/MWh	2017 LCOE (Lazard v11)[c] $/MWh	2022 LCOE (EIA)[d] $/MWh (2017 dollars)
Nuclear	24%		112-143	90
Natural Gas	17%	119-120	42-78	48
Solar	13%	116-119	43-53	59
Large Hydro	12%			73.9
Wind	8%	87-89	30-60	48
Geothermal	5%	100-122	77-117	43.1
Biomass and Waste	4%	126	55-114	102.2
Small Hydro	3%			
Unspecified[e]	14%			

Note: the absolute value of levelized cost of generation figures shown in this table depend heavily on financing, installed costs, capacity factors, and other assumptions; hence, they are not necessarily directly comparable from column to column.

[a] Source: PG&E power mix 2016, https://www.pge.com/pge_global/local/assets/data/en-us/your-account/your-bill/understand-your-bill/bill-inserts/2017/november/power-content.pdf. Note, this mix as presented does not reflect the potential impacts of the Community Choice Energy program that is available to consumers.

[b] California Energy Commission cost of generation model, Mar 2015. http://www.energy.ca.gov/2014publications/CEC-200-2014-003/CEC-200-2014-003-SF.pdf

[c] Lazard Levelized Cost of Energy Analysis, v11, Nov 2017. https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf

[d] EIA Annual Energy Outlook 2018, Levelized cost of New Generation, Mar 2018. https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

[e] Unspecified generation sources reflect transactions not specifically traceable to a generation source; they likely have higher natural gas sources in the mix than PG&E, as California's power mix is 36% natural gas.

3. Renewable Resource Quantification

As discussed, this section focuses on examining technical potential, the "achievable energy generation given system performance, topographic, environmental, and land-use constraints."[40] NREL and various State studies have provided maps of available solar, wind, biomass, and biogas resources in the County (in terms of resource quality). This study uses these resource quality estimates to calculate the total possible energy generation from specific locations and potential projects identified for this study. Cadmus selected the assessed sites by examining system performance, topographic limitations, and environmental and land-use constraints to find a maximum amount of energy possibly produced, given technical constraints. After identifying the total resources available (by type and subtype of renewable resource), this study explores typical costs for these resources to contribute to the County's deliberations in planning increased renewable deployment.

3.1. General Methodology Considerations

3.1.1. Stakeholder Input

Numerous stakeholders from the County and the participating cities strongly informed development of this technical potential study, in addition to significant contributions from local renewable energy project developers, community organizations operating in the County, environmental groups, and others. Input derived from regular County staff meetings and four broader forums with external stakeholders, the latter meetings held in May, July, September, and October 2018 at County offices. Participants also submitted numerous comments and suggestions in writing.

The substantial amount of varied feedback by external stakeholders included the following suggestions of particular relevance:

- From nonprofits and citizens groups:
  - Participants voiced support for the County to take a leadership role by developing renewable resources on its own properties. This input reaffirmed the importance of quantifying the potential for renewables on County-owned and leased properties.
  - Participants voiced support for the County to strongly encourage renewables on land where low or no tradeoffs exist, including brownfields and/or industrial buffer land, parking lots, rooftops, and sites with little or no ecological or agricultural value.
  - Participants voiced support for the County's stated goal to "increase the production of renewable energy."[41]

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40 https://www.nrel.gov/gis/re-potential.html

41 Page 56, Strategy #4, Goal 2: Renewable Energy, from Contra Costa County Climate Action Plan, Adopted Dec 15, 2015. http://www.co.contra-costa.ca.us/4554/Climate-Action-Plan

- From renewables industry representatives:
    - Plowed agricultural land often can be developed for wholesale renewables more easily and less expensively than urban land. Therefore, the County should not omit such lands in calculating its technical renewable potential.
    - Emerging solar and wind technologies may be compatible with multiple uses on site, and any regulations should account for these diverse technologies.
    - Renewable energy developers appreciate clarity and predictability related to values that the County finds most important to protect through land-use policy.

3.2. *Solar Methodology and Results*

As noted, this study focused on solar due to current market trends in California, the County's large solar potential relative to other new renewable generation sources, stakeholder interests, and the need to evaluate tradeoffs associated with land used for solar (when it could otherwise be used for other values).

Due to large-scale solar farms' land-intensive nature, the County sought to understand the magnitude of available renewable resources and the typical costs for these resources, in light of multiple types of solar. These range across the following:

- Solar with negligible impacts on future land use (e.g., rooftop solar)
- Solar *unlikely to* impact on future land use (e.g., solar on parking lots not expected to be redeveloped into other community assets, or solar on land deemed unlikely to be developed for other purposes within the ULL)
- Solar that could present land-use tradeoffs with agricultural uses, infrastructure needs, and/or environmental/habitat protection (e.g., solar outside of the ULL)

Pittsburg Unified School District (PUSD) is piloting innovative new technologies to co-locate solar with other technologies. PUSD is putting Agro Energy Solar Panels above a bioswale, where the AP Biology classes will be planting crops and measuring the impact of the solar panels on plant productivity.[42]

For each of these resource types, the County sought to understand typical costs and the likelihood of resource development.

Accordingly, the study organizes solar research according to those types, and the report's following sections present solar results in order from the least potential for tradeoffs and constraints to the highest potential for tradeoffs and constraints.

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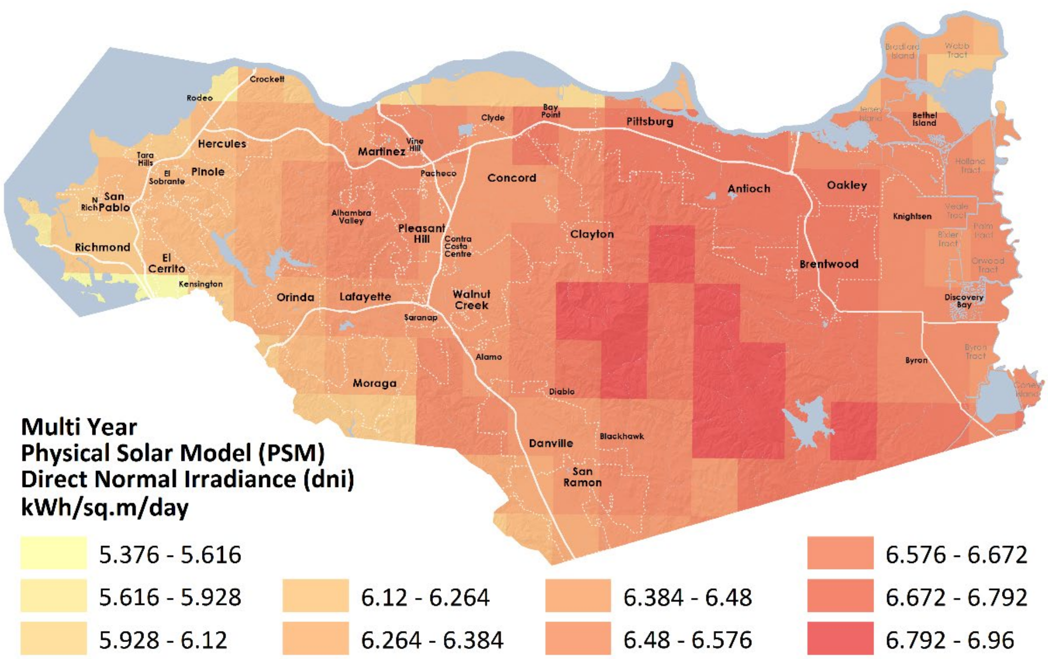
[42] Source: Interview with Krista Rigsbee, Constructive Systems, Inc. Graphic Source: https://commons.wikimedia.org/wiki/File:Pittsburg_Unified_School_District_Office_-_panoramio.jpg

Certain solar technologies may be compatible with co-located uses, particularly for agriculture, and, as such, it is important to note that siting solar in an agricultural area may not always result in a loss of farmland value. Stakeholders in the County serve as pioneering examples of such technologies, which can include pollinator-friendly solar farms, grazing-compatible solar, and "agrophotovoltaics," where solar panels are placed above greenhouse-grown plants and can *increase* plant productivity in certain cases.[43] The market development, however, for such technologies is still in the early stages, and, accordingly, the described framework—focusing on categorizing solar types from least potential tradeoff to most potential tradeoff—was deemed appropriate for assessing solar resource potential.

On average, the County's available solar insolation is quite high relative to the rest of the United States, and sufficient to support cost-effective solar deployment. Hence, land-use constraints drove the identification of potential solar sites rather than accounting for the "quality" of the solar resource (in terms of solar insolation). While certain parts of west Contra Costa County and the northern waterfront may have more fog and cloud cover at certain times of year, sufficient insolation still exists, as shown by NREL's solar insolation map (Figure 7). Insolation throughout the County remains nearly uniform, ranging from 5.4 to 6.8 kWh/m^2/day, with most locations above 6.0 kWh/m^2/day.

Figure 7. Contra Costa County Solar Insolation



Source: https://maps.nrel.gov/nsrdb-viewer

The study assesses the magnitude of the solar resource by independently summing the potential solar resource on rooftops, parking lots, land that the County deems urban but unlikely to be developed,

43 https://www.pri.org/stories/2018-06-08/energy-and-food-together-under-solar-panels-crops-thrive

Delta island land, and agricultural land with the least constraints. The study defines these considerations in greater depth below.

This section first describes the method used to quantify solar resources by type, and then addresses factors applied to assess the relative attractiveness of solar resources from a land-use perspective. From an economic perspective (i.e., the total resulting electricity cost), rooftop solar retrofits cost more to install due to smaller project sizes, but they avoid transmission losses. Parking lots offer a larger scale and possibly lower costs, but they incur costs for additional roof structures and foundations to resist wind forces. Though the least expensive, large-scale ground-mount projects may incur higher transmission costs and land costs. The indicative economic potential section outlines economic considerations after addressing technical potential.

3.2.1. Rooftop Solar

Approach

In evaluating rooftop solar potential in Contra Costa County, the study examined a number of software programs and methods that can account for orientation and shading by nearby buildings and trees. Solar mapping tools include Google Project Sunroof, Geostellar, Mapdwell, and Energy Sage. Using these tools, one generally types in an address, and a satellite image of that dwelling's rooftop is analyzed for nearby shadows to determine the site's solar potential.

Some of these sources can sum the potential for all rooftops within an area (e.g., Contra Costa County), providing a detailed picture of the county's rooftop resource. In obtaining this for the County, the study selected Google Project Sunroof to provide a first-order estimate of potential, given the software's ease of use and low cost.

The Project Sunroof tool estimates the technical potential of all buildings within a region, ignoring parking lots or land areas where larger solar arrays can be installed. Google's algorithm requires the following:

- Each panel area on a building receives at least 75% of the maximum annual sun in the County (a threshold of 1,233 kWh/kW
- Each included roof has a total potential installation size of at least 2 kW (135 sf)
- Only roof areas with enough space to install four adjacent solar panels are included

For further technical details, see Google SunRoof documentation.[44]

To calculate total potential capacity on County rooftops, the study employed Google's calculation of available unshaded rooftop areas (designated in 1.650m x 0.992m standard sized solar panels), and applied the following assumptions: 16% efficient modules (260W/module); 80% packing factor; 20%

[44] https://www.google.com/get/sunroof/data-explorer/place/ChIJ3QQ6ifNuhYAR4fM4Ln-yyVk/

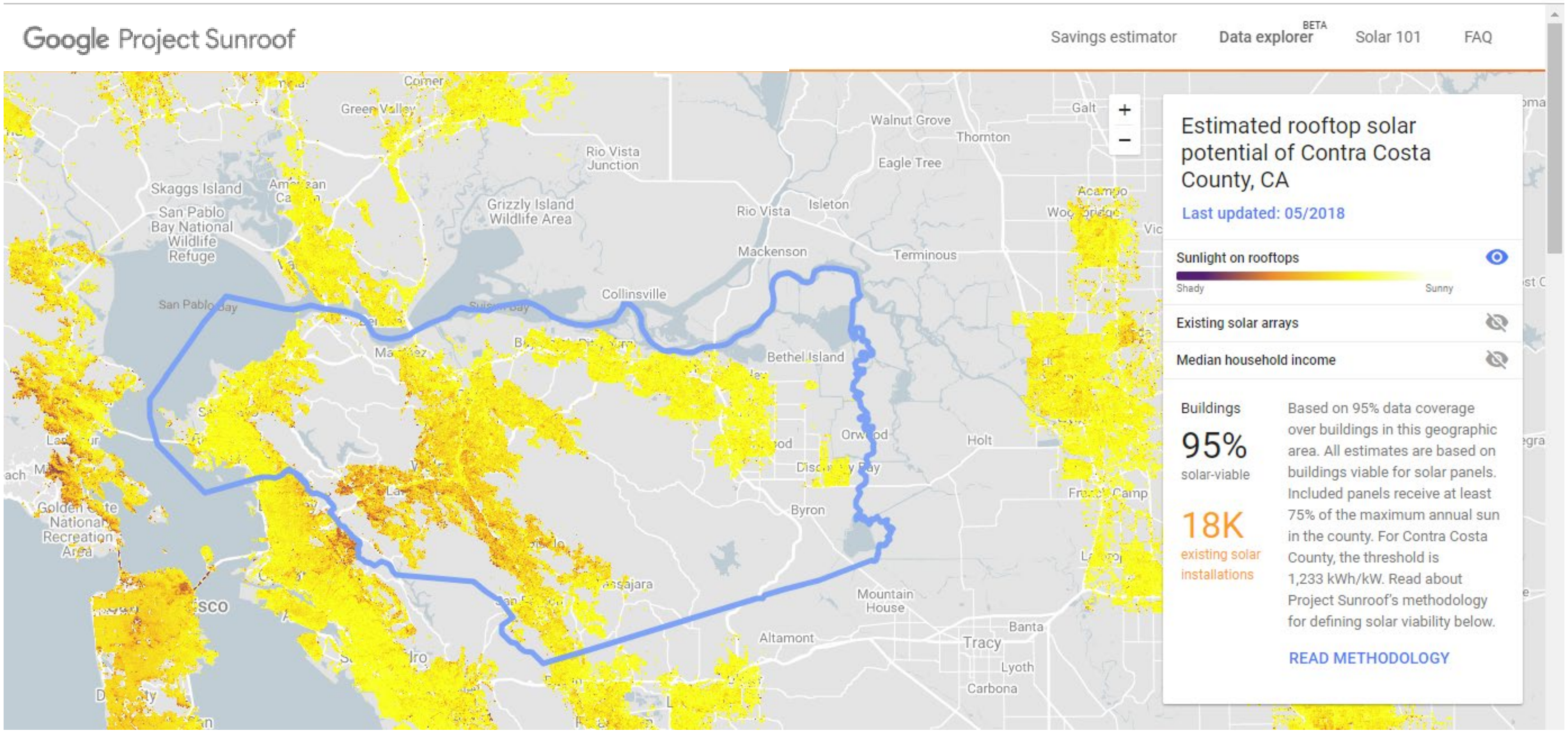
AC:DC derating factor; and a 20% reduction[45] to account for rooftop fire code borders, roof age (not all roofs can handle 4 lbs/sf), and auxiliary rooftop equipment (for example, rooftop air conditioners for commercial).

The analysis covered 95% of the buildings in the County.[46] Figure 8 shows areas with the greatest solar potential on rooftops, according to the tool. Figure 9 shows what this analysis looks like on individual rooftops, showing areas of shading from internal rooftop elements (vents, HVAC equipment, chimneys) and shading from surrounding features such as trees.

45 Standard building design can easily result in much higher roof area percentages not being available due to space taken by mechanical equipment, chimneys, vents, skylights, and other features as well as shading that these features cast on surrounding roof areas. One can, however, move these shade-generating features to a rooftop's north side, allowing an estimated 80% of area for solar. See Bryan, Harvey, Hema Rallapalli, and Jin Ho Jo. "Designing a Solar Ready Roof: Establishing the Conditions for a High-performing Solar Installation." American Solar Energy Society Solar 2010 Conference Proceedings.

46 The other 5% of buildings were not identified as such by Google's algorithm.

Figure 8. Contra Costa County Solar Rooftop Potential



Source: https://www.google.com/get/sunroof/data-explorer/, accessed 9/16/2018.

Figure 9. Zoomed in screenshot of Google Sunroof's characterization of rooftop solar availability and shading at DCD's offices and surrounding buildings in Martinez

Source: https://www.google.com/get/sunroof/data-explorer/, accessed 10/19/2018.

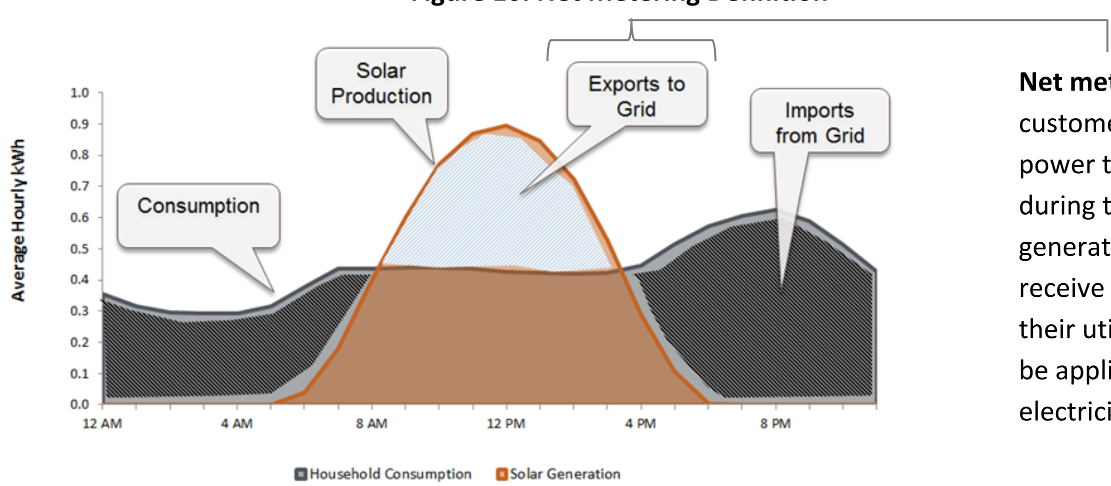
Appendix B lists solar potential by census tract, with a total estimated potential of 1,450–2,600 MW. The low estimate only includes south- and flat-facing roofs; the high estimate additionally includes east- and west-facing rooftops. Coupled with new energy efficiency standards (as part of "CalGreen," the California green buildings standards code), California requires that all new construction buildings under three stories install solar panels as part of the 2019 Title 24, Part 6, Building Energy Efficiency Standards. These estimates of rooftop solar potential do not include solar installed on newly constructed buildings.

Rooftop Solar Economics

Two key elements determine whether a rooftop makes a good candidate for solar:
(1) the age of the rooftop (if the roof is sufficiently old, it does not make sense to install solar and replace the roof 10 years later); and
(2) the presence of a significant on-site electrical load. If a large solar array is installed onto a roof, and the power generated is sold back to the grid, the array owner will receive a price somewhere between wholesale and retail from the utility (depending on local net metering pricing rules). If the owner has a large load and consumes the energy generated, they essentially receive a full retail-rate value. Consequently, the local electrical load's size serves as a key economic factor for rooftop installations.

Timing constraints limit how quickly the County can access this potential economically: it does not make economic sense to install a solar array, and remove and reinstall it five years later, when a roof needs replacing. Therefore, solar should be installed in conjunction with a new roof (+/- 3 years), with roofs typically lasting 25 years or more. Only 1/25th of this total potential (58–104 MW) makes economic sense to install each year over the next 25 years. Actual installations will be lower due to potential non-interest in solar by homeowners, homeowner financial barriers, or other barriers (for example, split incentives). For residential markets, potential financial barriers have been addressed somewhat by third-party leasing which can provide homeowners with no-money-down financing.

Figure 10. Net Metering Definition



Net metering allows customers to export power to the grid during times of excess generation, and receive credits from their utility that can be applied to later electricity usage

3.2.2. Parking Lot Solar

Neither a comprehensive database of parking lots in the County nor a satellite-based parking lot estimation software, similar to that used for rooftop solar, was found. Therefore, the study required creation of a new database, focused on large parking lots, primarily within the ULL. The study focuses on these sites for the following reasons:

- On average, sites within the ULL are likely closer to transmission and substations
- On average, such sites may be more likely to be associated with customers with significant net metering loads to balance against solar production, improving economics, and
- Solar shade structures in urban locations could be considered to offer greater co-benefits (e.g., more cars benefit from parking in the shade, more County constituents learn of progress made in renewable energy if solar is sited in places with higher population centers)

To create a new database of large parking lots, the study filters Contra Costa County's CCMap resource by the Tax Assessor Use Code. Several types of institutions were selected as they likely had relatively large parking lots (e.g., schools, shopping centers, churches, industrial facilities, business parks, regional parks). This list was given to a student intern and County GIS staff to trace the shape and area of the parking lots within these parcels, starting with parcels with the greatest acreage. This resulted in a list of nearly 1,300 parking lots that could be solar installation candidates.

Upon establishing locations, shapes, and acreages of these sites, the team reviewed specific examples of the tracing methodology and satellite imagery to estimate the fraction of identified parking lot area that would likely be shaded and not conducive to solar. This incorporated the following assumptions:

- Available space would be reduced by 33% to account for aisles between parking stalls and necessary inter-row spacing (panels at the expected tilt for Contra Costa County's latitude might otherwise shade directly adjacent panels). Most solar parking canopies cover stalls but not aisles.
- Surrounding buildings and/or trees can shade a parking lot. Based on satellite imagery of Contra Costa County, the study assumes that 50% of the time, two stories of obstruction would exist on all sides, with an average 3:1 length to width parking lot aspect ratio. This yielded a useable area ranging from 12% of the parking lot area for very small lots (0.1 acres) up to 85% of the parking lot area for very large parking lots (5 acres).[47]
- Parking lot areas shaded by large mature trees are generally avoided in quantification of the area available for solar, but areas with shrubs and/or small trees were not excluded, based on the assumption that a property owner *could* clear these smaller trees. The study did not address whether clearing shrubs and small trees would be a desirable action, and the study recognizes

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47 This assumes removing an area 8 feet wide from any edge of the parking lot for every story that the surrounding building or tree extends above a single story (e.g., no reductions in parking lot areas when surrounded by one-story buildings as solar panels are the same height as the building, with 8 feet cut from the edge for two-story buildings).

that vegetation and landscaping elements can provide, for example, urban heat island benefits, aesthetic benefits, and drainage benefits.

- The study also bases suitability for solar on the proximity to the closest substation, based on an expectation that interconnection costs increase with distance and many of these sites would offer more solar capacity than on-site loads. Tiers were defined as follows:

Tier	Distance
1	Up to 1,000 feet from a substation
2	1,000 to 5,000 feet from a substation
3	5,000 to 10,000 feet from a substation
4	>10,000 feet from a substation

Once useable square footage estimates were available, using the assumptions listed above, a solar capacity value was calculated for each potential site, adopting a rule of thumb that each megawatt requires approximately 2.4 acres of panel surface area (the same assumptions used for rooftops), which typically could fit on a site of about 7.5 acres.[48] These capacity values were summed for each proximity tier to a substation, as presented in Table 6.

Proximity to Substation

Many factors affect interconnection costs, and the exact interconnection cost cannot be easily predicted, short of applying to PG&E for an interconnection study.

Nevertheless, for large scale and parking lot solar opportunities, the study seeks to provide context on interconnection considerations without undertaking a full assessment of economic feasibility for any given site under PG&E Rule 21 standards for allocations of interconnection costs and fee schedules. The interconnection cost is driven by multiple factors: the distance to the substation, the cost of new infrastructure required (e.g., new substations and substation upgrades), and the fees assessed by PG&E. While important to a determination of a specific site's candidacy for large-scale or parking lot solar, these considerations go beyond the detail level possible for a study of this scale. Analysis of the *collective* impact on transmission and distribution (T&D) upgrade needs across all resources identified by this study would be necessary to attain this level of granularity, and assumptions would be required about which resources would be developed first, what changes would happen in PG&E's T&D system, what capacity each line and each substation carries, substation connectivity, and what changes might

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48 Reasons why panels require so much extra total acreage compared to area taken by the panels themselves include gaps between rows (often requiring wider spacing for single-axis tracking systems commonly used in ground-mount installations, and to avoid row-to-row shading), the need for access (roads, walkways), border shading (caused by fencing or trees on the edges), and other site-specific factors, such as a site's shape (e.g., the possibility that certain parts of the site are sloped or otherwise unsuitable for panels). See Ong et al, "Land-Use Requirements for Solar Power Plants in the United States", NREL, June 2013, for further information: www.nrel.gov/docs/fy13osti/56290.pdf

occur in PG&E's cost allocation formulas over a long timescale required to develop this renewable energy. Cluster studies and long-term holistic studies that project more widespread resource development would be needed.

Instead of delving into this detail level, the methodology uses a relatively simple metric for ease of utility interconnection— the calculated distance of each solar resource to the nearest existing substation.[49] Substation locations were obtained from PG&E substations shown in the PV RAM map,[50] substation locations from a spreadsheet emailed to Cadmus by PG&E representatives, and known WAPA substations and privately owned substations within the County. Laying a line from a site to a substation costs approximately $1 million per mile. The study creates distance thresholds to quantify the total resource available within 1,000 feet, 5,000 feet, 10,000 feet, and above 10,000 feet of the nearest substation. Figure 11 shows the location of these substations, buffers around them, and the network of transmission lines within the County.

49 An alternate approach would have been to calculate the distance from each site to the nearest mainline transmission asset and the cost of installing a new substation at that location. This approach was not selected based on the assumption that the cost of creating a new substation to tie into the transmission line would pose significant costs to the project and may or may not be possible or expedient for each project. A new substation is likely to cost over half a million dollars, not including the cost of running a line to the site.

50 PG&E provides a map called PV RAM that is designed to give an indication of the congestion on any given distribution line and limits to the amount of solar that could likely be placed on the system with minimal impact at the line segment level, the feeder level, and the transformer bank level. However, because this map relies on data last updated in 2015 and because this level of detail is beyond the level for a typical technical potential study, it was determined that using the values in the PG&E map was unnecessary for this analysis. Instead only the GPS locations were used. PV RAM map is available here: https://www.pge.com/en_US/for-our-business-partners/distribution-resource-planning/distribution-resource-planning-data-portal.page

Figure 11. Substation Locations

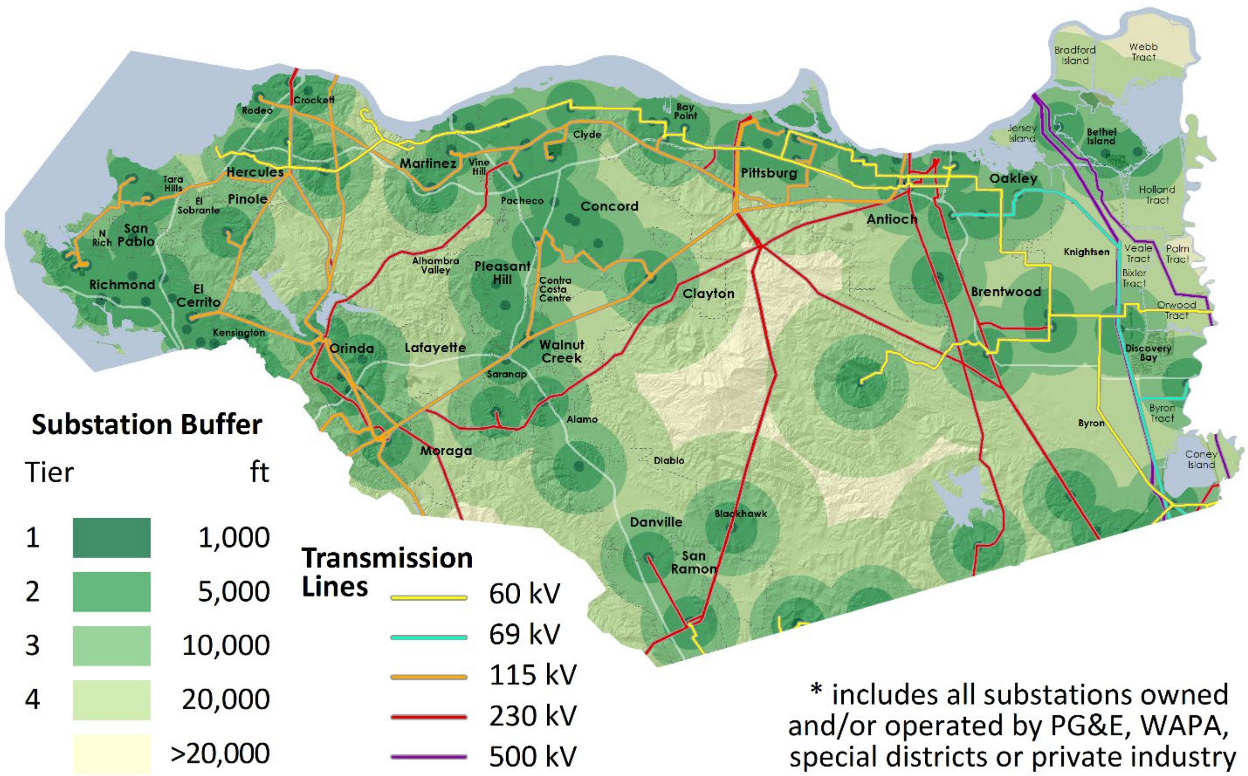


Table 6. Parking Lot Solar Potential

Tier	# Parking Spaces	Total Acres	Total MW
1	114,810	700	180
2	156,260	970	230
3	68,870	430	100
4	16,970	110	20
Total	**356,910**	**2,210**	**530**

Further analysis will be necessary to more precisely estimate technically available solar in parking lots. The methodology provides an order of magnitude estimate and establishes a lower boundary for total technical potential. This can be considered a lower boundary in that not every parking location in the County could be mapped within the study's scope and timing.[51] Another reason is that for parking lots smaller than half an acre, the total available area for solar was heavily discounted due to assumed shading from surrounding buildings.

[51] The study did account for over 1,250 parking lots. Despite the focus on the largest lots, the study included hundreds of lots smaller than one-half an acre.

For multiple reasons, actual development of solar on parking lots in the County will likely significantly lag behind other solar installations:

1. Parking lots have higher cost structures (structural support adds $0.10–$0.30/kW) and tend to be smaller-sized projects (i.e. < 1 MW).
2. Many large parking lots may exceed the size of local load available to net meter against, reducing a project's economic attractiveness.
3. Large parking lots are often owned by property management companies, with many tenants paying their own electric bills, resulting in split incentives that slow development of these resources.
4. Property owners may prefer to keep shade trees for aesthetic reasons.
5. Parking lots may be owned by many disparate property owners with varying interests.

Accordingly, parking lots currently account for 1%–4% of solar installations in California.

Nevertheless, the analysis indicates a significant resource is technically available. If programs and policies to address these barriers are put in place, and if structural support costs come down, these resources could be developed quickly in future years. Parking lots offer a key advantage over rooftop solar: one does not have to wait for the existing roof to wear out before installing solar.

3.2.3. Ground-Mounted Solar

The process of developing the technical resource potential for ground-mounted solar was to independently come up with estimates of solar resources on urban land and on land outside the urban limit line. To identify sites that should be counted within the technical potential estimate, a series of exclusion factors was applied. Within the remaining area after these factors were applied, staff searched for sites using satellite imagery to validate technical feasibility.

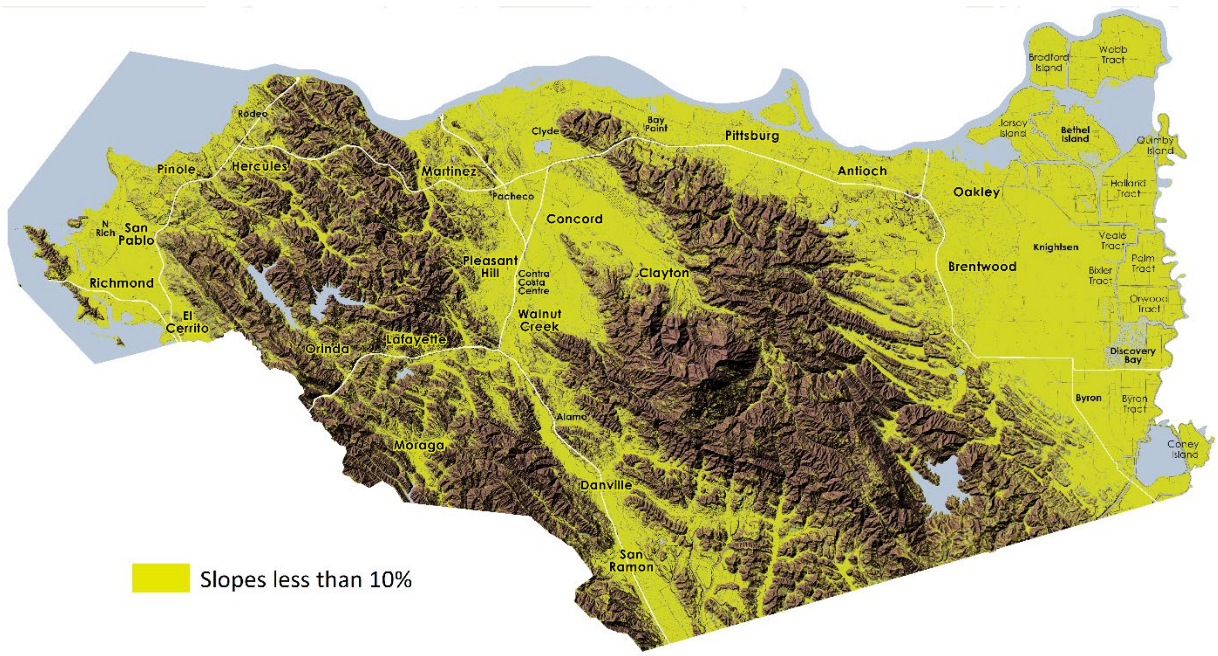
Ground-Mounted Solar Exclusions

The following factors were used to limit the areas in which solar potential was identified, grouped in three major categories – physical land attributes incompatible with large solar, biological and habitat value, and land use incompatible with large scale solar. These exclusion factors were applied to both the process of identifying rural and agricultural land that could host solar and "urban land unlikely to be developed" (meaning land that is unlikely to be developed for uses such as housing or jobs) that could host solar. Following this section, there is additional detail on how ULUTBD solar and solar on rural land were evaluated. Appendix D includes detailed maps that illustrate the evaluation process step-by-step, with a primary focus on rural lands.

Physical land attributes incompatible with large solar[52]

Lands sloped more than 10%. Highly sloped land is not suitable for solar primarily because the higher the slope, the higher the cost of the structural support, and the more engineering required. Additionally, solar on highly sloped sites would be more susceptible to erosion and earthquake risks. Because highly sloped hillsides are visible from far away, these locations may impact community aesthetics. Solar is not typically sited on land sloped more than 10%.[53]

Figure 12. Ground Mount Solar Exclusion: Slope Less than 10%



Biological and habitat resources incompatible with large solar

Wetlands were typically excluded for species protection and because of their important ecological functions and habitat value. Low lying land that is not wetlands was not excluded

52 Other attributes could have included fire hazard and flood hazard, but these attributes were not used to rule out lands for suitability, because it was assumed that they would simply increase insurance costs rather than make a project *technically* infeasible. Establishing the actual risks associated with these factors is a responsibility of potential developers.

53 Charabi et al, "Siting of PV Power Plants on Inclined Terrains", International Journal of Sustainable Energy, Feb 2014

because solar can successfully be sited in land with a 100-year flood risk.[54] There was not one single data layer that was sufficient for ensuring that all wetlands were removed from the analysis, but where wetlands were known they were excluded.[55]

Natural land cover types from the USGS's Multi-Resolution Land Characteristics (MRLC) National Land Cover Database (NLCD) Land Cover raster were excluded except for disconnected fragments. These natural land cover types have habitat value and may also pose viewshed concerns, and solar developers indicated they avoid such areas. Figure 13 displays land cover classifications for the entire County. Screening for natural land cover types and for steep terrain was sufficient to ensure that no priority areas from the Eastern Contra County Habitat Conservation Plan/Natural Community Conservation Plan (HCP) were included in the sites listed as suitable for solar.[56]

Critical habitat as designated by the U.S. Fish and Wildlife Service (FWS). FWS maintains a critical habitat for threatened and endangered species map, and several locations within the County provide habitat for such species, including the California red-legged frog, the Alameda whipsnake, the Santa Cruz tarplant, the vernal pool fairy shrimp, and others.[57] Areas designated as critical habitat were excluded, except for areas where natural land cover was not present.

Land uses incompatible with large scale solar

Areas with residential or potential residential uses were excluded from the analysis because of generally smaller parcel sizes and because most undeveloped land that is residentially designated, or zoned, and is not currently used for housing, is assumed to have potential for residential development. A combination of assessor use code, general plan designations, and zoning was used to determine the suitability of the land for residential use based on County staff expertise.

Undeveloped areas with job creation potential were excluded if job creation potential was deemed to be significant. This included commercial, industrial, or related land use designations.

Land surrounding airport runways was excluded. While solar near airports is feasible and has significant precedent, it was assumed that projects that attempted to site solar near runways

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54 For instance, Monterey County has provided guidance on siting solar in such locations here (http://www.co.monterey.ca.us/Home/ShowDocument?id=23403).

55 The County does not have its own map that covers the entire County. One known exception to the avoidance of anything that could be considered a wetland is that detention basins were not actively excluded.

56 The HCP was created to streamline permitting for habitat impacts while protecting biologically rich blocks of habitat within the County. The HCP has identified priority areas for permanent protection, which would not be suitable for solar.

57 https://ecos.fws.gov/ecp/report/table/critical-habitat.html

would encounter higher costs due to more extensive project review. FAA provides guidance for the length, width, and shape of "runway protection zones" where solar should not be sited.[58]

Military bases were excluded because it was assumed that the military may not wish to constrain usage of their lands in case of future changes in their operations. It also would be difficult for County staff to determine whether certain parts of military held land was actively used or not.

Parks, conservation easements, and watershed lands were generally not considered potential areas for large-scale solar. However, in cases where these areas contained parking lots and detention basins, those parts of the site were considered. Figure 14 shows a map of where such parks and land uses are located in the County.

58 https://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5300_13_chg11.doc

Figure 13. Multi-Resolution Land Characteristics (MRLC) National Land Cover Database (NLCD) Land Cover Classification

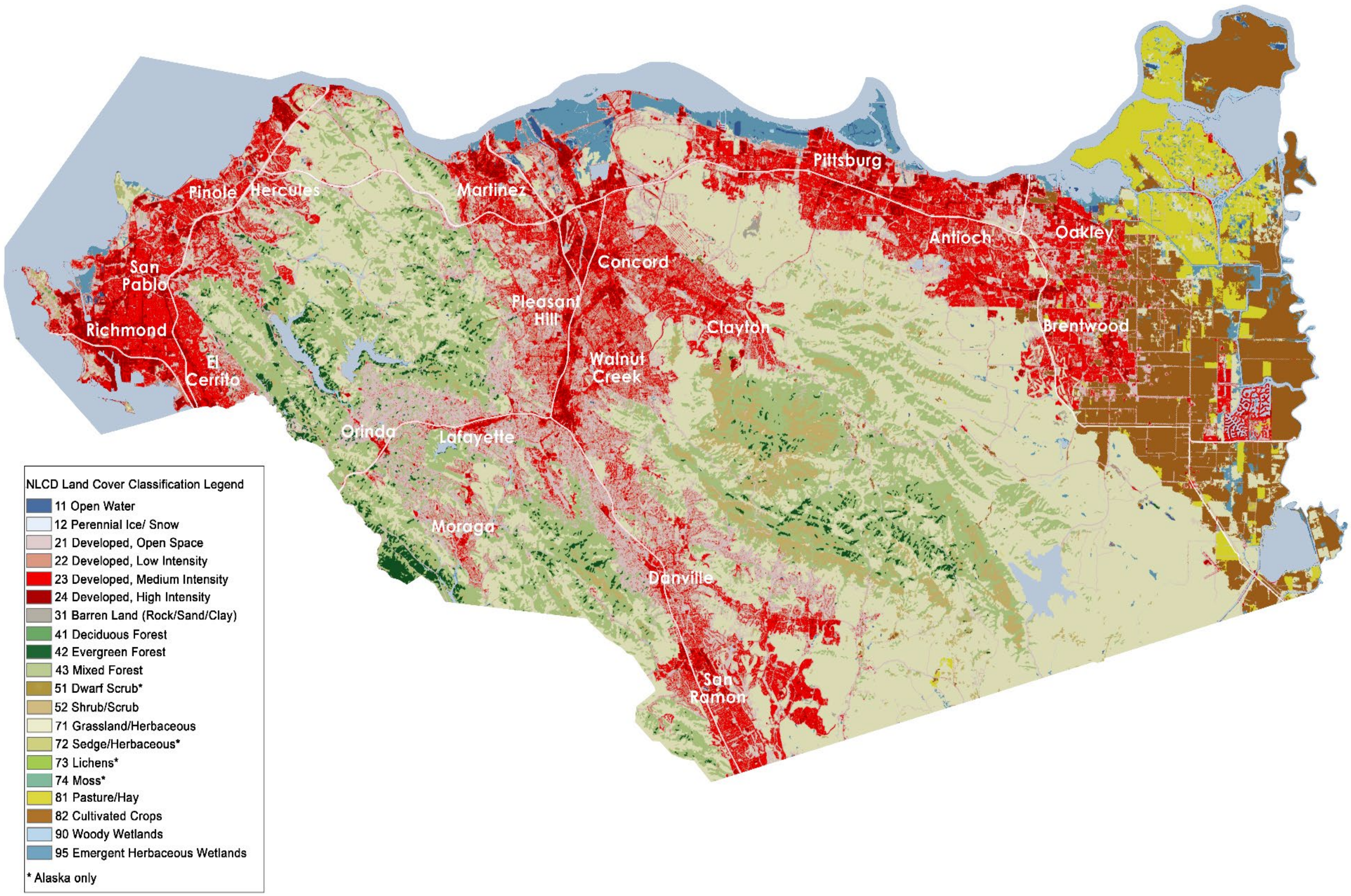
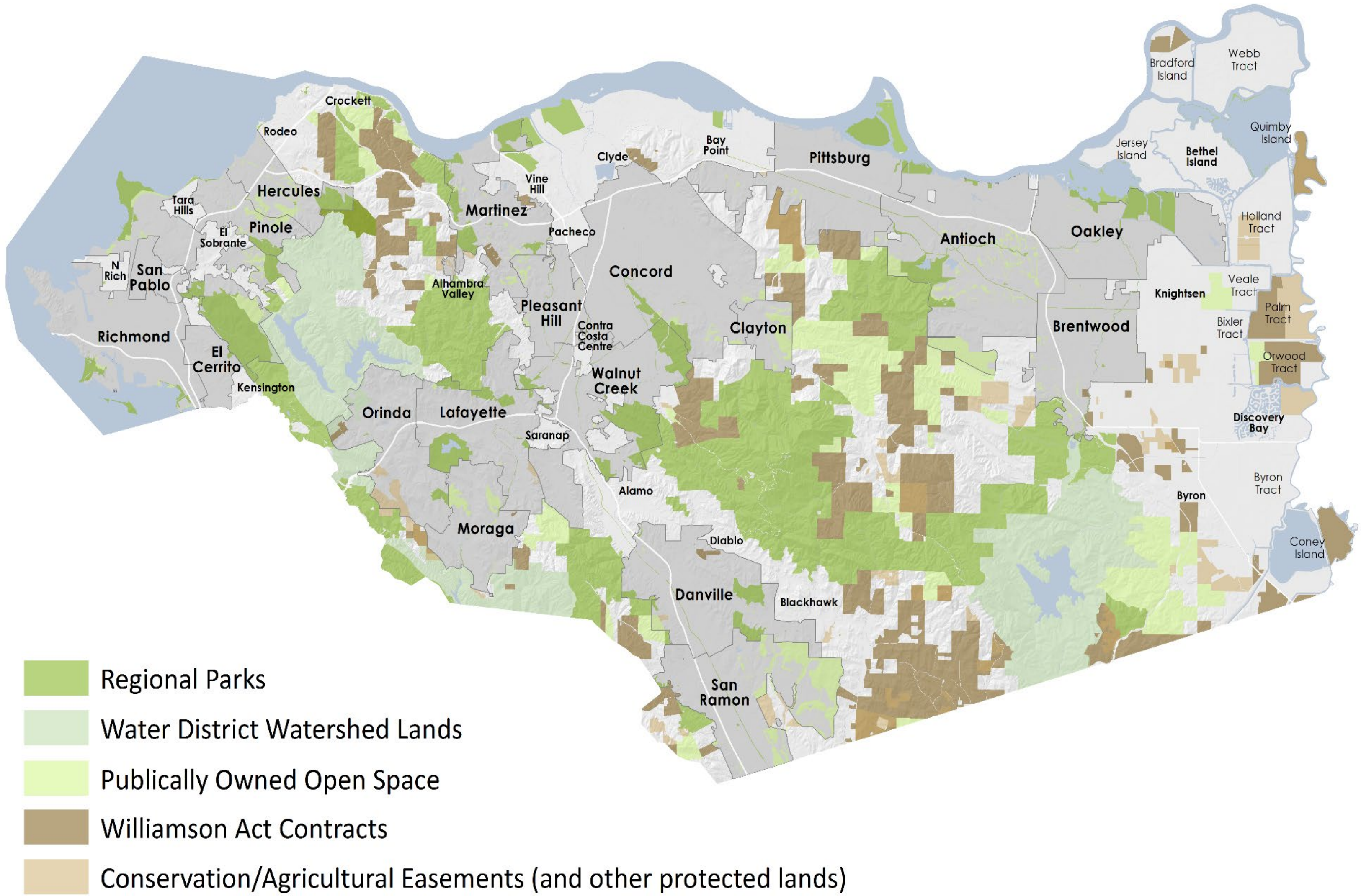


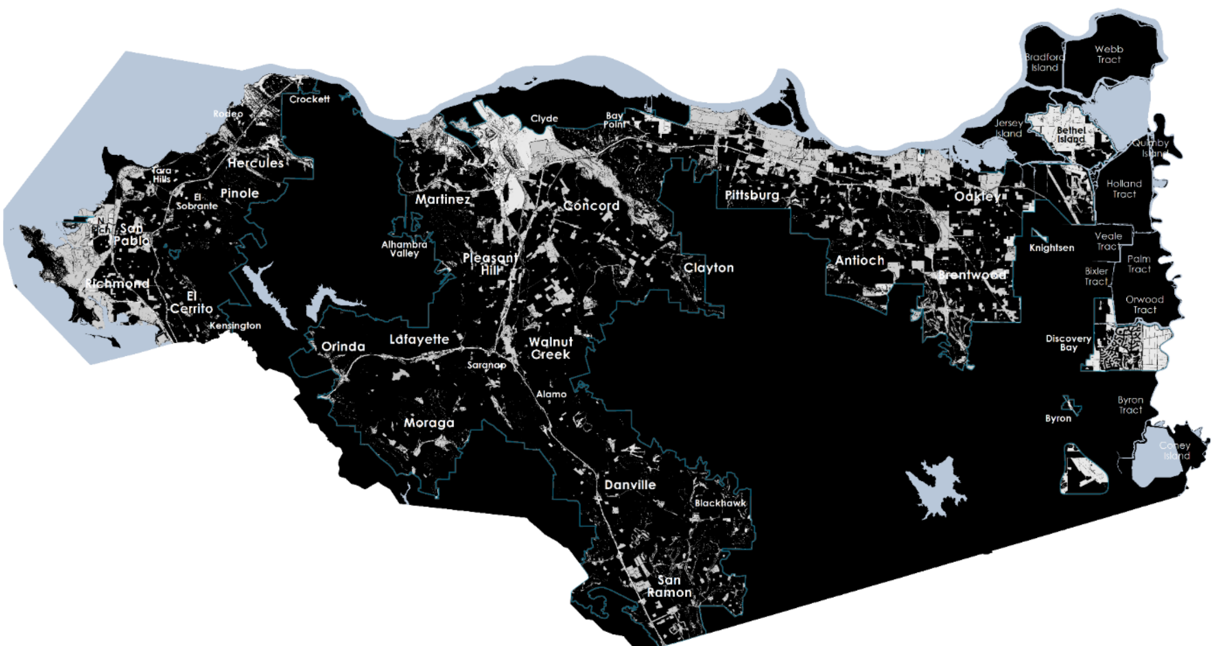
Figure 14. Parks, Open Spaces and Conserved Agricultural Lands



Ground-Mount Solar on Urban Land Unlikely to be Developed (ULUTBD)

Once the above technical exclusions were applied, County staff reviewed the remaining areas to further narrow and identify large plots of land that could potentially host solar within the Urban Limit Line.[59] The results of this process are shown in Figure 15. A goal for the County is to prioritize solar installation on "urban land unlikely to be developed," meaning land that is unlikely to be developed for uses such as housing or jobs (hereafter called ULUTBD). Such land includes industrial buffer land, transportation rights of way, industrially impacted or contaminated land, land isolated by uses incompatible with most development, landfills, property of waste water treatment plants, and more. Identification of this land reflects detailed County staff knowledge of development history, community planning priorities, and other factors. Not all ULUTBD spaces identified are conventional locations for solar, albeit all types have at least some examples of solar development in other parts of the country. For example, Figure 16 provides an example of a highway cloverleaf that was included within the ULUTBD dataset.

Figure 15. Land Unsuitable for Solar Inside the Urban Limit Line



County Urban Limit Line

Areas outside the urban limit line, areas with slope greater than 10%, residential general plan designations, residental parcel use codes, regional parks, water district watersheds, military facilites, restricted open space

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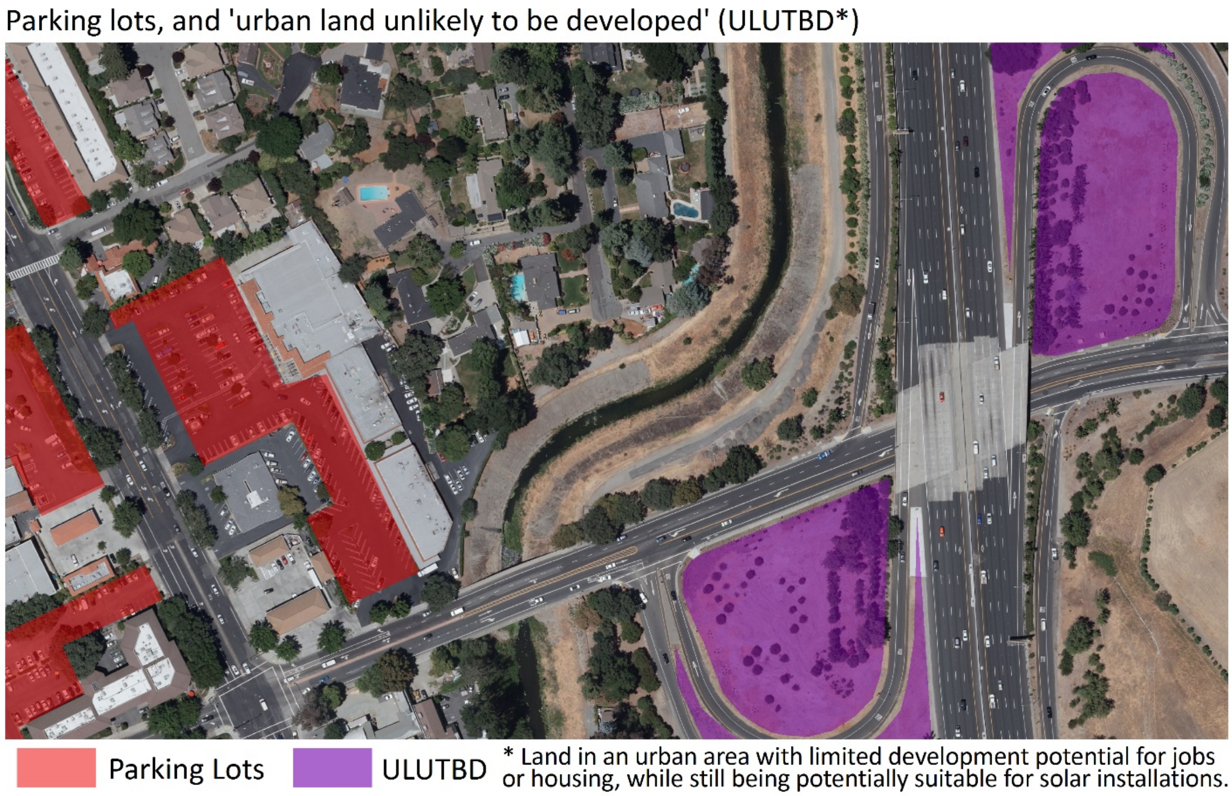
59 The Urban Limit Line was created by the voters in 1990 to restrict Contra Costa County urban development and preserve the remaining land for agriculture, open space, wetlands, parks, and other non-urban uses by directing development to existing urban areas and away from agricultural lands and open space.

Figure 16. Example ULUTBD Highway Cloverleaf Potential Solar Site



Finally, from within the set of ULUTBD areas identified, sites were removed that did not seem likely to be viable for solar due to considerations such as being in sensitive locations, being recently proposed for other uses, or other local neighborhood factors.

Not all of the ULUTBD will be attractive to solar developers due to parcel attributes like size, shape, contamination history, and other factors. Accordingly, our estimates of the total acreage available for solar within the ULUTBD category were conservatively trimmed by 33%. Similar to the approach for parking lots described above, suitability for ground mount solar was based on proximity to the closest substation, which impacts costs (it costs roughly $1 million per mile if transmission line capacity is not already available). As with parking lot solar, tiers were defined as follows:

Tier	Distance
1	Up to 1,000 feet from a substation
2	1,000 to 5,000 feet from a substation
3	5,000 to 10,000 feet from a substation
4	>10,000 feet from a substation

Once acreages were available, a solar installation size was calculated for each potential site, using a rule of thumb that each megawatt requires approximately 7.5 acres of land.[60]

Table 7. Ground Mounted Solar Potential on Urban Land Unlikely to Be Developed (ULUTBD)

ULUTBD Solar Potential		
Proximity Tier	**Total Acres**	**Total MW**
1	900	120
2	1,300	170
3	200	20
4	0	0
Total	**2,400**	**310**

Tiers indicate proximity to substation

Ground Mounted Solar in Rural Areas

In addition to urban land unlikely to be developed, there are areas in the County outside of the Urban Limit Line that may be suitable for solar. As noted above, several exclusion factors had already been applied to focus attention on least tradeoff lands and these factors were also used when considering rural land. Outside the ULL, it was also necessary to exclude areas with concentrations of smaller parcels generally describable as rural residential. Other factors included not looking at land with natural land cover, wetland areas, critical habitat areas, and parks and open space, among other factors, as described above. This focused the attention primarily on the undeveloped land in the eastern part of the County, much of which is used for agriculture or designated agricultural. This study first investigated agricultural land not located on the Delta Islands, and separately investigated land on the Delta Islands, which have their own mix of unique constraints. Together these areas are summarized in the inventory of potential renewable resources as “Agricultural Land with Relatively Low Constraints.” Appendix D: Cartography presents maps associated with this process.

Agricultural Land Excluding the Delta Islands

Because of the County’s interest in preserving high quality farmland, County staff performed extensive evaluation of the available data on agricultural land quality to inform this portion of the study. The methodology for assessing whether farmland could be suitable for solar included the usage of *t*he USDA’s Natural Resources Conservation Service (NRCS) Soil Survey and designations of farmland quality from the California Department of Conservation’s Farmland Mapping and Monitoring Program (FMMP). Each of these datasets rank agricultural land. The NRCS rankings lean heavily on soil science, while the FMMP rankings take into consideration how the land is currently farmed. The NRCS data uses several attributes to rank quality, including farmland capability class, grade, an index of soil quality, and a determination of land that is “prime farmland,” or “farmland of statewide importance.” The FMMP data

60 Ong et al, “Land-Use Requirements for Solar Power Plants in the United States”, NREL, June 2013, https://www.nrel.gov/docs/fy13osti/56290.pdf

also categorizes land that is “prime farmland,” “farmland of statewide importance,” ”unique farmland,” and “farmland of local importance.”

For the purpose of this analysis, land that has a Class I or Class II NRCS classification or a Storie Index Rating greater than 80 was typically considered unsuitable for solar. Soil attributes vary both between and within parcels, and areas of higher and lower quality soil are often tightly intermingled (see Figure 17 and Figure 18). Given that the shape of a large solar array would not likely be conformed to the exact boundaries defined by soil quality, a subjective effort was undertaken to identify sites that were primarily poor quality soil sites.[61] Two versions of this analysis were done, one which identified the agricultural lands that were least likely to have significant agricultural value, and a second version that loosened the criteria and included unique farmland and farmland of local importance. The locations identified are shown in Figure 19 and Figure 20.

Resulting from this analysis, 27 sites were identified in the former group and 58 sites in the latter group. The average size of these sites was 25.4 acres and 37.7 acres, respectively. These sites were not split by parcel boundaries or by ownership under the assumption that land from multiple owners could potentially be leased if needed in order to achieve a solar farm of the appropriate scale. Applying a ratio of 7.5 acres needed per megawatt of ground mounted solar, we obtained a low estimate of 90MW of capacity likely available, and a high estimate of 300MW.

Delta Islands

Most of the islands - Coney Island, Palm Tract, Orwood Tract, Holland Tract, Quimby Island, Webb Tract and Bradford Island -- were excluded based on a cumulative series of constraints. The cost of extending transmission lines, subsidence below sea level, insurance concerns regarding the condition of levees, and the high concentration of prime soils according to U.S. Department of Agriculture, even if they are not currently farmed, were all major factors. The remaining areas, on Jersey Island and Bethel Island, have unique distinctions that may counterbalance some of the constraints and for that reason, we feel they deserve more discussion. Jersey Island has a General Plan land use designation of Public Semi Public (PS) and is 100% owned by a special district. Bethel Island is inside the Urban Limit Line, has significant obstacles for large scale conversion of agriculturally designated lands for either jobs or housing, and has a larger risk pool, and more robust maintenance district regarding the levees. Based on these factors, specific locations on each of these islands were identified and mapped (Figure 19). Enough land for 240MW of solar was identified on Bethel Island and 430MW on Jersey Island.

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[61] If Contra Costa County were to adapt its General Plan and its zoning to allow solar in relatively low constraint agricultural areas, it would likely not follow the precise soil quality boundaries to set policy, but rather adapt these boundaries to existing parcel boundaries. The existence of a small sliver of prime farmland or other designated high value soil within a larger parcel of poor soils would not likely preclude the development of solar there, and conversely, the existence of small areas of poor soils in otherwise high soil quality parcels would not imply that the County would allow solar on any part of that parcel.

It should be stressed that this is an estimate of technical potential, not a recommendation. Compatibility with the Bethel Island community has not been evaluated in this study, but would need to be evaluated before any proposal were considered.

Figure 17. Contra Costa Prime Soils

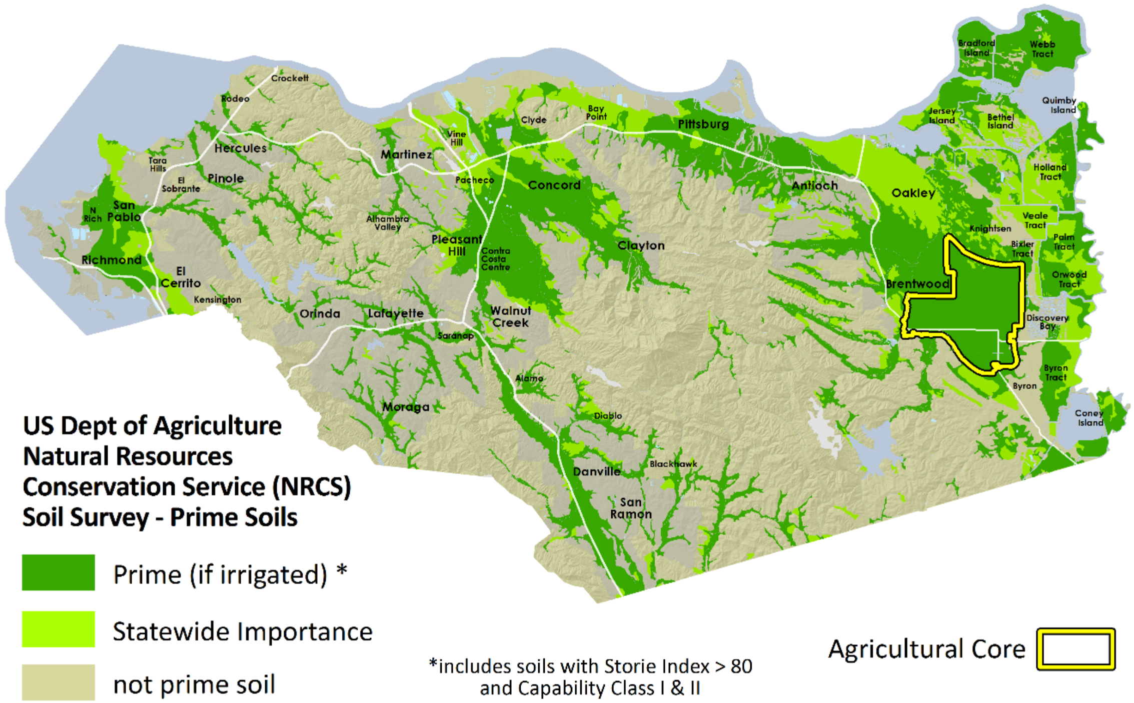
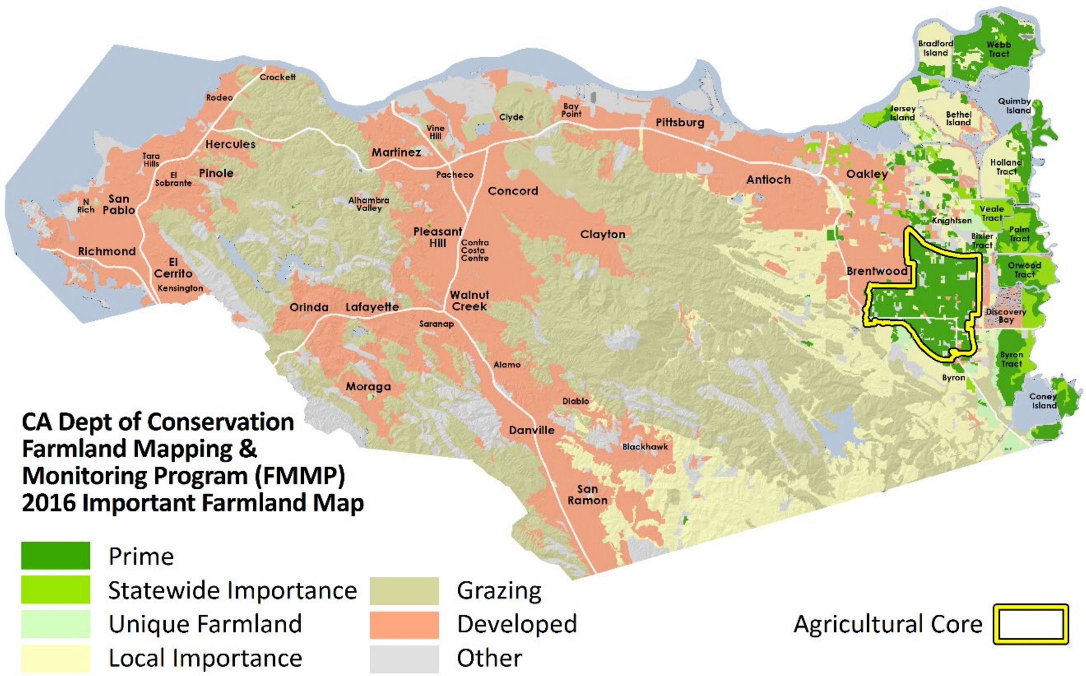


Figure 18. Contra Costa County Farmland and Prime Soil



As for the sites identified within the urban land unlikely to be developed (ULUTBD) category above, the rural solar sites were grouped by proximity to substations. The vast majority of the resource is located more than 2 miles from a suitable substation (Table 8).

Table 8. Ground Mount Rural Solar Potential by Proximity to Substation

Proximity Tier	Agricultural land and Delta Islands	
	Least constrained	Less constrained
1	0	0
2	0	0
3	430	430
4	330	540
Total	**760**	**970**

3.2.4. Total Solar Technical Potential

The sections above explore the solar potential available on rooftops, parking lots, urban land unlikely to be developed, agricultural land solar, and the Delta Islands. Building from this analysis, Table 9 presents total solar potential for the County.

Table 9. Contra Costa County Total Solar Potential

Type	MW Capacity		Annual MWh	
	Low	High	Low	High
Rooftops	1450	2600	2,290,000	4,100,000
Parking Lots	180	530	280,000	840,000
Urban Land Unlikely to be Developed	120	310	190,000	490,000
Agricultural Land with Least Constraints	760	970	1,200,000	1,530,000
Total	**2,510**	**4,410**	**3,960,000**	**6,960,000**

The numbers presented in Table 9 should be interpreted cautiously, because they do not reflect how quickly this solar potential could be achieved. While rooftop solar presents the largest opportunity, it is distributed over hundreds of thousands of roofs. The County would need to dramatically scale up from its current rate of rooftop solar installations (~1,500 permits/year) in order to fully capture the rooftop potential on these roofs in a reasonable time frame. Even if all building owners who could install solar decided to install it, the importance of having a relatively new roof for cost effectiveness means that it would take at least 25 years before this potential could be realized. Similarly, all forms of ground mounted solar depend on competing uses for the land, among other considerations. See the next section for further information on barriers to realization. Figure 19 shows all the solar resources identified, excluding rooftop solar.

Figure 19. Solar Technical Potential Areas in Contra Costa County (ground mounted only – see Figure 8 for rooftop potential)

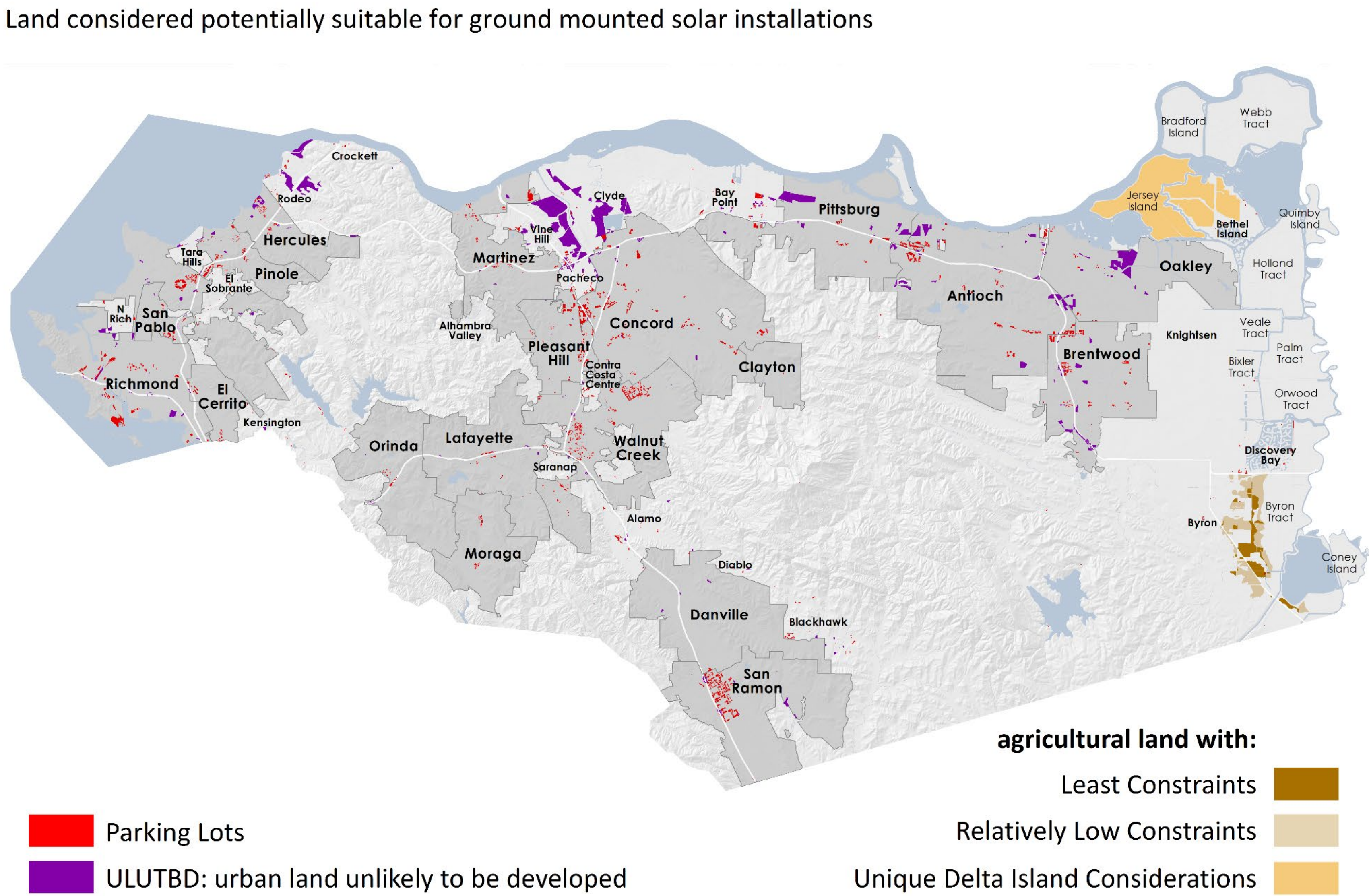
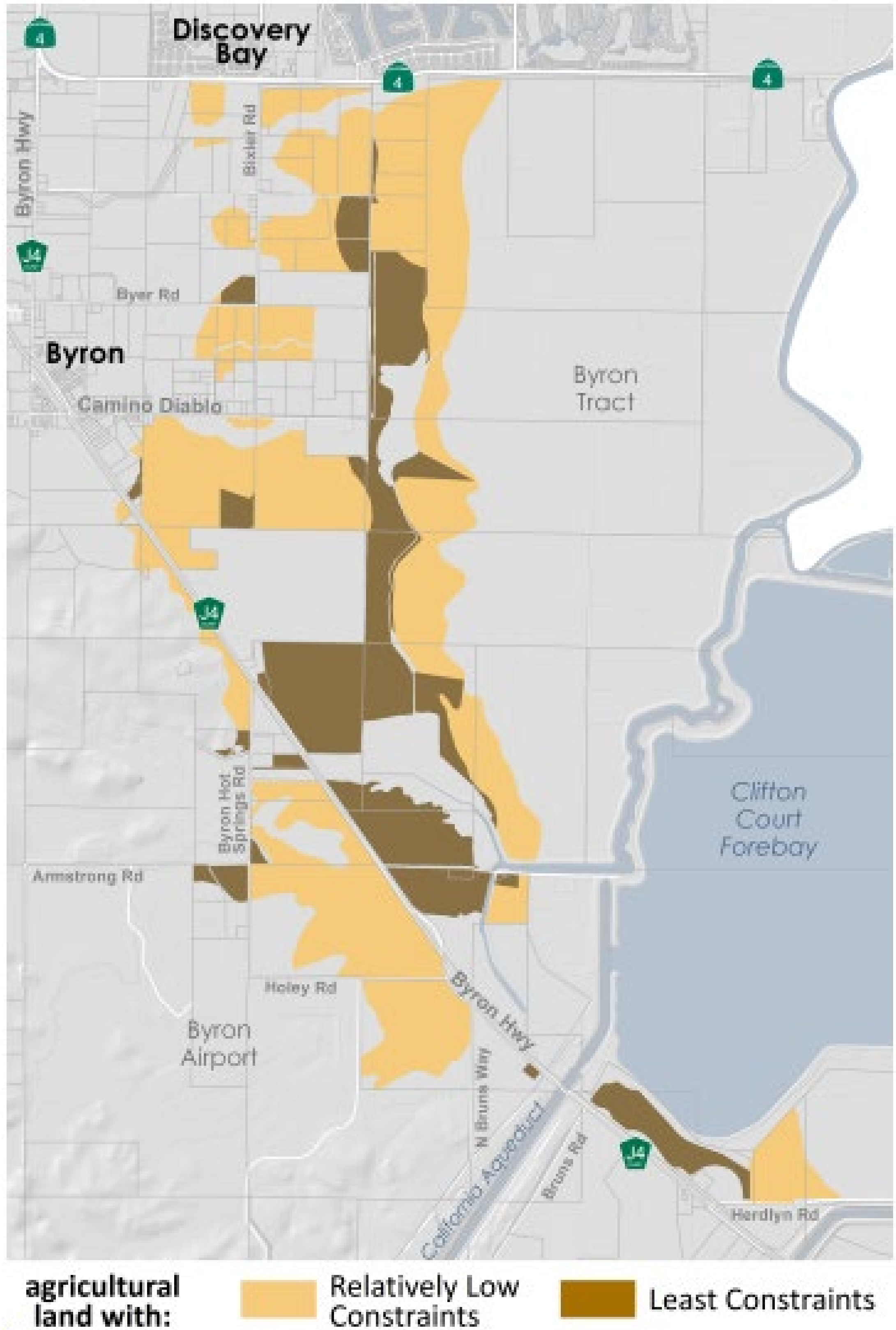


Figure 20. Agricultural Land of Relatively Low and Least Constraints



3.2.5. Indicative Economic Potential

The determination of sites most financially attractive for solar remains a task for the solar developer community. However, to provide input for County policy deliberations, this study compares rough financial desirability at a high level for the four types of described solar resources. Such a comparison was necessary to help the County understand the approximate resource available at different cost tiers.

Table 10 compares and contrasts characteristics for these four types of solar installations. Installation costs posed a primary consideration, directly affecting total electricity costs for consumers. Larger-scale ground mount solar present the lowest-cost resource; residential and parking lots, at a lower scale, are almost twice as costly (excluding land acquisition costs, which can be highly variable). For ease of comparison, all costs are on a third-party financing basis; costs can be significantly lower upon purchasing a system outright.

The table also compares land acquisition cost considerations, slopes, interconnection costs, net metering, and project timing between the four solar installation categories.

Actual costs will depend on many factors that cannot be estimated on a site-by-site basis within this study's scope (such as land acquisition or lease costs, site prep and engineering work, underlying soil conditions and foundations, transmission and distribution upgrades or costs, rooftop structural reinforcements, availability of easements if connecting substations are not adjacent to the property, and other factors). Costs shown in the table are indicative of the project class, not any specific installation.

Several installation trends will likely influence the identified types of solar (e.g., rooftop, parking lot, ULUTBD, agricultural/rural) developed most rapidly in the coming decades:

- Sites with the lowest costs are most attractive
- Large sites may encounter delays associated with transmission queues, or PG&E may not be able to accept further solar without storage, which itself may take some time to implement
- Parking lots have traditionally taken a 1% to 4% market share of the overall PV market due to their higher costs
- Commercial rooftop projects have averaged roughly 10% of the market due to higher complexity and split incentives[62] barriers (as many businesses rent their space)
- Interest rates have been at historical lows, but are currently rising, which may slow market development
- Policy at national, state, utility, and local levels may accelerate or slow market development

Absent major policy changes, the relative share of parking lot, rooftop, and primary-use ground-mounted solar can be assumed to not change rapidly in the County.

[62] Split incentives occur when solar benefits in the form of lower tenant utility bills do not accrue to the owner. As a result, owners tend to not install solar unless benefits can be shared with the tenant.

Table 10. Factors Affecting Economic Viability of Solar Projects, by Project Type

	Rooftop	Parking lots	Ground Mount		Rationale
			Unlikely to be developed	Agricultural land / Delta Islands	
Land acquisition (and potential mitigation) cost	Lowest (assumed to be zero)	Lowest (assumed to be zero)	Low to Medium	Low to Medium (excluding the most valuable ag land)	Agricultural land value is driven by quality as agricultural land. Land unlikely to be developed is assumed to be inexpensive because it is undesirable sites or sites with other problems. However, it may come with mitigation/cleanup responsibilities.
Slope	Not an issue	Assumed sufficiently flat (<10% slope)			Already filtered for slope. Projects could be done on more significantly sloped land, but at higher cost.
Interconnection cost	Lowest			Highest	For the purposes of this report, interconnection costs are assumed strictly proportional to distance to substation. Assumption is that substations are more likely to be near population; rural areas may have longer distances.
Scale	Smallest	Variable		Assumed to be largest	Sites within urban areas are generally surrounded by other uses and tend to be smaller. The chance of acquiring a large amount of developable land within the ULL is extremely low - economics will drive toward higher value uses. Smaller scale tends to drive the cost per watt higher.
Cost per kW of labor and parts (e.g., panels and balance of system)	High ($3.23/W,[a] $0.17/kWh)	Highest ($3.53/W, $0.15/kWh)	Lowest ($1.66/W, $0.10/kWh) (excluding any mitigation that may be required)		Parking lots canopies cost more than other types and tend to be smaller on average than the other site types; rooftop retrofits are more costly because installation size is small and fixed costs must be spread over a smaller project.
Net metering (non-wholesale)	Depends on ownership and surroundings			Not likely	Nearby building energy consumption affects net metering potential. Landlord/tenant split incentives may create challenges in some urban settings.

[a] All costs in this table are cited as cost per installed watt of DC power and converted to an expected “levelized cost of electricity” (LCOE) per kilowatt hour.
Sources for costs: Residential: Energy sage and Vivint.com | Ground mount: NREL’s Solar Advisory Model

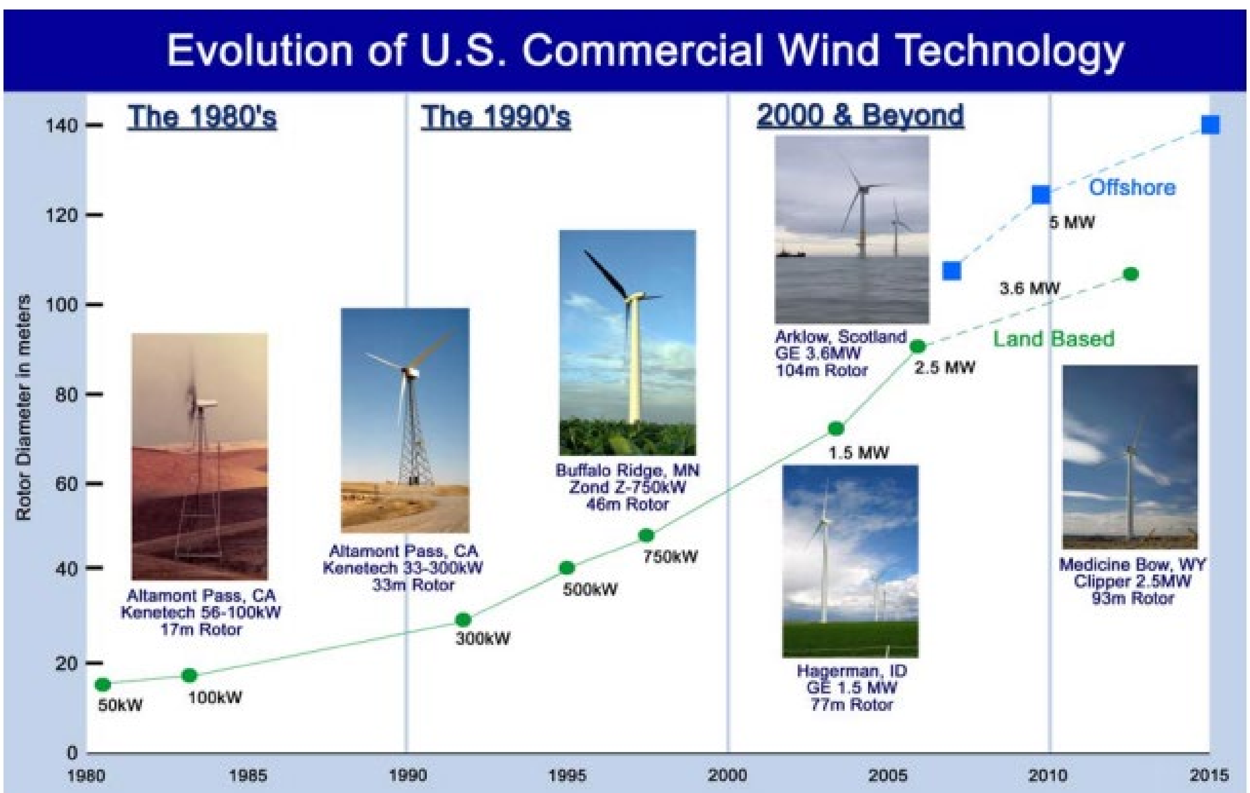
3.3. Wind

Stakeholder discussions around wind power indicated that the study did not require a quantitative estimate of total wind power available. The County wishes to understand broadly the available technologies and whether these can be considered as viable resources. A key rationale for limiting the quantitative focus on wind power is that the County has maintained a wind ordinance since the mid-1980s, and, according to County planners, has not received inquiries regarding zoning permits for wind in the designated areas. Nonetheless, a significant wind resource exists in the County, and the County deemed it important to assess what elements might contribute to wind development.

3.3.1. Large Wind Farms

One of the earliest large-scale wind farm areas in the country, the Altamont Pass Wind Resource Area straddles the border of Contra Costa County and Alameda County. Wind turbine technology has significantly improved since the mid-1980s, with power generated by a single turbine increasing 25X as individual turbine sizes have increased 5X, sharply reducing power costs and improving efficiency. The performance of these turbines and the issues that they raise can provide the County with a useful context in evaluating wind power. In particular, controversy surrounding raptor deaths at Altamont Pass and associated shutdowns during winter months suggest potential hurdles that may affect wind siting throughout the rest of the County.

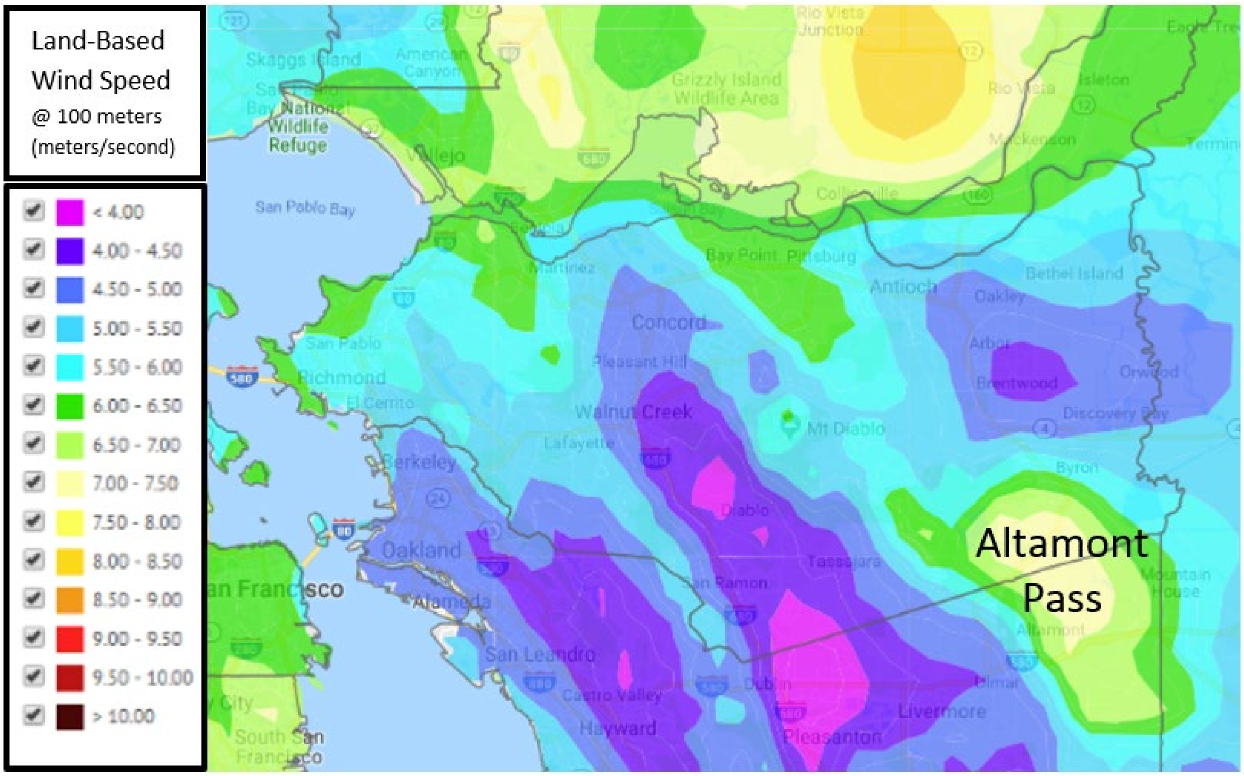
Figure 21. Wind Technology Evolution



Source: Thresher, Robinson, and Veers. "The Future of Wind Energy Technology in the United States", October 2008, NREL.

As shown in Figure 21, decades ago wind technology required relatively high wind speeds for large wind plants to be economically viable; the Altamont Pass wind farms are located in an area averaging 7 meters per second annually (class 3). Rotor diameter and tower heights, however, have increased five-fold, and low wind speed technology has improved, with 6 meters per second at higher 100-meter hub heights now economically viable in areas with transmission available.[63] Figure 22 shows these areas in green, white, and yellow, including significant portions of the Northern Waterfront.

Figure 22. Contra Costa County Wind Potential. Source: NREL Wind Prospector



The map indicates two main potential areas for large-scale wind projects, apart from Altamont Pass, which has already been developed. These potential areas include most significantly, **the industrial buffer lands east of Rodeo and the hills west of Bay Point**, both along the County's Northern Waterfront. While additional areas of average wind speeds greater than 6 meters per second are displayed at other locations along the Northern Waterfront, these were not studied due to anticipated engineering difficulties and ecological resource constraints (in the case of the northernmost Delta Islands, Bradford Island and Webb Tract, which are both substantially below sea level on soil prone to

[63] p 64, Chapter 2, "Wind Vision: A New Era for Wind Power in the United States", US DOE, Mar 2015, https://www.energy.gov/eere/wind/maps/wind-vision

subsidence) and due to their location within city boundaries (in the case of the waterfront west of Rodeo) and therefore being outside of the County's jurisdiction.

The two sites identified above were also subjected to screening to ensure that they had enough undeveloped land to accommodate at least 10 MW of wind. While most large-scale wind farms in the United States are 120 MW or above, due to multimillion dollar development costs, successful large-scale wind farms can be as small as 10 MW.[64] Using a rule of thumb that 45 acres are required per MW,[65] it was determined that both sites had enough available land for consideration. Nonetheless, it is worth noting that substantial hurdles may preclude the development of these sites, not the least of which being that the cost of transmission studies, wind studies, land acquisition, permitting, environmental impact studies, local approvals, and other costs must be amortized over a relatively small energy output compared to most wind projects.

To determine the amount of available area in each of the locations, several exclusion factors were applied, including avoiding regional parks and planned parks, avoiding important habitat corridors, avoiding locations slated for development, avoiding locations within city boundaries, and avoiding militarily owned land.

Table 11 shows the total potentially suitable undeveloped area for both these sites after the above factors were accounted for. It also shows that each of these locations is very close to substations,[66] which may be a favorable factor in their suitability.

Table 11. Contra Costa Large Scale Wind Potential

Region	Potentially Suitable Undeveloped Area (acres)	Transmission Distance (miles)	Wind Technical Potential (MW)
Industrial buffer lands east of Rodeo	580	<1	13
West of Bay Point	997	<1	22
Total	**1,600**		**35**

In addition to the above wind potential, potential exists to upgrade use of the Altamont Pass land by repowering existing wind farms. Turbine rotor diameters have quintupled, tip speeds have slowed, and output power has improved 100-fold compared to wind turbines first installed in the 1980s. The latest

64 See https://www.windpowerengineering.com/wind-project-map/; while there are a few <10 MW turbine projects in California, wind farms tend to start at 10 MW and up.

65 https://www.nrel.gov/analysis/tech-size.html

66 As with solar, proximity to transmission lines plays a key role in large-scale wind project siting, as it costs roughly $1 million/mile if transmission line capacity is not already available. Refer back to Figure 11 for a transmission line and substation map for Contra Costa County, indicating high-voltage transmission lines lie relatively close to all of these areas, generally at less than one mile.

Contra Costa County project to repower the Altamont Pass was the 78 MW Vasco repowering project in 2011. Because fewer turbines are needed to produce the same or more power, repowering reduces bird fatalities according to the 2010 settlement agreement.[67]

3.3.2. Small-Scale Wind

Large-scale and small-scale wind projects differ in multiple ways:

1. Smaller tower heights and turbine rotor diameters sharply increase costs. Per KW, small wind projects generally cost four to five times more to install than large-scale wind projects. A quote received from a vendor of 10-kW small, vertical axis, wind turbines required $80,000 just for the turbine alone (not including site prep, electrical, structural, permitting, or interconnection costs).[68]
2. Due to higher costs, small-scale wind should be matched to local electricity consumption that can absorb the wind electricity generation on site as opposed to selling it wholesale.
3. Technical potential remains extremely sensitive to local topology, including nearby buildings; and the fixed cost of measuring wind potential is relatively expensive for smaller projects.
4. Nearby residential neighborhoods may object to wind turbines' noise as well as the wind turbines' aesthetics.

A thorough assessment of technical potential of roof-mounted and small-scale wind would require an analysis level beyond this study's scope, given small-scale wind's extreme sensitivity to local wind variability. In general, the presence of ground, buildings, and trees reduces wind speeds sharply and with high variability due to turbulence—one reason that tower heights have generally increased over time.

Technical trends are as important as wind resource potential quality. Wind technology providers discovered that turbine wind power output is proportional to the rotor diameter cubed. The resulting dramatic increase in turbine diameter size enabled wind power to become one of the lowest-cost power sources available in the United States today.

Such large turbines, however, are not appropriate or safe when mounted on buildings. Designs restricted to lower-turbine diameters therefore have lower power output per turbine and higher costs. These reasons explain why roof-mounted wind has not become commonplace in the County. Therefore, it is more appropriate to qualitatively describe the potential posed by roof-mounted and small-scale wind, noting that, in future years, technology innovation and policy design could lower costs and/or

[67] Vasco Winds Repowering Project, Final Environmental Impact Report, April 2011. Also see Alameda County's website regarding Altamont Pass project activity: https://www.acgov.org/cda/planning/landuseprojects/windturbineproject.htm

[68] Krista Rigsbee, Constructive Systems. Email communication, 2018-09-06

encourage a diversity of renewable resources with multiple generation profiles, making small wind an attractive opportunity for property owners.

Roof-mounted wind applications vary significantly regarding technology, form factors, and wind-speed requirements. Roof surfaces in urban environments experience highly variable wind resources based on their locations relative to street canyons, wind shadows from adjacent buildings, and the roughness of the urban environment's terrain.[69] Small wind feasibility may depend on a property owner's willingness to site microturbines at optimal heights above roof ridges, and a roof's optimal shape. Additionally, feasibility may be affected—positively and negatively—by neighbors' construction practices.

Buildings in less dense areas of the urban environment (e.g., buildings surrounded by large parking lots or fields) and buildings near the edge of a developed area may present promising locations. Such buildings, on average, may present fewer obstructions to steady and higher-velocity wind. These types of buildings may also be desirable for additional reasons, such as a reduced density of neighboring uses (which can, in turn, affect a small wind project's wind speed). Shadow flicker, glare from solar reflection from turbine blades, and noise emitted by small turbines all may disturb occupants of neighboring buildings. As such, small wind may be less desirable for residential neighborhoods or office settings pending the location of the turbines and their shadows. On the other hand, careful study can identify roofs where small wind is unlikely to cause any neighbor complaints, and noise suppression technology continues to improve.

Another challenge presented by small wind arises from a wind resource inherently more variable and less predictable than solar within the County; small wind is typically of a scale that cannot support the detailed and lengthy studies required to determine whether small wind would be economical for any specific roofline. Average shading can be assessed with a single site visit and knowledge of the surroundings (e.g., whether affected trees are deciduous), but wind varies hourly and seasonally. Local residents and property owners, however, may have strong contextual knowledge about wind speeds from their experience over the years, allowing them to make educated guesses that do not necessitate a multi-season anemometer study.

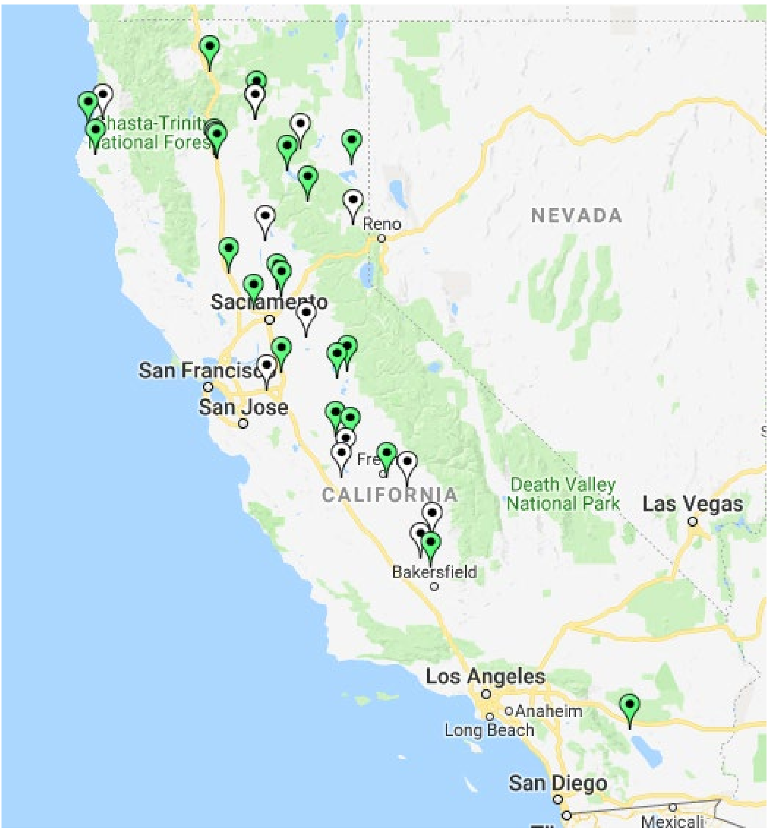
Given these resource measurement difficulties, the relatively low wind speeds throughout the County (excepting, as noted, Altamont Pass), the technology's commercial status, and the much higher costs of small-scale wind projects, this study omits small wind. Despite this, some applications within the County make economic sense. For example, a water pump far from an electric grid distribution line can receive power from a small wind turbine, avoiding the cost of a new distribution line. Still, in general, small wind will likely remain at the demonstration scale until significant breakthroughs reduce these barriers and make this generation source competitive with large-scale wind, solar, and natural gas.

69 https://www.sciencedirect.com/science/article/pii/S0378778811001101

3.4. Biomass

While this resource assessment focused primarily on solar, significant biomass resources in the County offer an advantage in being dispatchable (e.g., they can operate at any time). On the other hand, air emissions are a notable disadvantage. With California forest fires increasing in extent and ferocity,[70] over 50 million dead trees in California can provide fuel for the biomass industry, but which are not prevalent in Contra Costa County.[71] While economic conditions remain unfavorable for biomass-based electricity at present, this resource assessment establishes the potential for biomass-based power if these conditions improve.

Figure 23. Biomass Facilities in California



Green = Active. White = Idle. Source: http://www.calbiomass.org/facilities-map/

3.4.1. 2018 California Biomass Market Status

California permits 34 biomass facilities to operate within the state, but only 22 of these are active, as shown in Figure 23. None of these facilities are located in Contra Costa County, with the closest idle

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70 See, for example, https://www.axios.com/fires-rage-with-no-regard-for-season-1513206927-2f9644ce-e9b0-4225-8737-d2e3c73f66d8.html

71 http://www.latimes.com/local/california/la-me-sierra-tree-mortality-20161129-story.htmlhttps://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd537991.pdf

facility in Tracy, and the closest active facility in Stockton. As discussed in the market status section, the total wholesale cost of biomass-based electricity generation is higher than the nuclear, natural gas, solar, hydro, or wind sources that power Contra Costa County currently, as shown earlier in Table 5. At present, solar and natural gas-based power—the fastest-growing generation sources in Contra Costa County—are both 25% less expensive than biomass. Therefore, utilities seeking to lower electricity costs for consumers favor retirement of biomass plants as their long-term biomass power purchase agreement (PPA) contracts expire.

3.4.2. Biomass Resources in Contra Costa County

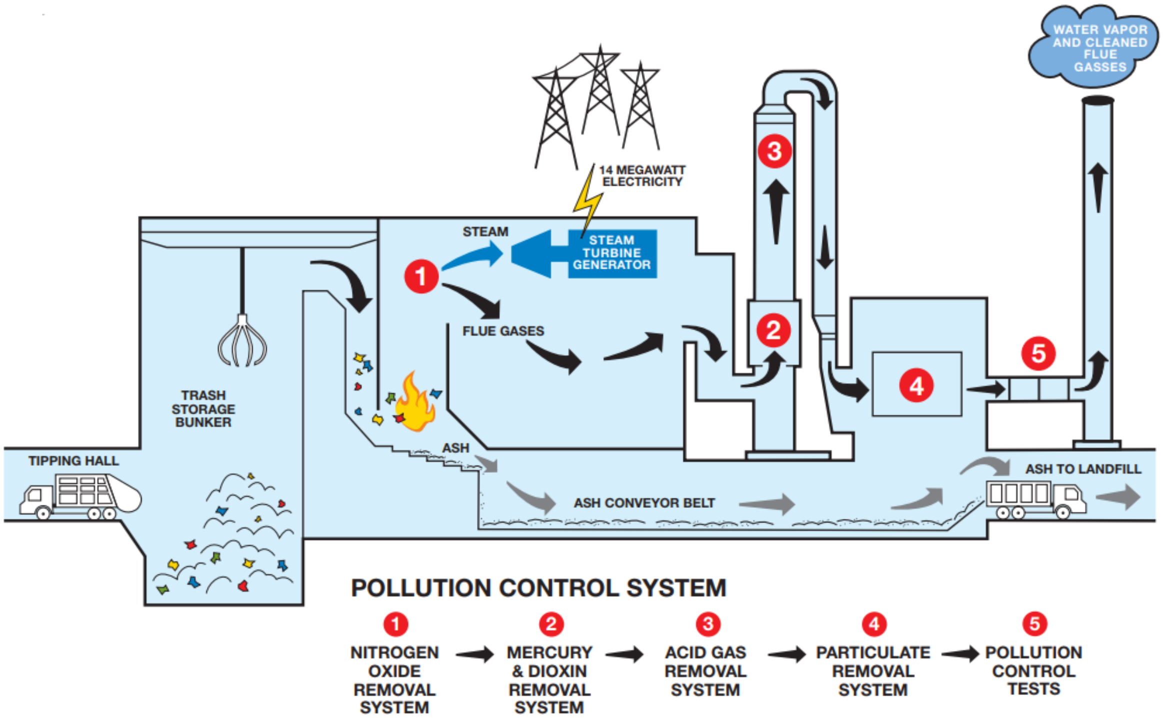
Contra Costa County has a wide variety of plant and animal waste materials for potential use in generating electricity. Principle sources include the following:

- Agricultural waste (corn husks, plants)
- Wood waste (chipped up shrubs/landscaping/yard waste, and construction and demolition wood waste)
- Compost (food waste, manure, other green waste)
- Forest slash (dead trees, brush)
- Landfill waste

Anaerobic digestion composting processes produce methane gas, as do landfills as waste slowly decomposes in place. Similarly, wastewater sludge can be processed by anaerobic digesters to produce methane. Though the following biogas section considers these processes and sources, this resource assessment's scope does not include biomass crops used to produce fuel (e.g., corn for ethanol, experimental algae, experimental cellulosic crops), as these sources are de minimis in the County.

In all cases, the study assumed the above waste would be burned, releasing heat to boil water to generate steam and then electricity, akin to power generated by coal-fired power plants.

Figure 24. Biomass Power Plant



Source: https://archive.epa.gov/epawaste/nonhaz/municipal/web/pdf/processdiagram-2.pdf

Incinerating waste reduces its volume approximately four-fold, reducing landfill volumes in addition to generating electricity. Two landfills operate in Contra Costa County, and the in-County landfills have at least 48 years of disposal capacity remaining as of December 2017, according to CalRecycle (see CalRecycle report "State of Disposal in California Updated in 2016"[72] for further information on waste stream movement within the state and for further context regarding waste movement in California).

Agricultural Waste

To estimate acres of land used for various crops, Cadmus used the County's public, crop-specific pesticide use records for 2016–2018.[73] Table 12 shows the planted acreage.

[72] CalRecycle, "State of Disposal in California Updated in 2016", Feb 2016, http://www.calrecycle.ca. gov/ publications/Documents/1556/201601556.pdf

[73] The Permittees 2017.xls file (www.co.contra-costa.ca.us/6243/download-pesticide-use-data)

Table 12. Agricultural Waste Available

	Total Acreage	Total Bone Dry Tons(BDT)/Yr	MW Generation Capacity
Nuts	28,000	20,580	2.79
Corn For Food	7,369	14,886	1.78
Wheat	4,161	3,391	0.40
Corn, Human Con	3,287	6,641	0.79
Tomato Process	2,819	148	0.02
Safflower	2,749	1,004	0.13
Grape, Wine	2,612	2377	0.31
Cherry	1,201	219	0.03
Wheat for Food	875	713	0.08
Tomato	847	44	0.01
Olive	813	558	0.08
Walnut	656	482	0.07
Totals			**6**

Using the crop acreage estimates, Cadmus calculated available biomass feedstocks based on factors from the latest 2008 California Energy Commission (CEC) biomass resource assessment,[74] which provides estimates of the bio-waste tonnage generated per acre and the amount of this tonnage available for combustion; this varies from 5% to 70% of the total tonnage, depending on the crop.[75] Crop wastes must be dry prior to biomass combustion, and each crop has different dry weight percentages, ranging from 14% to 35%. Applying this factor yields the total amount of bone-dry tons per year, serving as the basis for calculating megawatts of generation capacity.

The 2008 CEC study also estimates the heating value for each biomass material type in BTU/BDT (bone dry ton). The right-most column in Table 12 estimates the MW generation capacity per crop, using a 20% efficiency of conversion to electricity and an 85% capacity factor.[76]

Summing Table 12 produces the total generation available from agricultural waste in the county: 6 MW of capacity. Though a value 50% higher than the previous 2008 CEC study results, the value should be more accurate as pesticide use directly correlates with land in agricultural use.

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74 Williams Jenkins, and Kaffka. "An Assessment of Biomass Resources in California, 2007, 2010, and 2020", California Energy Commission, Dec 2008, CEC-500-2013-052

75 Soil must be replenished with some of this waste, therefore not all of the tonnage listed above is available for combustion.

76 See Chapter 3, footnote 52, p 96-105, for calculation details.

Wood Waste and Forest Slash

As shown in Table 13, CalRecycle compiles a list of facilities permitted to operate as wood chipping facilities.[77]

Table 13. Contra Costa County Wood Chipping and Grinding Facilities

SWIS Number	Name	Tons / Yr	Facility Description
07-AA-0059	Fahy Tree Service	50,000	Grinds incoming materials through portable grinders. Processed materials are shipped to various customers that use it in various markets.
07-AA-0061	Green Waste Recycle Yard	1,200	Accepts whole trees, culled logs, and brush to divert from landfills, material is stored at the site until it can be processed/converted and reused as recycled mulch, dimensional lumber, or wood fuel.
07-AA-0062	Woodmill Recycling Company	18,525	Accepts yard trimmings, untreated wood waste, natural fiber products, and construction/demolition (C&D) wood waste. Mechanically chipped, ground, screened, and processed material is then removed from the site.
07-AA-0067	Hamilton Tree Services, Inc.	12,000	Screens arbor mulch into two natural sizes and color with non-toxic colorant and sold to retail. Some go to co-generation or logs to saw. On occasion, material ground on site to produce more wood chips.
07-AA-0069	Expert Tree Services	1,500	Green waste, wood chips, stumps, and C&D wood waste, staged and processed for further recycling and reuse.
07-AA-0070	Atlas Tree Service, Inc.	2,600	Removed plantings, hedges, and shrubs are ground and sent out to biofuel plants.
07-AC-0044	CCW Wood Chipping / Grinding	25,000	Accepts green materials and untreated wood (max. 200 tons per day) for chipping and grinding operations.
07-AA-0072	Pacific Wood Recycling	156,000	Chipping and grinding facility

Facility descriptions clearly indicate that ground-up material goes to a variety of outlets— landscaping use (as mulch), wood fuel for home heating, or incineration for electricity in a biomass plant. If all this material were diverted to electricity generation, current chipping facilities waste streams represent 270,000 tons of material. An assumed 42% moisture,[78] a 15 MJ/kg heating value for the fuel, 20% conversion efficiency, and 85% capacity factor[79] equates to 640,000 MWh/year heating value of generation potential, or 26 MW.

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77 http://www.calrecycle.ca.gov/SWFacilities/Directory/SearchList/List?COUNTY=Contra+Costa

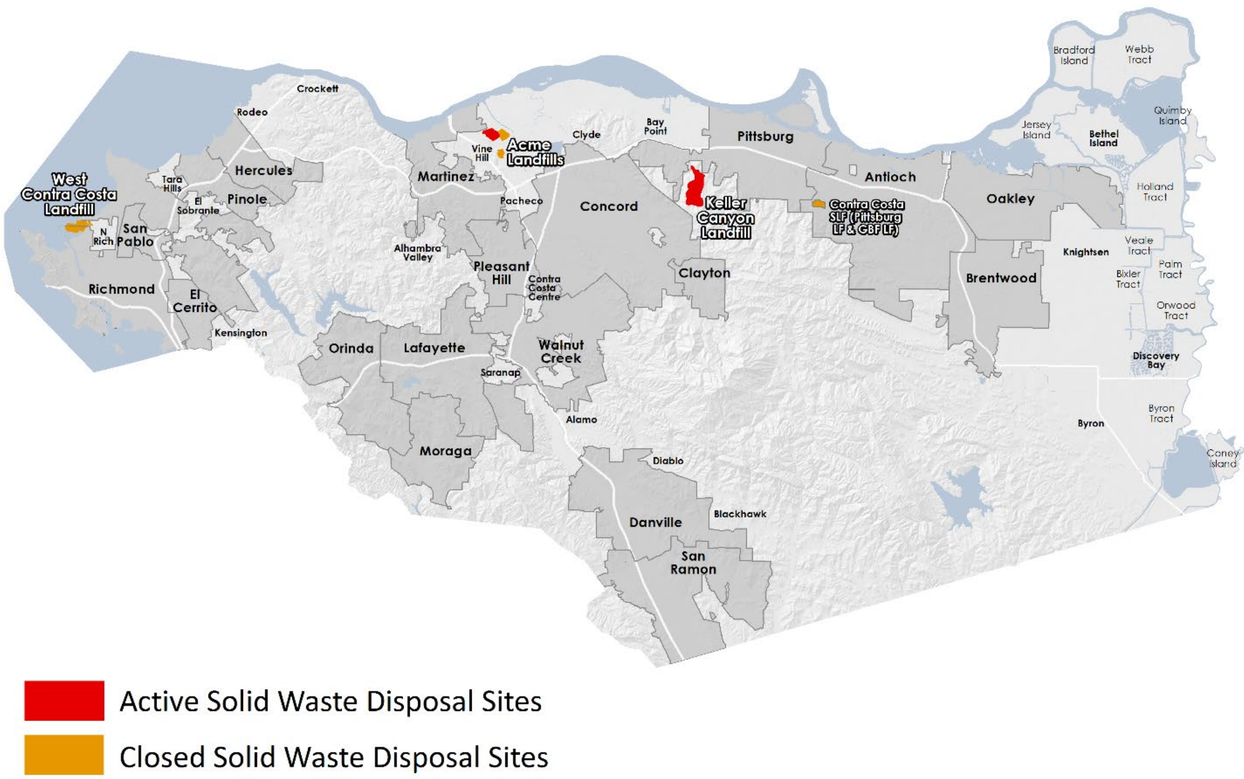
78 Per the U.S. EPA, wood chips green vs. dry: https://www.epa.gov/sites/production/files/2016-04/documents/volume_to_weight_conversion_factors_memorandum_04192016_508fnl.pdf

79 See footnote 52 for these values and calculation details.

Landfill Waste

As shown in Figure 25, two active landfills operate in the County.

Figure 25. Contra Costa County Active Landfills



Source: Google maps, accessed 7/25/2018

The Keller Canyon landfill (located between Concord and Pittsburg) processes approximately 2,370 tons/day,[80] while the Acme Landfill (in Martinez) processes 56 tons/day.[81] In total, the study calculates these landfills process 0.79 million tons annually.[82] In the absence of readily available data on the amount of landfill waste exported from and imported into the County, an estimate of the refuse available for incineration may be better sourced from estimates of the population's per-capita waste generation. CalRecycle estimates a 10-year average per-capita landfill disposal rate of 4.7 lbs/capita/day

80 Cal Recycle Annual Report, 2017, based on average rates for 2015-2017

81 Ibid.

82 Assuming 307 and 256 days of operation per year for the Keller Canyon and Acme landfill respectively. This calculation matches closely with data provided by the County indicating that 0.77 million tons and 0.80 million tons were disposed of at these facilities in 2016 and 2017, respectively.

in California.[83] With a population of 1.127 million people, this equates to 1 million tons of waste disposed of annually.

With 19% moisture assumed, a 12.9 MJ/kg heating value of the fuel, 20% conversion efficiency, and 85% capacity factor,[84] this equates to a 2,300,000-2,900,000 MWh/year heating value, with 62-78 MW available.[85] Note that some proportion of the wood waste/forest slash chipped up and ground also may find its way into the County's landfills. The study did not attempt to quantify the extent to which Contra Costa County exports or imports landfill waste.

3.4.3. Technically Available Biomass Resources Summary

Table 14 summarizes the above analysis and compares total results to the latest 2008 California Energy Commission (CEC) biomass resource assessment.[86] The County, without regard to economics, air emissions, or other considerations, could generate 2.7-3.8 million MWh/year heating value from technically available biomass resources. This is double the amount found in the 2008 CEC study, despite using more conservative energy conversion assumptions (i.e., 20% vs. 30% conversion efficiency). The difference is primarily driven by higher levels of landfill use than that assumed a decade ago.

Table 14. Technically Available Biomass Contra Costa County

	MWh/year Heating Value	MW Capacity	2008 Study[a]
Agricultural[b]	120,000-240,000	3-6	4
Wood Waste[c]	105,000–420,000	4.2–17	1
Landfill Waste	2,300,000–2,900,000	62-78	39
Total Biomass Resource	2,700,000–3,800,000	71-110	44

[a] Table 88, Williams Jenkins, and Kaffka. "An Assessment of Biomass Resources in California, 2007, 2010, and 2020." Table 88. California Energy Commission. December 2008. CEC-500-2013-052

[b] The lower end of this range is based on assuming only 50% of crop residues are available to be incinerated, with the rest being used to replenish the soil.

[c] The lower end of this range is based on assuming only 25% of wood waste would be incinerated, whereas the upper value assumes 100% would be incinerated. Alternate uses include landscaping mulch, landfill cap/fill, and home heating.

83 http://www.calrecycle.ca.gov/LGCentral/goalmeasure/disposalrate/Graphs/Disposal.htm

84 See footnote 52 for these values and calculation details.

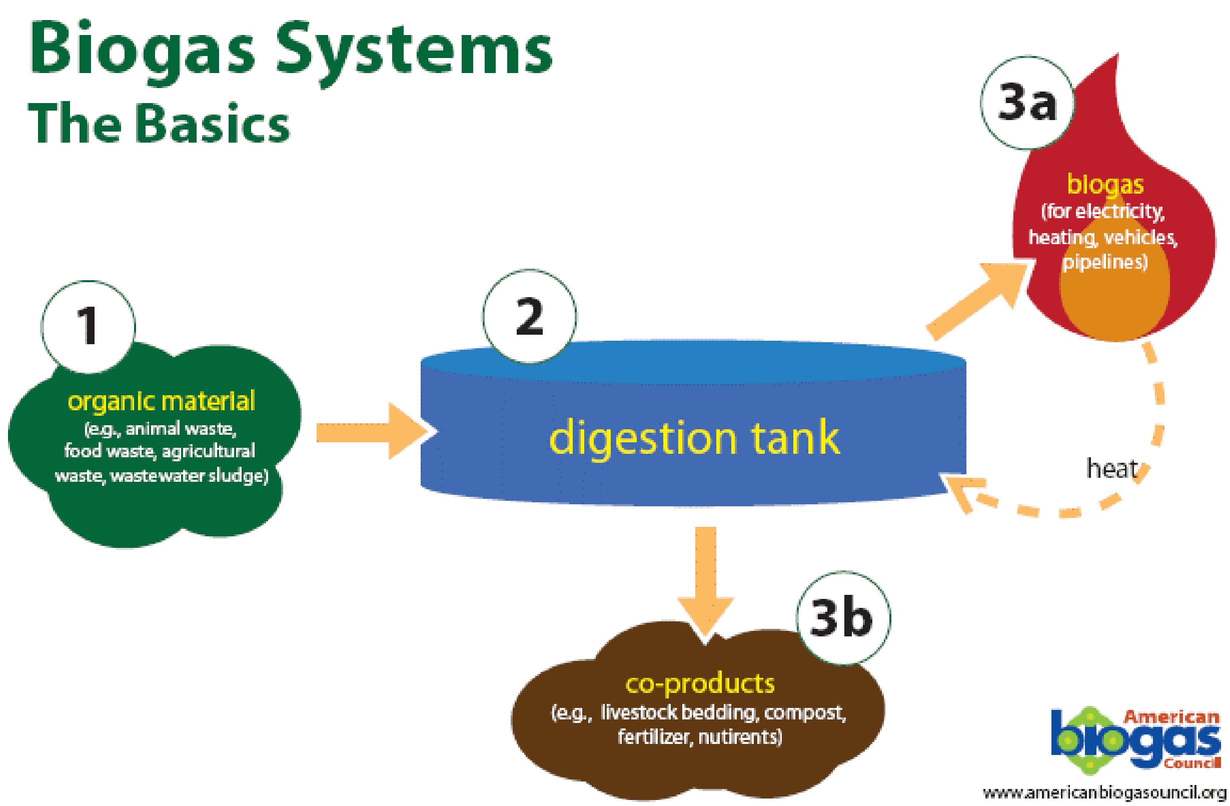
85 If this calculation is instead done using the volume from the County's active landfills (assuming no net export of landfill waste), a slightly higher heating value and capacity is obtained, 3,830,000 MWhr/year or 103 MW at 85% capacity factor. Our results present the range between these two estimates.

86 Williams Jenkins, and Kaffka. "An Assessment of Biomass Resources in California, 2007, 2010, and 2020", California Energy Commission, Dec 2008, CEC-500-2013-052

3.5. Biogas

As shown in Figure 26, anaerobic digestion (AD) is the primary process used for producing biogas, with the resulting methane-containing gas mixture then burned to produce electricity. AD process feedstocks include animal manure, wastewater sludge, and industrial fats, oils, and grease. In addition to these sources, landfill methane off-gassing directly produces biogas that can be burned for power. In addition to electricity uses, biogas can also be purified (removing sulfides, siloxanes, and CO_2) and compressed, and then be used as a vehicle fuel or injected directly into the natural gas grid.

Figure 26. Anaerobic Digestion Schematic

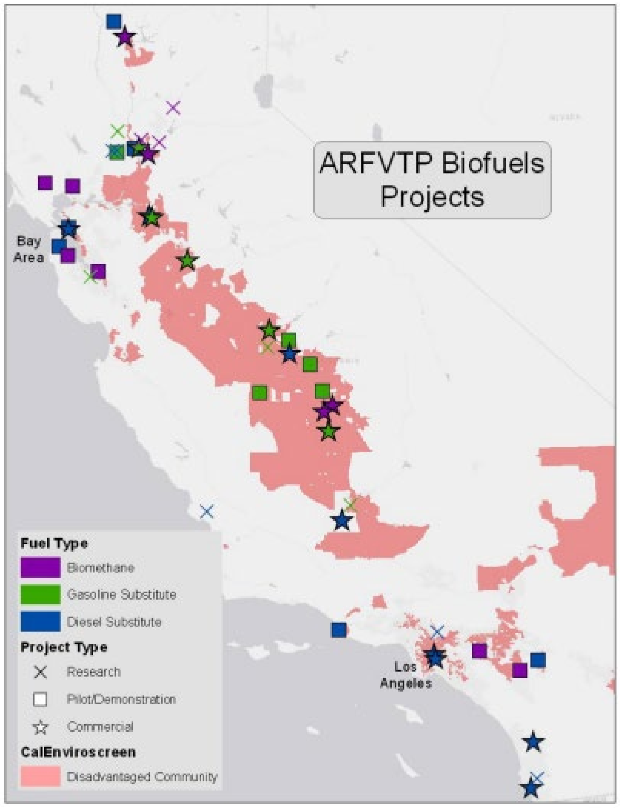


Source: https://www.americanbiogascouncil.org/biogas_what.asp

3.5.1. 2018 California Biogas Market Status

Though the biogas market remains nascent in the United States, California serves as a center of this activity. Figure 27 shows locations of current research project pilots in the biofuel/biomethane space. In addition to research, demonstration projects are being conducted in Contra Costa County. For example, Contra Costa Waste Services partners with the Food Bank of Contra Costa and Solano to increase the volume of organic waste sent to existing anaerobic digesters, reducing landfill waste tonnage.[87] The Keller Canyon landfill also burns its off-gas methane to produce electricity.

Figure 27. Biofuel Research Projects in California



Source: Tim Olson, "California Biofuel/Biomethane Projects from Waste Residues", CEC, USDOE workshop, June 2017, https://www.energy.gov/sites/prod/files/2017/07/f35/BETO_2017WTE-Workshop_TimOlson-CEC.pdf

3.5.2. Biogas Resources in Contra Costa County

As discussed, Contra Costa County has a wide variety of anaerobic digestion feedstocks and landfill off-gas that can potentially be used to generate electricity. The principle biogas sources include the following:

- Animal manure
- Compost
- Food waste
- Waste-water sludge

[87] Erin Voegele, July 2018, "CalRecycle funds anaerobic digestion projects", http://biomassmagazine.com/articles/15432/calrecycle-funds-anaerobic-digestion-projects

- Industrial fats, oils, and grease
- Landfill methane off-gassing

For this study to more directly compare to the above solar, wind, and biomass resource assessment, Cadmus assumed all these sources will produce biogas that can be burned to produce electricity. Contra Costa County's total greenhouse gas emissions may be more effectively reduced by using these resources to produce transportation fuels, thereby decreasing the County's mobile source emissions (rather than generating electricity). As the County considers utilization of its biogas resources, these tradeoffs should be considered.

Animal Manure

While the County supports 20,000 cattle,[88] these do not include dairy cows.[89] To economically collect manure, cattle must be located in central locations rather than spread out over 15,000 acres[90] of range and pasture land. Therefore, cattle manure is not calculated as a feasible source of biogas in the County.

Compost—Wood Waste and Other Organics, Excluding Food Waste

The West Contra Costa Sanitary Landfill (WCCSL) Compost Facility is permitted to process 1,134 tons of organic material and wood wastes per day as feedstock for composting. The facility also is permitted to accept up to an additional 196 tons of wet wastes and dusty materials per day—not to exceed 51,000 tons per year—for transfer and processing.

While compost could be burned to produce electricity, it more commonly is used to replenish soil fertility, mulch, or provide landfill cover. Therefore, the study discounts this fuel source relative to electricity generation.

Compost—Food Waste

Currently, most food waste is part of the landfill waste stream, as discussed in the biomass section. According to the 2014 CalRecycle Waste Characterization study,[91] food waste comprises approximately 18% of the landfill waste stream in the State. California AB1826 requires large businesses to recycle their organic waste after 2016, depending on the amount of waste generated per week.

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88 Contra Costa County 2015 Crop Report, http://www.cccounty.us/DocumentCenter/View/41302/CropRpt2015

89 2012 census of agriculture contra costa county profile, USDA, https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/California/cp06013.pdf

90 Per pesticide records for 2016-2018 for the County.

91 https://www2.calrecycle.ca.gov/WasteCharacterization/Study

With 70% moisture assumed, a 5.2 MJ/kg heating value of the fuel,[92] a 20% conversion efficiency, and an 85% capacity factor,[93] this equates to 102,833 MWh/year heating value of generation potential, or 2.8 MW.

Wastewater Treatment

Water resources in the County are apportioned by basin and water supply infrastructure and are somewhat fragmented.

Table 15 shows results from a search for water treatment plants for each of the County's water districts, conducted to assess their nominal capacity.

Table 15. Contra Costa Wastewater Treatment Facilities

Water Treatment District/Plant	Capacity (million gallons/ day)	Source/Comment
		East Bay Municipal Utility District
EMBUD Wastewater Treatment Plant	320	http://www.ebmud.com/wastewater/collection-treatment/wastewater-treatment/
		Central Contra Costa Water District
Town of Discovery Bay Community Services District	4.5	https://www.todb.ca.gov/wastewater-services
		Delta Diablo
Delta Diablo WTP	19.5	https://www.deltadiablo.org/about-us/about-us
		West County Wastewater District
WCWD WTP	12.5	http://www.adaptingtorisingtides.org/wp-content/uploads/2015/12/WCounty-Wastewater-PollutionCtrlFac_PS_120315.pdf
		Ironhouse Sanitary District
Ironhouse Sanitary District WWTP	2.6	https://www.waterboards.ca.gov/rwqcb5//board_decisions/tentative_orders/0804/ironhouse/isd_wwtp_buff.pdf

92 Moisture content and heating value from https://www.waste360.com/mag/waste_profiles_garbage_food; Heating value is cited as 1500-3000 BTU/lb. 5.2 MJ/kg is the average of this converted to MJ/kg.

93 See footnote 52 for these values and calculation details.

Water Treatment District/Plant	Capacity (million gallons/ day)	Source/Comment
		Central Contra Costa Sanitary District
Central San WTP	54	https://www.centralsan.org/treatment-plant
		Rodeo Sanitary District
Rodeo WTP	1.1	http://www.contracostalafco.org/municipal_service_reviews/west_county_water_wastewater/6.0%20Rodeo%20San%20Dist%20Final.pdf
		Mount View Sanitary District
Mt. View Sanitary District WTP	3.2	http://www.contracostalafco.org/municipal_service_reviews/central_county_water_wastewater/7.0%20MVSD%20Water%20Wastewater%20Final.pdf
		Crockett Community Services District
Crockett WTP	1.8	**http://www.contracostalafco.org/municipal_service_reviews/west_county_water_wastewater/5.0%20Crockett%20CSD%20Final.pdf**
		Byron Bethany Sanitary District
Byron WTP	.1	**https://www.waterboards.ca.gov/centralvalley/board_decisions/tentative_orders/0902/byron/byronsd_buff.pdf**
		Individual Cities
Brentwood	5	https://www.brentwoodca.gov/gov/pw/sewer/default.asp
Richmond WTP	9	http://www.contracostalafco.org/municipal_service_reviews/west_county_water_wastewater/4.0%20City%20of%20Richmond%20Final.pdf
Pinhole/Hercules WTP	4	http://www.ci.pinole.ca.us/publicworks/treat_plant.html

This adds up to 170 million gallons per day of wastewater treatment capacity in the County. Average actual utilization is 62% of capacity, based on a few plants in the list that publish that statistic. Using technical assumptions[94] in the 2008 California biomass resource assessment,[95] wastewater in the County contains 70,000 MWh/year heating value, or 2 MW of capacity.

Industrial Fats, Oils, and Grease

As shown in Figure 28, numerous manufacturers operate in Contra Costa County.

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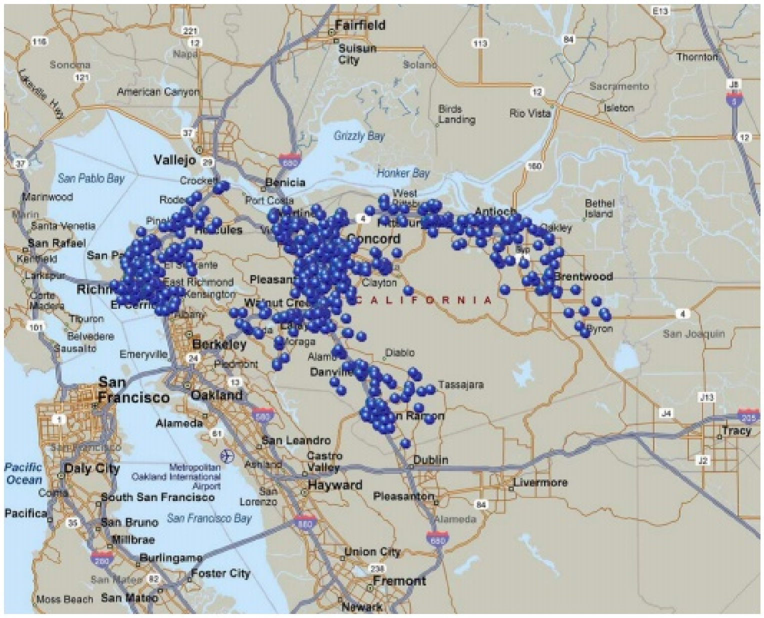
94 Namely, 169 mg BOD / liter, 80% biodegradability, .36 m^3 CH_4 / kgBOD, a heating value for sludge of 22.4 MJ/m^3, a 20% efficiency conversion factor, and 85% capacity factor

95 https://www.waste360.com/mag/waste_profiles_garbage_food, and footnote 52, for these values and calculation details.

Figure 28. Manufacturing Firms in Contra Costa County



Source: "Advanced Manufacturing in Contra Costa County", June 2013, Contra Costa County Workforce Development Board, p22.

Contra Costa County's manufacturing sector includes major manufacturing firms, such as Shell, Chevron, Phillips66, Andeavor, Dow Chemical, General Chemical Corporation, Praxair, USS POSCO, Henkel Loctite Aerospace, BEI Sensors & Systems, Giga-tronics, Bio-Rad Labs, Berkeley Process Control, MuirLab, Sun Power, and C&H Sugar, among others.[96] Given the County's wealth of manufacturing, some sources of industrial byproducts (e.g., fats and oils) may be available to burn to produce electricity. Cadmus did not attempt to quantify the generation potential associated with burning these byproducts for two reasons. First, industrial biomass sources are very industry-specific and process-specific, and determining the resource from each industrial process was not feasible on the timeline of this study. Second, because these byproducts are in some cases sent to landfills, there is a potential for double counting the electricity generation potential.

Landfill Methane

The U.S. Environmental Protection Agency maintains a database of landfill off-gassing, which the study uses to estimate existing and potential additional landfill methane electricity generation. The database annotates existing reciprocating engines, co-generation, and micro-turbine electricity generation projects operational at the County's active landfills, as shown in Table 16. Similarly, potential can be estimated by examining landfill waste-in-place at active and closed landfills in the County, shown in Table 17. CalRecycle provided a full list of waste processing and disposal facilities within the County, but only solid waste landfills were included in the study's calculations for Table 17, as many other disposal sites were land application of sludge, chipping facilities, or industrial waste disposal with unknown

96 Ibid.

suitability for methane generation. Applicable technical parameters to calculate the MWh/yr heating value and MW capacity are the same as those used above for wastewater treatment.

Table 16. Existing Contra Costa County Landfill Gas Projects[a]

Landfill	Generation		Waste in Place (Tons)	MWh/yr Heating Value	MW Capacity
Acme	Cogeneration	IC engine	10,800,000	70,737	1.9
Acme LF	Microturbine	4 70kW Ingersoll-Rand microturbines	10,800,000	10,424	0.28
Acme LF	Boiler		10,800,000	0	
Keller Canyon LF	Reciprocating Engine	(2) GE Jenbacher engines	17,641,658	141,474	3.8
West Contra Costa SLF	Reciprocating Engine	(3) Waukesha engines	14,950,000	74,460	2
West Contra Costa SLF	Reciprocating Engine	Original (3) Waukesha engines (overhauled multiple times)	14,950,000	5,585	0.15
Total					**8.1**

[a] https://www.epa.gov/lmop/lmop-national-map

Table 17. Theoretical Contra Costa County Landfill Gas Potential

Landfill	LFG Collected (mmscfd)	Waste in Place (Tons)	MWh/yr Heating Value	MW Capacity
West Contra Costa SLF	2.79	14,950,000	179,017	5
Acme LF	1.8	10,800,000	115,495	3
Keller Canyon LF	3.31	17,641,658	212,382	6
Contra Costa SLF	0.22	4,153,922	14,116	0.4
Total				**14.4**

Note that if waste is directly incinerated to generate electricity as described above in the calculation of biomass resource potential, less landfill material (waste in place) will be available to offer this capacity of methane.

3.5.3. Technically Available Biogas Resources Summary

Table 18 summarizes the above analysis, comparing the total results to the 2008 CEC study.[97] These technically available biogas resources for the County, without regards to economics or other considerations, offer 19MW of capacity.

[97] Williams Jenkins, and Kaffka. "An Assessment of Biomass Resources in California, 2007, 2010, and 2020", California Energy Commission, Dec 2008, CEC-500-2013-052

Table 18. Technically Available Biogas Contra Costa County Potential

	MWh/year Heating Value	MW Capacity	2008 Study[a]
Animal Manure	Lack of cattle concentrated collection points		
Compost	Not used to produce Electricity		
Food Waste[b]	80,000-100,000	2.4-3.0	0
Wastewater	59,500-70,000	1.7-2.0	10
Industrial Fats	Process specific, unquantified, but may be significant		
Landfill Methane Potential	408,000-520,000	11-14	14
Total Biogas Resource	**550,000-690,000**	**15-19**	**24**

[a] Table 88 and Table 103, Williams Jenkins, and Kaffka. "An Assessment of Biomass Resources in California, 2007, 2010, and 2020", California Energy Commission, Dec 2008, CEC-500-2013-052

b The low values in this table are 80% of the high values, reflecting uncertainty with regards to the percentage of food waste content in County landfills; variable actual usage relative to capacity of the wastewater treatment plants; and actual landfill outgassing of County landfills (the last measurement was in 2012, and these reduce over time).

3.6. *Overall Summary of Resource Potential*

The resources identified by this study sum to a substantial fraction of the total electricity consumption within the County. Table 19 shows the sum of estimates for each type of solar, wind, biomass, and biogas resources in Contra Costa County. While it is unlikely that the minimum or the maximum estimates are likely to be achieved in the near future, this table provides useful context as to how much could be achievable with maximum development of available resources. As described above, total electricity usage in Contra Costa County in 2016 was 9.6 million megawatt hours.[98] If the maximum technical potential was developed, this could account for 83% of total County usage (taking a more modest view of technical potential, the low, this percentage would be 50% of annual consumption).

Table 19. Contra Costa County Renewable Resource Technical Potential[a]

Type		MW Capacity		Annual MWh	
		Low	High	Low	High
Solar	Rooftops	1450	2600	2,290,000	4,100,000
	Parking Lots	180	530	280,000	840,000
	Unlikely to be Developed	120	310	190,000	490,000
	Agricultural Land with Low-High Constraints	760	970	1,200,000	1,530,000
	Total Solar	**2,510**	**4,410**	**3,960,000**	**6,960,000**
Wind	**Total Wind**	**35**	**35**	**76,700**	**76,700**
Biomass	Agricultural	3	6	24,100	48,200
	Wood Waste	6	26	48,000	192,000
	Landfill	62	78	460,000	580,000
	Total Biomass	**71**	**110**	**531,000**	**821,000**
Biogas	Food Waste	1.5	1.8	10,000	13,200
	Waste Water	1.7	2.0	12,400	15,200
	Landfill Gas:	11	14	83,400	104,200
	Total Biogas	**14**	**18**	**107,000**	**133,000**
Grand Total		**2,600**	**4,600**	**4,674,000**	**7,990,000**

[a] Includes resources located in both the unincorporated areas of the County and the cities in the County. Estimates reflect future potential and do not include current renewable generation in the County.

3.6.1. Breakout of Potential in Specific Location Types Within the County

Resource Potential in Disadvantaged Communities

In the project's next phase, the County will work with three communities within the County's unincorporated area, focusing on opportunities for community residents to benefit from renewable energy. The focus will likely be on solar and potentially on large wind, in the case of hills south and west of Bay Point. Biomass and biogas resources were not considered as potential community energy resources due to potential for increased local pollution and for odor or other nuisances.

98 http://ecdms.energy.ca.gov/elecbycounty.aspx

While this report's scope does not cover research on current incentives and regulations surrounding community solar and other renewable development for disadvantaged communities, it does summarize available resources within and proximal to census tracts identified by the State of California as disadvantaged.[99]

As noted, this study focuses on solar resources available. Therefore, the study categorized each source, regarding whether it was within CalEnviroScreen 3.0's top 25% of communities.[100]

Table 20. Disadvantaged Community Solar Potential

Type	MW Capacity		Annual MWh	
	Low	High	Low	High
Rooftops	233	339	370,000	530,000
Parking Lots	40	80	60,000	130,000
Unlikely to be Developed	30	100	50,000	160,000
Agricultural Land With Relatively Low Constraints	0	0	0	0
Total Solar	**303**	**519**	**480,000**	**820,000**
Total Wind	**22**	**22**	**48,000**	**48,000**
Total Solar and Wind	**325**	**541**	**528,000**	**868,000**

County-Owned Solar Resource Potential

In addition to the solar that is already installed on County-owned buildings, there may be significant potential for solar on additional County rooftops. The County currently has eleven interconnection agreements with PG&E for new solar installations on its facilities as of summer 2018. The County provided a full list of its real property for analysis of the total solar potential.

Appendix A contains an analysis of ~350 buildings owned by the County and which may be suitable for solar. Cadmus used Google Project Sunroof to estimate solar potential for the buildings (in the exact same manner and with the same assumptions as that used in the rooftop analysis, but for a building rather than Census Tract). Rather than conduct an analysis for all 350 occupied buildings supplied by the County, the study statistically sampled buildings, large to small, with three to five samples per size category (defined roughly into 10 categories, based on statistical distribution of building square footage). Approximately one-third of the buildings are leased, hence the study assumes split incentives

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99 Some sources that should be evaluated include grant funding available through the Sustainable Communities Planning Grants and Incentive Programs, Affordable Housing and Sustainable Communities, and Weatherization Upgrades/Renewable Energy through LEAP. Additionally, the County should evaluate how MCE plans to implement programs similar to the Green Tariff Shared Renewables Program and should conduct further research to understand community renewables' feasibility and pathways within MCE territory, including learning from Solar One in Richmond.

100 See https://oehha.ca.gov/calenviroscreen/how-use for further information on defining disadvantaged communities.

would make it more difficult to install solar on those buildings. Consequently, the report presents them separately.

Table 21. County-Owned and Leased Solar Potential

Type	MW Capacity		Annual MWh	
	Low	High	Low	High
Owned	7	11	11,100	16,700
Leased	4	5	5,600	8,400
Total	**11**	**16**	**16,700**	**25,100**

A number of these facilities can be termed "high impact" locations: libraries, community centers, and other facilities visited by the public. Solar installations at these locations could raise the profile of solar and educate the public, while potentially saving the County money on energy costs.

Additionally, as shown in the table, the 16,700 to 25,100 MWh/year that could be generated by solar on County-owned or leased rooftops could generate between 40% and 60% of the County's annual electricity consumption, which is 42,336 MWh/year. Given that the County spends approximately $7 million per year on electricity, investments in additional solar over time could help defray some of these costs.

MCE Eligible Solar and Wind Resource Potential

As discussed, most of the County falls within MCE's territory, excluding the cities of Hercules, Pleasant Hill, Orinda, Clayton, Antioch, and Brentwood. For the above solar resources, categorized by census tracts, Cadmus generated a list of MCE Feed-in Tariff (FIT)-eligible resources, excluding census tracts in these cities. Of the solar types evaluated in this study, only urban land unlikely to be developed and agricultural land with least constraints were considered for the total MCE FIT-eligible resource estimate. Rooftop solar and parking lot solar was assumed not to use the FIT as they would be net metered in most cases. Notably, the amount of solar that could be sited on these sites exceeds the available FIT queue by an order of magnitude (as of this report, MCE's FIT and FIT+ queues add up to 30 MW). All of the wind potential identified in this study is also within MCE's territory and therefore FIT-eligible.

Table 22. MCE-Eligible Solar Resources[a] in Contra Costa County

Type	MW Capacity		Annual MWh	
	Low	High	Low	High
Unlikely to be Developed	110	260	170,000	410,000
Agricultural Land with Relatively Low Constraints	760	970	1,200,000	1,530,000
Total Solar	**870**	**1,230**	**1,370,000**	**1,940,000**
Total Wind	**35**	**35**	**77,000**	**77,000**
Total Solar & Wind	**905**	**1,265**	**1,447,000**	**2,017,000**

[a] The reported MCE-eligible potential in this table may slightly underestimate as some census tracts spanned multiple cities, and the study excluded any tract that included land in a nonparticipating city. This factor is not expected to significantly impact overall amounts.

NWEDI Solar Resource Potential

The Northern Waterfront Economic Development Initiative (NWEDI) covers approximately 55 miles of shoreline, stretching from Hercules to Brentwood. It contains cities and unincorporated communities, from the San Pablo Bay to the Sacramento and San Joaquin Rivers, and hosts numerous manufacturing and industrial sites. The County wishes to understand how much solar and wind potential falls within the NWEDI area; estimates have been compiled in Table 23.

Table 23. NWEDI Solar and Wind Resources in Contra Costa County[a]

Type	MW Capacity		Annual MWh	
	Low	High	Low	High
Rooftops	Not measured[b]			
Parking Lots	50	140	80,000	220,000
Unlikely to be Developed	110	260	170,000	410,000
Agricultural Land with Relatively Low Constraints	0	0	0	0
Total Solar	**160**	**400**	**250,000**	**630,000**
Total Wind	**35**	**35**	**77,000**	**77,000**

[a] This table includes resources located both in the cities and the unincorporated communities within NWEDI.

[b] Rooftop solar is estimated by Census Tract elsewhere in this report. However, since NWEDI does not strictly follow Census Tract boundaries, an estimate of rooftop potential within this area is not broken out from the total. It is worth noting that this district contains a significant amount of large industrial rooftops, which are likely suitable for large rooftop installations.

3.6.2. Development Challenges and Success Factors

When viewing the summary of total technical resource potential shown above, readers should bear in mind that these estimates do not produce guidance regarding the amount of renewable resource development actually achievable on a short-, medium-, or long-term time horizon. The resource amount actually developed is a function of key success factors and barriers. Success factors include availability of significant quantities of land with low competing uses and low financial value, proximity to transmission, and the quality of the underlying renewable resource (e.g., solar irradiation, wind speed).

Numerous market, technical, and economic barriers will make it difficult to develop much of the technical potential estimated above:

- The best time to add solar is when a roof is replaced, but this can exacerbate homeowner cash flow difficulties, as it adds the cost of solar to the cost of the roof. This timing also may slow retrofitting of rooftops with PV systems.
- Approximately seventy-five percent of homeowners do not have rooftops facing south.
- Split incentives in the residential building stock. When renting buildings to tenants, if the landlord adds a solar array to the building, the tenant typically receives the benefit of reduced electricity costs. Therefore, building owners usually do not add solar to their buildings, or they only add enough to cover common area usage.

- Split incentives in commercial real estate. Similar to the residential split incentive, most businesses rent their facilities, and real estate owners may be slower to install solar due to the increased difficulty in capturing the savings.
- Interest rates may rise in the future, impacting the availability and affordability of financing.
- International trade policy may increase solar costs, as recent tariffs have done.
- Large wind projects face acute siting challenges due to the large geographic areas required and due to concerns regarding aesthetics, noise, and bird fatalities.
- Biomass projects struggle to economically compete with solar, wind, and conventional energy sources, and air emissions are a negative factor.
- Biogas projects are at too small a scale to be broadly cost-competitive.
- California utilities are struggling to address the "duck curve," described in the California context section above. As solar penetration levels rise, this challenge will become increasingly significant. In Hawaii, the utility banned further solar installations unless energy storage was installed concurrently. Further solar penetration in Contra Costa County therefore may be limited by economics and the availability of energy storage or other techniques that can mitigate solar's variable generation profile.

In addition to the broad national- and state-level barriers, local barriers impact renewable development and soft costs:

- The cost (in time and money) of land acquisition, permitting, resource verification, environmental impact studies, transmission studies, and attaining local approvals.
- "Not in my backyard" resistance to renewables.
- Transmission and distribution capacity.
- Zoning barriers.

Of the above barriers, zoning and permitting fall most substantially within the County's control. The next section discusses possible approaches the County could take to reduce zoning and permitting barriers, project delays, and "soft costs" of renewables.

4. Zoning Options

Given the resources identified in the technical potential assessment, the zoning best practices assessment's key priority was to evaluate available options to update zoning to facilitate appropriate development of these resources, while remaining mindful of long-term planning considerations and potential tradeoffs. As a relatively urban county with a significant population, significant commercial activity, and significant land constraints, developing local large-scale renewables that can serve a large proportion of the County's load is an inherently more difficult task than in a more rural, less populous county. Therefore, policy best practices that facilitate development of more limited available resources is of heightened importance, presuming the County desires to contribute what it can towards realization of California's renewables and climate goals. This chapter describes policies implemented in peer counties, policies considered statewide, and national best practices, and it discusses potential benefits and tradeoffs associated with each of these options.

4.1. General Methodology

Cadmus researched and reviewed a variety of sources and presented these to County staff and stakeholders for discussion of such best practices that could apply in the County's unique context. Sources included best practices from technical industry experts and reports, California statewide office research reports, and actual zoning policy and municipal ordinances from neighboring and similar California counties (peer counties). A particular emphasis was placed on identifying policies in place in peer counties as many of them face similar challenges from strong population growth and development pressures, increasing concerns about habitat preservation, and increasing risks from loss of farmland and open space resources. Many of these counties also have set ambitious renewable energy development goals.

The methodology was implemented as follows:

- The project team, including County staff and the consultant, identified potential comparable counties. These included Alameda, Marin, Sonoma, Solano, and San Joaquin. Initial research reviewed their ordinances, general plans, energy plans, climate action plans, and other public documents addressing renewable energy development.
- At the July 2018 stakeholder meeting, initial findings were presented to stakeholders, including representatives from cities in the County, County departments, environmental groups, renewable energy developers, Sustainability Commission members, and other interested parties. These stakeholders suggested additional counties for review and suggested examining policy language and outcomes in terms of actual renewable resource development in each county. In addition to these suggestions, stakeholders made numerous suggestions about policy types that the County should and should not adopt.
- Following the July stakeholder meeting, further research was conducted, and results from the technical potential analysis became available. Zoning policies addressed below are presented as options rather than recommendations as the level of ambition for renewable energy

development and the amount of acceptable tradeoff have yet to be determined, and these serve as critical inputs to developing recommendations.

4.2. Which Counties Have Had the Most Success Developing Renewables?

Responsive to stakeholder feedback from the July meeting, the team evaluated the amount of renewables developed county-by-county in California, using data from CEC.[101] However, apples to apples comparisons of each California county's relative success in renewable resource development proved difficult to evaluate due to the unique nature of each county's available land and development patterns.

By land mass, Contra Costa County is the eighth-smallest county in the state, containing only ~0.5% of the state's land area,[102] yet it has the ninth-largest population of California's 58 counties. For three reasons, higher population density works against the goal of sourcing higher percentages of energy consumption from local renewable generation:

1. The total load to serve is proportional to the county's population and economic activity.
2. Available land for renewable resource development is scarcer.
3. The value of available land in counties with higher population densities will, on average, likely be higher than the value of land in less densely populated counties.

Several of California's most populous counties are less urban than one might assume; as such, they offer more opportunities to use rural land in developing large renewable resources. For instance, Los Angeles County has the second-most solar capacity of any county in the state and the fifth-most renewable capacity, despite having a population three times as large as the next most populous county. One reason that Los Angeles County can host so much large-scale solar and other renewables is the county actually contains a substantial amount of less-developed land to the north of the mountain range bounding the LA basin, where several very large solar projects are sited.[103] Similarly, San Bernardino and Riverside Counties include urban areas on their western edge (in the Los Angeles metro area), but span vast expanses of open land all the way to California's eastern border.

As shown in Table 24, Contra Costa has the fourth-most installed capacity from renewables (when including only resource types within this study—specifically, those that are RPS-eligible), compared to its neighbors in the nine-county Bay Area and San Joaquin County, which staff identified as another peer county to assess. In terms of solar development, Contra Costa County has **the most PV capacity of any of these counties**, narrowly exceeding Santa Clara County. The numbers provided in Table 24 must be

[101] December 2017 Tracking Progress report: http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

[102] http://www.counties.org/pod/square-mileage-county

[103] http://www.energy.ca.gov/maps/renewable/renewable_development.html

interpreted cautiously as several exclusion factors exist in the CEC's methodology for estimating renewable capacity. For instance, in the Altamont Pass region, Contra Costa County has two large wind projects totaling 116 MW (Vasco Winds, at 78.2 MW, and Buena Vista at 38 MW). The County has also permitted the Tres Vaqueros wind project, which will be 43.7 MW when fully constructed.

Table 24. Existing Renewable Capacity in Nine-County Bay Area Counties, Plus San Joaquin County[a]
(Sorted by Total Installed Capacity of Renewables)

County	Biomass MW	Solar MW	Wind MW	Total Bioenergy, Solar, and Wind MW (only the renewable technologies studied for this report)	Population
Solano	10	18	1,035	1,063	445,458
Alameda	24	15	182	221	1,663,190
San Joaquin	82	10	4	96	745,424
Contra Costa	7	31	38[b]	76	1,147,439
Santa Clara	3	30		33	1,938,153
Sonoma	8	14		22	504,217
San Francisco	2	14		16	884,363
San Mateo	11			11	771,410
Marin	4	3		7	260,955
Napa	1	2		3	140,973

[a] Data from December 2017 Tracking Progress report (CEC): http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

[b] Note that this undercounts the total installed wind in the County, most likely because the output of some of the County's wind projects is likely being purchased by entities that are retiring the Renewable Energy Credits (RECs) without directly being counted toward a compliance obligation.

The top five counties for biomass, solar, and wind electricity generation in the state break down as follows:

- Biomass: Los Angeles, Shasta, Kern, Orange, and San Joaquin
- Solar: Kern, Riverside, Imperial, Kings, and Tulare
- Wind: Kern, Solano, Riverside, Imperial, and Alameda

As noted, many counties outside of the Bay Area may have more options for renewables siting due to their significantly larger geographic size and smaller populations. The following sections summarize options uncovered through examinations of these counties and of other sources related to each energy type.

4.3. Rooftop Solar

4.3.1. Do the County's Planning and Zoning Policies Facilitate Appropriate Development Rooftop Solar in Contra Costa County?

Per guidance from the State of California's legislation AB2188 and Section 65850.5, Contra Costa County already allows small standard rooftop installations by right. This means zoning does not tend to pose barriers to development of rooftop solar. Several nationally recognized best practices have been adopted, such as the following:

- Offering an online submission process for streamlined solar permits (Section 65850.5)
- Administratively approving applications for rooftop solar energy systems through a building permit or similar nondiscretionary permit
- Not requiring design review and aesthetic considerations to be met, and capping permit fees (in compliance with CA SB1222)

Contra Costa County currently approves approximately 1,500 rooftop solar systems per year. Furthermore, the County has earned a Bronze designation from the U.S. Department of Energy's SolSmart program, which recognizes communities' actions to reduce solar soft costs and barriers and their actions to advance their local solar markets.[104]

4.3.2. Actions for Consideration

1. The County could convene a group of cities within its boundaries for regional coordination, including sharing experience with best practices on permitting and inspections.
2. The County could work with U.S. Department of Energy (e.g., SolSmart) and other technical assistance programs to further streamline local processes, implement new market development initiatives, and make it easier for homeowners and businesses to go solar.
3. For new construction not subject to 2019's solar requirement for low-rise residential buildings, the County could offer development incentives to encourage incorporation of solar PV in new buildings. Such measures could include density or height bonuses (as implemented in Portsmouth, Virginia)[105] or expedited permitting of development (as implemented in San Diego).[106] Watsonville, California reduces or waives its Carbon Impact

[104] www.solsmart.org

[105] https://www.planning.org/pas/infopackets/eip30.htm

[106] https://www.sandiego.gov/development-services/industry/incentive/sustainable

Fee for buildings that install renewable energy covering 40% or 80% of their annual load, respectively.[107]

4. For new subdivisions, the County could provide guidance and/or incentives for orienting structures through subdivision regulations (e.g., orienting lots to maximize the amount of south-facing roof space). Numerous municipalities around the country have provided this guidance, including the Twin Cities, Minnesota,[108] and the Cincinnati, Ohio, region.[109] Incentives that provide more density points for solar orientation and/or solar installation have been awarded in Pullman, Washington.[110]
5. While not strictly a planning and zoning measure, the County could install solar on its most publicly visible County-owned facilities, such as fire stations, libraries, community centers, courthouses, and other facilities visited by the public.
6. Outside of the planning and zoning realm, another opportunity would be working with local lenders to reduce financing costs for solar via loan-loss reserves, credit enhancement, or other provisions (Connecticut Green Bank and other organizations have developed successful models in this regard).[111]
7. Address split incentive barriers via green leases[112] or other strategies.

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[107] While Contra Costa County does not have a Carbon Impact Fee, this is included as an example of a progressive approach to mitigating the emissions effects of new development. https://www.cityofwatsonville.org/DocumentCenter/View/198/Frequently-Asked-Questions-About-the-Carbon-Fund-Ordinance-PDF

[108] http://mn.gov/commerce-stat/pdfs/solar-ready-building.pdf

[109] https://www.solsmart.org/media/OKI_RooftopSolarReadyConstructionGuidelines.pdf

[110] https://planning-org-uploaded-media.s3.amazonaws.com/legacy_resources/research/solar/briefingpapers/pdf/localdevelopmentregulations.pdf#page=2

[111] https://www.ctgreenbank.com/wp-content/uploads/2015/11/CGB_FY15_and_FY16_Comprehensive_Plan.pdf

[112] Green leases are leases that realign cost structures such that landlords have incentive to invest in efficiency and/or renewable energy on their property. Under conventional leases, if the tenant pays for their own utilities, the landlord cannot recoup the investment in reducing utility costs. For instance, Brixmor Property Group has implemented green leases in California that stipulate that when the landlord installs renewable energy systems, the tenants are required to purchase electricity from the landlord (https://www.imt.org/wp-content/uploads/2018/08/Green-Lease-Leaders-Using-the-Lease-to-Drive-Innovation-and-Clean-Energy.pdf).

4.4. Ground-Mounted Solar

4.4.1. Do the County's Planning and Zoning Policies Facilitate Appropriate Development of Ground-Mounted Solar in Contra Costa County?

As shown in Table 25, Contra Costa County has a greater installed capacity of non-net-metered solar that the other nine Bay Area counties. Many counties in other parts of California have installed orders of magnitude more solar than Contra Costa, although many of these counties also have significantly larger quantities of undeveloped and lower constraint land available than Contra Costa has.

Until late 2017, the County did not have an ordinance that allowed commercial solar resources where the energy produced would be sold to an off-site purchaser. At that time, the County amended its General Plan and the Ordinance Code Chapters 84-54 and 84-58, allowing commercial/ distribution-scale solar in General Commercial, Light Industrial, and Heavy Industrial zoning districts, subject to land-use permits. Currently, it is too early to determine what effects this will have on the County's overall solar development rate, although County staff cited an increasing frequency of solar developer queries in such areas as a rationale for text amendments.[113] Industrial lands eligible for commercial ground mounted solar (subject to a land-use permit) are concentrated in the Northern Waterfront and North Richmond.[114]

Notwithstanding the 2017 General Plan Amendment, the majority of the County's unincorporated land acreage falls within zones where ground-mounted solar is not a permitted use, and solar developers often prefer to evaluate sites on farmland of marginal value as these may offer lower site preparation, acquisition, and mitigation costs. Therefore, a more permissive approach to solar permitting outside of the Urban Limit Line would likely result in more solar project applications, though accompanied by the potential tradeoffs described below.

Table 25. Existing Renewable Energy Generation Capacity by County for Bay Area Counties, Sorted by Quantity of Solar[a]

County	Biomass MW	Solar MW	Wind MW	Total MW Bioenergy, Solar, and Wind	Population	Solar per 100,000 People (MW)
Contra Costa	**7**	**31**	**38**	**76**	**1,147,439**	**2.7**
Santa Clara	3	30		33	1,938,153	1.5
Solano	10	18	1,035	1,063	445,458	4.0
Alameda	24	15	182	221	1,663,190	0.9
San Francisco	2	14		16	884,363	1.6
Sonoma	8	14		22	504,217	2.8
San Joaquin	82	10	4	96	745,424	1.3

113 "DCD Staff Report: General Plan and Ordinance Code Amendments to Allow Commercial/Distribution-Scale Solar Energy Projects in Certain Commercial and Industrial Areas." November 8, 2017.

114 Ibid.

Marin	4	3		7	260,955	1.1
Napa	1	2		3	140,973	1.4
San Mateo	11			11	771,410	0.0

[a] Data from December 2017 Tracking Progress report (CEC): http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

4.4.2. Planning Considerations for Ground-Mounted Solar

Large, ground-mounted solar requires careful consideration due to the significant amount of land required for its development. However, significant benefits are associated with developing planning policies that facilitate its installation. Some of these benefits include rapid development (a small number of projects can have a large impact on overall renewable penetration) and significant economies of scale associated with large, ground-mounted projects. A ground-mounted installation using less than 10 acres of land can produce the same amount of energy as hundreds of individual residential rooftop arrays. Economies of scale can lead to costs as low as one-half of rooftop installations' costs, according to a recent Brattle Group study.[115] Parking lot solar offers additional side benefits, such as providing shade to keep parked cars cooler on hot days.

On the other hand, ground-mounted and parking lot solar present significant planning considerations. Zoning should account for potential land-use impacts, including loss of productive farmland, loss of habitat, conflict with planned new roadways and infrastructure, and conflict with economic development, job creation, and other uses, in addition to impacts on scenic viewsheds and rural community character/aesthetics.

As described in the methodology for the County's resource potential quantification, this study took each of these considerations into account. Some planners go further concerning the potential impacts of solar arrays on storm water runoff, erosion, and hydrology, since rainwater falling on panels is channeled to the drip line below a panel's lowest edge. NREL's guidance concludes that, if vegetated land lies beneath the solar panels, solar farms should not be considered impervious surfaces and, as such, should not be subject to lot coverage restrictions.[116]

California has well-explored frameworks for identifying least-conflict land for solar development. Two particularly relevant studies are the UC Berkeley School of Law's *Identifying Least-Conflict Solar PV Development in California's San Joaquin Valley* and the California County Planning Directors' Association's (CCPDA) *Solar Energy Facility Permit Streamlining Guide*. The former used an extensive stakeholder process to identify least-conflict sites, arriving at an estimate of approximately 5% of the

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115 http://www.brattle.com/news-and-knowledge/news/study-by-brattle-economists-quantifies-the-benefits-of-utility-scale-solar-pv

116 NREL Zoning for Solar 10-3-17, SolSmart program presentation.

study area containing non-controversial land for PV development; if entirely developed, this could generate enough electricity to power as many as 23 million California homes.[117]

The CCPDA study outlines the many considerations that counties should account for when assessing the suitability of large-scale solar on specific lands under their jurisdiction. It developed a tiered framework that counties can customize for their own planning priorities and constraints. Though a full description of the CCPDA document's guidelines falls beyond this current discussion's scope, the clear, organized framework provided has influenced several California counties in developing their ordinance language.

[117] https://www.law.berkeley.edu/research/clee/research/climate/solar-pv-in-the-sjv/

4.4.3. Options to Facilitate Appropriate Solar Development Through Planning and Zoning Action

As discussed, planning and zoning actions could possibly have significant impacts on ground-mounted solar development within the County. A review of the zoning codes, general plans, and other planning documents of neighboring counties resulted in identifying several policy options for implementation, as described in Table 26.

Table 26. Range of Planning and Zoning Options for Ground-Mounted and Parking Lot Solar

Category	More Protective of Uses in Potential Conflict with Solar (and Example County)	More Permissive/Encouraging of Solar (and Example County)
Geographies allowed	Only allowed in defined zones (many counties)	Allowed except in certain zones (e.g., mapped Important Farmlands) (Sonoma County)
Permit requirements	Accessory ground mount: • Accessory ground-mounted solar is not defined or permitted in code (Alameda County)	Accessory ground mount: • Administrative permit for almost any district as long as <15% of the parcel, up to 10 acres (CCPDA model ordinance)
	Primary ground mount: • Not allowed on agricultural land (Solano County)	Primary ground mount: • Minor solar (up to eight acres) is subject to architecture and site approval (and sometimes a use permit) in specified farmlands (Santa Clara County)
Other required studies	Glare study required and proof of no glare directed at occupied structures, recreation areas, roads, and airport flight paths (Sonoma County)	Glare study not required, except if required by FAA (NREL best practice)
Goals	None	Solar goal for deployment on a percentage of commercial buildings, industrial buildings, and parking lots (Alameda County)
Requirement to install renewable energy	None	New commercial parking lots with over 200 spaces required to mitigate heat gain through shade trees, solar arrays, or cool pavement (Alameda County)
Actions to directly facilitate renewable development	None	Regional collaboration with the utility to identify locations where interconnection would not trigger extensive upgrades (Philadelphia)
		County-led technical assistance and coordination between property owners and solar developers (Alameda County)
		Work with local lenders to reduce the financing costs for community-shared solar via loan-loss reserves, credit enhancement, or other provisions

4.4.4. Actions for Consideration

To meet the County's renewable goals, it is desirable to take actions that can accelerate the development of solar on land with few competing land uses and not serving some other function in the public interest. For example, certain sites present constraints that preclude using the site for real estate development (or are generally hard to develop). If these sites do not serve or could not serve some other function, they could be considered prime candidates for solar or other energy resources. The County has identified "urban land unlikely to be developed" and parking lot areas suitable for solar, as described in this report's technical resource potential component.

The actions described below can be categorized as accelerating development of these sites for solar and enabling development of ground-mounted solar in other locations. While this report has focused on zoning actions, this section presents a broader set of tools, given the many advantages of (and few drawbacks to) accelerating development of solar on parking lots and "urban land unlikely to be developed." Such tools include targets/mandates, financial arrangements, and facilitating development of County-owned sites.

Accelerating Development of Parking Lot Arrays and Arrays on "Urban Land Unlikely to be Developed"

1. **Mandates**. Similar to Alameda County, the County could consider requiring solar installations on all new parking lots with a square footage above a certain size threshold. The County also could set a goal for installation of solar shade structures on a certain percentage of its existing parking lots. Providing shade also helps counter heat island effects and, depending on the type of solar structure installed, the solar electricity generated can be used to charge electric cars. Impacts would have to be considered on the cost structure for commercial property developers, but the value generated by parking lot PV might mitigate incremental costs through net metering arrangements, as long as tenant leases captured the value.
2. **Tax policy**. For solar arrays with property tax assessments within the County's jurisdiction,[118] consider measures to reduce tax burdens. In California, incremental increases in property values associated with construction of a solar array are exempt from property taxes; this exemption applies to large-scale projects assessed locally.[119] To favorably affect solar project economics on these sites, the County would need to determine whether it could reduce the property tax assessed on the underlying property for sites used for solar arrays exclusively. Furthermore, the County could consider exempting battery storage located at

[118] Certain solar systems may be centrally assessed by the State of California, depending on their size and other attributes. https://www.stoel.com/legal-insights/special-reports/the-law-of-solar/tax-issues

[119] http://www.nortonrosefulbright.com/knowledge/publications/151031/california

commercial solar locations from property tax, as it is not included in the aforementioned legislation that exempts solar systems from property tax assessments.[120]

3. **Offering County-owned land**. Lease County-owned land to renewable energy developers at a lease rate that would enable project development. The County also could serve as the off-taker for electricity generated and could even agree to above-market PPA rates for the electricity, provided the developer used sites that the County deemed preferable for solar development.
4. **Coordinated studies**. Consider using identified least-constraint solar areas (e.g., parking lots, urban land unlikely to be developed) to convene potential solar developers and PG&E, and could conduct area-wide interconnection studies to reduce timelines and costs for each prospective developer (compared to approaching PG&E in an uncoordinated manner).
5. **Work with MCE and other potential partners to explore incentives**. The County could consider a collaboration to explore whether it would be possible to preferentially encourage the development of solar on parking lots or urban land unlikely to be developed for other uses through potential future versions of the MCE FIT program. Several completed projects within MCE's service area provide instructive examples for utilizing these types of locations, including MCE's Solar One (built on a remediated brownfield); Novato's Cooley Quarry (built in a closed quarry), and Oakley's RV and Boat Storage (a solar carport).
6. **Consider expedited permitting in limited cases**. Consider whether to further refine zoning policies in industrial and commercial areas to enable certain solar projects in areas with little other potential use and little or no impacts to be constructed without a land use permit. An important consideration is whether such areas are likely to support job-rich alternative uses or other economic development priorities.
7. **Consider developing a commercial-scale solar guidebook** that would educate potential developers about where systems can be permitted, the permitting process, the agencies involved, and other project development advice.

Enabling Development of Ground-Mounted Solar in Other Locations

1. Amend the zoning code and General Plan to **define specified additional areas where commercial ground-mounted solar may apply for a land use permit**. This change would establish that primary-use solar may be allowed in certain Contra Costa County zoning districts, while still providing flexibility for the County to address the desirability of each proposed solar farm, based on its own merits and tradeoffs. In the development of the additional areas where ground-mounted solar may apply for a permit, the County could take into consideration the extensive analysis of potentially conflicting uses and values of the land that was performed for this study. Some of these factors vary not only between parcels

[120] https://www.law.berkeley.edu/wp-content/uploads/2018/11/New-Solar-Landscape-November-2018.pdf

but also within parcels (e.g., agricultural parcels that contain soils of varying soil classifications and qualities). The County could use judgment to adapt the boundaries of the areas where commercial solar would be allowed to align with parcel boundaries as opposed to soil quality boundaries.

2. **Continue to update and revise the opportunity and constraints analysis** for solar in rural areas as additional data and technologies become available.
3. **Consider methods to deal with emerging co-location opportunities** (such as "agrophotovoltaics," described above).
4. **Include requirements for developers to hold monetary reserves** for end-of-useful-life decommissioning.
5. **Consider identifying and implementing strategies to streamline permitting**, such as an umbrella approach to complying with the California Environmental Quality Act (CEQA), mitigation, and/or other permitting needs. As noted in the November 2018 report, *A New Solar Landscape*[121], by UCLA and UC Berkeley Schools of Law, this could be done by including specific guidelines on commercial solar within a General Plan and/or zoning code and by developing a programmatic Environmental Impact Report (EIR) that covers the impact of commercial solar under the conditions specified by the General Plan. If these steps were taken, solar developers could reduce the length and complexity of their project-specific EIRs, only needing to address unique elements specific to the project in question. The analysis of Contra Costa County agricultural lands with least constraints could form the basis of the development of guidelines for where commercial solar developers can apply for land use permits. If these guidelines are integrated into County land use policies and if the potential environmental impacts were analyzed in a programmatic EIR, future commercial solar projects could proceed with lower costs, litigation risk, and risks of delay, so long as they follow the County's prescribed process and adhere to the parameters analyzed in the EIR. It should be noted that this approach will have significant costs, and it may be worth assessing the number of solar projects that are likely to benefit from this in determining whether to undertake this action. It may also be worth assessing options for recouping these costs. Further legal guidance should also be obtained to implement this policy option appropriately.
6. **Consider developing a commercial-scale solar guidebook** that would educate potential developers about where systems can be permitted, the permitting process, the agencies involved, and other project development advice.
7. **Develop job training programs** to enable local workers to benefit from local development of renewable technologies. These job training programs could facilitate the hiring of local labor for projects, and the MCE Solar One project in Richmond provides precedent for utilizing local labor.

[121] https://www.law.berkeley.edu/research/clee/research/climate/renewable-energy/new-solar-landscape/

8. **Consider sales tax and/or community benefit approaches to securing revenue and/or power that supports affected local communities.** As noted by the report *A New Solar Landscape,* solar generation provides environmental and cost-saving benefits both globally and statewide, but local communities do not always experience direct benefits if agreements are not negotiated with developers. Such agreements could include using local labor and providing job training (as described above), selling electricity to local customers/providing electricity cost savings, committing to aesthetic improvements, and more. In some cases, these community benefit programs are financial contributions through impact fees. As noted by John Gioia of the Contra Costa County Board of Supervisors, "Demonstrating public benefits upfront will engender trust from the beginning. It builds a larger stakeholder support group." The increased public support that may be obtained through such efforts may outweigh the cost of the community benefit program to prospective solar developers. This approach could be beneficial both for solar in rural areas and for solar on urban land unlikely to be developed. More discussion is provided in UCLA and UC Berkeley's report. [122]

4.5. Large-Scale Wind

4.5.1. Do the County's Planning and Zoning Policies Facilitate Appropriate Development of Large-Scale Wind in Contra Costa County?

Contra Costa County has roughly one-third of the 576 MW of large-scale wind in Altamont Pass[123], shared with Alameda County on its southeastern border, creating one of the larger wind farms in California, as noted in Table 27. The County's current zoning ordinance (Chapter 88-3) allows commercial wind on agricultural districts, subject to a land use permit and dimensional and noise considerations. The large-scale wind zoning code has not been updated since the 1980s, and the County has not seen applications for large-scale wind projects in recent years, likely due to the limited additional areas within the County that have sufficient undeveloped land area and sufficient average wind speed. Therefore, it appears that the zoning ordinance is not presenting a direct barrier to additional development.

[122] Ibid.

[123] Note, not all of this wind resource is tracked under the CEC's Tracking Progress report, which is used to track renewables used for RPS compliance. As such, this value represents the whole wind resource size and will not match Table 24 and Table 25.

Table 27. California Large Scale Wind Farms[a]

Wind Farm	County	Capacity (MW)
Altamont Pass Wind Farm	Alameda County/Contra Costa County	576
Alta Wind Energy Center	Kern County	1,500
Ocotillo Wind Energy Project	Imperial County	320
San Gorgonio Pass Wind Farm	Riverside County	620
Shiloh Wind Project	Solano County	500
Tehachapi Pass Wind Farm	Kern County	700
Tule Wind Energy Project	San Diego County	130

[a] https://www.windpowerengineering.com/wind-project-map/

4.5.2. Planning Considerations for Large-Scale Wind

Similar to large-scale solar, large-scale wind requires careful consideration due to large amounts of land required. It offers, however, many benefits:

- Offering one of the least-costly reliable sources of low-emissions renewable power in the United States
- Generating power at night when solar is unavailable
- Providing a domestic source of energy
- Using only a fraction of the land, allowing farming or ranching to occur, and providing landowners with additional income
- Not consuming water

Wind project impacts addressed through zoning include noise considerations, flicker/glare, electromagnetic interference, aesthetics, safety setback in case of blade throw or tower toppling, and provisions for plant decommissioning. Despite relatively low blade speeds, turbines can produce sound as loud as a lawnmower (105 dbA) right at the turbine, with sound levels dropping to be as loud as a refrigerator (40 dbA) one-fifth of a mile away.[124] As spinning blades can produce flicker or glare and electromagnetic interference, they generally are not sited near airport operations. The increased modern turbine height (330 feet) is as tall as a football field's length, and can be seen from far away, leading to aesthetics concerns. Though rare, turbine blades can fail, and wind turbines may be subject to earthquakes in the Bay Area. Wind turbine foundations can extend deep into the earth, and turbines generally weigh over 150 tons; therefore, proper disposal and decommissioning costs must be provided once the turbine exceeds its lifetime.

[124] Tom Kellner

4.5.3. Options to Facilitate Appropriate Wind Development through Planning and Zoning Action

Table 28. Options for Planning and Zoning Action for Large-Scale Wind

Category	More Protective of Uses in Potential Conflict with Wind (and Example County)	More Permissive/Encouraging of Wind (and Example County)
Permit requirements (electromagnetic interference)	Shall be filtered or shielded to prevent RFI or will use other mitigation (braking and overspeed controls) (Solano)	None
Geographies allowed	Agriculture zones (many counties)	Agriculture, Industrial, Natural Resource, Estate, Minimal Agriculture, or Recreation Forestry zones, with a minimum size of 20 acres (Kern)
Dimensional requirements: Setbacks	3X height (Contra Costa)	1.25X height (Kern, Solano); the CEC recommends that counties consider reducing throw setbacks as turbine blade velocities have decreased since the 1980s[a]
Noise	45/50 dba (residential/other) at existing buildings (Kern)	60/65 dba (residential/other) at property line (Contra Costa)
Other department jurisdictions	N/A (large-scale projects always require environmental reviews, structural and electrical engineering reviews, transmission studies, and more)	
Actions to directly facilitate renewable development		Kern and Solano have integrated economic development, planning, and climate action plans

[a] http://www.energy.ca.gov/2005publications/CEC-500-2005-184/CEC-500-2005-184.PDF

4.5.4. Actions for County Consideration

1. **Consider reducing setbacks** to 1.25–1.5 times height rather than the current 3 times height, reflecting technology changes since the 1980s, per the CEC recommendation above.
2. **Assess whether decommissioning defaults have presented problems** (current County zoning language requires a financial surety guarantee and a reclamation plan). Other counties require decommissioning plans and escrow accounts similar to Contra Costa.
3. **The County could conduct anticipatory planning** to guide developers to focus on certain more viable locations.[125] These actions could include (1) working with PG&E to understand transmission constraints in areas with high wind resources; and (2) compiling information

[125] As recommended by National Academies Press. Environmental Impacts of Wind-Energy Projects. 2007.

about bird and bat habitats, migratory routes, and other environmental impacts likely to arise during CEQA environmental studies.

4. Convene PG&E, MCE, the industry, developers, and investors to assess whether these are areas of interest; and, if warranted, conduct transmission and environmental impact studies for all areas simultaneously, reducing overall costs and accelerating development.

4.6. Small-Scale Wind

4.6.1. Do the County's Planning and Zoning Policies Facilitate Small-Scale Wind Development?

Though few small-scale wind projects have been built in the County, current codes echo other counties' small wind ordinances. Given that small wind project economics are less favorable than other net metering projects, few systems have been proposed or installed in the County. Contra Costa County's code (Chapter 88-3) contains a provision for granting building permits for small wind (i.e., turbines with a capacity less than 50 kW), but this has been little used.[126] Therefore, financial viability considerations likely present the strongest current impediments to small wind.

4.6.2. Planning Considerations for Small-Scale Wind

Though small-scale wind planning considerations are the same as those for large wind, aesthetics and noise considerations occur more prevalently as these installations are likely nearer to or in residential zones.

4.6.3. Options to Facilitate Small-Scale Wind Through Planning and Zoning Action

Table 29. Options for Planning and Zoning Action for Small-Scale Wind

Category	More Protective of Uses in Potential Conflict with Small Wind (and Example County)	Most Permissive/Encouraging of Small Wind (and Example County)
Permit requirements	Shall be filtered or shielded to prevent RFI or use other mitigation (braking and overspeed controls) (Solano)	None
Dimensional requirements: Height	<40 feet on <1 acre, <65 feet on 1–5 acres, and maximum height of 80 feet on a 5+ acre parcel (Sonoma)	<120 feet (Kern)
Setback	1.25 x Height (Solano)	0.5 x Height (Marin) 65/30 feet res/non-res (Kern)

126 Conversations with County planners indicated that few such projects had been proposed in recent memory.

4.6.4. Actions for County Consideration

1. **Convene industry participants** to obtain further information on technology development, cost curves, and new opportunities for applying these technologies as pilots and early deployments.
2. **Participate in pilot projects** to prove the value and to develop lessons learned.
3. **Proactively prepare to update planning and zoning** as these technologies become more prevalent.

4.7. Bioenergy (Biomass and Biogas)

4.7.1. Do the County's Planning and Zoning Policies Facilitate Appropriate Biomass/Biogas Development?

Due to project economics, developers have not been contacting the County for biomass project approval, comporting with overall industry trends in California. On the biogas side, the County's waste management operations (solid waste and waste water) have been exploring increased opportunities to collect biogas on site, but, as these are existing land uses (landfills and waste water treatment plants), zoning presents less of a consideration than air, water, and disposal permits.

4.7.2. Planning Considerations for Biomass and Biogas

Biomass and biogas installations may be on similar or smaller scales as large-scale wind and solar plants, but they likely use less land area. Benefits of these technologies include: biomass and biogas are dispatchable at any time, allowing them to be used when the wind is not blowing and the sun not shining; they can produce agriculturally useful wastes; and they reduce landfill disposal volumes. Biogas may enable renewable transportation fuels in lieu of electricity and offers a domestic energy source.

Biomass and biogas project impacts protected against by zoning include noise considerations, nuisance smells, and aesthetics. Air quality, water use and discharge, and environmental impact permits are administered and governed by agencies outside of the County's control: EPA/CARB, CA Water Quality Control Board, National Pollution Discharge Elimination System (NPDES)/EPA, and the California Natural Resources Agency/CEQA. Generally, these permits are more difficult and expensive to attain than zoning permissions.

4.7.3. Options to Facilitate Bioenergy Development Through Planning and Zoning Action

Table 30. Options for Planning and Zoning Action for Biomass/Biogas

Category	Example Threshold (County)
Permit requirements	125% of on-site energy usage (Sonoma)
Geographies allowed	Non-prime farmland agricultural areas (Sonoma)
Dimensional requirements: setback	200 feet from residential (Sonoma)

4.7.4. Actions for County Consideration

1. **For biomass, focus planning efforts on convening local refuse haulers** and waste sources with operators of nearby biomass plants (outside of the County's boundaries). If economics become favorable for any waste class, help participants negotiate and plan with biomass plants for transport of feedstocks to plants.
2. **Continue observing what other nearby counties do** and monitor for signs of renewed interest prior to engaging in a comprehensive effort to update bioenergy zoning considerations.
3. **Consider transportation fuel vs. electricity tradeoffs** relative to Contra Costa County greenhouse gas reduction goals; using biogas resources for transportation fuels may be more economical.

5. Conclusions

Contra Costa County has the potential to expand its leadership in local clean energy production and bring the benefits of clean energy to its constituents through the judicious development of its renewable resources that is mindful of long-term planning considerations and potential land use tradeoffs. This study finds that there is a significant amount of potential distributed across solar, wind, biomass, and biogas, and subtypes of each of these resources. While economics are currently more favorable for certain types of renewables (e.g., solar and large-scale wind), it is desirable for renewable resources to come from a mix of different sources for diversity of generation profiles and grid reliability. Economics and land use policy will drive realization of development potential.

As a technical potential study, this project does not purport to predict that the identified resources will be developed or to suggest that all of the resources identified would be economically feasible to develop given current or foreseeable market and policy environments. Rather this study uses estimates of resource quantity and quality (e.g., annual solar irradiance, wind speeds, and the energy value of bioenergy feedstocks) to evaluate specific locations and aggregate them to determine how much energy could be generated in total.

The sites that were assessed were selected by examining system performance, topographic limitations, and environmental and land-use constraints to find the maximum that can possibly be produced given these technical constraints. A strong emphasis was placed on identifying renewable resources within the Urban Limit Line (ULL), which was established in 1990 to preserve farmland and open space.

Quantification of Technical Potential

At a high level, this study estimates that between 4,674,000 and 7,990,000 MWh could be generated within the County by new renewable resources. For reference, total electricity consumption in the County in 2017 was 9,644,000 MWh.[127] The high estimate is dependent on aggressive action and optimistic assumptions, because the development of this amount of renewable resource is dependent on making it cost effective and on balancing commercial-scale renewables with local planning objectives and local community buy-in.

Of the resources, rooftop solar has by far the highest potential, both in terms of capacity and in terms of annual generation. Rooftop solar is followed in magnitude by non-urban ground mounted solar including agricultural land with the least constraints. Parking lots could be a significant solar resource and have the added benefit of providing shade, as well as minimal tradeoffs associated with their development. Similarly, there are many urban locations unsuitable for other development where solar could be located with minimal tradeoff. If the County wished to divert all landfilled biomass waste to incinerators, this waste would provide the largest single component of bioenergy resources, but such a

[127] It should be noted that new electricity loads have the potential to significantly increase county-wide electricity consumption, including the adoption of electric vehicles and heat pumps. Usage statistic sourced from California Energy Commission: http://ecdms.energy.ca.gov/elecbycounty.aspx.

policy change appears unlikely for multiple reasons, including the current economics of the biomass combustion industry in California. The other resource types all have less annual generation potential but taken together could yield a significant amount of generation.

From a financial perspective, the large amount of rooftop and parking lot solar that is technically available comes at a higher cost per watt than solar and wind that could be built with large scale resources. Rooftop solar costs tend to exceed $3/W, and parking lot solar is closer to $3.50/W, while solar on agricultural lands or urban lands unlikely to be developed could be as low as $1.60/W. This significant cost differential suggests that a cost-effective strategy would be to evaluate opportunities for the appropriate development of ground-mounted solar.

Given these caveats on the rate of development and the relative cost of the rooftop and parking lot solar available in the County, commercial-scale solar remains a critical component of a comprehensive renewable resource development strategy. At the same time, the development of ground-mounted commercial-scale resources must be balanced with the increasing scarcity and value of land in the County. At present, most commercial-scale solar is land intensive and does not allow for multiple uses of the same land, although technologies that enable the co-location of ground-mounted solar with agriculture hold future promise that should not be overlooked. Therefore, County strategy should continue to encourage and facilitate solar in low or no tradeoff settings such as rooftops and parking lots, while concurrently defining parameters for the appropriate development of ground-mounted solar, now and in the future..

Extending the Benefits of Renewables to All

Of the identified technical potential, there are significant opportunities to site solar in or near the “disadvantaged” census tracts in the unincorporated County as defined by the State of California. This includes the 200 megawatts of wind that could be sited in the hills south and west of the developed portions of Bay Point, and up to 519 megawatts of solar in disadvantaged tracts throughout the County. In the next phase of this project, the County will work with three communities in the unincorporated area of the County on opportunities for residents of those communities to benefit from these identified renewable resources. The benefits of renewables can also be extended to all segments of the population through community solar and wind programs, which allow renters to directly purchase parts of a renewable project; both MCE and PG&E offer these types of programs.

Leading by Example

The County owns or leases approximately 350 buildings that may be suitable for solar. The County has already taken great strides to assess many of its facilities for solar, and has numerous installations, both on rooftops and parking lots, though more could be done.

Planning and Zoning Options

Given the significant amount of resource availability within the County, this study reviews best practices to facilitate renewable development, while still being mindful of long-term planning considerations and potential tradeoffs. As a relatively urban county with a significant population, significant commercial activity, and significant land constraints, developing local large-scale renewables that can serve a large proportion of the County's load is inherently a more difficult task than it would be in a more rural and less populous county. Therefore, policy best practices that facilitate the development of the more limited resources that *are* available are of heightened importance, presuming the County desires to contribute what it can towards the realization of California's renewable energy and climate goals.

Some of the options described in this study include mandates, zoning language revisions, financing strategies, development of County-owned sites for renewables, property tax waivers, and other financial mechanisms to encourage development of the resources that the County would most like to see developed. Stakeholder input that was provided indicates that County constituents have strong interests in protecting farmland, habitat, open space, and other valued land uses, as well as strong interests in encouraging the development of local clean energy resources at attractive costs. There is significant support for developing solar on parking lots as well as industrially related lands and urban land unlikely to be developed for other uses. The County must balance numerous values to assess the appropriate path forward to expand its clean energy leadership in a cost-effective way while being mindful of and minimizing potential tradeoffs.

Appendix A: Solar Potential on County Owned and Leased Facilities

The County owns or leases a significant amount of property within its borders. The County provided its asset list for this study, which the project team pared down to the approximately 350 buildings that are currently occupied.

Rather than conduct an analysis of all 350 occupied buildings supplied by the County, Cadmus analyzed the top 10 largest buildings and statistically sampled the rest of the smaller buildings across approximately 10 building size categories (three to five samples per category). This analysis was done with Google Project Sunroof, with the same assumptions and adjustments described above in the section on rooftop solar. Table 31 shows the solar potential on the top 10 buildings by size.

Table 31. Largest 10 County Owned or Leased Buildings

Type		Address	Square Footage	Google Sunroof Rooftop (sf)	Estimated kW
Owned	Hospital	2500 Alhambra Ave, Martinez, CA 94553	210,000	26,093	184
Leased	Outpatient Care Facility	2311 Loveridge Rd, Pittsburg, CA 94565-5117	130,900	37,809	266
Owned	Juvenile Detention Center	202 Glacier Dr, Martinez, CA 94553	120,000	300	2
	Government Office Building	2530 Arnold Dr, Martinez, CA 94553-4359	115,091	14,976	106
		50 Douglas Dr, Martinez, CA 94553	92,024	21,653	153
		651 Pine St, Martinez, CA 94553	90,498	6,959	49
	Medical Center	100 38th St, Richmond, CA 94805	83,884	27,573	194
	General Purpose Library	1750 Oak Park Blvd, Pleasant Hill, CA 94523	63,912	33,211	234
Leased	Government Office Building	1275A Hall Ave, Richmond, CA 94804-3763	60,000	62,862	443
Owned		4545 Delta Fair Blvd, Antioch, CA 94509-3950	52,800	24,595	173

As approximately one-third of the buildings were leased, the study assumes split incentives will result in solar not place on leased buildings.

Appendix B: Google Project Sunroof Solar Potential by Census Tract

On September 17, 2018, Cadmus downloaded the following data from Google Project Sunroof. For the rightmost column, estimated potential is calculated as the sum of the number of panels facing south and west, multiplied by an 80% packing factor, a 20% AC:DC derating factor, and multiplied by 80% (not all roofs can handle 4 lbs/sf for solar arrays); reductions will occur due to accommodate rooftop equipment (e.g., rooftop air conditioners, fire borders). Cadmus additionally assumed that the panels had 260 W/modules and 16% efficiency.

Table 32. Amount of Rooftop Solar Potential in Each Census Tract

Census Tract	State	# of Panels Facing				Estimated kW	
		South	East	West	Flat	South + Flat	East + West
3010.00	California	10057	8567	9465	28512	4813	7064
3020.05	California	34279	21724	33831	27166	7668	14602
3020.06	California	22025	16593	22269	6959	3617	8467
3020.07	California	40425	23567	36115	11935	6535	13983
3020.08	California	41814	23688	37658	10602	6542	14197
3020.09	California	40985	28999	34227	37310	9771	17662
3020.10	California	84582	54382	77555	9861	11786	28252
3031.02	California	61728	39548	62054	43146	13088	25768
3031.03	California	61330	30814	48222	101777	20356	30219
3032.01	California	67496	49326	57595	20367	10965	24309
3032.02	California	49890	26773	39864	4495	6787	15104
3032.03	California	68549	42451	63679	43604	13997	27242
3032.04	California	24046	17223	24615	11672	4458	9679
3032.05	California	70983	56224	69712	11051	10238	25955
3040.01	California	36010	26593	31055	19350	6909	14103
3040.02	California	228	127	241	184	51	97
3040.03	California	44936	35124	37113	14428	7409	16424
3040.04	California	44753	38840	41250	6518	6399	16394
3040.05	California	51638	34587	40199	28028	9942	19276
3050.00	California	34638	25780	35587	125551	19992	27650
3060.02	California	22804	17185	21715	55068	9718	14573
3060.03	California	23267	14699	22425	21679	5609	10242
3060.04	California	17677	11608	15189	27279	5611	8955
3071.01	California	31330	17624	20113	13014	5534	10244
3071.02	California	19885	12369	20252	14095	4241	8312
3072.01	California	12680	12025	12618	23693	4539	7615
3072.02	California	11575	10799	10494	8881	2553	5210
3072.04	California	27071	24230	26453	1753	3597	9922
3072.05	California	27734	24451	26733	24748	6550	12938

Census Tract	State	# of Panels Facing				Estimated kW	
		South	East	West	Flat	South + Flat	East + West
3080.01	California	48808	34313	40341	34785	10432	19749
3080.02	California	33466	24475	26350	6964	5046	11389
3090.00	California	22827	22898	21901	56469	9896	15487
3100.00	California	14989	15228	15918	28853	5471	9359
3110.00	California	17099	13259	12645	16369	4177	7410
3120.00	California	8881	9741	9099	37856	5833	8184
3131.01	California	40292	28053	28359	87400	15936	22976
3131.02	California	22098	15877	16114	27261	6160	10152
3131.03	California	53736	45648	52059	7988	7703	19897
3132.03	California	17342	16828	17814	1042	2294	6618
3132.04	California	25418	22079	24469	4676	3756	9565
3132.05	California	10342	7655	7963	1477	1475	3424
3132.06	California	23776	22071	21988	9546	4159	9657
3141.02	California	26083	17895	21710	11225	4656	9599
3141.03	California	24729	12973	19439	14863	4941	8986
3141.04	California	23234	12437	17403	10713	4237	7961
3142.00	California	25302	14071	17197	34223	7429	11331
3150.00	California	26667	17208	20888	155840	22777	27531
3160.00	California	5163	2512	3953	18124	2906	3713
3170.00	California	8243	4348	7901	11768	2497	4026
3180.00	California	10787	8206	9277	19051	3724	5906
3190.00	California	36671	24035	30126	21766	7293	14052
3200.01	California	20014	15971	16193	73895	11720	15734
3200.03	California	16986	11341	15377	25096	5252	8586
3200.04	California	33033	24423	28922	26594	7441	14099
3211.01	California	44846	33239	38430	26415	8893	17838
3211.02	California	46991	34743	39289	4600	6439	15678
3211.03	California	31947	20717	25551	9012	5112	10886
3212.00	California	23507	14885	17851	61379	10594	14679
3220.00	California	43075	28877	32268	45122	11007	18638
3230.00	California	30814	15912	21201	8379	4891	9523
3240.01	California	12864	8889	10972	55692	8556	11034
3240.02	California	20165	11389	15114	43967	8004	11311
3250.00	California	29687	19934	24484	23277	6610	12153
3260.00	California	26977	16457	20031	5496	4053	8606
3270.00	California	17520	15062	16240	268926	35748	39655
3280.00	California	5337	3030	4609	59326	8070	9023
3290.00	California	33939	30640	29678	21346	6900	14427
3300.00	California	31429	24346	25206	14967	5790	11974
3310.00	California	39042	27596	32710	22085	7629	15155
3320.00	California	47233	44684	36463	17932	8133	18260

Census Tract	State	# of Panels Facing				Estimated kW	
		South	East	West	Flat	South + Flat	East + West
3331.01	California	23285	21766	17697	8267	3938	8863
3331.02	California	27372	23427	20594	9921	4654	10148
3332.00	California	37861	35094	27723	26062	7978	15817
3340.01	California	17604	16381	15016	6385	2994	6912
3340.04	California	34796	31211	30330	33056	8468	16148
3340.06	California	25380	33126	37787	3156	3561	12411
3342.00	California	42842	22073	33443	23738	8309	15238
3350.00	California	18628	17427	15264	23135	5212	9292
3361.01	California	8299	4214	4882	19251	3438	4573
3361.02	California	6275	3648	5391	34338	5069	6197
3362.01	California	13634	10928	14050	12698	3286	6403
3362.02	California	8192	4441	6993	26374	4314	5741
3371.00	California	24029	21347	18080	6159	3767	8688
3372.00	California	33483	18789	26525	68885	12776	18431
3373.00	California	48545	38608	44715	12558	7626	18024
3381.01	California	16282	13184	13457	12015	3531	6856
3381.02	California	22362	17349	23944	6361	3585	8738
3382.01	California	37702	29999	38978	83303	15101	23710
3382.03	California	17302	10956	13713	7628	3111	6190
3382.04	California	26844	22437	31287	10747	4691	11396
3383.01	California	32499	23783	27438	11571	5500	11892
3383.02	California	43726	30706	38659	40040	10454	19111
3390.01	California	3566	3393	3624	73904	9668	10544
3390.02	California	8673	5149	7730	115907	15548	17155
3400.01	California	27315	15017	21107	45903	9138	13646
3400.02	California	47104	29997	33015	24736	8966	16830
3410.00	California	25005	15735	20687	17249	5273	9819
3430.01	California	23479	16433	18211	14654	4759	9083
3430.02	California	27444	13848	17526	17604	5622	9537
3430.03	California	31624	16402	20319	6656	4777	9360
3451.01	California	36643	24584	30283	10649	5902	12749
3451.02	California	29296	19851	25219	5264	4313	9938
3451.03	California	33363	30422	38844	6620	4990	13634
3451.05	California	48292	31206	40511	20852	8629	17579
3451.08	California	40597	23659	36329	110009	18796	26282
3451.11	California	32414	14609	25415	26600	7365	12360
3451.12	California	25486	19330	25317	3182	3578	9150
3451.13	California	21850	18098	19330	1378	2899	7570
3451.14	California	54250	37982	49142	4713	7359	18232
3451.15	California	46969	31403	38618	4761	6456	15195
3451.16	California	22101	15877	18076	1603	2958	7196

Census Tract	State	# of Panels Facing				Estimated kW	
		South	East	West	Flat	South + Flat	East + West
3452.02	California	40352	26725	33649	51033	11405	18940
3452.03	California	53820	31938	38427	31243	10616	19397
3452.04	California	28996	15679	24605	9517	4806	9834
3461.01	California	32381	24477	29393	5195	4689	11412
3461.02	California	62301	38534	48452	11317	9188	20043
3462.01	California	70457	43638	53656	11832	10270	22412
3462.03	California	32450	21383	27140	3057	4431	10487
3462.04	California	50515	32972	36393	4890	6915	15571
3470.00	California	50071	34448	38995	12383	7794	16960
3480.00	California	35994	21601	24061	22986	7361	13059
3490.00	California	24427	16971	20908	26275	6328	11055
3500.00	California	34655	21033	23082	33733	8535	14040
3511.01	California	11827	8146	9397	24309	4510	6699
3511.02	California	13732	13035	10639	45020	7332	10287
3511.03	California	12740	17222	18997	11532	3029	7549
3512.00	California	42994	30328	35103	10528	6680	14845
3521.01	California	23320	18811	21361	4470	3468	8482
3521.02	California	45832	30173	36142	12095	7229	15505
3522.01	California	38944	33240	37859	29325	8520	17393
3522.02	California	10942	9622	11077	10036	2618	5201
3530.01	California	19110	12246	13489	9765	3604	6815
3530.02	California	27581	18296	19613	12287	4976	9707
3540.01	California	3857	3073	2556	4665	1064	1766
3540.02	California	37372	22023	27223	31082	8543	14689
3551.07	California	32915	28632	30327	820	4210	11568
3551.08	California	79444	70846	74972	14414	11713	29912
3551.09	California	43419	33038	37254	12163	6937	15709
3551.10	California	22768	14730	18022	9429	4018	8106
3551.11	California	34171	28731	30317	626	4343	11712
3551.12	California	48625	28779	34229	5855	6799	14663
3551.13	California	44937	34906	42073	4063	6115	15722
3551.14	California	64907	46654	56931	9726	9314	22242
3551.15	California	25706	21979	27265	3687	3668	9814
3551.16	California	38755	32328	37173	5141	5478	14152
3551.17	California	35121	29503	35071	972	4504	12563
3552.00	California	57016	49383	51150	15774	9084	21631
3553.01	California	60806	42481	47345	14919	9450	20661
3553.02	California	34799	23552	28379	2773	4689	11170
3553.04	California	62484	44206	50389	8415	8848	20654
3553.06	California	40706	36958	40669	6939	5946	15634
3560.01	California	19373	17909	21080	2951	2786	7652

Census Tract	State	# of Panels Facing				Estimated kW	
		South	East	West	Flat	South + Flat	East + West
3560.02	California	22612	13698	21519	1543	3015	7410
3570.00	California	15520	10825	15395	15439	3864	7136
3580.00	California	24990	19694	23166	34911	7476	12825
3591.02	California	21011	15971	19555	27947	6110	10544
3591.03	California	19351	12732	15884	36928	7024	10595
3591.04	California	6304	5297	6204	1667	995	2430
3591.05	California	15138	12459	17453	6311	2677	6410
3592.02	California	39894	27898	35679	10265	6260	14194
3592.03	California	40844	32964	40091	11044	6476	15593
3592.04	California	27171	22623	26746	7472	4323	10485
3601.01	California	28364	22114	24784	26691	6871	12724
3601.02	California	33403	23990	25819	5394	4842	11058
3602.00	California	20667	13096	14638	31801	6548	10009
3610.00	California	14747	16485	17033	19624	4290	8473
3620.00	California	9515	6935	10871	20216	3710	5933
3630.00	California	29651	22793	27337	74479	12995	19252
3640.02	California	20910	18481	22059	26840	5959	11019
3650.02	California	14290	16070	19705	57034	8901	13366
3650.03	California	11715	6737	8133	87565	12390	14246
3660.01	California	7636	6599	6734	37603	5646	7310
3660.02	California	15385	10084	9287	27120	5305	7722
3671.00	California	14002	12334	15163	50561	8057	11489
3672.00	California	15526	10237	12604	23755	4902	7753
3680.01	California	6860	11538	14895	15700	2815	6114
3680.02	California	10031	5493	5421	19725	3714	5076
3690.01	California	12268	11132	11028	55753	8489	11255
3690.02	California	8268	4271	6464	30045	4781	6121
3700.00	California	9980	6890	9709	20117	3756	5828
3710.00	California	15732	13767	14951	25617	5160	8744
3720.00	California	21071	15661	20685	30295	6410	10946
3730.00	California	8610	7053	9512	14405	2872	4940
3740.00	California	10899	9555	10308	29645	5060	7539
3750.00	California	8173	4835	6726	18889	3377	4820
3760.00	California	15920	8583	11736	36862	6587	9123
3770.00	California	15697	9028	12418	45095	7587	10263
3780.00	California	27218	16152	18917	282678	38675	43052
3790.00	California	16273	11446	15443	64634	10097	13453
3800.00	California	33426	19447	26267	213277	30789	36494
3810.00	California	15047	12690	16630	70230	10643	14302
3820.00	California	19743	16088	17740	46449	8261	12482
3830.00	California	13437	9898	14547	32125	5686	8737

Census Tract	State	# of Panels Facing				Estimated kW	
		South	East	West	Flat	South + Flat	East + West
3840.00	California	14503	9226	14450	29648	5510	8465
3851.00	California	14573	10744	16284	24639	4894	8267
3852.00	California	5994	4608	5902	15240	2650	3962
3860.00	California	9294	4407	7016	41102	6289	7715
3870.00	California	12073	5451	8581	22068	4261	6012
3880.00	California	9779	4569	6931	14867	3076	4511
3891.00	California	7977	3616	5128	26209	4266	5358
3892.00	California	2528	1121	1617	12433	1867	2209
3901.00	California	9452	6153	8237	14743	3020	4815
3902.00	California	7696	3828	5857	11904	2446	3655
3910.00	California	9226	5865	11064	13983	2896	5009
3920.00	California	9911	5624	9730	13413	2911	4827
3922.00	California	37553	29748	34005	166612	25480	33436
3923.00	California	12379	10294	13846	32247	5569	8582

Appendix C: Glossary

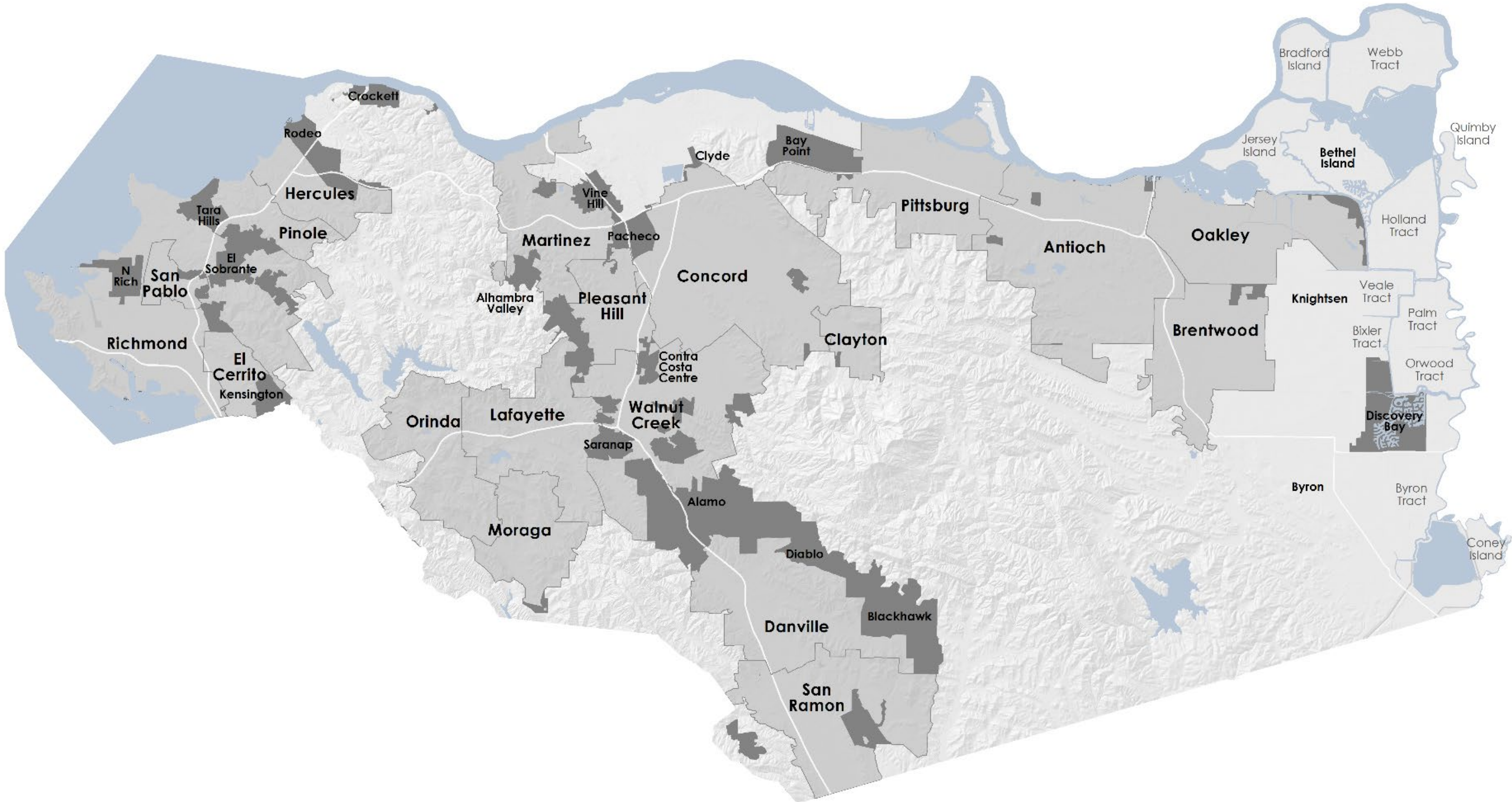
Acronym	Term
AC	Alternating Current
AB1826	California Assembly Bill on Recycling of Solid Organic Waste
AB2188	California Assembly Bill on Streamlined Solar Permitting
AB32	California Assembly Bill, Global Warming Solutions Act of 2006
AD	Anaerobic Digestion
BDT	Bone Dry Tons
BTM	Behind the Meter
BTU	British Thermal Unit
C&D	Construction and Demolition
CAISO	California Independent Systems Operator
CAP	Climate Action Plan
CARB	California Air Resources Board
CCA	Community Choice Aggregator
CCE	Community Choice Energy
CCMap	The County's portal for on-line property information is CCMAP. Browse to https://ccmap.cccounty.us for further information
CCPDA	California County Planning Directors' Association
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CO2	Carbon Dioxide
Dba	Decibels
DC	Direct Current
Dni	Direct Normal Irradiance
DOE	U.S. Department of Energy
EE	Energy Efficiency
EIA	Energy Information Administration
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
EV	Electric Vehicle
FAA	Federal Aviation Administration
FERC	Federal Energy Regulatory Commission
FIT	Feed In Tariff
FWS	U.S. Fish and Wildlife Service
GHG	Greenhouse Gas
GW	Gigawatt
GWh	Gigawatt Hour
HCP	Habitat Conservation Plan
IOU	Investor-Owned Utility

Acronym	Term
ITC	Investment Tax Credit (Federal)
kW	Kilowatt
kWh	Kilowatt Hour
LCOE	Levelized Cost of Electricity
LFG	Landfill Gas
MCE	Marin Clean Energy
MJ	Megajoules
MRLC	Multi-Resolution Land Characteristics
MW	Megawatt
MWh	Megawatt Hour
NCRS	Natural Resources Conservation Service
NEC	National Electric Code
NLCD	National Land Cover Database
NPDES	National Pollution Discharge Elimination System
NREL	National Renewable Energy Laboratory
NWEDI	Northern Waterfront Economic Development Initiative
PG&E	Pacific Gas and Electric
PPA	Power Purchase Agreement
PSM	Physical Solar Map
PV	Photovoltaic
PV RAM	Solar Photovoltaic and Renewable Auction Mechanism
REC	Renewable Energy Credit
RFI	Radio Frequency Interference
RPS	Renewable Portfolio Standard
SB100	California Senate Bill on 100 Percent Clean Energy
SB1122	Renewable Bio-Energy Projects California Senate Bill on Renewable Bioenergy Projects
SB1222	California Senate Bill on Solar Permits
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
T&D	Transmission and Distribution
ULL	Urban Limit Line
ULUTBD	Urban Land Unlikely to be Developed
WAPA	Western Area Power Administration
WCCSL	West Contra Costa Sanitary Landfill
WTP	Wastewater Treatment Plant
ZTA	Zoning Text Agreement

Appendix D: Cartography

This appendix consists of a series of maps that demonstrate the evaluation of available data used to determine the rural areas in the County that may be suitable for ground mounted solar. The first eight maps in the appendix show the boundaries of the Urban Limit Line and the incorporated cities, and how slope, natural land cover and exclusion factors as described in Section 3.2.3, were used to locate areas of the County with significant acreage potentially suitable for large-scale ground mounted solar. The next series of maps focuses on the less constrained agricultural eastern part of the County, presenting data layers associated with attributes such as soil quality and classifications, zoning overlay status, General Plan land use designation, elevation, transmission lines and substations, and other factors. The final five images of the appendix show maps of land potentially suitable for solar installations after removing specific classifications of land with high agricultural value.

Evaluation of constraints for siting solar outside the Urban Limit Line*

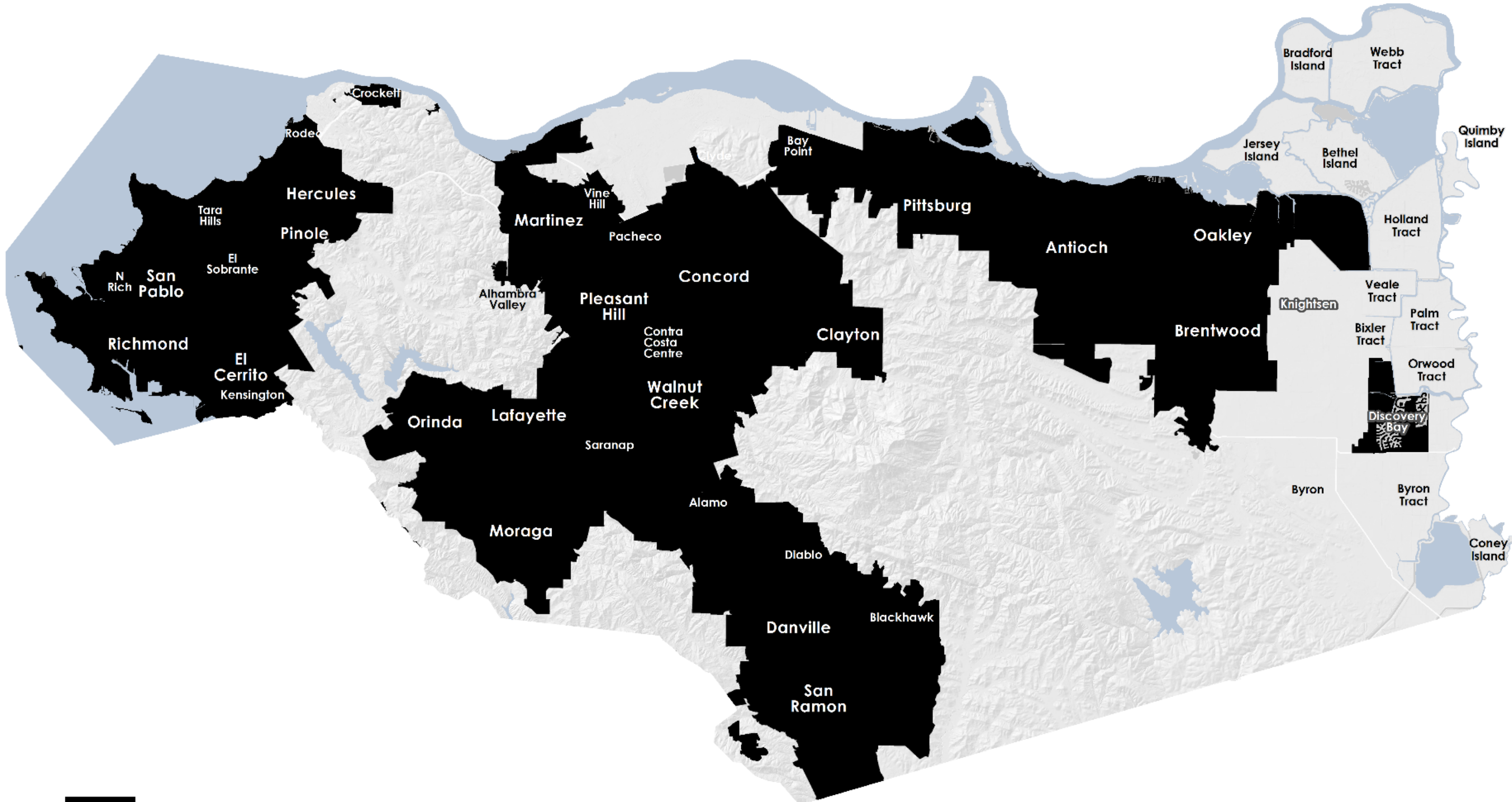


Incorporated Cities

Unincorporated Communities inside the ULL*

* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

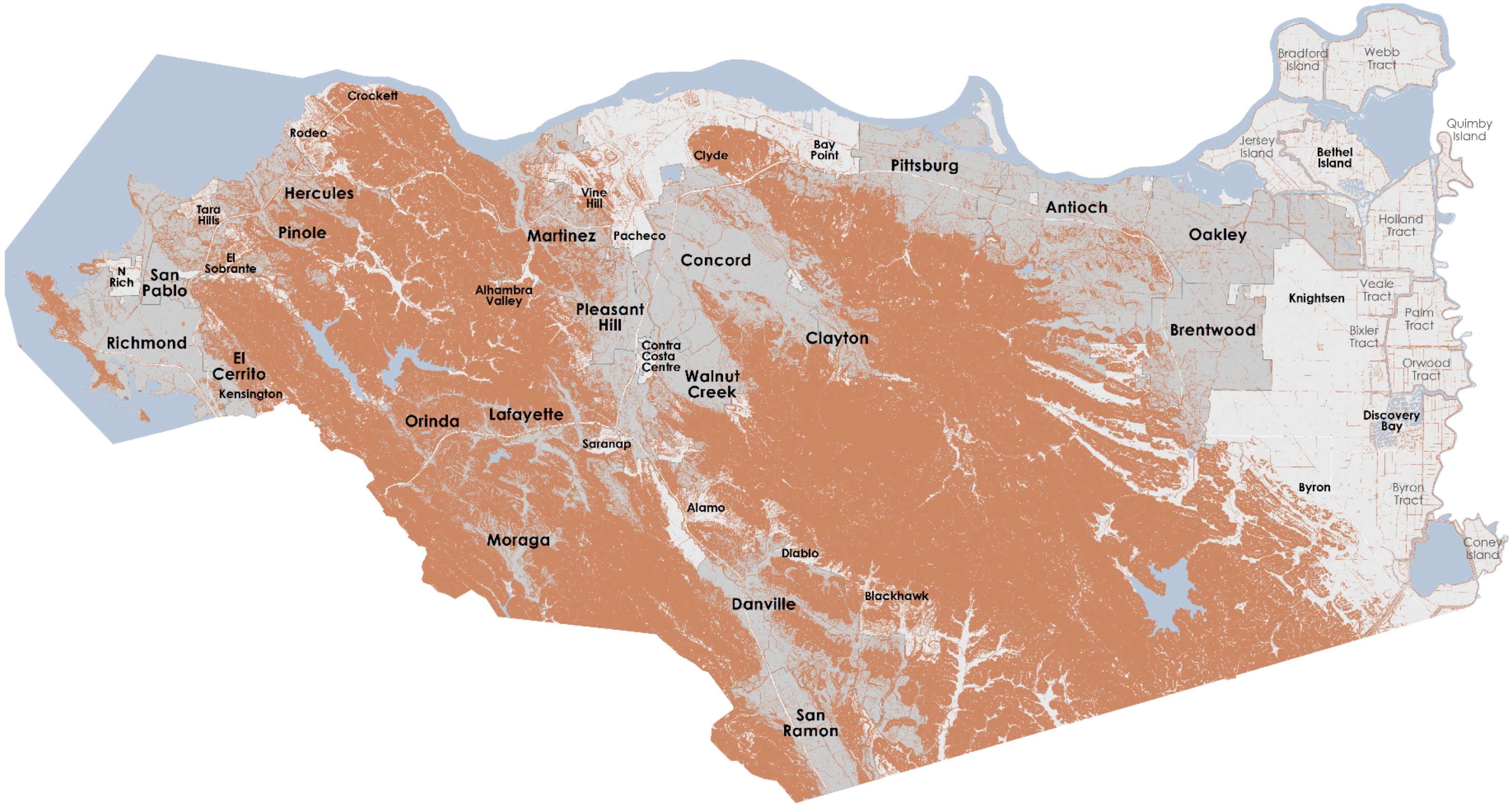
Evaluation of constraints for siting solar outside the Urban Limit Line*



Incorporated Cities and unincorporated communities inside the Urban Limit Line*

* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

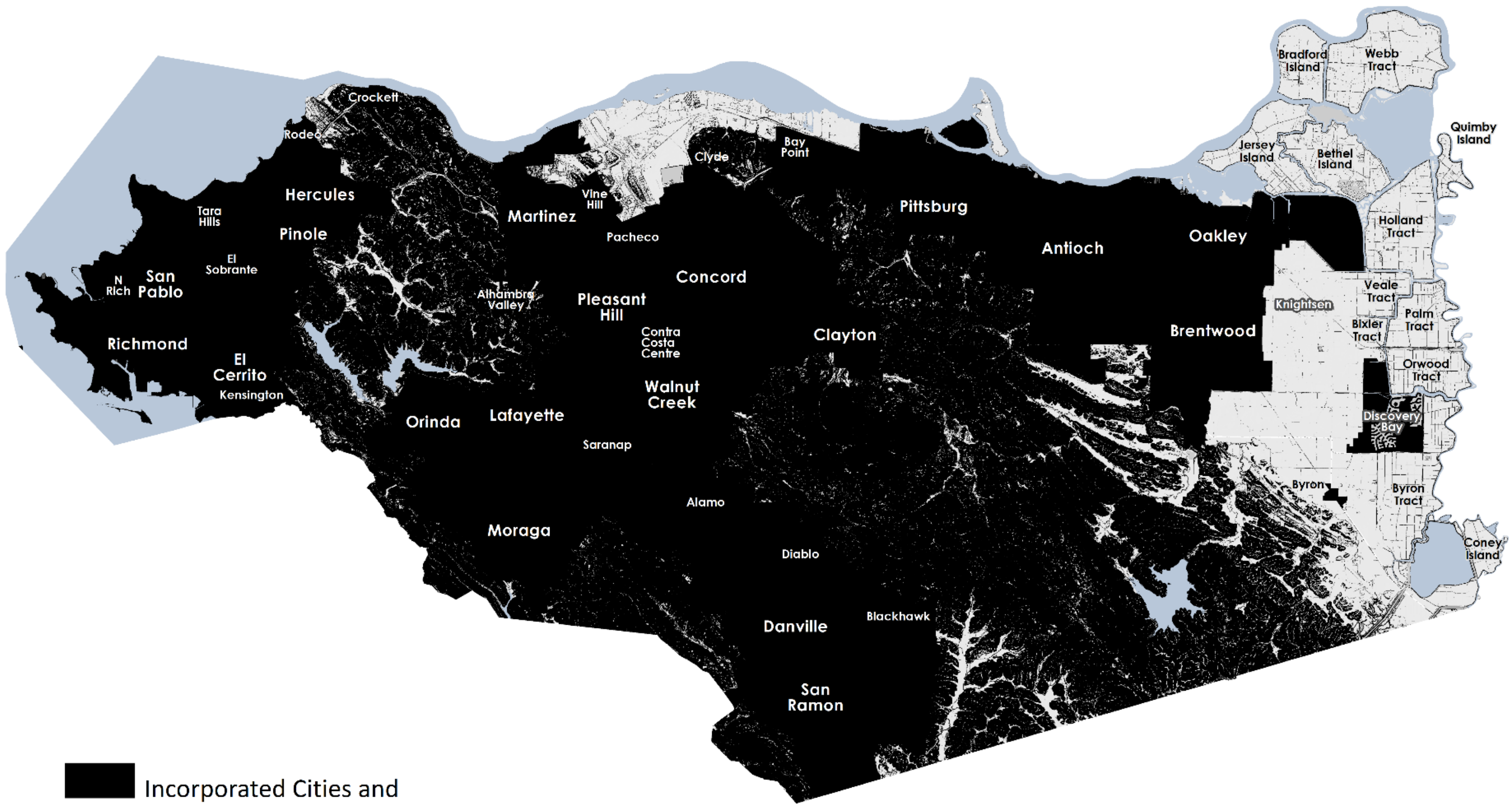
Evaluation of constraints for siting solar outside the Urban Limit Line*



Incorporated Cities
Slopes greater than 10%

* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

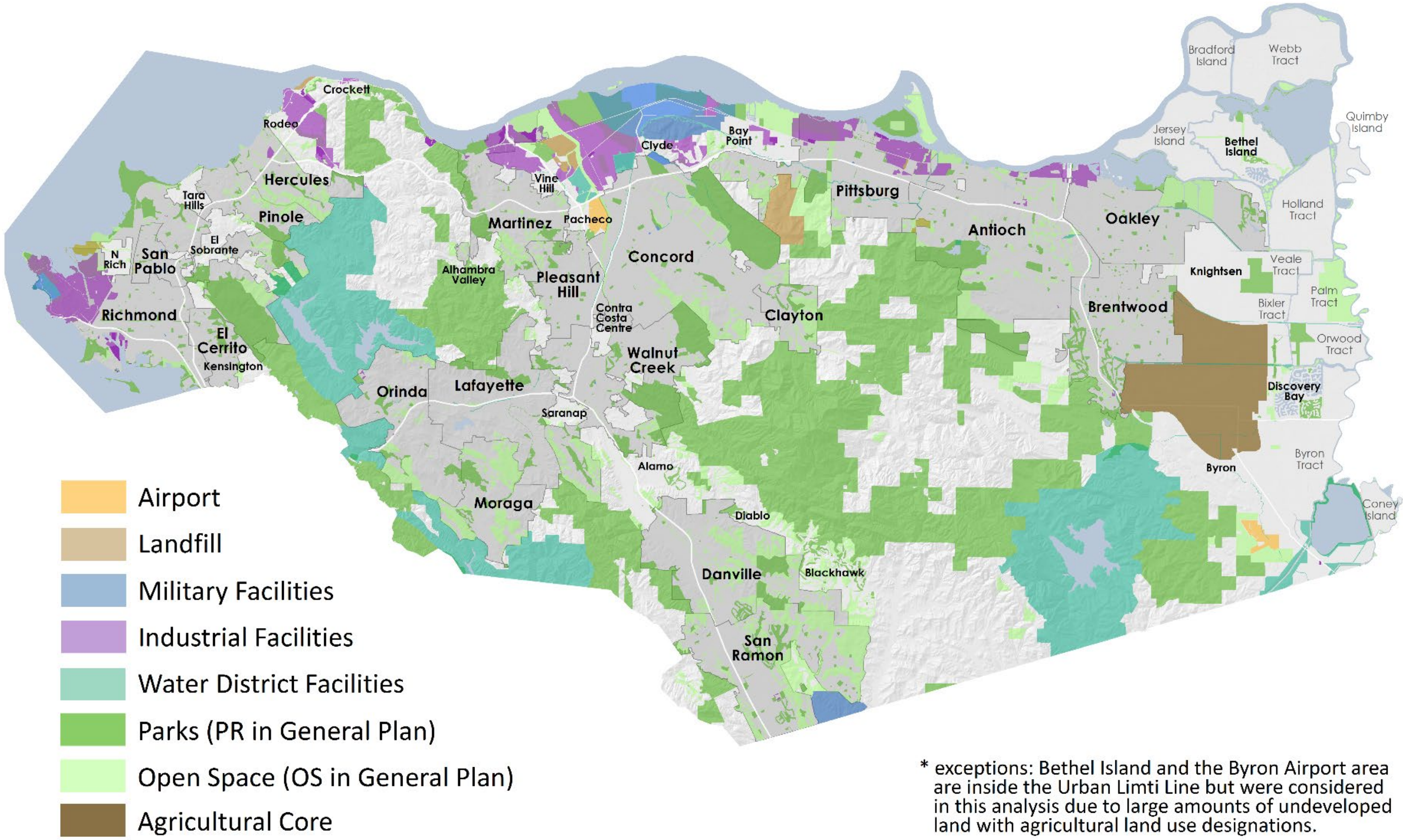
Evaluation of constraints for siting solar outside the Urban Limit Line*



Incorporated Cities and unincorporated communities inside the Urban Limit Line* and slopes greater than 10%

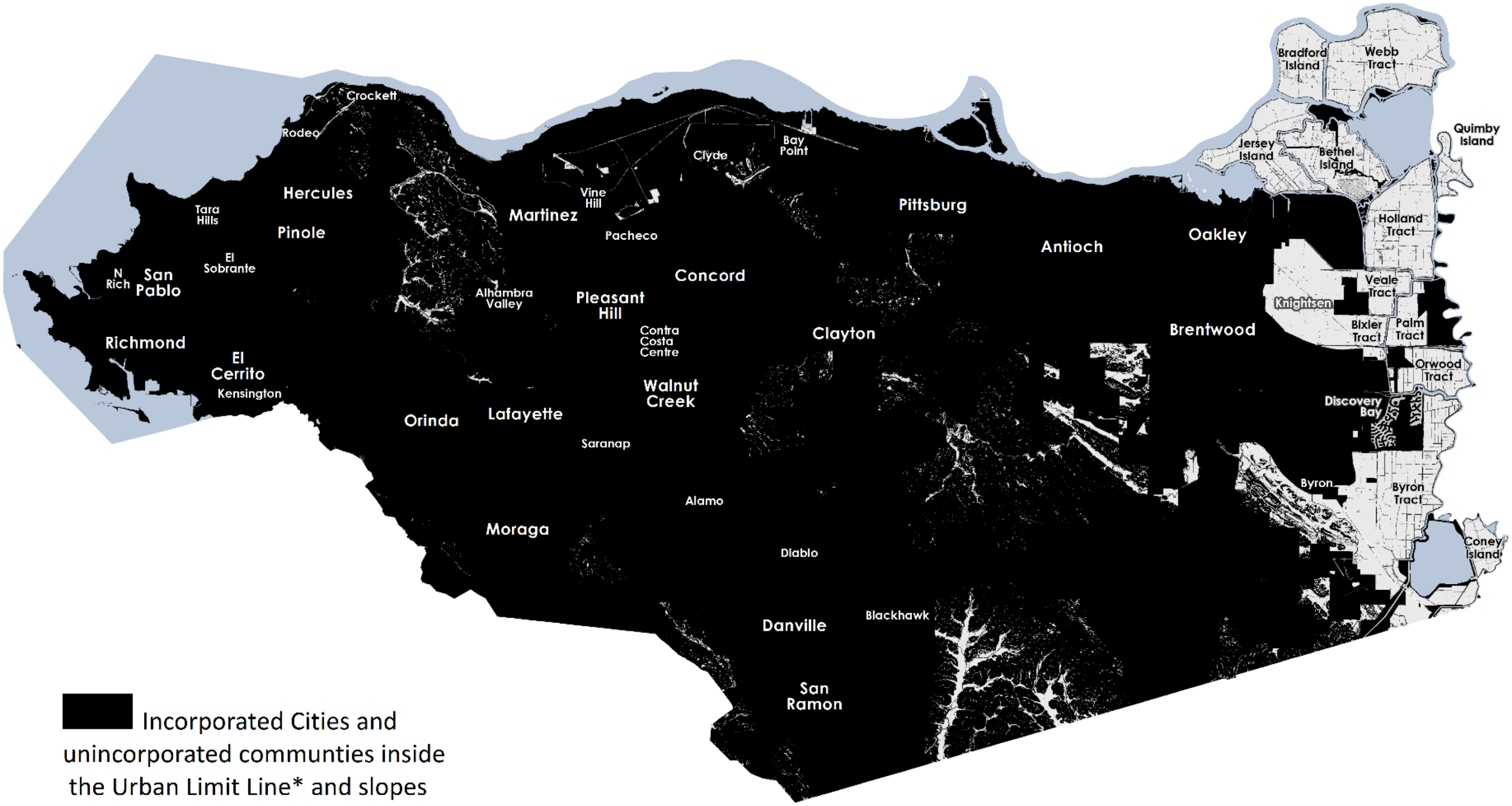
* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

Evaluation of constraints for siting solar outside the Urban Limit Line*



* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

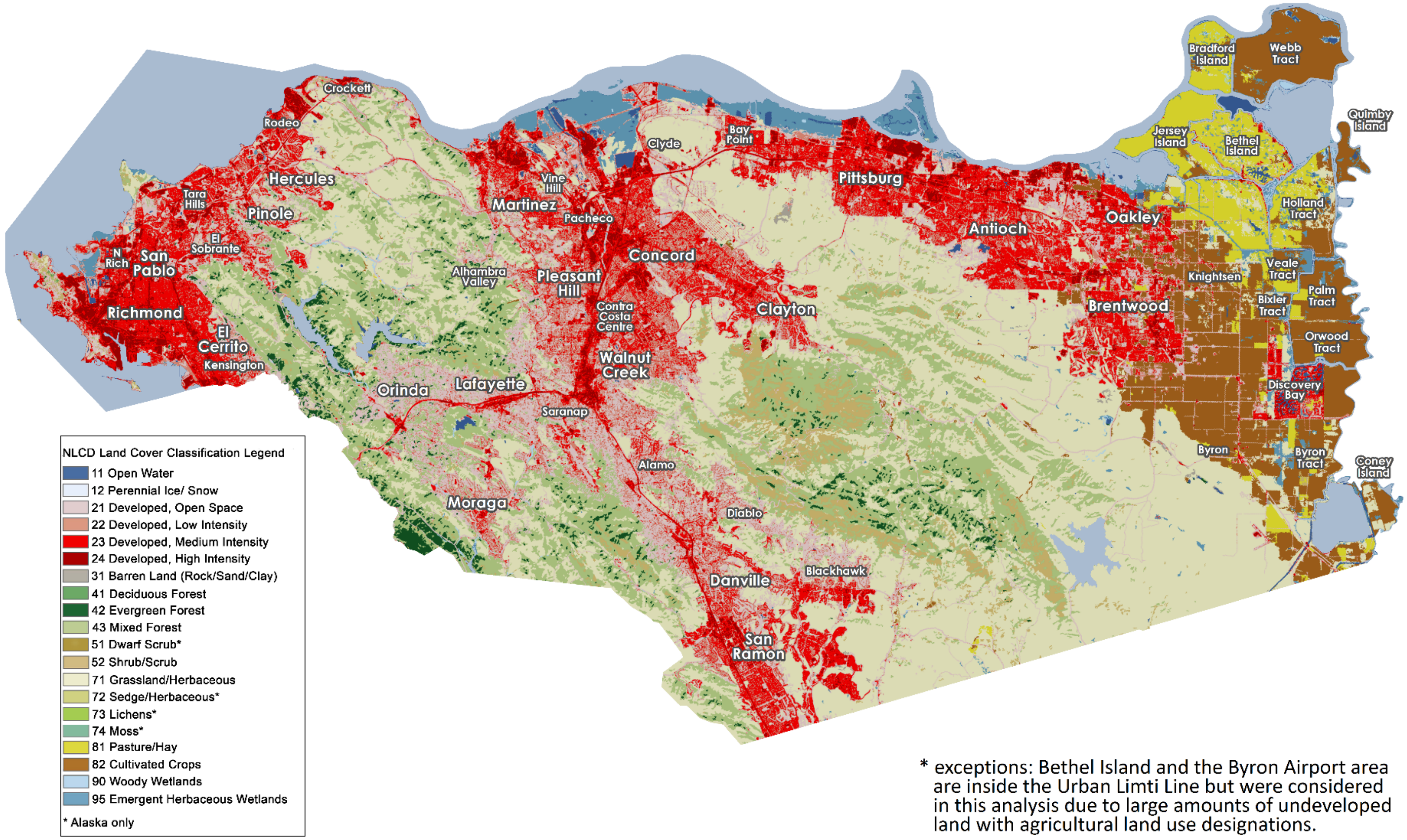
Evaluation of constraints for siting solar outside the Urban Limit Line*



Incorporated Cities and unincorporated communities inside the Urban Limit Line* and slopes greater than 10%, parks, open space, water district facilities, airports, landfills, industrial facilities, agricultural core

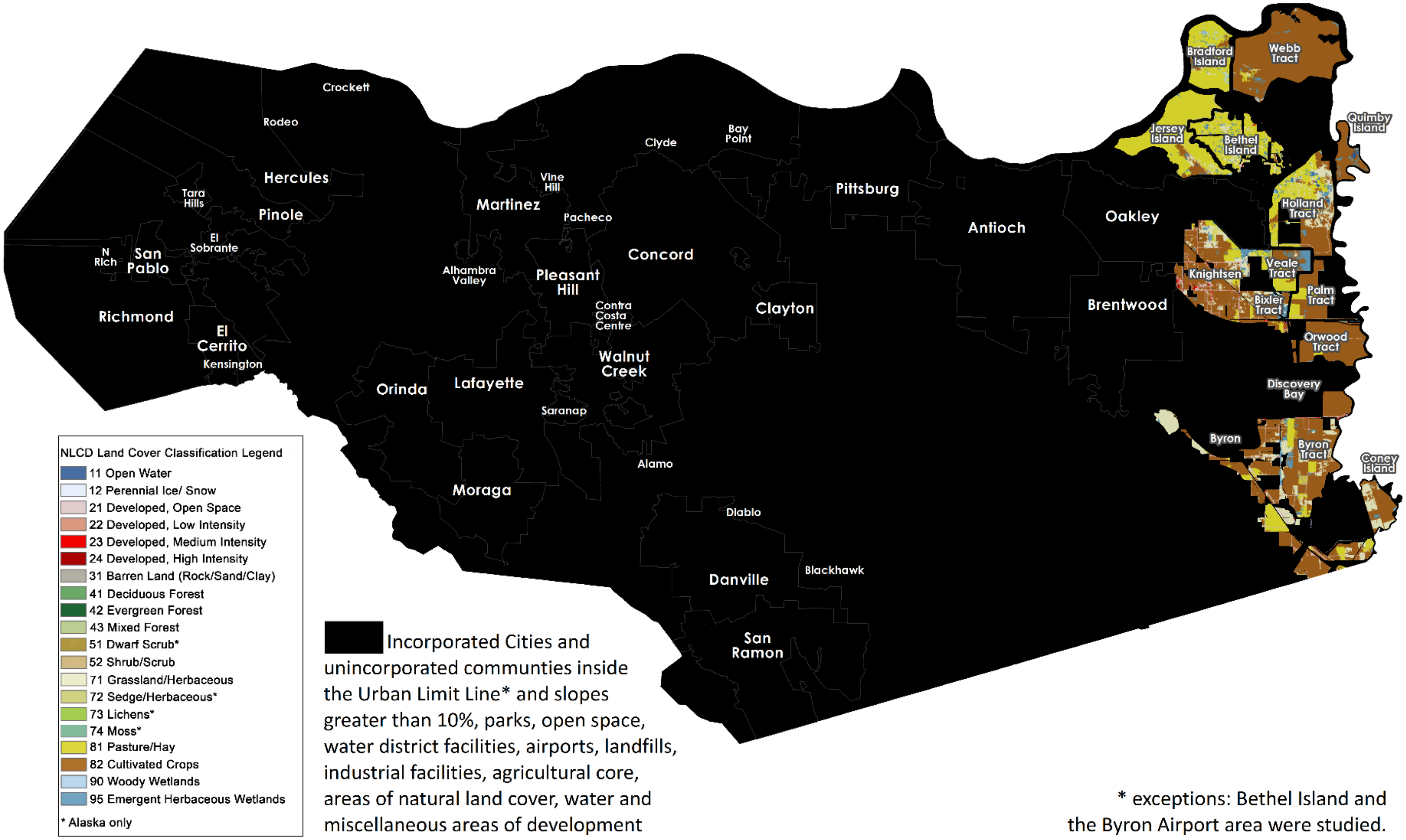
* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

Evaluation of constraints for siting solar outside the Urban Limit Line*



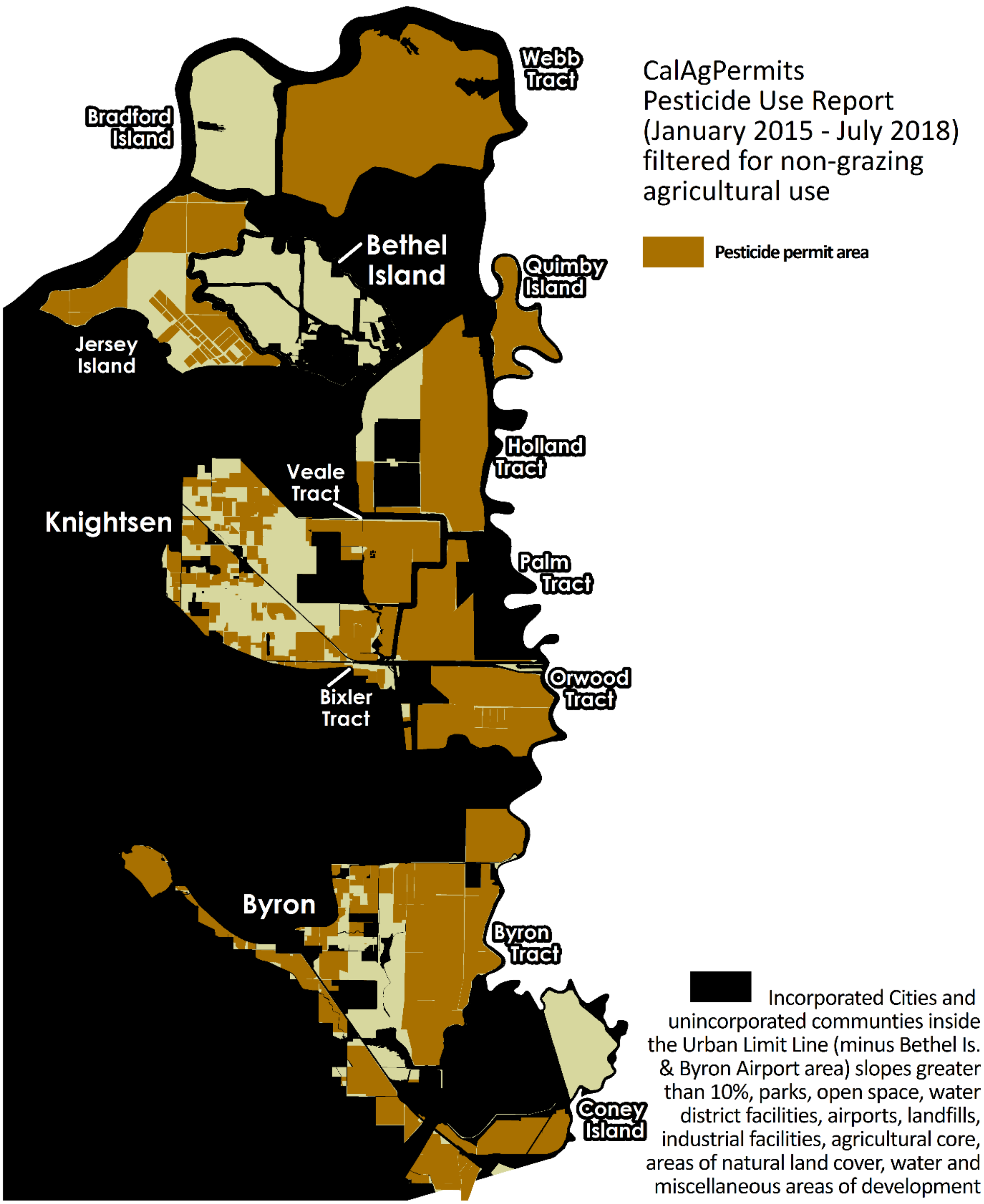
* exceptions: Bethel Island and the Byron Airport area are inside the Urban Limti Line but were considered in this analysis due to large amounts of undeveloped land with agricultural land use designations.

Evaluation of constraints for siting solar outside the Urban Limit Line*

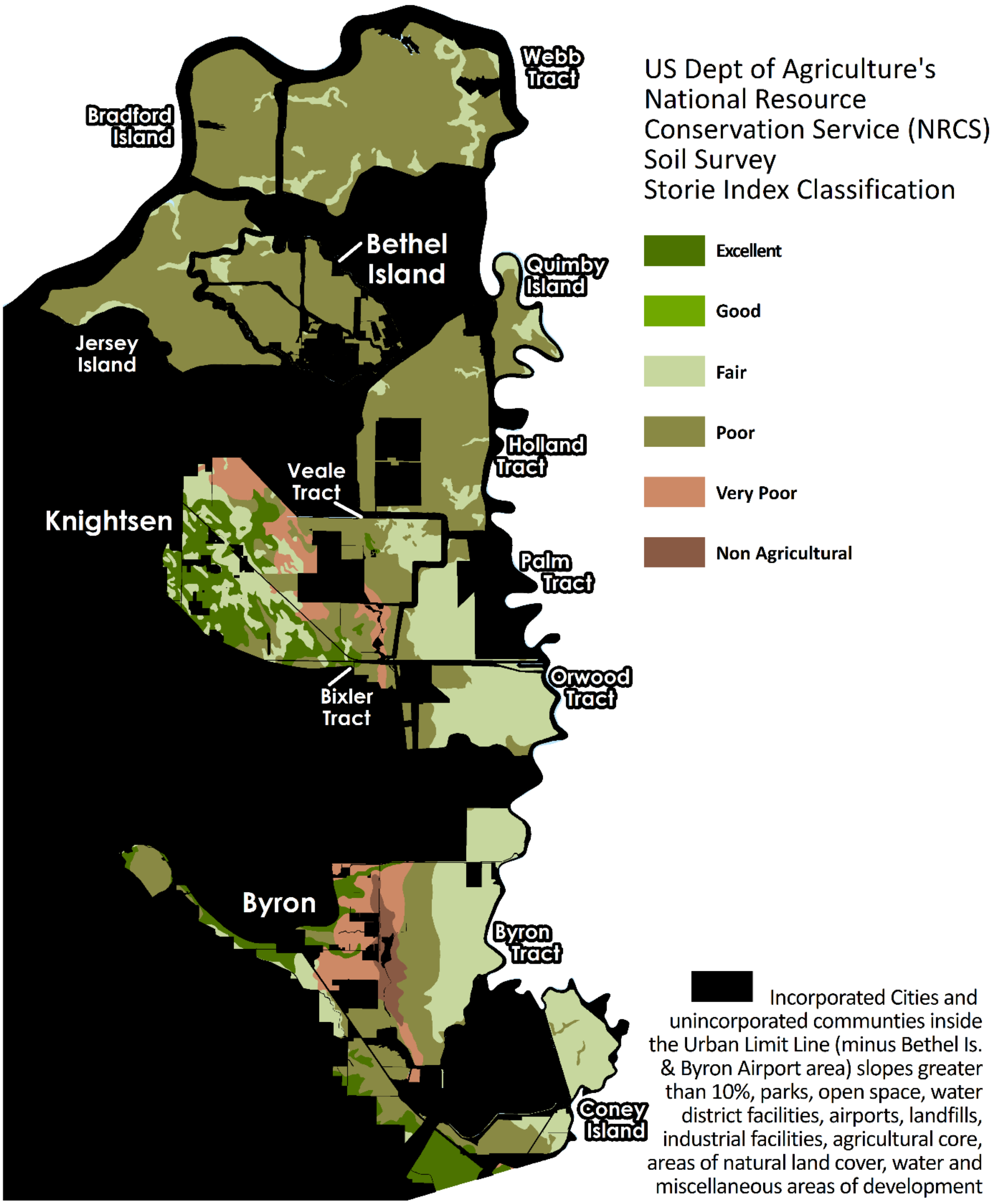


* exceptions: Bethel Island and the Byron Airport area were studied.

Evaluation of constraints for siting solar on agricultural lands



Evaluation of constraints for siting solar on agricultural lands



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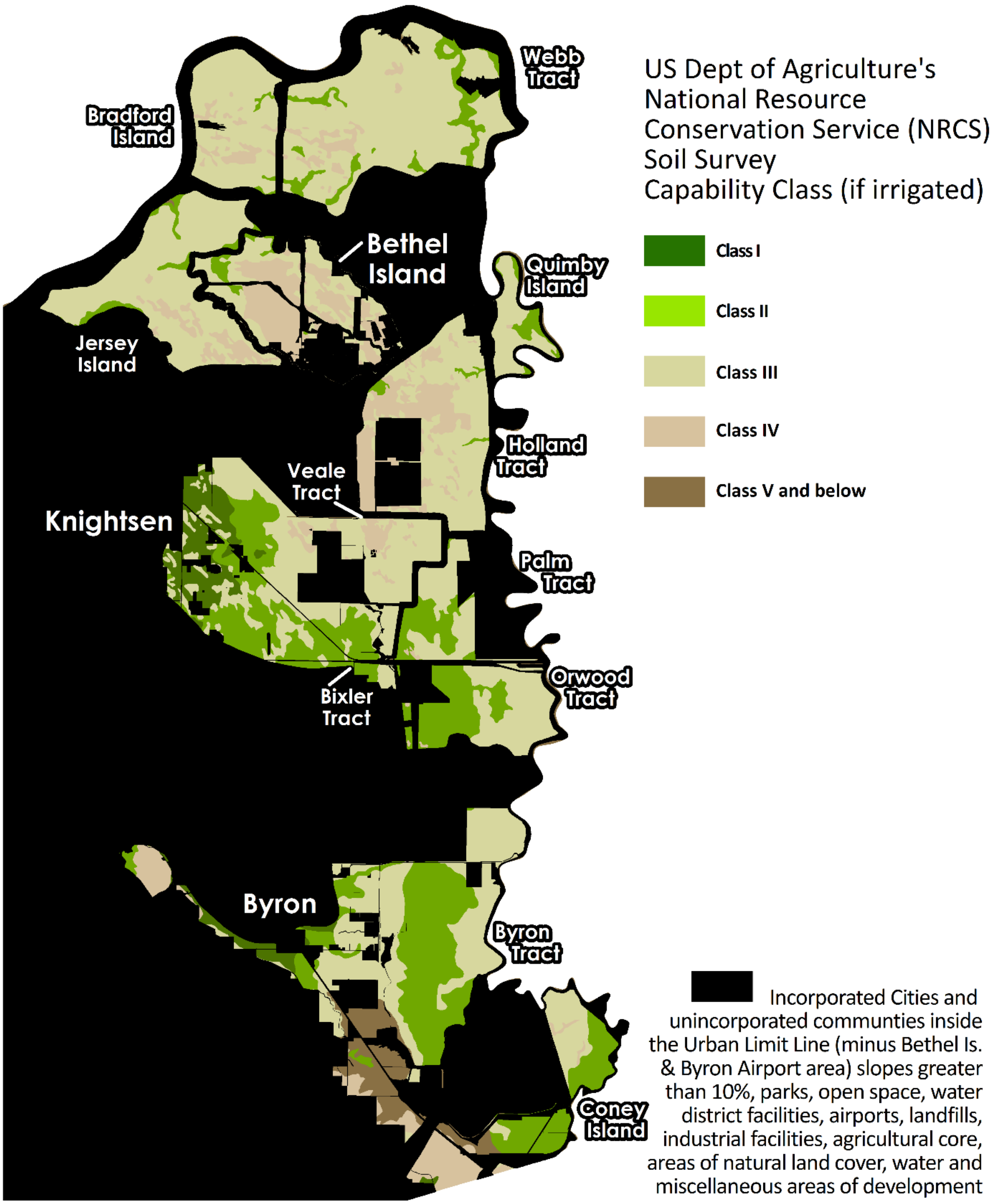

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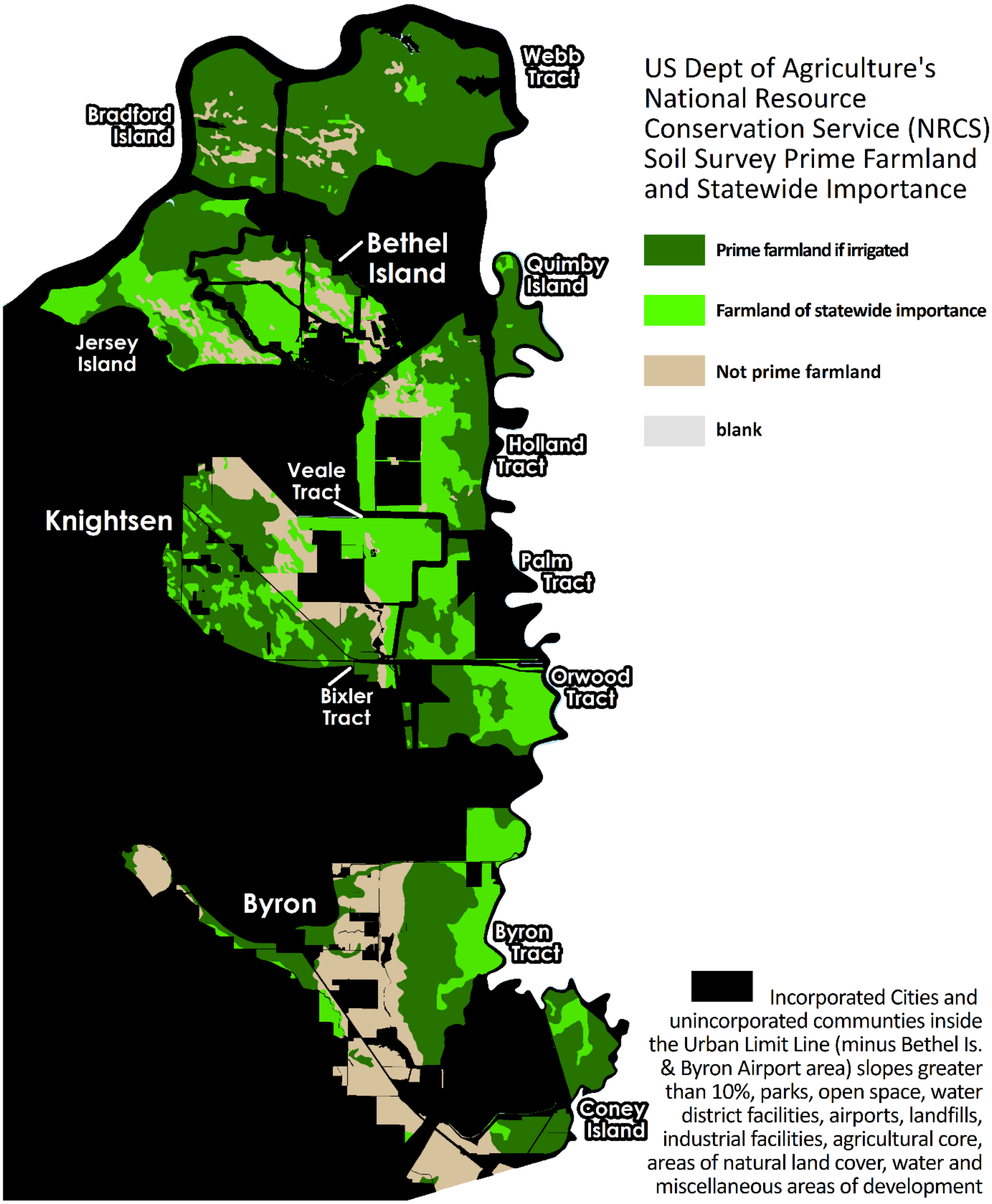

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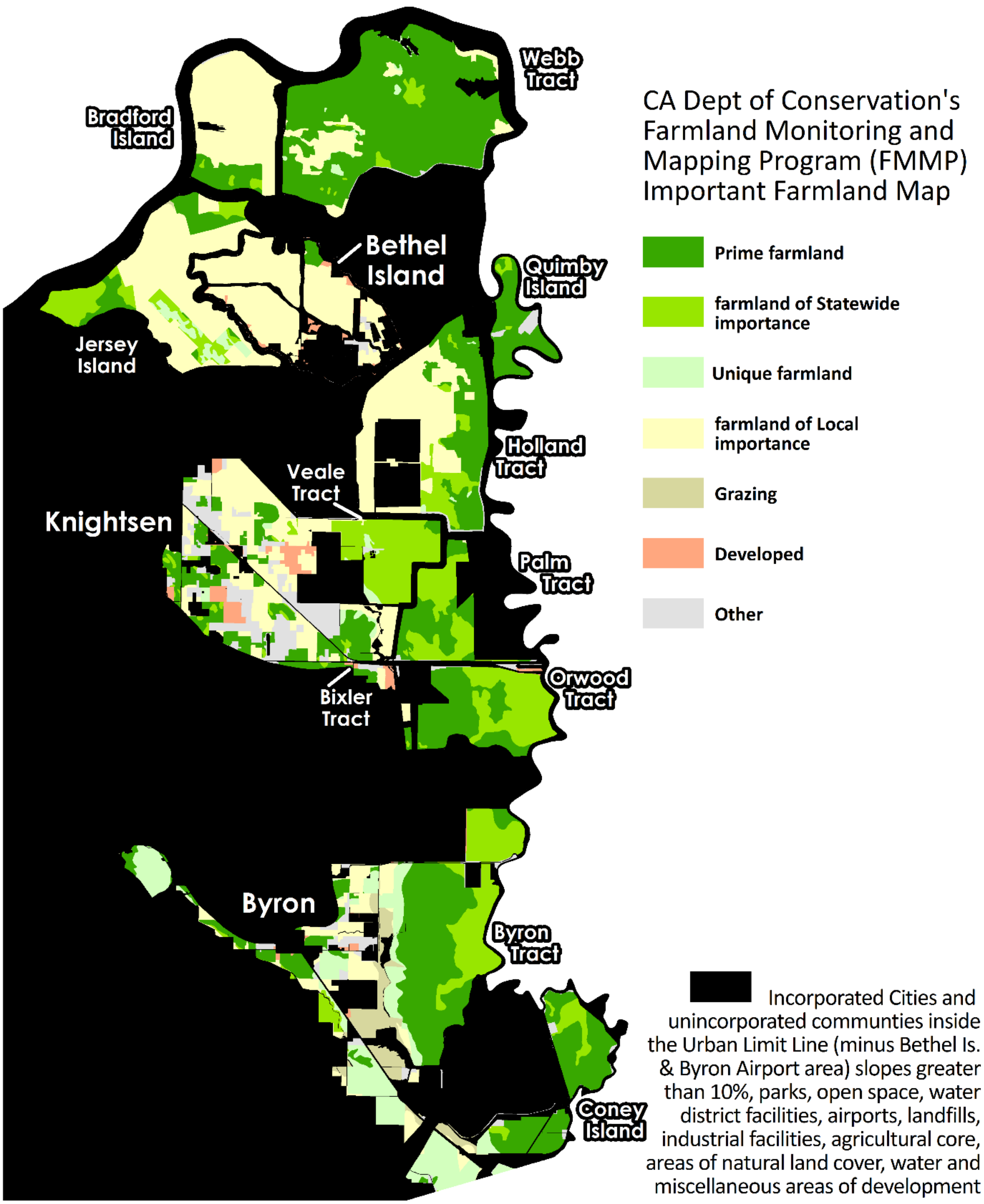

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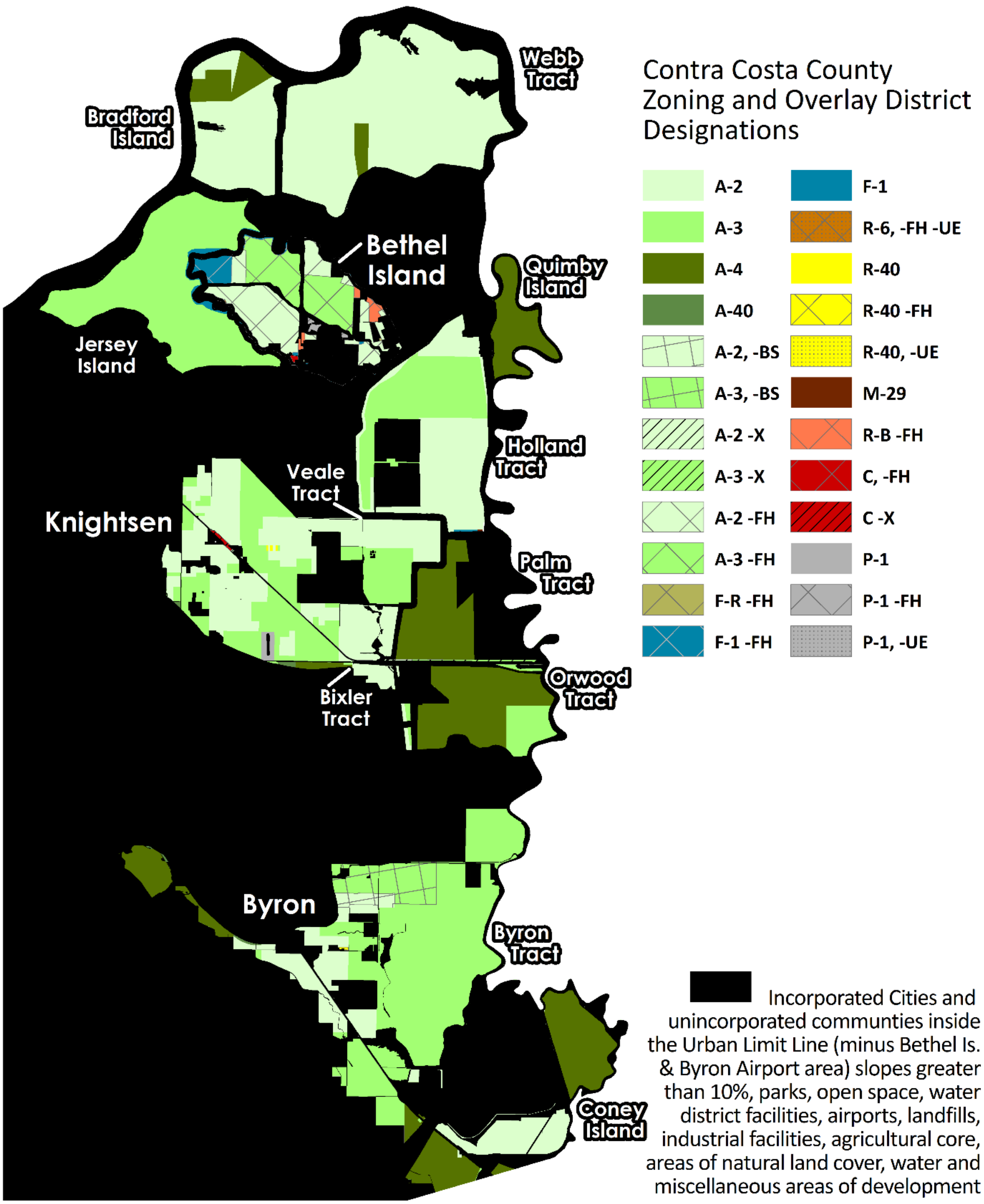

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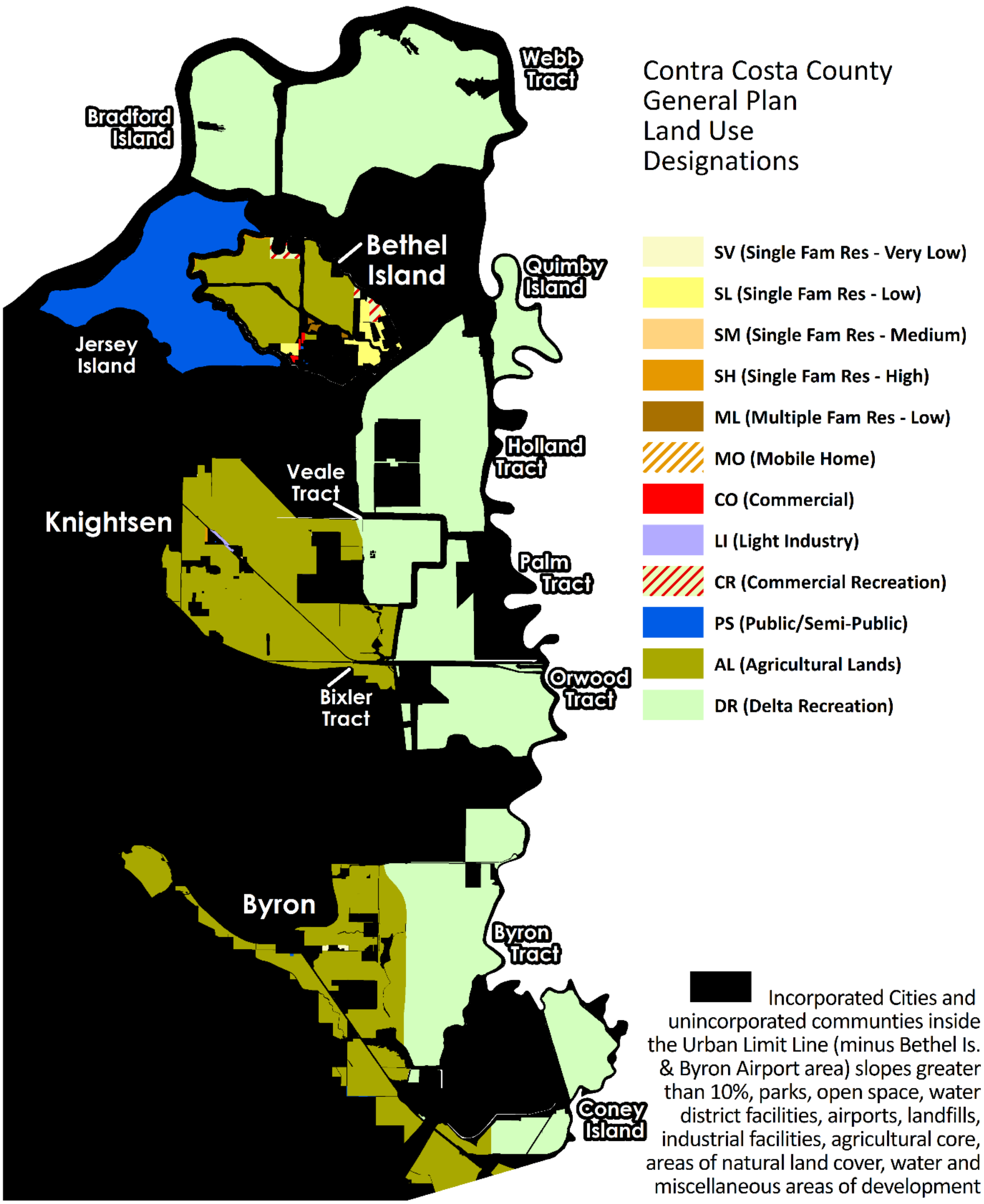

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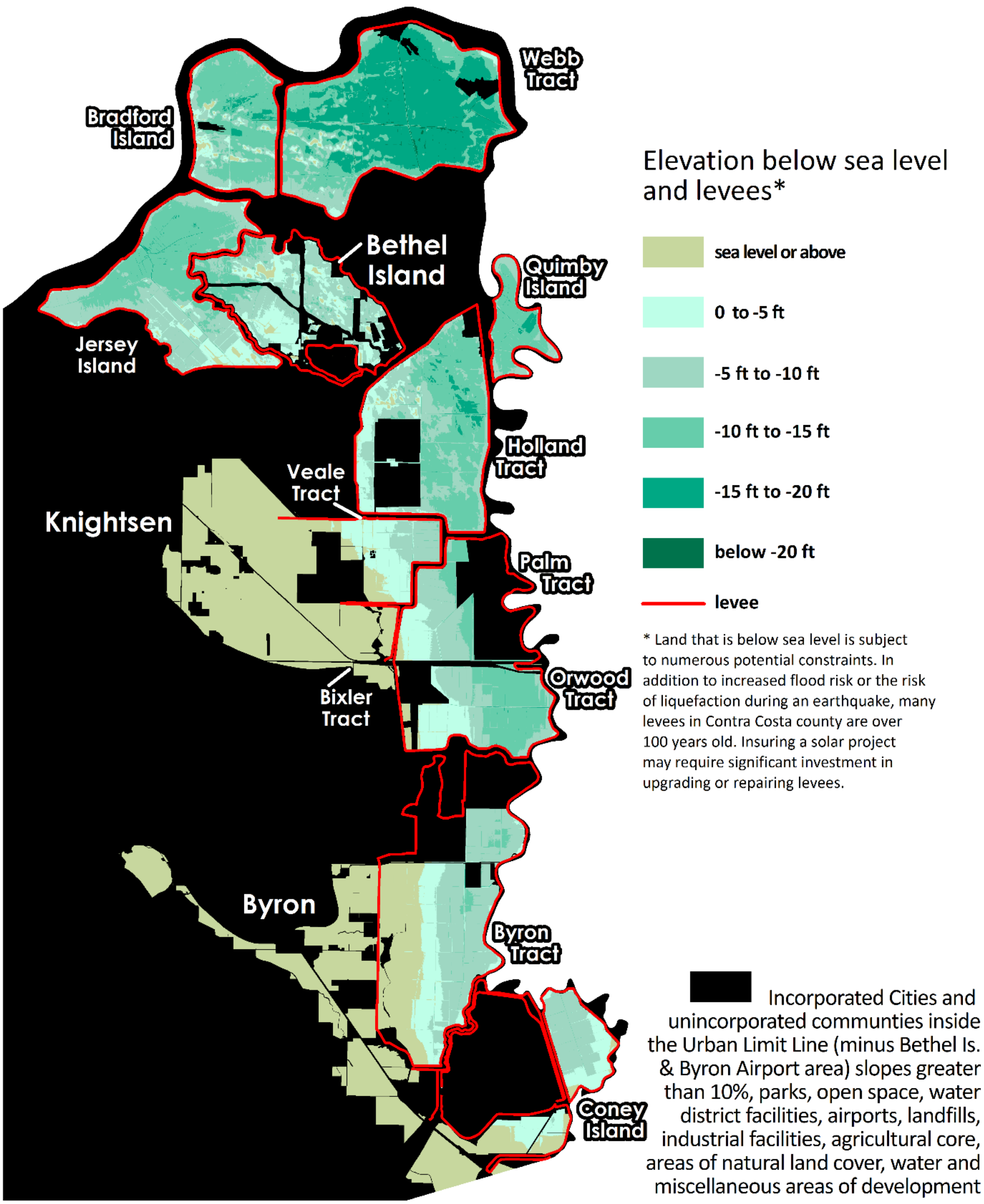

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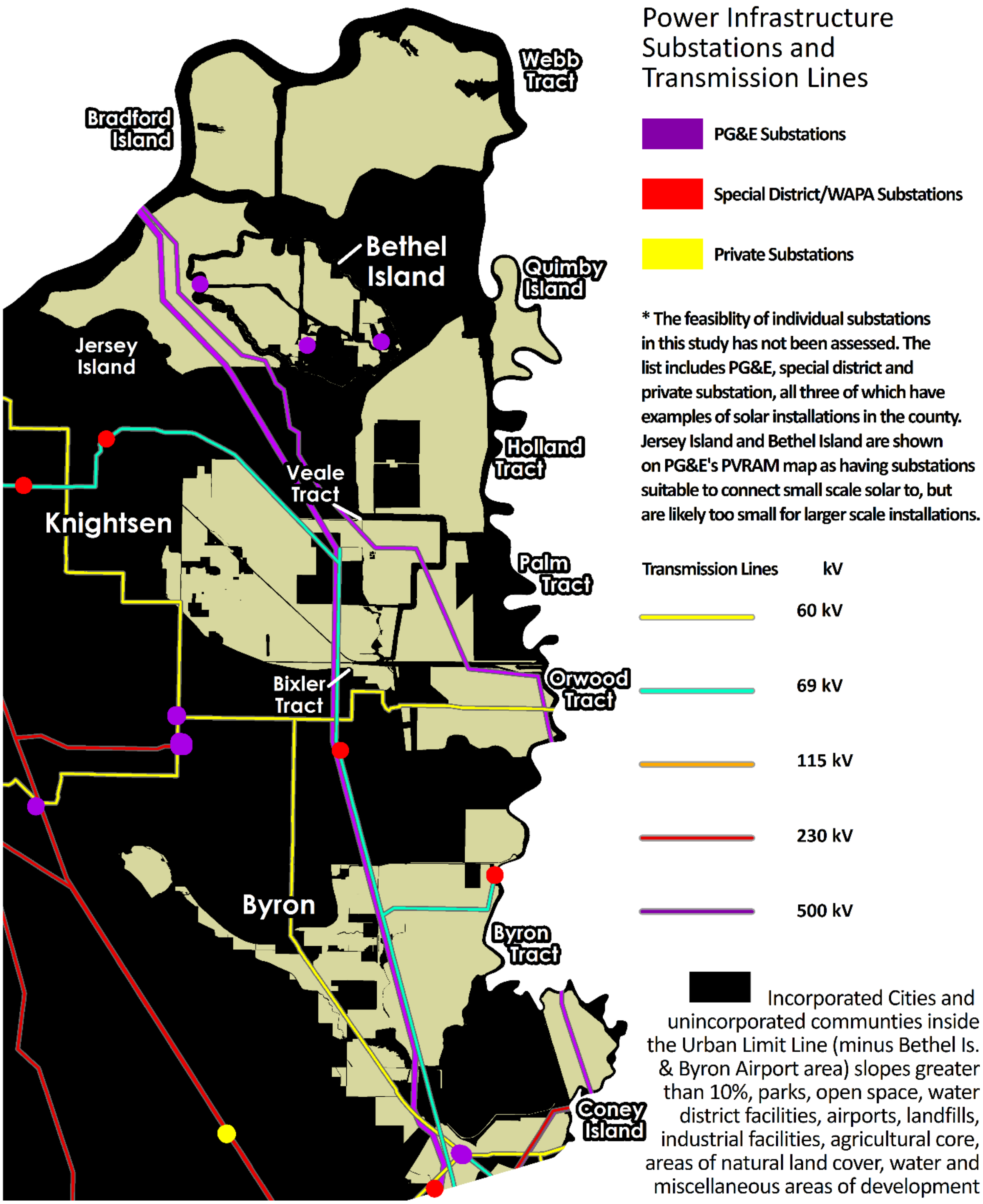

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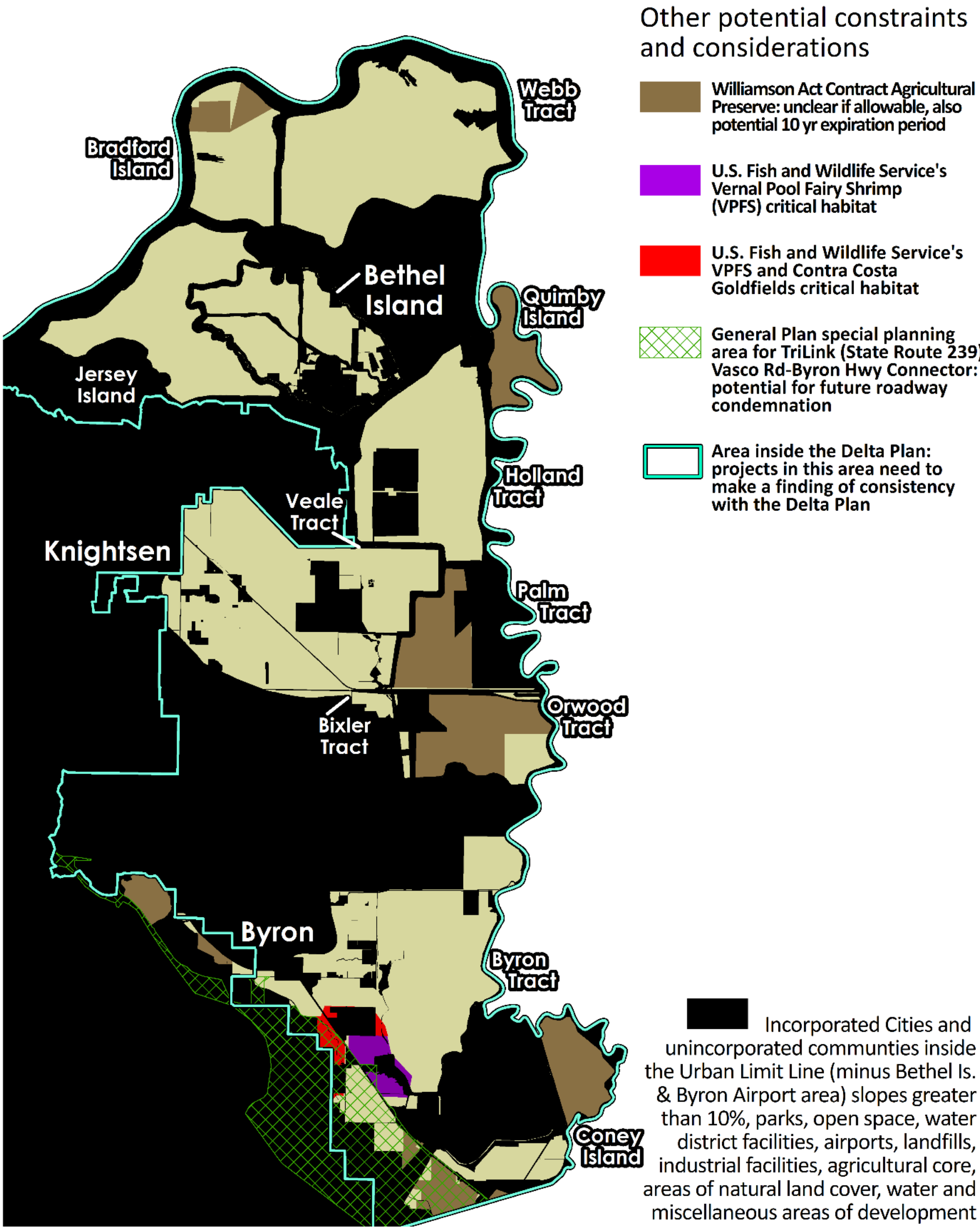

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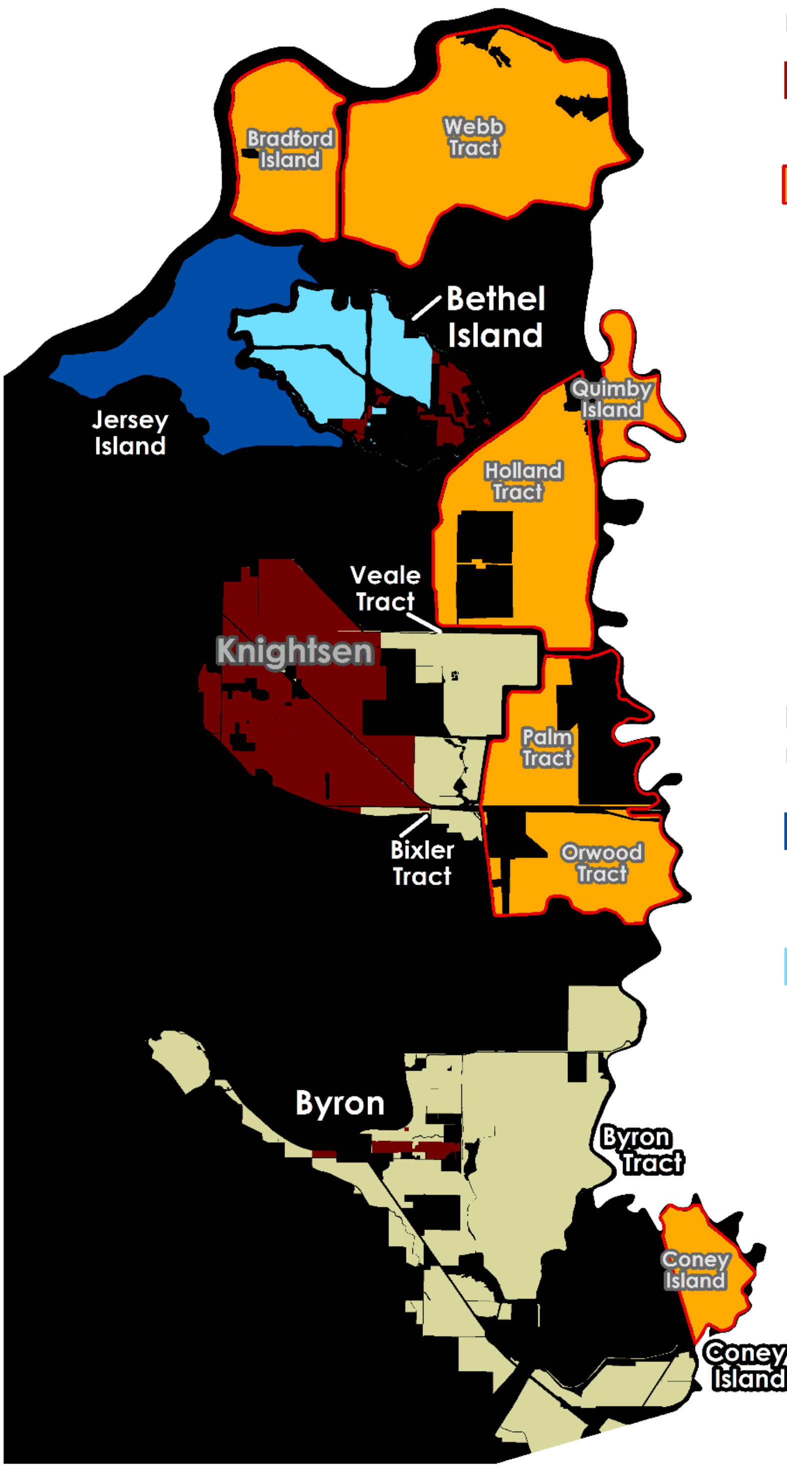


Significant constraints removed from consideration

Rural residential area: generally smaller parcels. and potenially out of character with community

Delta Islands primarily under private ownership with older levees maintained by small Reclamation districts. These locations are farther away from electrical infrastructure

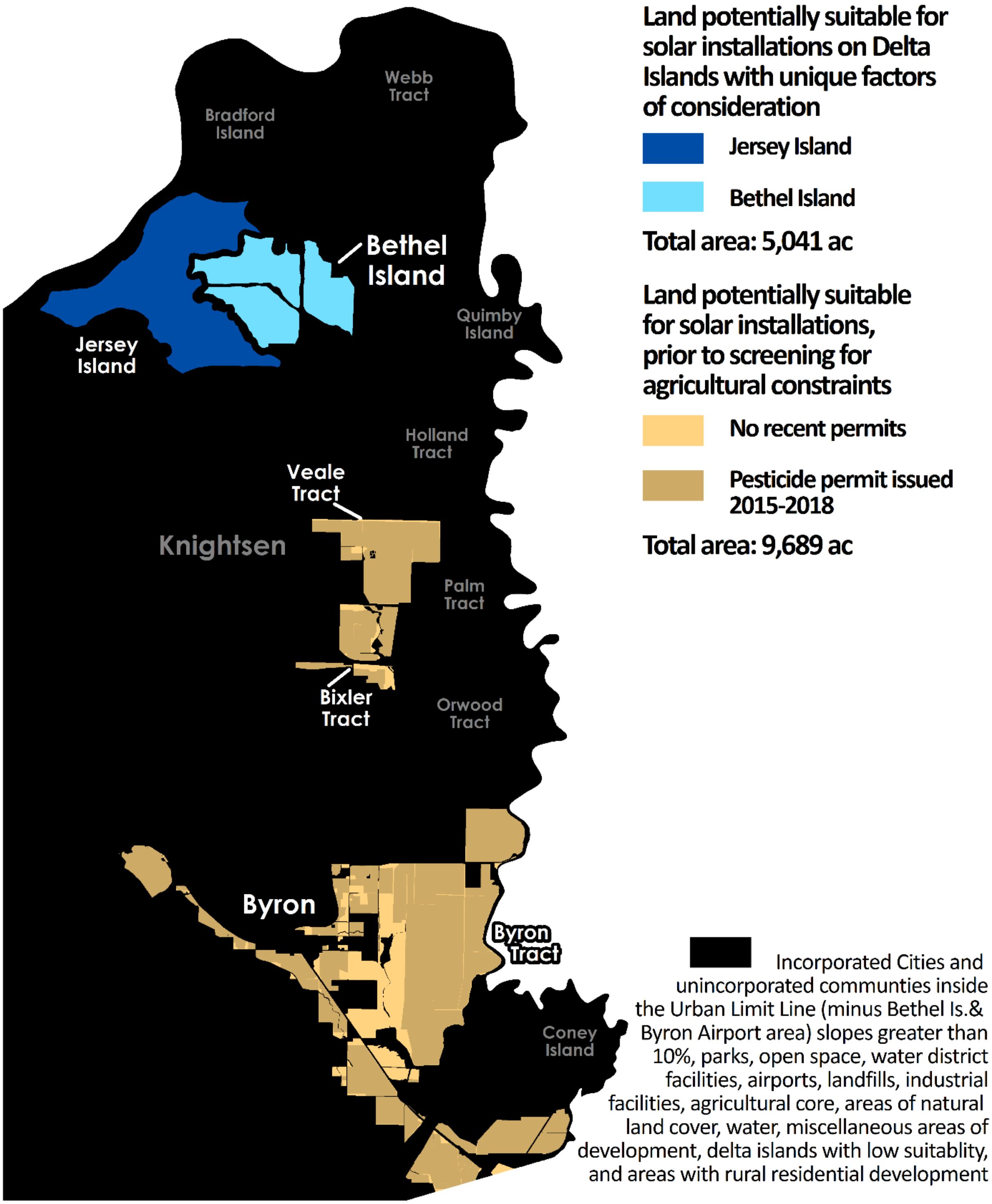
Delta Islands with unique considerations

Land owned by Ironhouse Sanitary Disitrct. It has a general plan designation of PS Public - Semi Public. The agency is considering different uses.

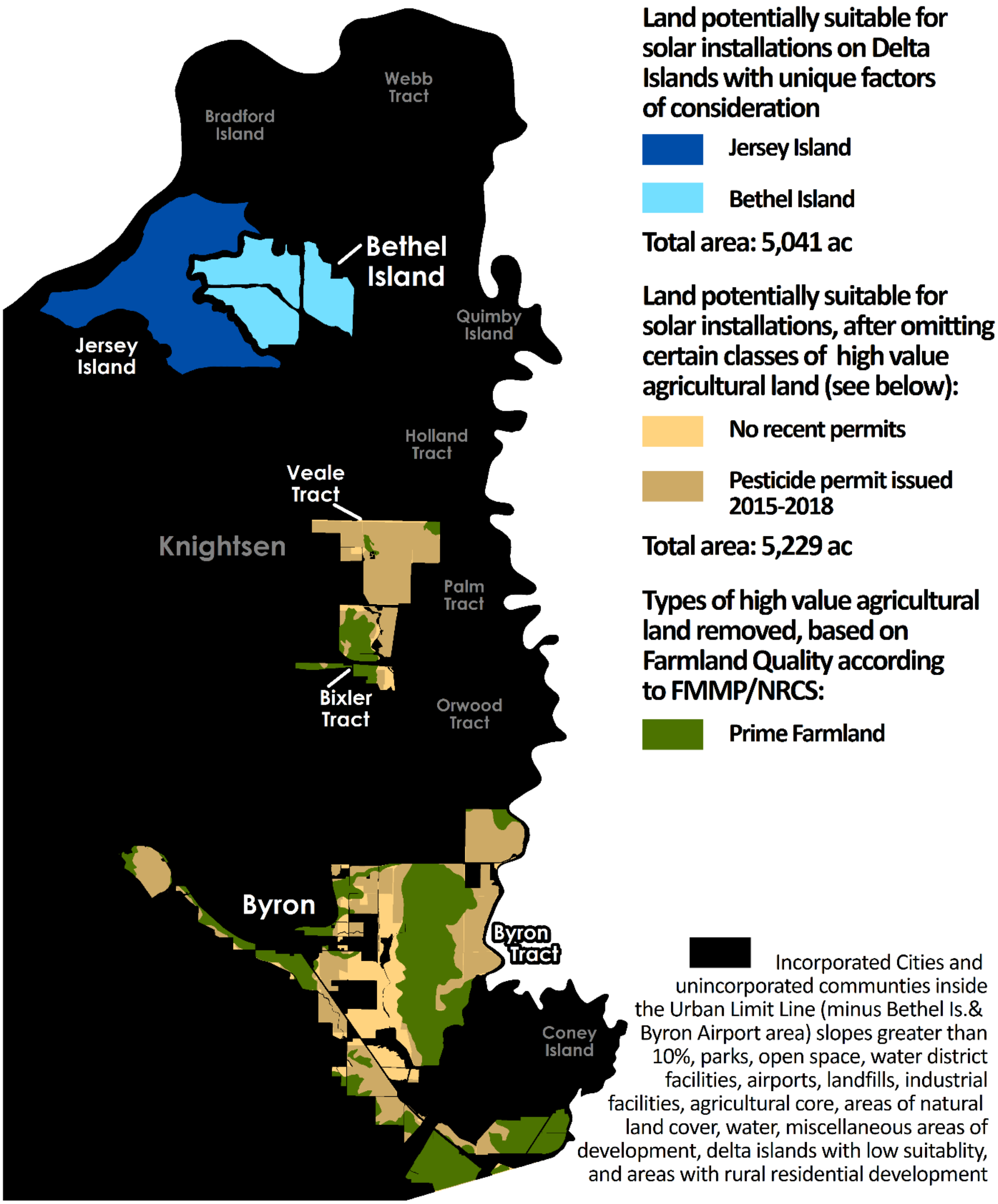
Bethel Island is inside the Urban Limit Line. In general there are signicant obstacles to urban development on the island, but it does have a more robust levee maintence district, more infrastructure, a wider risk pool in the event of levee failure, and fewer tradeoffs than other delta islands.

Incorporated Cities and unincorporated communties inside the Urban Limit Line (minus Bethel Is. & Byron Airport area) slopes greater than 10%, parks, open space, water district facilities, airports, landfills, industrial facilities, agricultural core, areas of natural land cover, water and miscellaneous areas of development

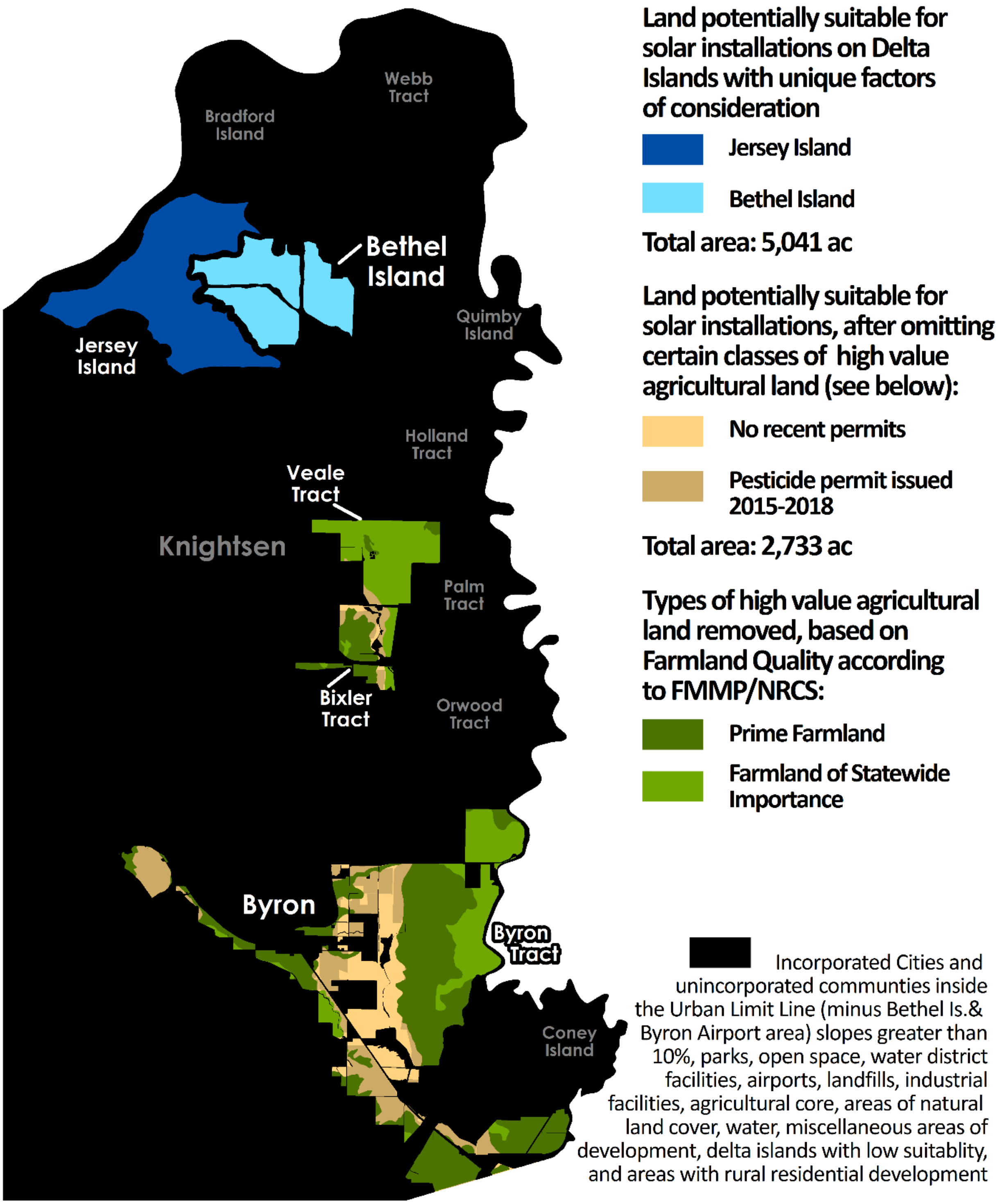
Evaluation of constraints for siting solar on agricultural lands



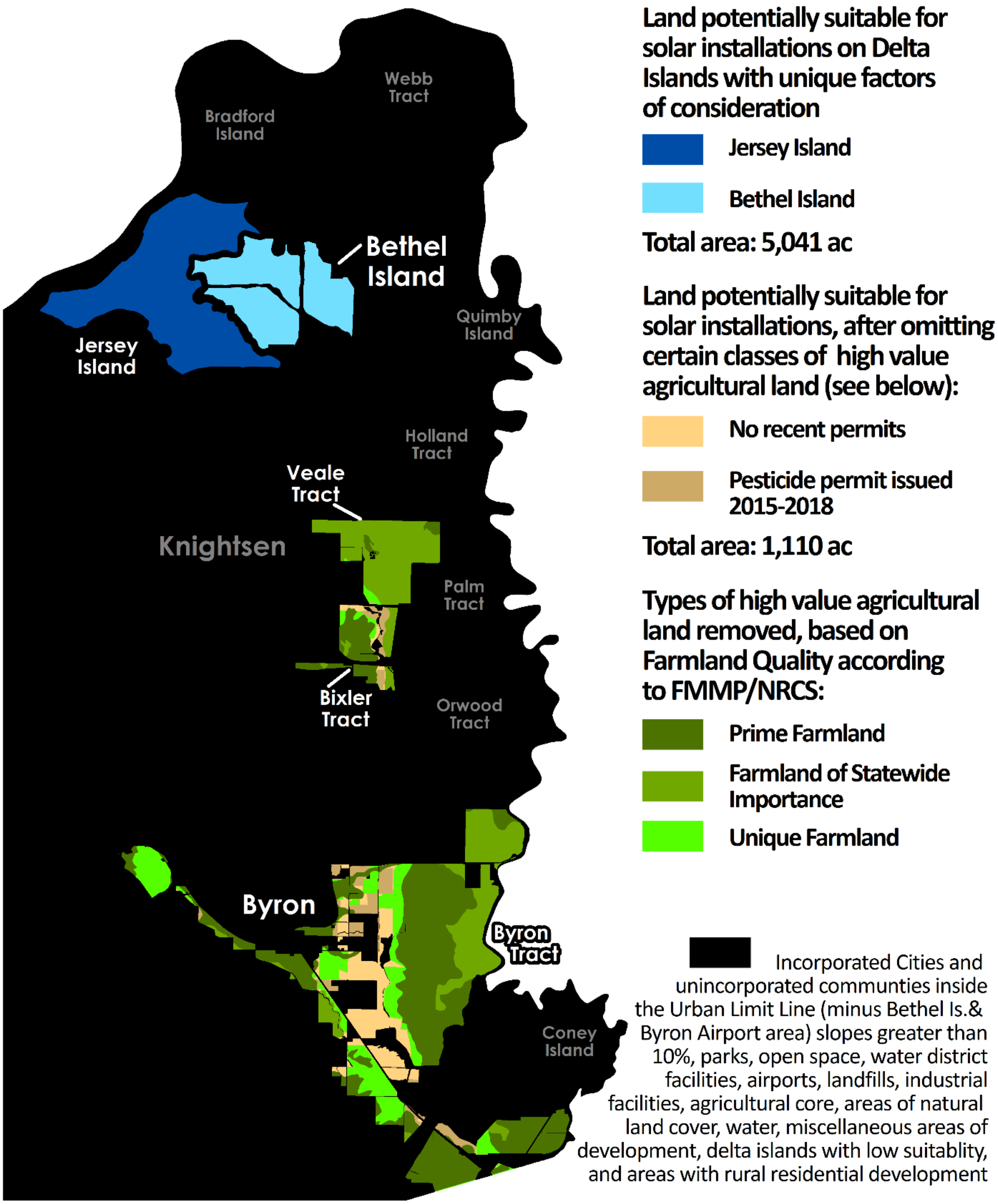
Evaluation of constraints for siting solar on agricultural lands



Evaluation of constraints for siting solar on agricultural lands



Evaluation of constraints for siting solar on agricultural lands



Evaluation of constraints for siting solar on agricultural lands